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Evolution hypothesis as a means for linking system parameters and laws of engineering system evolution

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Abstract

One of the significant breakthroughs brought by TRIZ approach is to drive problem statement and solving in a direction that is not in priority customer-oriented. This presents a considerable shift in Design Theories' world since it is going against most acknowledged quality rules. The argument developed within the frame of TRIZ research was expressed through the postulate that Technical Systems are driven by objective laws. This paper pursues two objectives, first stating on the actual published work mainly in citing relevant and significant contributions on this subject. Further in the article, a discussion will be engaged for providing sense to our research orientations towards a logical use of these laws within the choice of the appropriate conflicting pair, prior to ARIZ deployment. Second, a procedure aiming at operationalizing our findings will be proposed and discussed through a case study. In this section will be presented the concept of "Evolution Hypothesis" and discussed how our attempt of contribution to TRIZ body of knowledge usage possibly adds relevance to TRIZ practices.

Keywords: Evolution hypothesis; Laws of engineering systems evolution; Contradictions; TRIZ;

1. Introduction

Since the socio-economical paradigm of the past seven decades was turned towards enhancing value through statistically balancing procedures, elaborated Engineering Design Theories were (and still are) mainly "optimization-driven". When observing actual "leading" approaches empowered by industries, six-sigma-like methodologies are still employed and have proven their financial usefulness in most cases. Nevertheless, an increasingly amount of researchers are now turned towards innovation paradigm and are actively trying to contribute in elaborating new knowledge that differs from optimizing theories [1].

It is nowadays often recognized that Laws of Engineering Systems Evolution (LESE) constitutes one of TRIZ's main axiom. Most of TRIZ teachers/professionals are providing their students/clients with some theoretical elements related to LESE so as some crispy illustrations about their relevance in various cases together with anecdotes of lived situations where they have been of a great assistance for unlocking/orienting a study in the appropriate direction. If we more carefully observe what has been proposed and published on the subject of LESE, it might even be understood that Altshuller's willingness was not to build out of their theoretical description some operational useful way to benefit from them. But despite some interesting theoretical explanations associated with an attempt of

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operationalization [2], most of TRIZ's newcomers are later disappointed, in their dedicated time to learn TRIZ, to realize that no available tools or techniques clearly present a use of LESE.

After having learned and practiced most of TRIZ techniques and tools, we understood that System of Inventive Standards (SIS) was built upon previous research having led to the synthesis of Inventive Principles (IP) [3] and the way these inventor's techniques may be used in the logic of LESE matching. Nevertheless, when the choice to enter in ARIZ has been established, the use of SIS appear very late in the algorithm of TRIZ body of knowledge use (like in ARIZ's step 1.7 for instance) [4]. We have also noticed that prior to ARIZ, a significant job has to be performed in order to target the appropriate set of parameters involved in the Technical Contradiction pair (TC1 & TC2). Apparently, and after having observed various contributions in that regards, some methods were proposed to assist conflicting pair choice prior to ARIZ [5] but no one have proposed to orient the designer towards the choice of a conflicting pair in coherence with LESE.

2. The notion of law from TRIZ viewpoint

2.1. From Altshuller's viewpoint

The first appearance of the term "law" expressed through Altshuller's viewpoint (as it is publicly known) was in his article "An essay on the psychology of inventiveness" in 1956 [6]. In his text, references were made among others to Marx and Rubinstein and were stating also the limitations of current visions like enlightenment and trial & errors procedures. The conclusions clearly expressed the vision that technical systems were evolving according to laws and that these laws should be practically used when designing methods in relation with inventiveness. Here the "usability" was brought forward in his last sentence where he draws the following perspective « … the objective of the psychology of inventiveness is to be translated into practice: its inherent laws must be used during the development of scientific methodology to work on inventions. »

Further known relevant work

From 1956 until 1991, after the publication of Salamatov's book in Karelia's series [2], a significant amount of work has been achieved for clarifying their exhaustibility, their illustration, their mechanism, their meaning and their role in Inventive Thinking. Despite the fact that Altshuller himself is not the author of this work, we can consider that he "more or less" validated the presented vision of laws (with an amount evolving from 8 to 9).

Another book went a step forward [7] where a series of authors have structurized each laws in "lines" of internal developments, here the amount of laws have evolved from 9 to 11.

