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THE LAW OF SUPERSYSTEM COMPLETENESS

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Abstract

The paper introduces the Law of Supersystem Completeness and explains reasons of why it was proposed. This law belongs to the category of Laws of Static originally developed by the founder of TRIZ G. Altshuller. Main purpose of introducing the law is to provide formal background for further development of criteria which would help to identify potential mismatch between a technical system and its supersystem due to unavailability or immaturity of supersystem components which are required to ensure not only successful operation of a technical system and proper execution of its functions but its success on the market as well. The paper is illustrated by the examples.

Keywords: TRIZ Laws, Technology Development, Law of Supersystem Completeness,.

1. Introduction

The System of Laws of Technical Systems Evolution was introduced by G. Altshuller in 1979 [1]. The original system consisted of 8 laws divided to three groups:

- **The Laws of Static** which define conditions for a technical system emergence, composition and viability.
- **The Laws of Kinematic** which are observed independently from specific technological and physical factors which produce impact on evolution of a technical system.
- **The Laws of Dynamic** which imply that evolution of every technical system depends on specific technological and physical factors which produce impact on evolution of a technical system.

Afterwards, the system has been revised and updated by a number of TRIZ co-developers and TRIZ schools, some laws were redefined, new lines of evolution (also known as trends and lines of technical systems evolution) were proposed. These updates resulted in several systems of TRIZ Laws and Trends of Technical Systems Evolution known today [2,3,4,5]. New trends of evolution were suggested, like in [6] and are introduced by TRIZ authors today [7]. Later the term “Law” for certain laws defined by G. Altshuller was replaced by some TRIZ authors with the term "Trends of Technical Systems Evolution" due to the lack of exact statistical proof that the these laws are valid for all technical systems under certain circumstances without exception. All these facts indicate that research on the Laws and Trends of Technical Evolution are still in the developing state and the system is far from being complete.

2. Current Situation

2.1. Definition of Supersystem

According to the most important law of TRIZ – the Law of Technical System Completeness which belongs to the category of Laws of Static, a minimally viable technical system includes at least four components (subsystems) which provide functions of 1) Engine, which is fed by energy received from supersystem (energy source), 2) Transmission, 3) Control Unit, and 4) Working Unit which delivers main useful function with respect to a certain target, which is also known as "product" in Classical TRIZ (Fig. 1). Both Energy Source and Target belong to supersystem.

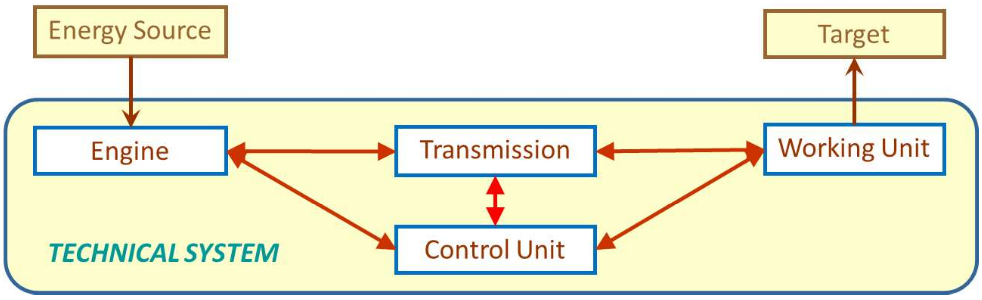

Fig. 1. A Complete Technical System

If we look carefully at the most of the systems of the Laws of Technical Systems Evolution (Development) we can notice that all the laws and trends relate to either technical system or to its particular subsystems. However it is obvious that a technical system does not exist for itself. Every technical system delivering a specific main function is created with a certain purpose to be utilized by its higher system, which is known in TRIZ as a "supersystem".

