TRIZ and Transitions in socio-technical and socio-ecological Systems. A Comparison

Hans-Gert Gräbe
Uni Leipzig, Leipzig, Germany

Goal of the Presentation

- We compare systemic transition concepts of (large) technical systems from TRIZ background with transition concepts on the sustainable management of ecological systems.
- **Parallels:** In both areas existing systems should be further developed, transforming contradictory, interest-based requirements into a functioning «world model» in order to implement them practically.
- We underline the **engineering quality also of management processes** and **propose a uniform TRIZ-methodical approach** to the processes of decision preparation and decision making, that supports connectivity of models in even more complex situations.

Goal of the Presentation

- We draw parallels between challenges of modern company development and challenges of socio-ecological transition processes.
- It's my belief, that TRIZ as systematic innovation methodology can contribute to both topics and thus build a bridge between the sustainability discourse, which sharpens long reaching goals without realistic ideas about appropriate tools, and an industry discourse, which focuses on the development of human resources as «tools» and qualifications only, without formulating clear goals of long reaching target corridors of societal development.

Details: http://dx.doi.org/10.14625/graebe_20200627 (in German), English version submitted to TRIZ Reviews.

Socio-ecological and Socio-cultural Systems

Socio-ecological and socio-cultural systems differ from socio-technical systems mainly by the fact that the former are not «built by purpose» but «built naturally». However, this assumption is misleading for the following reasons:

1. The interest in resolving contradictions also in socio-ecological systems is essentially determined by purposes and interests.
2. Socio-ecological systems have been transformed by human activity for thousands of years. This moves the socio-cultural character of such systems closer to technical ones.
3. Transition concepts for such systems have clearly technical character in the sense that socio-cultural processes are designed with methods largely adopted from engineering approaches.

System Notion

We use a self similar **concept of a system as "reduction to the essential"**,

- Consisting of
  - **components,**
  - **"essential relations"** between them
  - and a **structure-constituting throughput**,
- with a **main functional behaviour**, theoretically expressed by a **specification** and practically by a **guaranteed performance**,
- provided the **necessary infrastructure requirements** are practically present.

System Notion

Components are systems by themselves, but with reduction to a different "essential". Practically functioning components are **required** both

- for the **reproduction of the internal structure** of the system
- and for the system‘s ability to **provide the offered service**.

This requirement structure defines a **directed graph of dependencies** between systems thus putting the supersystem-system relation on a similar basis as the system-component relation. We avoid the notion of supersystem in favour of the notion of neighbouring system.

System Dynamics

The reductionistic character of our system notion requires to differ between theory and practice as difference between *theoretical prediction* v(t) and *practical development* p(t) of the system.

v(t) expresses *justified expectations* and p(t) *experienced results*.

More precisely, as in the theory of dynamical systems, we start from a phase space Φ, in which the two processes

$$v: T \to \Phi \qquad \text{and} \qquad p: T \to \Phi$$

evolve in time, assuming Φ a metric space to express the *size of deviation* d(t) between prediction and real development.

We further assume that v(t) can be described through movement equations, which approximate a temporal progress of the process and whose solutions are **close to a steady state equilibrium** (attractor).

System Dynamics

With Holling [Ho2001] we further assume that the system dynamics p(t) are influenced by the effect of restoring forces and usually moves in the vicinity of this attractor and thus d(t) remains small as long as there is room on the attractor for further development (*Holling's r phase*).

This development potential is exhausted when the system goes into a local extremum of the attractor – then the system reacts on disturbances returning to the same reference point on the attractor (*Holling's K phase*).

