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From a Toolbox to a Way of Thinking – An integrated View on TRIZ

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Abstract

TRIZ is known as a powerful toolset for inventive problem solving. Its algorithms, methods and findings are applied to a wide range of engineering problems – experiences for the successful use in non-technical areas are published as well. The industrial application of TRIZ mostly starts with moderated workshops or trainings. Subsequently, TRIZ is often moved into the company's own "warehouse of methods" and pulled out when needed. While this approach is straightforward and quite useful, it limits the potential of what TRIZ has to offer for innovation activities and product development processes of companies from all industries.
Hinged on the System Approach, 9-Screen-Model and Function Analysis, the paper describes how those operational aspects can be integrated into the strategic use of Trends of Engineering Systems Evolution (TESE) and S-Curve Analysis. This integrated view can be used to evaluate and expand the development potential for any engineering system. The paper is aimed at the TRIZ professional as well as the TRIZ newcomer. The professional gets a fresh view on TRIZ as a way of thinking and input for new approaches to strategic product development with TRIZ, trying to "connect the dots" in innovation. Those new to TRIZ will get a "helicopter-view" introduction to the spirit of TRIZ, which is more than a box full of methods and algorithms.

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Keywords: TRIZ; Altshuller; Systematic Innovation; Strategic Product Development; Trend of Engineering System Evolution; Mulit Screen Model; S-Curve

1. Preface

This paper is neither a scientific research, nor a case study. It is aimed at a high-level view on well-known TRIZ findings and tools, trying to give an alternative perspective on how TRIZ can contribute to a systematic innovation and product development process.

2. More than a Toolbox

Not long after the second World War, a young Russian named Genrich S. Altshuller, wanted to find out how to learn to invent. Until then, inventions were mostly described as result of accidents, luck or inborn genius of gifted people. As a counterpoint, Altshuller's attitude was "If a Methodology for Inventing did not exist, one should be developed" [1]. So the Theory of Inventive Problem Solving was brought to life and continues to be an invaluable and unrivaled resource of methods, tools and algorithms to tackle inventive problems based on the findings of past break through inventions and the condensed strategies of histories most gifted problem solvers.

In today's corporate environment, TRIZ is rightly valued as a toolbox for inventive thinking, having positive effects on problem solving capabilities of groups and individuals. It's findings enable systematic approaches to otherwise "fuzzy" topics. Reports of the use of TRIZ and presented case studies are mostly split into the operative use of certain methods, which are pulled out of the Toolbox when needed, and strategic considerations that are mostly detached from the operative work [2, 3, 4, 5, 6]. However, the findings of Altshuller, his colleagues and successors are worth a more thorough look at what TRIZ actually offers for the task of "making things better", also known as "Product Development".

One of the stories that MATRIZ-students frequently hear, is that Altshuller gave out the task to his students to describe the most important notion of TRIZ in only one sentence. It is said that Altshuller preferred the following description for the essence of TRIZ (loosely quoted):

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"TRIZ is the realization that Engineering Systems evolve according to objective, universal Trends and Patterns, which can be taught and learned."

All tools and methods of TRIZ are based on this finding, and those universal trends and patterns represent the "Voice of the Product" which is independent from the individual and true for all engineering systems [7].

While this statement might be too ambitious for some, it implies that TRIZ is an emerging science that deals with the evolution of engineering systems. As such, TRIZ has much more to offer than a toolbox for problem solving. This paper discusses some generic aspects of TRIZ that might lead to a broader, more open view on the topic of product development viewed through the "TRIZ-lens".

3. Everything is a System

One of the basics of TRIZ is the "System Approach" (also known as Multiscreen Approach, Talented Thinking, 9-Windows etc.), according to which each system is made of Subsystems and is embedded into (or surrounded by) Supersystems. This structuring aspect is enriched by a timeline, that generally describes past, present and future (or before, during and after) for the System, Subsystems and Supersystems [8, 9, 10].