In TRIZ, supersystem is defined as "*A system that includes a technical system given as its part (sub-system)*." [8]

However, each system has its own lifecycle which demands different supersystems for the same system at each phase of its lifecycle. For example, during delivery of a new digital photo camera to a customer, the camera is stored in a package. Is the package a part of supersystem of the camera? Classical TRIZ usually considers supersystem only within the context of a time frame when a technical system is in operational mode. Nevertheless, without focusing on each phase of the technical system lifecycle, the system will not be able to work as and where required.

Therefore, supersystem of the camera during its transportation and delivery has the high degree of importance as well. The package will be a part of supersystem since it interacts with the camera at a particular stage of the TV set lifecycle and delivers useful purpose – protects the camera from damage during transportation.

In other words, we can expand the definition of a supersystem and define it as "*a system which interacts (through physical or informational links) with a technical system at each phase of the technical system's lifecycle*".

2.2. Complete Technical System is Not Enough

Just creating a complete technical system that would include all abovementioned four components which properly deliver their functions does not mean yet that the system will work as expected. Such a system exists inside its supersystem, and it is crucial that its supersystem also possesses the minimal number of ingredients necessary to provide proper functionality of the technical system at all stages of its planned lifecycle. According to [9], each year more than 30,000 new consumer products are launched and 80 percent of them fail. There is a number of reasons why products fail on the market, and one of them is mismatch between a product and its supersystem.

One of the most known historic cases of mismatch between a technical system and its supersystem is invention of the mass car production by H. Ford. Before his famous *Ford Model T* car, only rich people could afford a very expensive custom-built car. A number of Ford's innovations in the car design and the assembly line made it possible to produce a car available to people with average income. By 1914, his plants were producing 260.000 cars annually. But there was one big challenge: the roads which existed at that time in the U.S. were not built for cars, most of them were not paved. It meant that producing a large volume of cars could meet serious barriers. One of the solutions in *Model T* was to use strong and light vanadium steel for critical parts thus making the car very durable on rough roads. But the other solution was success of convincing government to increase rate of building paved roads which was a necessary ingredient of the car's supersystem. Further attraction of investors and introduction of gasoline tax part of which was used for building new roads helped to drastically increase the number of paved roads in the country which, in turn, increased cars production and sales [10].

Another case is evolution of digital music players. Before Apple announced its famous *iPod* in 2001, there were other digital music players on the market, produced by some major brands including Sony. However, their sales were rather slow: one of the reasons was that legal music files were hardly available on the Internet rising a simple question: "*Where to get music?*" *iPod* disrupted the market by producing a solution in supersystem: Apple linked *iPod* with *iTunes* online web store where everyone could purchase separate music files from a very large collection without the necessity to purchase expensive full albums [11]. As a result, by the end of 2002 *iPod* captured 82% of the U.S. retail market share.

The examples above illustrate the immaturity of supersystems with respect to system's targets and use. Often, a technical system fails due to immaturity of supersystem providing energy source. Attempts to widely distribute transistor radios in African rural areas in the 1970th failed due to the lack of electricity supply networks and high price of batteries.

There are plenty of examples in the history of technology demonstrating how ignorance of availability or immaturity of supersystem components led to failure of new innovative products which either arrived too early on the market or failed due to a lack of one of the critical supersystem components.

Thus the question emerge: how can this ignorance be avoided? Partly, building Technology and Product Business Roadmaps [12] helps with answering this question. However there is no formal background for systematic assessment of supersystem which can be used to identify potential mismatches.

Therefore the author's opinion and proposal is to expand the Laws of Static with one more law: The Law of System Completeness which describes conditions necessary for a technical system to be functional, viable and adding value in the outer world.