Recently Vladimir Petrov has published several interesting articles in this regards [8][9], he features a more structurized way of presenting them compared with Altshuller's traditional decomposition "static" "kinematics" and "dynamic".

The attempts of understanding

When TRIZ's body of knowledge appeared in western world (in the early 90's), LESE have attracted many industrialists, researchers and consultants. By reading what was accessible publicly, several interpretation were expressed and various terms qualifying laws can be red like "trends" "logics" "tendencies" "patterns". What is mainly argued by several authors, either in their article, in their public presentations or in various web forum discussions, is that the term "law" should be carefully used; moreover, the use of LESE from description to prescription should not lead to a "naive" form of forecasting [10].

On the usability of the notion of LESE

In 1999, one of the authors has performed an attempt to share Altshuller's findings with scientific communities regarding laws [11] through the postulate that they could play a role in orienting designers in projects having inventive aims. After this publication, some attempts of operationalization through software's shape have raised [12] and received a positive feedback in education, an average success in industry and a refusal in scientific communities. Therefore, could we ask ourselves that Altshuller's laws are under-used at present time?

We are inclined to answer positively to the above question, but firstly, we will try to summarize where within elements of TRIZ body of Knowledge, LESE are tacitly or explicitly present:

	Element from TRIZ BofKn	Type of presence	Where
Tools	Multi-screen analysis	Tacit	From past to present and from present to future
	Matrix	None	
Methods	Substances-field modelling	Tacit	Within the transformation logic from initial situation to solution model
	ARIZ-85C	Tacit	Through Inventive Standards use, and IFRs formulation
Knowledge bases	System of Inventive Standards	Explicit	Through the structure of classes and sub-classes
	Inventive Principles	None	
	Separation principles	None	

Table 1: Tacit or explicit presence of LESE in TRIZ Body of Knowledge

In his text "about laws of engineering systems evolution", [13] Altshuller has forecasted these interrogations people still have nowadays regarding LESE. His answer was to mention that "laws are encrusted …in ARIZ". May we interpret that laws are in ARIZ through the presence at various stages of the algorithm (before step 1.1; step 1.7-3.6-4.4) of the standards and S-field modelling? At least we can answer positively to this question but can we advocate that in the logic of Technical Conflicting pair choice laws are used? The available texts are vague regarding this point and, as a result, are preventing most of TRIZ users to efficiently benefit from LESE apart from basic understanding of technical system evolution's logics.

Synergy or oppositions from significant contributors

To start with our intention in this article, we would like to rapidly review available literature on the subject of Technical Systems, Objects, Machines or Artefacts evolution.

Reflection on technique is as old as philosophy, since Greek philosophers and first considerations on the notion of "tekhnè", the first metaphors technicians or artisans and also the first relegations of technique in a scale of values, in particular Plato's [14]. Also, "the originality" of thought on technique must be relativized since, in a certain manner, this debate always was an actual concern. Technique has not ceasing accompanying human history, to influence on it and to feedback with philosophical interpretation. But what characterize the current debate is more oriented to reactualization, further discussion on theories and concepts formulated in the past, as well as appearance of new descriptive approaches.

Bertrand Gille [15] has observed history through the succession of technical systems. One of his main assertions is that technical system's adoption involves necessarily the adoption of a social system to maintain coherences. He emphasizes that technical system advances are disharmonized with other human systems (legal, political, economic…) and encounters resistance to changes. As we can understand from his conclusions, a structural limit is felt at the end of the period of expansion of the system: this moment is characterized either by the difficulty in increasing the quantities, or by the difficulty in lowering the production costs. In his contribution the existence of "blocked technical systems" is also described.

Gilles Deleuze and Felix Guattari [16] evoked a concept of "mechanical fitting" thus moving the question of invention of techniques themselves to psychological and social aspects, in which they are taken with their uses. This concept is as an example illustrated by the specificity of the weapon compared to the tool. If the weapon and the tool are not distinctive, there is no other manner of differentiating them than to bring back the generic object (stick, axe, or other) to a "model" - a "form of life". The tool supposes work; the weapons suppose hunting, or war and the formal features of the mechanical fitting act like internal stresses without being for as much intrinsic.