As simple as this scheme is, as powerful are its conclusions: The first task of a TRIZ project is to define: "What is the system we are dealing with?". This definition sets the stage for the upcoming efforts, it has even the power to determine the level of inventiveness we are aiming for. We can easily imagine that there are huge differences if we call our system "Water Pump", if we call our system "Water Treatment Plant" or if we define our system as "Ball Bearing inside Water Pump". Each definition is valid, and all systems interact with each other and therefore depend on each other.

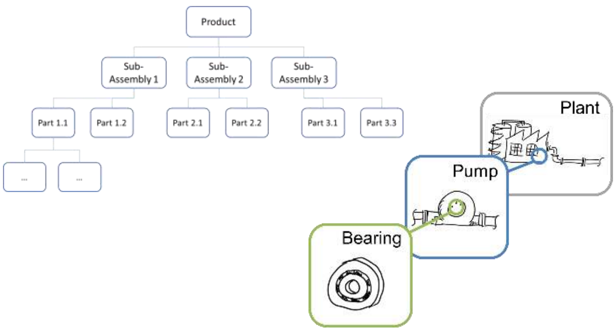

Fig. 1. Hierarchical System Structure.

While it is common to define the product that a company sells as the system, the Multiscreen Approach always calls for consideration of Supersystems as well. Even a producer of ball bearings should not hesitate to watch higher level Supersystem developments to evaluate changes that might affect one's own products. From this point of view, the definition of the System to work on decides if we are dealing with disruptive inventions or incremental inventions, with the terms disruptive and incremental being relative as well. As a pump producer we are free to zoom into the pump and work on e.g. the bearing to incrementally improve the pump without changing the overall principle of moving water. At the same time, we are free to zoom out to the water treatment plant and ask questions about changes on the plant level which might affect our pump - even changes that renders the pump unnecessary. Those changes might be quite disruptive for the pump producer, while the operator of the plant only sees this change as a minor improvement inside the whole plant.

The freedom to choose the system level according to the task, aim and expectations holds great power and consequently leads to a more open and unbiased look on systems [11]. We understand that our current product is just a part of bigger picture and it might be only one of many ways to perform a certain function. It even leads to the realization that each system, like a living organism, is dependent on its surroundings. If the boundary conditions change, the system will have to react and adapt in order to survive. Examples of disappearing industries due to changes on Supersystem-level are manifold [12, 13, 14].

4. "What does it do?" - Modelling of Systems

The Multiscreen Approach can be used in multiple ways, but as a starting point it is aimed at the definition of the system and an analysis of its structure and history, identifying significant changes in the past [15]. Another tool, which can be linked seamlessly with the Multiscreen Approach, is the TRIZ Function Analysis [16]. This tool helps to assess what the components of a system (or the "Subsystems") actually do with each other and how they interact with components in the environment of the system (or the "Supersystems"). The TRIZ definition of a Function itself [7, 17] objectifies the view on a given system: What does the system actually do? Which parameter of the target component is changed? Inherently, the question of "which different action principle can change the same parameter as well? What could be an alternative, maybe more efficient way of performing that function?" leads to an objective look at new opportunities.

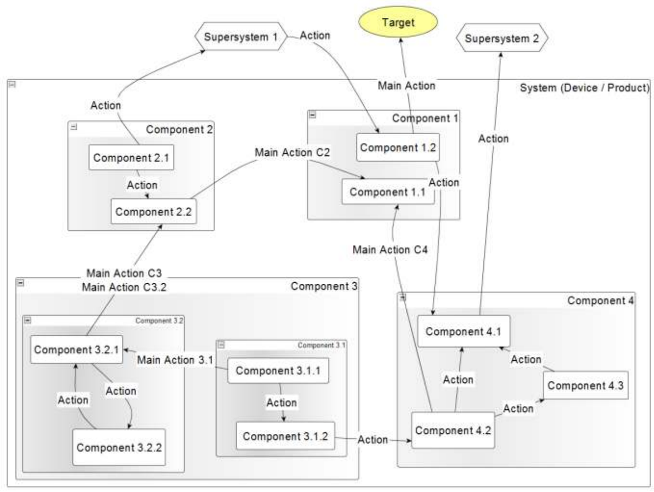

Fig. 2. Nested Function Model.