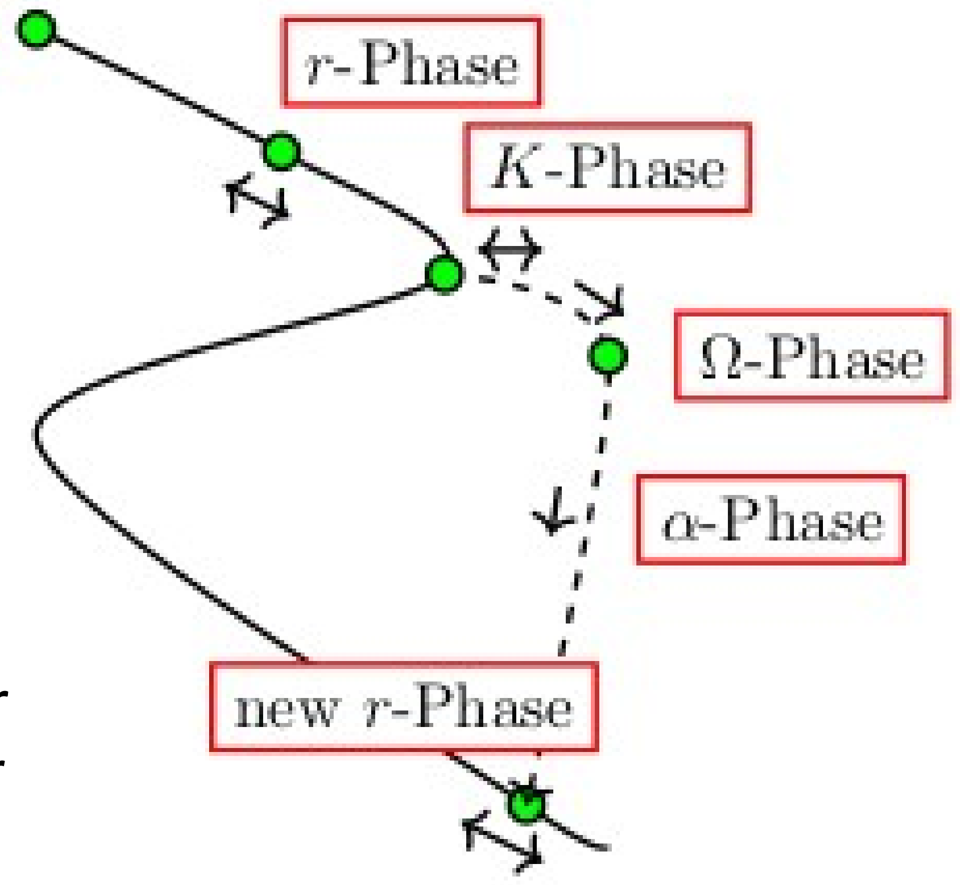
Crawford S. Holling (2001). Understanding the Complexity of Economic, Ecological, and Social Systems. In: Ecosystems (2001) 4, 390–405.

System Dynamics

Then disturbances build up, the system status moves further away from the attractor, the near field influence of the restoring forces fails and the system «moves» to «search» for a new, often distant reference point on the attractor (*Holling's Ω phase*).

On this distant new reference point a modification of the system's structure and dynamics are required according to the new parameters (*Holling's α phase*),

After that modification the system enters another longer stable development phase (*Holling's next r phase*).



System Dynamics

At the core of the problem of systemic transition concepts is the question, to which extent such transition processes propagate in the causal network of interconnected systems.

This network arises from a double reduction of the real-world totality

- not only from a reduction of the complexity of the *system‘s description*,
- but also from structuring processes of the *real world implementation* of the systems according to the *reasonable expectations* resulting from the systems‘ (plural!) descriptions.

Transition Paths

[GS2007] describes a number of types of possible transition paths. This can be considered as an attempt to introduce some structure in the Ω-α conversion phase.

The *need for system transition* arizes if local development possibilities on the system attractor are exhausted, because the system moved with progressing «idealization» into a local extremum of the attractor.

Such a system change puts a greater stress on systems, connected with this system (components in the system, neighbouring systems, general «unsystematic» relations to other systems). In this sense, *systemic transition processes migrate along causal relationships* more or less far through the network of systems.

The *source of disturbance* and the *location of the transition* can occur in different places within that network.

There are *structural transitions* and *processual transitions*.

Frank W. Geels, Johan Schot (2007). Typology of Sociotechnical Transition Pathways. In: Research Policy 36 (2007), 399-417. https://doi.org/10.1016/j.respol.2007.01.003

Transition Paths

[GS2007] further introduces **organisational levels** – individual, organizational subsystem, organisation, organisational population, organisational field, society, world system – mainly to concentrate on *structural transitions* of institutionalised organizational structures at the different levels (for example in the «Society System») together with their «Luhmann codes», required to be literally able to communicate about disorders at all and to decide at least roughly whether the system is faced with an «incremental, radical, system or techno-economic» **type of disorder** aka «innovation» and **how to react to this in a type-appropriate manner**.

If a «**conjuncture of multiple development**» is present, then the *thesis of the source of the disturbance in a single system* becomes fragile, if that disturbance is propagating wavelike in the network of systems and so it is hardly to distinguish whether this «wave» was triggered by a point source or *is an emergent phenomenon of the network* (which itself can be regarded as a system, but on a different level of abstraction) as a *resonant response* to an external disturbance.

Transition Paths

To make matters worse, in such transitions three spheres interact substantially:

- The sphere of description forms (the *socially available operational knowledge*),
- The sphere of the real existing, in systems structured reality (the *institutionalised operational procedures*) and
- The cooperative subjects (with their *«private» operative procedural skills*).

In [GS2007] the interaction structures, driving such a mediation in a «model of agency», are identified as basis of a **common «interpretation of the world» of cooperative subjects**, which has to prove itself useful and has to be mounted in the actions of those structures («use rules», «rules are not only constraining but also enabling» [GS2007]).