Gilbert Simondon is opposed to apprehend technical objects under the exclusive angle of their use. According to him, it corresponds to make of them utensils deprived of significance and characterized by their inertia. However the industrial technical object is not inert. It possesses an intrinsic genetic logic which is declared to be its "mode of existence". In a certain manner, the book of Simondon [17], defining this "mode of existence of the technical objects" by their genesis, their evolution (with the concept of "process of concretization" is an impressive refutation and, to date best argued, of this instrumental design of the technique, current and misleading vision of the technical objects.

The anthropologist André Leroy-Gourhan, thinks that jointly man and object have Co-evoluted. In [18] he explains why gradually the hand released the jaw then the hand built increasingly fine techniques (cut flint, engine…). He also presents the fact that implementing producing techniques also transformed the operation of the mind which was also transformed by the incipient language. He continues while advancing that to pass from a primitive language, with a language structured by words, verbs, structures of sentences, there are qualitative jumps caused by a quantitative accumulation where technique and language are in permanent interaction.

Stiegler indeed poses (following Leroi-Gourhan's vision) technicality like one of the essential and original components of mankind [19], justifying the impossibility of any deterministic design of technique on man or from man on technique. Both are constitutive one of the other, they are co-determined since prehistoric times.

The list is too long to be further pursued in this article, but the abundance of literature and significance of each contribution brings forward the question of exchange with this "community of thoughts". A community in which TRIZ contributors have been absent lately, loosing the fundamental aspects of confronting our ideas with our peers.

Very few authors have attempted a comparison or tried to underline analogies or thinking proximities between for instance Simondon (who is probably the closest) and Altshuller. A text available at [20] and a master's thesis [21] have only approached the subject by presenting the visions and describing each contributor's with references. Unfortunately they didn't go into an analytic process for disclosing proximities.

The following table is summarizing partially extracted texts from both authors.

Year of publication	Reference	Altshuller's extracted text	Year of publication	Reference	Simondon's extracted text
1969	Creativity as an exact science [22]	"…if certain methods improves one part (or one parameter) of a technical system, it is inadmissible for another part (or another parameter) to deteriorate in the process."	1966	Imagination and invention – P277 [23]	« Is problematic the situation which dualize the action,… because the realization of one part of the action destroys another part being also necessary »
1956	An essay on the psychology of inventivity [6] – P40	« Between main components of a machine, mainly between working organ, transmission mechanism and engine, exists a given correlation since all these parts are tightly linked and depend from others. »	1958	On the mode of existence of technical objects – P62	« The coherence of a sum of techniques reaches its maximum when this association is constituted of a series of sub-associations possessing the same level of relative individualization. »
1991	Interview of Altshuller by Leonid Lerner "G.S.Altshuller, father of TRIZ" [24]	« I have investigated scientific and technical literature without being able to find a single manual, even an elementary one destinated to inventive engineering. I couldn't be satisfied hearing scientists claiming that all inventions were based on hazardous facts, mood …»	1968	Invention and the development of technologies - P156	« Up to now, there exists no method to invent. If « ars » signify method, way of driving across difficulties and toward a goal, there is not art of inventing; only a gymnastic of the inventor for being trained in his activity. »
1969	Creativity as an exact science	« The ideal technical system is the one whose weight, volume and area strive towards zero although its ability to carry on functioning at the same time is not diminished. »	1958	On the mode of existence of technical objects – P30	« One should not misunderstand rising the concise character of an object with the enlarging of its technical possibilities through Complexification of its structure. »

1969	Creativity as an exact science - 229	« The development of parts of a system proceeds unevenly; the more complicated the system, the more uneven the development of its parts… [provoking] occurrence of technical and physical contradictions... »	1958	On the mode of existence of technical objects – P39	« …Minor improvements are harmful to major improvements, since they may hide true imperfections of a technical object… its true internal antagonisms… »
1969	Creativity as an exact science - 225	« Any technical system arises as a result of a synthesis of various parts into a single whole…. There exist at least three laws whose fulfilment is necessary for the system to be capable of life…completeness…energy conductivity…[harmonization]. »	1958	On the mode of existence of technical objects – P43	« The beginning of a « line » of technical objects is land marked by this synthetic act of invention constituting a technical essence… who remains stable… producer of functions through internal developement and progressive saturation;… »

Table 2: An excerpt of Altshullerian and Simondonian possible proximities

This short extraction will be in a near future pushed forward and thoroughly discussed by researchers from both communities of thoughts for a better understanding of the entire scope of these proximities.