Knowing that every system is made of Subsystems, which themselves are again made of Sub-Subsystems etc. inevitably leads to a "Matryoshka"-like image, where Function Models can be build on different levels and linked throughout the "system tree". This enables a very detailed analysis and scalable representation of complex systems, starting from a high System-level and going down to an arbitrarily detailed Sub-Sub-(…)-System level (see Fig. 2) [16].

Again, the level at which we build function models determines the level of invention (disruptive or incremental) we are aiming for. With such a "Nested Function Model" we have a solid base for evaluating changes on several levels. To get the most out of Function Models, we should not stop modelling only our product that we sell, but rather model higher level interactions were our product itself is only one of many components and might be subject to trimming or other Supersystem changes, opening our eyes for a bigger picture, e.g. what the end user actually wants or in which context our product is used. Consequently, we might move from "customers don't need a drill, they want holes" to "customers want to have decorations on their wall", depending on the level at which we model the situation (see Fig. 3).

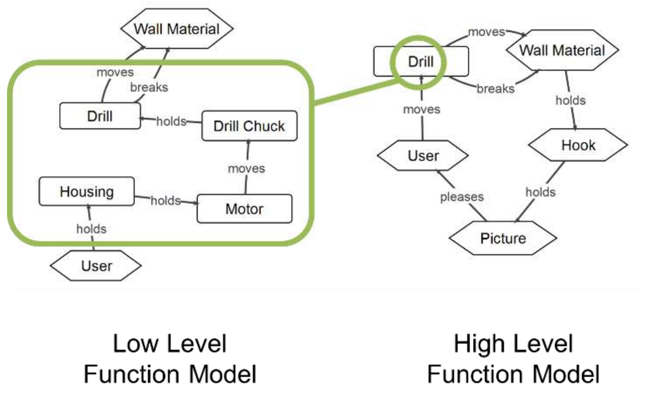

Fig. 3. Function Modelling on different Levels.

If we further expand the Function Analysis into the past (according to the time axis of the Multiscreen Scheme) and model previous versions of our System with the respective Sub- and Supersystems, we are able to assess how our system evolved until now, making it more easy to identify applicable Trends of Engineering Systems Evolution (also see Fig. 4 and Chapter 5).

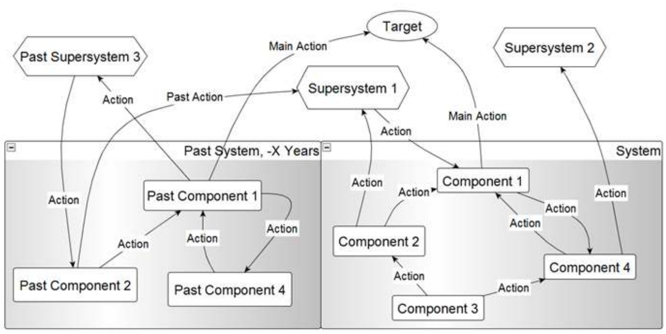

Fig. 4. Function Model of Past and Current System Generation

By consciously considering such interdependencies we can actively monitor and evaluate market situations and technological changes, actively mapping out future actions. By focussing on different system levels, we can decide to asses for incremental or disruptive changes. From a strategic viewpoint, Function Models on different levels help us to plan short term and long term measures alike [16].