These are the forms in which the pragmatics are mediated and thus *conceptuali-sation processes in the real world* are induced up to the «conceptualisation of sociotechnical landscapes» that «... form an external context that actors cannot influence in the short run» [GS2007].

Transition patterns

[GS2007] discusses six transition patterns P0 to P5:

P0: The system is in the *r phase* and can absorb the pressure for change from one of its components («no external landscape pressure»). The same remains correct if the pressure comes «from outside» (i.e. from other systems) and is not too big.

P1: Pressure comes from «outside», no pressure from the components, the system is leaving or beyond the *K phase*. The system can react only reorganizing the internal relationships.

The example (Danish hygiene transition from cesspools to sewer systems) is clearly one for the dynamics of the *Ω phase*, which on the TRIZ side corresponds to a transition from one S-curve to another one.

P2: The system is disassembled, its components are reorganized differently. As typical accompanying phenomenon a «vacuum» is diagnosed, as it appeared as power vacuum in the collapse of the Eastern bloc.

Transition patterns

The example (automobile replaces transport by horses) does not take into account that the new conditions are structurally developing in the subsystems for some time yet – «in the bosom of the old society».

P3: The pressure does not come from the environment, but from individual components. The system can reorganize itself in such a way, that the external conditions, required for the reorganization of the components, can be ensured, without giving up the functionality of the system as a whole to the outside world.

The explanatory potential is weak. «avalange change» and «disruptive change» as «landscape pressures» exist all the time as «disturbances» and are not causal, although possibly triggering.

In the example (Brithish transition from sailing ships to steam ships) the effect of the Kondratieff wave around 1890 is not considered. Also «market cleansing», typical for such transitions, are not discussed, resulting from productive roll-out of new technologies on a larger scale, requiring larger amounts of advanced capital.

Transition patterns

P4: Components in Ω *phase* meet a system in *α phase*. Actually, however, the transition is triggered from a causally deeper technology level, that effects *many components* and puts them into Ω *phase*, but which is absorbed by the system in *α phase* (and thus in a particularly flexible *r phase*). So also the example (American transition from traditional factories to mass production).

P5: Unlike P4, the changes can *not* be absorbed in the system and are forwarded. This means that also the relationships of the system to the external world become unstable. The authors are quite helpless (they propose a «sequence of transition pathways») and have no example at hand.

In general, it is noted that such complex processes not only can't be explained monocausally, but also the variables in a mathematical description model cannot be divided into dependent and independent ones. Therefore one can only speak about *evolutionary patterns*.

Transition Scenarios and TRIZ

How transition scenarios are conceptualized in the context of TRIZ?

Transition concept plays a relatively central role also in TRIZ, since to solve a contradictory situation of requirements, arizing in a systemic context, means to identify a suitable *transition of this systemic context* into a state in which the contradiction is resolved. The TRIZ methodology helps to find a path of transition in a systematic way.

This approach differs significantly from the previous approach in two dimensions:

1. It's directed towards a *practical solution* of such a transition.

2. The approach is *problem-driven* and not analysis-driven.

Transition Scenarios and TRIZ

[M2019] discusses the question, whether problem solving methodologies play a similar role in the management context as in solving engineering problems. Referencing a «**theory of complex adaptive systems**» (CAS) from [SB2007], the relation to the theoretical background of [FRS2009] is evident, but [SB2007] focuses on «leader's decision making» and not, as [FRS2009], on participatory decision-making processes (adaptive management) or transition management.

Darrell Mann (2019). Systematic innovation in complex environments. In: Online Proceedings of the TRIZ Summit 2019 Minsk.

David J. Snowden, Mary E. Boone (2007). A Leader's Framework for Decision Making. Harvard Business Review, November 2007.

Timothy J. Foxon, Mark S. Reed, Lindsay C. Stringer (2009). Governing long-term social–ecological change: what can the adaptive management and transition management approaches learn from each other? Environmental Policy and Governance, 19 (1), 3–20. https://doi.org/10.1002/eet.496

Management of Transitions

In [SB2007] transition processes are described from a **decision-making perspective**.

Decision-making techniques show great proximity to engineering, but this is in no way a surprise, since structured approaches do not end leaving the technical area in the strict sense of the term.

The arguments go clearly beyond [M2019], but also [FRS2009] and [GS2007], since [SB2007] does not so much focus on the *analytical dimension of the* ***preparation of a decision***, but on the *procedural dimension of* ***decision making***, and develops a «framework for decision making».

The four system classes «simple», «complicated», «complex» and «chaotic» are used to **classify decision-making processes** mainly according to the **quality of the available basis of decision**.

Systems of Decision Making

Systems of decision making have to consider, besides purely technical arguments, a large number of other mutually exclusive arguments. Decision making thus bundles the often contradictory statements and requirements from *various other systems*, in particular from technical systems in the strict sense.