3. The Law of Supersystem Completeness

3.1. Definition

As becomes clear, The Laws of Static can be expanded with one more law: The Law of Supersystem Completeness. The definition of the Law is as follows:

> *For successful and sustainable delivery of functionality, providing required performance and quality, and staying viable, a technical system (TS) should possess a supersystem which consists of at least four components:*
>
> 1. *Supersystem providing TS' energy source.*
> 2. *Supersystem providing TS lifecycle.*
> 3. *Supersystem providing TS control.*
> 4. *Supersystem of TS' target.*

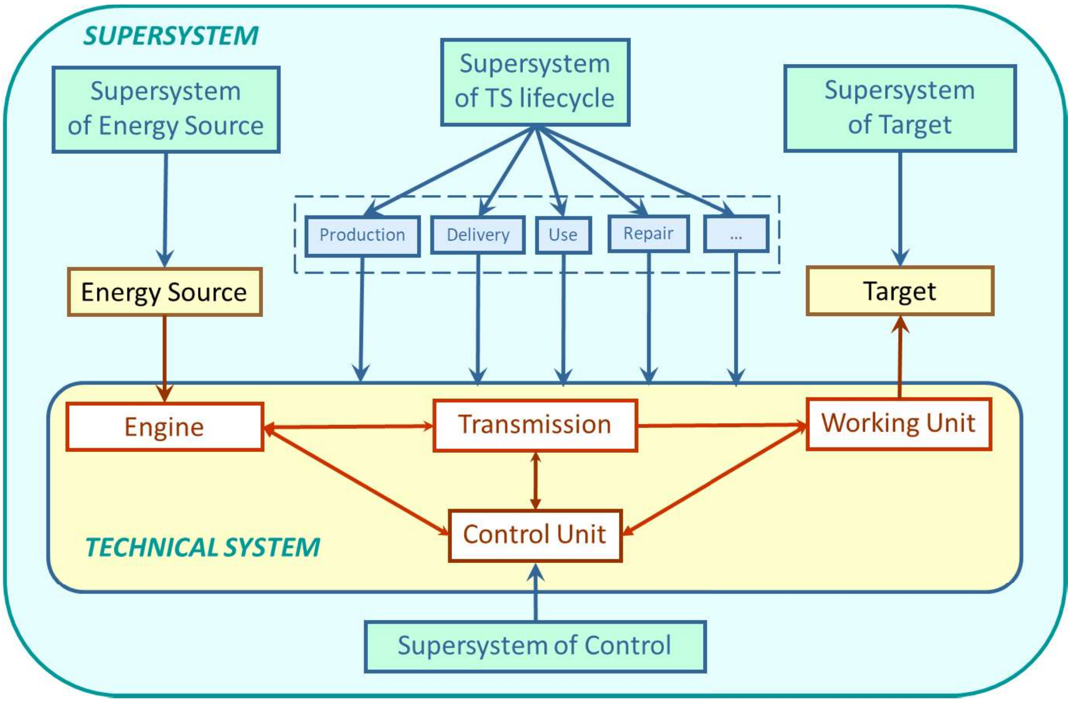

Fig. 2. The Law of Supersystem Completeness

3.2. Explaining Key Components

As seen, the completeness of supersystem is defined by four key components (Fig. 2):

1. **Supersystem providing Energy Source:** every component of a supersystem which is needed to provide, supply and deliver energy necessary to ensure expected TS functionality (including its different parts). Electric home appliances will be useful unless electric current is provided by the city grid or by a standalone diesel generator which, in turn require diesel fuel. Electric *Tesla* cars would not run unless there are charging stations at homes and parking places. Thus the supersystem of Energy Source must ensure that energy needed to feed a technical system and its parts is always available and delivered to the system as long as it is needed.

2. **Supersystem providing TS Lifecycle:** everything which is needed to provide different phases of TS Lifecycle. Most critical among them are:
    - *Production*: Minimal number of subsystems of a supersystem which is needed to enable manufacturing and distribution of TS: R&D; design, manufacturing facilities and HR; supply chain of parts; marketing and sales channels, logistic operations, etc.
    - *Delivery*: Minimal number of subsystems required to deliver a system to its operation location unless the system will be operated exactly at the same place where it was built.
    - *Use*: Minimal number of subsystems of a supersystem which is needed to use a TS. Includes support, maintenance, production and delivery of parts and consumables needed for TS to operate, etc.
    - *Repair*: Minimal number of subsystems of a supersystem which are necessary to repair the technical system.
    - *Utilization*: Minimal number of subsystems of a supersystem related to utilization of a system or its second-hand use.