5. Learning from the Past to shape the Future – Trends of Engineering System Evolution

As stated in Chapter 1, the Trends of Engineering Systems Evolution are a crucial base of TRIZ. While Altshullers generic 9 Laws of Evolution [8] were mere statements, recent works have developed those laws into the System of TESE [7]. As of 2010, eleven main Trends have been identified that are structured within a hierarchical system (see Fig. 5). The trends represent statistically proven directions in which Engineering Systems evolve. Each Subtrend contributes to a higher level Trend, each Subtrend is a specific way an Engineering System evolves along a Trend line. While still in development, the TESE represent useful universal strategies how to make things work better, based on best practices from the past which have been observed across all kinds of Engineering Systems.

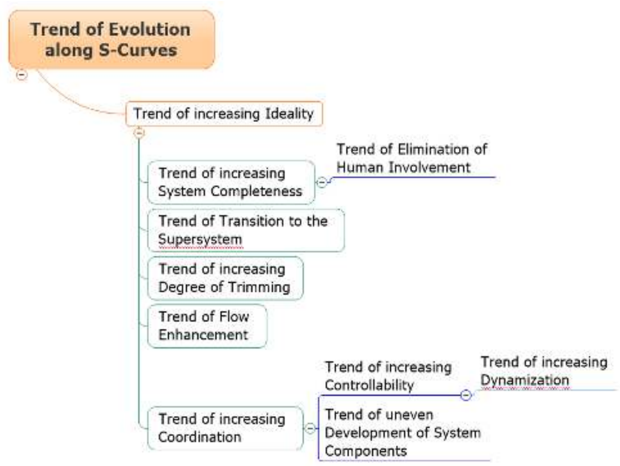

Fig. 5. System of TESE.

The topmost Trend is the Trend of S-Curve Evolution. Being on the highest level, this Trend can be considered a universal, basic law: Each Engineering System evolves along an S-shaped curve that has distinct phases. Each S-Curve describes the evolution of a so-called Main Parameter of Value (MPV) along a time axis. An MPV is a key attribute or outcome of a product or service that is important to the purchase decision process [7, 18]. So MPV represent system characteristics for which the customer is willing to pay money. As a system evolves, MPV increase through S-Curves (incremental) as well as jumps in S-Curves. Those jumps again represent disruptive changes for the system under consideration (e.g. speed of an airplane increased through the jump from propellers to jet engines). Speaking in TRIZ-terms, the jumps indicate where contradictions have been solved to move an Engineering System forward for the respective MPV (see Fig. 6).

As each system might have several MPV, those usually are on different stages on their respective S-Curve. An assessment of the MPV and their position indicates, how to push each MPV most effectively. This is possible because each stage of an S-Curve has its own recommendations based on the analysis of the most successful strategies of the past [7, 17].

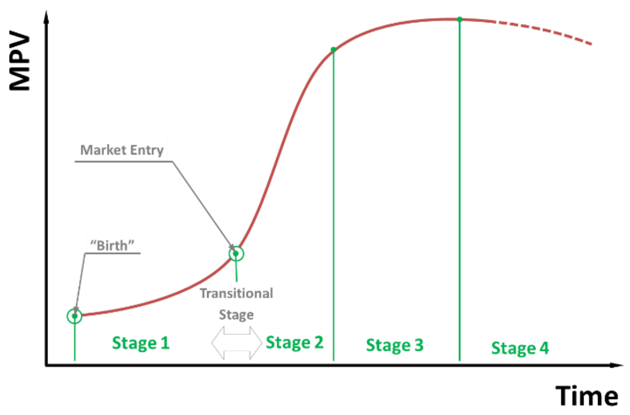

Fig. 6. Stages of the S-Curve.

The mere acceptance that each Engineering Systems evolves along S-Curves and jumps from one S-Curve to the other holds great value for strategic decisions. S-Curves make clear that each new invention has to go through a first "prototype"-stage and that a new system is likely to underperform in the beginning, compared to established "old" systems, but the new system has the potential to surpass the old system in the long run. The S-Curve also makes clear, that each system is bound to either being replaced by another system, being integrated into Supersystems or exist in degraded form after a new system takes over. It teaches us that change is inevitable, but that we are able to be aware of those changes and possibly drive them. Again, the Trends are true for all Engineering Systems, so the Trends can be applied to each System Level and therefore be used for either incremental changes or disruptive changes, depending on the point of view (see Fig. 7).