2.2. Understanding the layout of TRIZ Body of knowledge (BoKn) usages

Coming back on the use of Altshuller's law, many designers nowadays are limiting the use they bring out of TRIZ Bokn in the formulation of a more or less significant contradiction inherent to the system they study and the use of forty Inventive principles, sometimes partially reduced when using the matrix. Despite that such usage can't benefit from the whole powerfulness of TRIZ tools (S-fields, Standards, ARIZ) the results are already satisfactory improvements compared to what traditional brainstorming-like techniques would have offered.

We have started an important testing through 85 engineering student of the fifth year, coming from seven different field of engineering. Statistically, in industry, out of 100 engineers claiming to have empowered TRIZ, only 5 mention ARIZ as a regularly used framework. As it is now commonly agreed, three axioms constitute the grounding of the theory (extracted from [25]):

- First axiom: Technological systems evolve not randomly but according objective laws of evolution. These laws do not depend on human. They should be observed, formulated and used in order to develop efficient methods of problem solving.
- Second axiom: Technological systems evolve not randomly but they have to overcome contradictions. In order to get breakthrough idea we should find a way how to overcome contradictions.
- Third axiom: Each specific problem must be solved in accordance with restrictions of the specific problematic situation, with peculiarities of each specific case and could not be solved in general. A robust solution is a solution that involves as less new resources as possible.

How one can benefit from the first and the second axiom at the level of the matrix? As it is stated in [6] a contradiction stands out on the way of a law, preventing the technical System from moving ahead. An issue to target would then be to create a link between the contradiction and the law in order to better identify which contradiction blocks which law. After reviewing TRIZ literature, no such link has thoroughly been established.

2.3. Problematic unifying laws and contradictions

The starting point of this study is to consider that a group of contradiction have been disclosed. Our initial question is the following:

"How contradictions can be ordered in accordance to the fact that they present an opposition to a specific law?"

The expected result is to be able to ensure that the treated contradiction (consequently being solved using TRIZ tools) is standing out on the way of a specific law. To achieve such an objective, let's start with some of TRIZ basics.

A contradiction is validated once a given active parameter (APx) at a specific value (Va) is leading an evaluation parameter (EPn) to evolve in a satisfactory way. Then, the opposite value ($\neq$ Va) (where $\neq$ represents V's antonym) is leading another evaluation parameter (EPm) to evolve in a satisfactory way. If the "mirror" situation is "true", then the contradiction can be validated.

There are nine laws characterizing technical system's evolution. Each law is more significantly playing a role at a given stage of its lifetime. Detailed description of laws can be found in [2]. In our paper we will name them the following way:

Law 1: Law of system's completeness
Law 2: Law of energy conductivity
Law 3: Law of harmonization
Law 4: Law of Ideality
Law 5: Law of uneven development of parts
Law 6: Law of transition to the super system
Law 7: Law of transition to the micro level
Law 8: Law of dynamization
Law 9: Law of inner Substance-Field deployment

The scheme to establish a link between contradictions and laws can b summarized as follows:

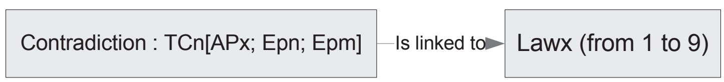

Figure 1: linking scheme between contradictions and laws

Our proposal is to create the notion of Evolution Hypothesis (EH) as a component of the reflexion for linking contradiction to laws. EHs are literal interpretations of a given law, expressed as a sentence. This sentence is the result of a possible direction the technical system may undertake in his evolution. The semantic interpretation of a law will obviously bring more detailed and specified elements (parameters, values, new elements) than the generic expression of a law (its postulate). By observing and analyzing how these elements may refer to a list of parameters aiming at evolving in an appropriate direction, it is possible to establish a semantic proximity unifying a parameter to a specific EHx. Our representation will then become:

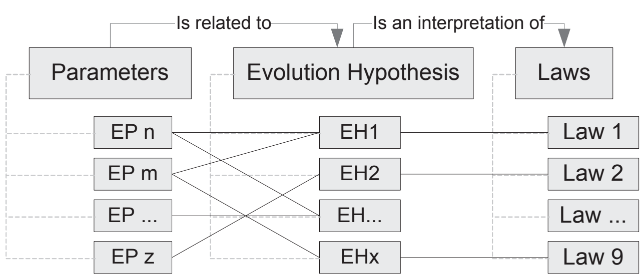

Figure 2: Contradictions and laws linked through Evolution Hypothesis

While developing a methodology to build such links, we have tested the capacity of engineering students to use LESE within their project after a basic training on TRIZ. We recorded the miss-usages (either wrong usage or no usage) of LESE of each group:

Types of engineers	#	wrong usages	No usage
plastics engineers	14	5	4
mechatronic engineers	25	7	9
industrial & energetic engineers	13	3	5
production engineering engineers	14	9	2
materials and processes engineers	19	8	7

Table 3: Partial results of the first test using simple path within TRIZ elements (MSA, laws, TC formulation, matrix)

The missusage of our initial procedure (32%) was mostly due the fact that engineers practicing TRIZ are already formulating hypothesis when using Multiscreen Scheme Analysis (MSA), resulting in confusion when it was asked to interpret LESE in addition. Our conclusions lead us to expand the concept of EH to MSA, creating a second series of EH (EH1.x) coming from the three future screens of MSA. Furthermore, we have observed redundancies in the formulation of EH1 and EH2.x.y ("x" coming from laws 1→ 9 and "y" their order of appearance). To face with this situation, we have chosen to create a third type of EH (EH3.x) as the result of the fusion of EH1s and EH2s having the same meaning. A fusion also results in the elimination of previous EH1s and EH2s at the origin of EH3's creation. We now have evolved towards such a representation:

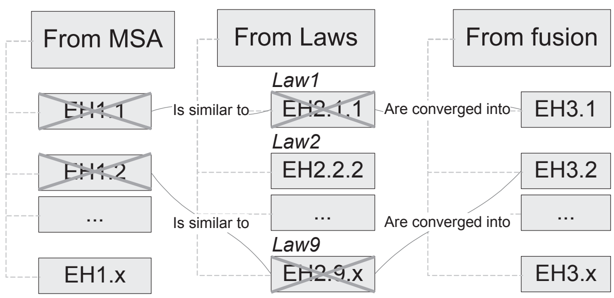

Figure 3: Links between the 3 types of Ehs

The next tests with our group of engineers were satisfactory (from 32% to 5% of miss usage) even if the new procedure required additional time and efforts to be completed. The new structure leads our approach to be operationalized as follows:

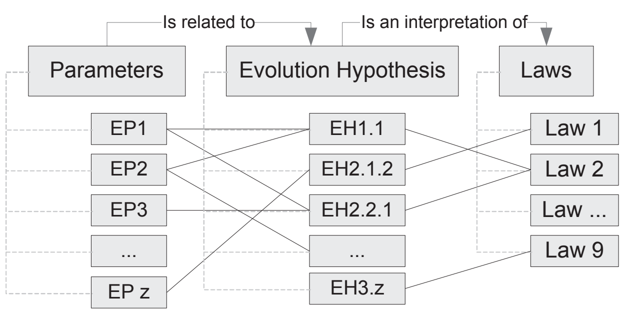

Figure 4: Evolved linking scheme between contradictions and laws

We now have stabilized the links between parameters (as components of a contradiction) and laws (as generic guides for the design activity). The next step is to link laws with the engineering design situation.

2.4. Linking laws with design situation

Assuming that a list of contradictions has been built according to the frame TCn [APx; EPn; EPm], for priorizing contradictions according to laws, we need to organize the ordering of laws in regards to the design situation. We now fall into a problem having already been disclosed by Altshuller in [22] where he underlines the importance of stating of the maturity position along the “S” curve. Such positioning is obviously not an easy task. More, it is one of the most challenging researches nowadays in industry. The findings of this research is aiming at reliably stating on the maturity of a technology and forecast in a narrowest spectrum of variants where does the studied technology is moving towards [26].