But these «other» systems appear both as supersystems and also as components. They are **supersystems** to the system of decision-making in so far as their *logic is causally prior to the logic of decision-making*, they are **components** in so far, as the *contradictory* ***relationships*** *between these individual logics* are to be addressed and equally respected in the decision process.

Systems of Decision Making

Thus in the sense of our system concept the system of decision making (SDM) has to be separated from the various systems of decision preparation (SDPs) to achieve the necessary reduction in complexity.

The SDM draws on the results of the SDPs via their *interfaces* and has to *process the compressed quality* of these contradictory information systemically.

However, the socio-technical SDM does not «combine with the technical objects and contexts also social ones» (Rubin), but those «technical objects and contexts» from the SDPs are present within the SDM *alone via their interfaces*, **importing the SDPs as components into the SDM**. The supersystem is not characterized by more relationships, but by another direction of complexity reduction to «the essential».

Systems of Decision Making

In [SB2007] methodological advice is given for this purpose, which is solely based on the *perception of a degree of inconsistency in the signals from the components*.

The situation is «**simple**» if the descriptions imported from the components harmonize to such an extent that only «sense, categorize, respond» is required.

The situation is «**complicated**» if the «experts» from the components can clearly express their contradictory positions and «at least one right answer exists». Dangers are faced in «entrained thinking» of a routine treatment and thus underestimation of such contradictions, the approach to be taken «welcoming novel thoughts and solutions from others» (i.e., shortly: brainstorming) is recommended.

The situation is «**complex**» if the decision has to be filtered out and formulated in the SDM itself, the decision is seen as an «emergent phenomenon», that can only be formulated after a thorough view of the interactions between the components, and is more than the sum of the parts.

Systems of Decision Making

[SB2007] can be interpreted in a different way than in [M2019], that opens the door to a better understanding of the relationship between the **technical analysis processes** of classical TRIZ and the **business decision processes**, which are both necessary for the practical implementation of a transition process.

In the SDM the systemic decision-making processes are based solely on the input of the SDPs, imported into the SDM via the corresponding *interfaces* of the neighbouring systems as *components* of the SDM.

In the best case an *iterative decision making model* is implemented, which allows to communicate back *partial solutions* via the same interfaces to the components in order to *improve the partial solution* within the logics of the SDP and communicate the objections back into the SDM via the interface.

The SDM thus takes on an apparent role of a supersystem, **but only from an internal view of the SDM itself**, because such coordination does only work, if the systems in the network of the SDPs are ***functionally disposed*** *to such responses*.

Systems of Decision Making

The coordinating request from the SDM **has to meet a function in the neighbouring system that is able to generate a response**. For this, within each of the neighbouring systems in the SDP network, the SDM has to be present as a component that provides input in a well-defined format and expects output in an equally well-defined format.

A **real supersystem** results only from a systemic view on the relations between the systems in the SDP network. However, this requires to climb a next level in the epistemic layer architecture. Its topic is **not** the concrete problem solving process in this concrete network of SDPs, but the **generalized analysis of a larger number of such problem solutions**. This is a process of conceptual creation on a different level and goes well beyond all the approaches discussed here.

Summary and Outlook

How far does a systems theory approach lead in general? We stated at the beginning that there is not a single system theoretical approach, but we are confronted with a whole universe of interrelated approaches.

The concept developed here goes with the consideration of the unity of description and realization forms a significant step further.

Especially the **unspecific notions of «environment» and «supersystem»** are shaped more precisely: the environment can be introduced in this descriptive approach only again as a system and thus *not as totality*. In such an understanding a system can be related to *several* supersystems. Thus the system-supersystem relationship looses its exclusive character among the systemic neighborhood relationships.

Summary and Outlook

On the other hand, one has to **distinguish between modeling and metamodeling**, where the latter is regularly becoming significant when it comes to a *systemic version of description forms of relationships between systems*.

The latter gives rise to a stratification of reality along the **levels of conceptualisation of the description forms**. This can be considered to be formative for high-tech societies. This description stratification as a specific form of complexity reduction (»fiction« in [Gr]) finds its equivalent in technical layer architectures such as the OSI 7-layer model.

Hans-Gert Gräbe (2020). DOI: http://dx.doi.org/10.14625/graebe_20200627

Summary and Outlook

Systemic considerations identify **unity in diversity** in the description form, from which **diversity has to be restored** in practical applications.

Here people are both subject and object of action. The associated contradictions can in principle be consciously handled, but this contains another stumbling block – self-reference.

System theory is overtaxed in this respect and must be embedded in a **more general theory of society**.

Communicating Author:
Hans-Gert Gräbe, graebe@informatik.uni-leipzig.de