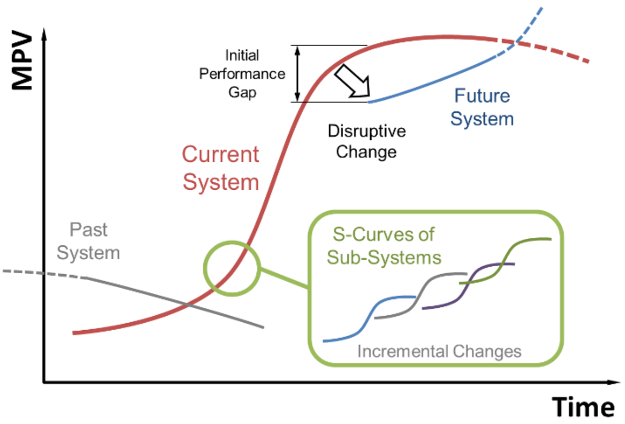

Fig. 7. S-Curve Transitions and Incremental vs. Disruptive Changes.

Another aspect that bridges the gap between the more strategic looking TESE and the operative Problem Solving Tools like the Inventive Principles or Standard Solutions is the fact, that each of the Principles or Standard Solutions are the building blocks of the TESE. They represent the actions through which Engineering Systems have evolved in the past and can be developed further in the future – no matter if the System is a tiny bolt inside a combustion engine or a complex paper production line. Newer studies work on enriching the Trends with mechanisms and algorithms that make the system of TESE more and more useful for operational work [6, 7]. The TESE show us that we can actively shape the development of our Systems with winning strategies of the past. They tell us when to let go of "old" products and when to invest in improvement or disruptive change.

If we combine the TESE with Nested Function Models and the Multiscreen Approach, we are able to build a complete Product Map as a basis for assessing our systems on desired levels and plan future developments. Those aspects go far beyond the sporadic problem solving activities with the Contradiction Matrix or Standard Solutions when FMEA-, Six Sigma- or Value Engineering-projects brought up problems – they are a way of looking at Engineering Systems and the way they evolve. Multiscreen Thinking, Function Analysis and TESE combined can be a crucial part of designing an innovation process that is based on the best strategies for breakthrough solutions in the past. It is not a "be all, end all" methodology, but surely TRIZ is often underrated with respect to its strategic value and how it can significantly complement other strategic management tools.

6. "This is where the Real Work starts" - From Invention to Innovation

The powerful TRIZ is, it is still just an auxiliary means. Its findings and implications might be powerful to start thinking, inventing and designing consciously, but it alone does not guarantee market success. Looking at past B2C examples like "Nespresso", the "iPhone" and "iPad" or more recent B2B products like the "Galaxy Drive" by Wittenstein or the "Twin CC8800" Crane by Terex, we have to accept that the invention, the idea, concept or even a working prototype is just the first step. The real work starts after the concept is decided: We'll face lots of secondary problems, we need project management, funding, accounting, business models and marketing to turn an invention into an innovation. But TRIZ can cover our backs on this journey with its best practices from past breakthrough inventions. We can trust its findings and be more courageous about new developments as we can rely on proven strategies. It gives us strategic recommendations for each stage of the Product Lifecycle and tools to move an Engineering System forward consciously on any level we chose. TRIZ minimizes the chance of being surprised by an "unexpected move" from a competitor or by a start-up that is breaking the unwritten laws of the branch (just think of Uber, Tesla and the likes) and it can teach us to be innovative, driving and embracing change. TRIZ is more than a toolbox, it provides a different perspective on the Development of Engineering Systems and as such sparks a new way of thinking.

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