This is not in the scope of our current research activities, but nevertheless the necessity to move ahead, pushes us to simplify the approach (even if we assume we introduce a significant dose of imprecision) in providing to decision makers (together with the whole team of study) to locate along two “S” curves, both present and future situations.

Present cursor (P) is representing the actual situation, prior to this, an approximation using Altshuller’s approach developed in [22] can be used or simply let management, marketing and R&D representative commonly agreed on this statement (qualitatively).

Future cursor (F) is representing the aim of the study; it clearly indicates whether the company is aiming at developing a totally new concept or a slight improvement. Usually, “S” curve positioning is supposed to assist such decisions but in our case, again, the strategy of the company should provide R&D with a clear vision on “how important” the leap is acceptable, even if very often, large scales companies usually launch several alternatives (from slight improvements to pure research) in order to both move forward carefully while protecting eventual inventive solutions, representative of a significant technical leap of their technical system’s evolution.

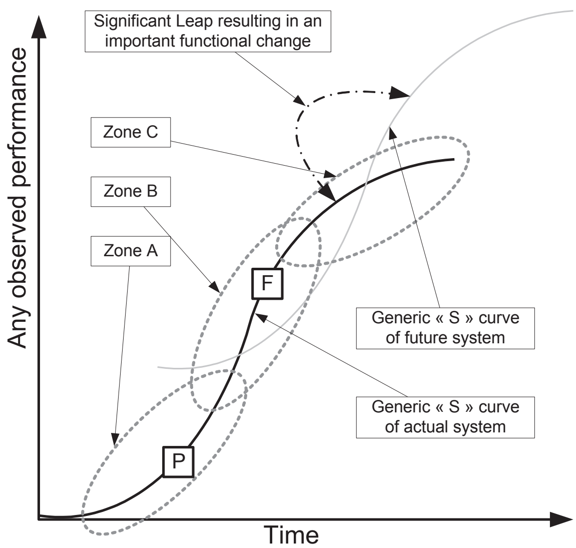

Figure 5: Two cursors along two generic “S” curves

In order to allocate a specific importance to certain laws when a specific configuration of cursors P and F is given, we have tried to interpret Altshuller’s texts [22] and [27] so as chapter 5 of Salamatov’s book [2]. From our understanding of these readings, we drew the following pre-set statements:

Case 1: $\because P \in ZA \wedge F \in ZA \therefore$ L1=4; L2=3; L3=2; L4=2; L5=1

Case 2: $\because P \in ZA \wedge F \in ZB \therefore$ L2=4; L3=3; L4=2; L5=1

Case 3: $\because P \in ZA \wedge F \in ZC \therefore$ L2=4; L3=4; L4=2; L5=1

Case 4: $\because P \in ZB \wedge F \in ZB \therefore$ L3=4; L2=4; L4=2; L5=1

Case 5: $\because P \in ZB \wedge F \in ZC \therefore$ L3=4; L2=3; L4=2; L5=1

Case 6: $\because P \in ZC \wedge F \in ZC \therefore$ L3=4; L4=2; L5=2

Case 7: $\because$ $P \in ZA \vee ZB \vee ZC \wedge F \in ZA^{+1} \vee ZB^{+1} \vee ZC^{+1} \therefore L6 \wedge L7 \wedge L8 \wedge L9 = 2$

Each statement has not the aim to indicate an accurate assumption, but to focus attention on a specific law, more than another (as it was indicated in [11]). The ordering importance of laws will further impact on each parameter they have been associated with. In order to be able to modify these pre-set statements, the cursor associated with each law (settled to a value from 0→5) must remain changeable. From the position of each cursor, we have affected a multiplying coefficient dedicated to raise the value (the importance) of certain parameters.

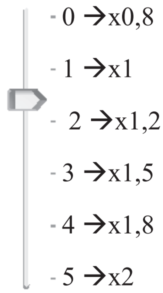

Figure 6: Each law's influence on a set of EPs being linked with it

This multiplication has the objective to influent on the weight of a contradiction possessing these parameters inside. The contradiction's weight is therefore as follows:

Value of TCn = Coef. APx (weight EPn x Max. coef laws + weight EPm x Max. coef laws)]

Each EP from EP's list, extracted from contradiction formulation and MSA, having been linked to LESE through EHs, will then be respectively impacted by the existence of a link and its importance. This importance is directly associated to what strategically has been settled in "S" curve observation and the predominant law in the specified context.