    These five parts of supersystem needed to provided technical system lifecycle mentioned above are most critical parts. There might be more parts involved depending on a specific technical system.
3. **Supersystem providing TS Control**: Minimal number of subsystems of a supersystem which provide control over a TS. It can be both human-based and automated. For example, a human driver is needed to drive an ordinary car, but GPS and traffic monitoring systems can be used to control an autonomous car.
4. **Supersystem of TS Target**: Minimal number of subsystems of a supersystem which is needed to enable supply, processing, creating and use of a target (product) of a technical system. This supersystem is different from the supersystem required for the use of technical system because it relates to the technical systems only partly, instead it focuses on supersystem of target of the technical system. For example, it might be not wise to try to distribute perfectly working coffee machines in areas where people do not drink coffee at all. Another part of such a supersystem are components which must interact with a technical system to enable the full use of its purpose. For example, in the above mentioned case with *iPod*, supersystem provided music files to enable effective use of the digital music player. Supersystem of TS' target also includes those target's parts which might be needed for production (change, preservation) of the target but which are not parts of a technical system, like a mill to grind coffee beans before coffee powder can be placed to the coffee machine.

It is important to note that certain components of supersystem might belong to several categories depending on their particular purposes and involvement. For example, a person can be considered as a part of supersystem of TS control and supersystem of TS's target: first, the person controls the coffee machine to prepare the required type of coffee drink, and then consumes the prepared drink.

In addition, today we observe a trend of technical systems becoming components of so-called product "ecosystems" which integrate various technical systems on the basis of technology platforms to enable effective use of their targets. For example, a photo taken by a digital camera can be instantly transferred to a digital cloud or shared to smartphones of friends without participation of a user.

3.3. Example

In the example below, the minimal number of necessary components of supersystem for an ink-jet computer printer are presented.

1. **Supersystem of Energy Source (electricity):**
    - Functioning electrical grid
    - Electrical power supply
    - Electrical connections in a house/office
    - Connecting cable
2. **Supersystem of TS Lifecycle (printer):**
    - Production
        - Printer manufacturing facilities
        - Supply chain of parts for printer manufacturing
        - Sales and delivery channels
    - Use
        - Electronic device (connected to the printer)
        - Electronic file with printing data
        - Internal driver software
        - Connection cable
        - Electricity supply converter
    - Repair
        - Repair facility
        - Spare parts
        - Technical specialist
    - Utilization
        - Waste collection
        - Used cartridges processing
3. **Supersystem of Control:**
    - A person (user)
    - External printer control software
    - Computer
4. **Supersystem of Target (printed text and image):**
    - User

- Printer paper
- Printer paper delivery channel
- Cartridges with ink
- Cartridges with ink delivery channel
- Customer support

4. Practical Use

During practical activities, the author often meets with start-up founders who propose new products to create Blue Oceans, or with investors who are interested in evaluating potential of new disruptive products and technologies suggested by inventors at both small and large companies. It might sound surprising but it is a fact that little attention is paid to the assessment if a supersystem which will provide the TS lifecycle, its energy source, and the most effective use of its target is ready and mature enough. However such assessment is crucial to ensure success of new products on the market.

5. Conclusions

The issues of correct definition of availability and maturity of supersystem parts that are critical for successful production, operation and maintenance of technical systems are important for timely identification of potential failures of new innovative products and technologies. Therefore assessment of such critical parts is needed.

The Law of Supersystem Completeness formulated in the paper may serve as a basis for designing a set of criteria which must be met for each new innovation. Such criteria can be used, for example, first, for evaluation of the degree of potential of success of new products and technologies, and second, as a part of Product and Technology Business Roadmaps which are developed to plan future innovative development of existing products and technologies.

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