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Human and their Technical Systems

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Technical Systems in the TRIZ

"… a *number of components* combined to a system by establishing *specific interactions* between the components … assigned to *perform a controllable main useful function* … within a particular context." (Glossary V. Souchkov)

Purpose, ability to work, environmental compatibility. The laws of development of the system must be respected. (V. Petrov, 2020)

Significance of the system operator in TRIZ, non-triviality of the anti-system (N. Feygenson, 2020)

Basics

Despite its importance, the definition of a Technical System remains vague.

How this concept can be developed more precisely?

1. Which aspects should be considered?
2. Four dimensions of the concept *Technical System* (TS).
3. Technical systems as Black Boxes.

Aspects

Distinguish between design time and runtime

- During design time, the basic cooperative actions are *planned*.
- During runtime *this plan is executed*.

Distinguish between

- interpersonal forms of description that are communicated as *justified expectations*, and
- interpersonal forms of realization, whose *experienced results* are in a contradictory relation to the justified expectations.

Aspects

Aspect of Reuse

- Reuse of TS as artifact is one of the central points in TRIZ evolution theory.
- Reuse as artifact does not apply to most large TS – these are *unique specimen*, even if they are assembled from standard components.
- Most computer specialists work on *unique specimen*, too, because the IT systems that operate such large TS are also unique.
- The same applies to offices, institutions, government agencies, etc.

Aspects

Thesis 1:

The main part of the real world power of technical systems is concentrated in the *interactions of components* in a *World of Technical Systems*.

The whole is much more than the sum of its parts.

First Approximation

The four dimensions of the concept of a TS

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1. The real-world unique specimen.
2. The *description* of this real world unique specimen.

For components that are manufactured in large numbers, additionally

3. The description of the *design of the system template*.
4. The description and functioning of delivery, assembly and operation *infrastructure* around the real-world specimen produced on this template (e.g. production plan, quality assurance plan, delivery plan, plans for operation, maintenance and service).

TS as Black Box

The basis of this concept of a TS is the *concept of Open Systems* from the more general Theory of Dynamical Systems.

Existing TS are normatively characterized

- at the level of their description form by the *specification of their interfaces* and
- at the level of their realization by the *guaranteed functioning according to this specification*.

The concept is self-similar: A TS consists of components, which in turn are TS.

Within a TS, the specification-compliant functioning of its components is assumed.

TS as White Box

The core of a technical system is ...

... the description of specific processes by reducing them to the essentials with the goal of their practical application.

1. TS and the Reduction to the Essential.
2. TS and the World of Technical Systems.

TS as White Box

The reduction to the essentials ...

... focuses on the following three dimensions:

(1) Delimitation of the TS from the outside *environment*, reduction of these relationships to input / output relationships and guaranteed throughput.

(2) Delimitation of the TS inwardly by grouping parts as *components* whose use is based on a "behavioral control" via their interfaces.

(3) Reduction of the relationships in the TS itself to *causal essential* ones.

TS as White Box

The concept is based on the availability of existing TS, which are available in (2) as components and in (1) as neighboring systems.

Engineering practices thus take place in a *World of Technical Systems*.

Neighboring systems and components appear in the description of a TS only via their specifications.

Thesis 2:

A requirement for the smooth operation of a TS is the *guaranteed specification-compliant operation of the corresponding infrastructure*.

The World of Components

TS are assembled from existing components. Components provide

- a *core functionality*, called *core concern* in the Theory of Component Software (TCS) and MPV in the TRIZ,
- and require a large number of *supporting functions*, called *cross cutting concerns* in the TCS, that use *established concepts* (description dimension) and are integrated as services of already *prefabricated components* (realization dimension), based on *other* technical principles.

The majority of components is purchased from third parties.

Thesis 3:

Real-world components are in this sense always *function bundles*, which bundle procedural knowledge from *several* areas and services from *third parties*.

Standardization

The evolution in the World of TS is driven by a process of Modularization and Standardization as a central engineering approach.

Modular systems are widespread and enable *standardization of the design* of the vast variety of the unique real-world specimen of a TS.

A component combines the *application logic* as *core concern* and the *logic of infrastructural networking* as *cross cutting concerns*.

Standardization

Application logic and infrastructure logic are orthogonal to each other, which means that the evolutionary trends *4.2 of increasing completeness of a system* and *4.4 of migration to the supersystem* practically act contradictory.

Thesis 4:

An improvement in the understanding of the *infrastructure requirements* of interacting components (transition to the supersystem) as form of description allows to *reduce the level of completeness* of individual components.

Economies of Scale

Standardization opens up the prospect of economies of scale for standard components. Economies of scale lead to lower costs per unit and thus shift the leading role of competition from competition *about the better technical solution* to the competition for its *cheaper economic production*.

The S-curve thus changes at its top in phase 3 of general availability of a sophisticated technical solution (including standardization) into a *different mode* in which the reduction of economic costs of the availability of this "state of the art" takes over the control of the further development of this TS.

Economies of Scale

Thesis 5:

The *technical trend 4.1 of increasing (technical) value* turns on the third stage of the development of the S-curve into an *economic trend of decreasing (economic) value*.

Or, in economic terms: a demand-driven market turns into a supply-driven market. The same (mature) *use value* has an ever lower *exchange value*.

Conclusions

Thesis 6:

The TRIZ theory of evolution of TS should distinguish between young and mature technologies.

In mature technologies ...

- TS are *bundles of technical principles*, which
- in the description form extract *unity from diversity* (core concern) and
- in the realization form restore *diversity* in real-world local application contexts as complex functional bundle from these unities, constituting the *World of TS*.

Discussion

Many thanks for your attention.