The formula attributing a value to a TC remains nevertheless an approximation, but by such an approximation, we can "at least" postulate that LESE (from first axiom) are influencing on contradiction's ranking (from second axiom).

3. Case example

We presented in section 2, a panel of engineers from 7 different fields of engineering. The condition of the second test campaign was assumed in the following conditions:

Groups of study were constituted from 3 to 4 persons; the choice of the subject in their domain was free, as long as the target was to synthesize an inventive concept within the required time by following a procedure inspired by certain elements brought to TRIZ.

The available time for this test was 28 hours:

- 14 hours of theory for teaching the new procedure (largely inspired by TRIZ's fundamentals)
- 14 hours of project divided in 7 sessions of two hours each.

Due to the limitation of time, both for teaching and directed work, chosen cases should be simple (not carrying a lot of components and different technologies). Only simple tools and methods out of TRIZ BofKn were taught and subjected to use (for instance limited to Altshuller's matrix and Inventive Principles). The table of tests can be viewed in appendix 1.

As we can observe, the mean of successful use of laws, prior and after EH notion introduction, significantly increases. In order to illustrate what has been developed in section 2, we have extracted out of appendix 1, the study #23 (fin's evolution) and next are presented the key elements of the students analysis.

Decomposition of fins according to law of completeness

This first statement is aiming at stating on the boundaries of the studied technical system. This step requires decomposing the "tool" in the four elements of the system achieving (as a whole) its main function.

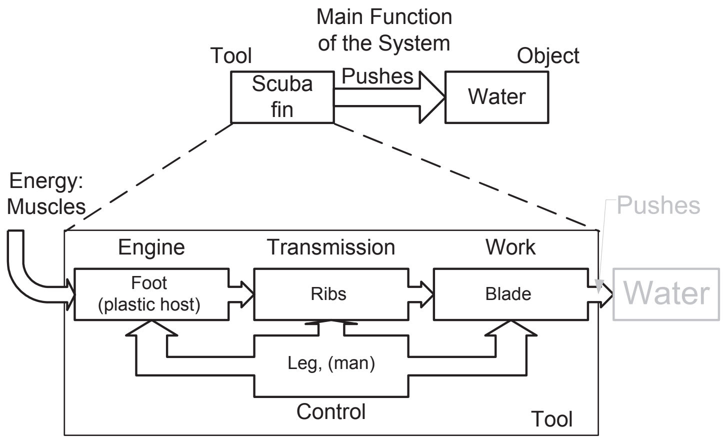

Figure 7: Decomposition of studied system according to law of completeness

First set of hypothesis from MSA

Placing fins in the context of their evolution using MSA framework is the next step in our methodology, at this stage, a first attempt of parameter formulation is also achieved.

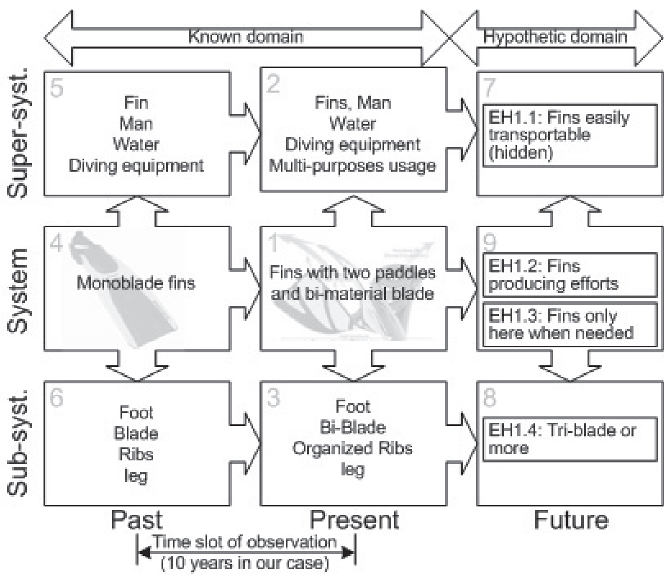

Figure 8: MSA resulting in EH1.n formulation and first set of parameters

Set of secondary evolution hypothesis in regards with LESE

This figure is summarizing the links between each law and its interpretation decomposed in one or more EH2s.

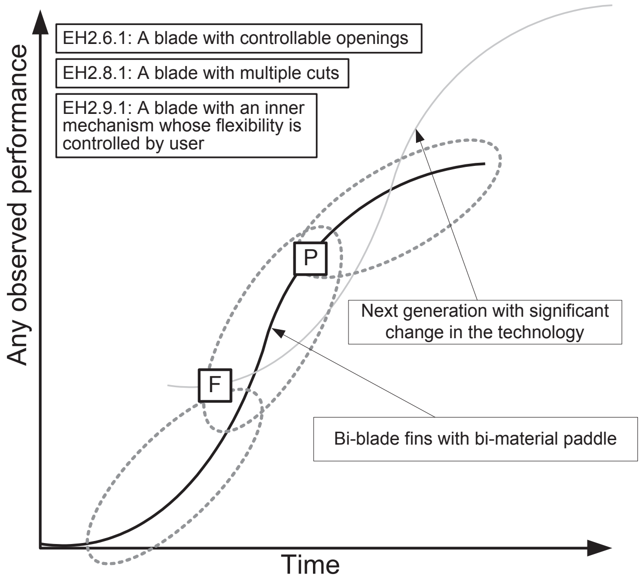

Figure 9: Formulation of EH2.x.n according to “S” curve expected jump (Case 7 in section 2)

Fusion of hypothesis

Once EH1s & EH2s have been disclosed, the fusion prevents from having redundancies in these two categories.

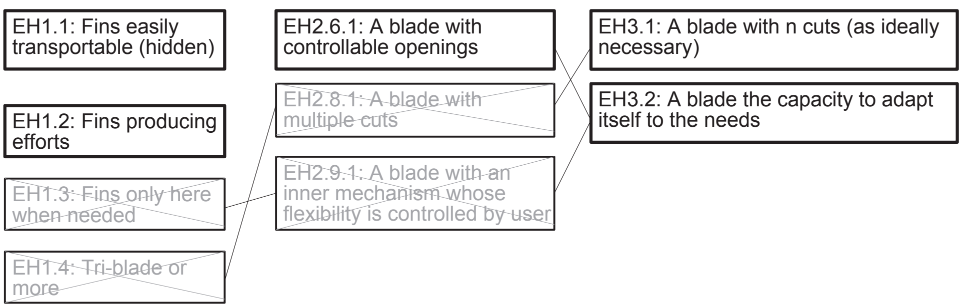

Figure 10: EH1s-EH2s & EH3s links

Partial set of contradictions

The first set of parameters (gathered within the stage of MSA’s exploitation) is used to start the constitution of a more complete contradiction set formulation.

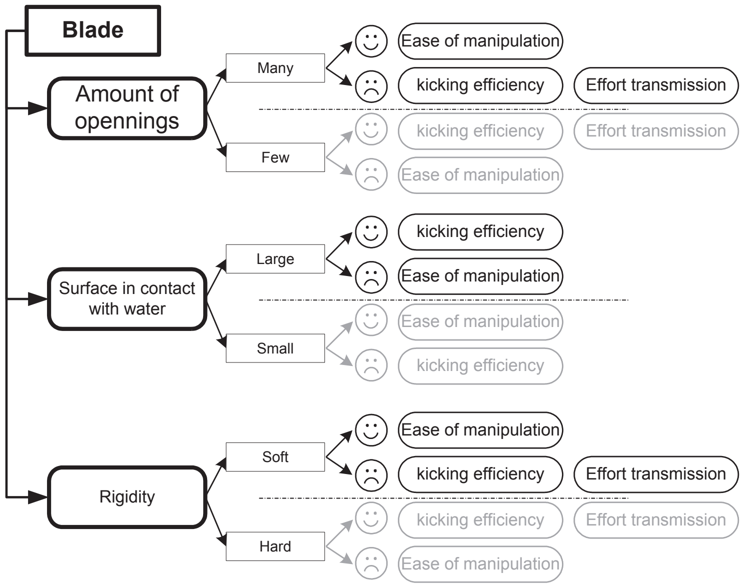

Figure 11: Partial list of TCs for fin's evolution

Linking Eps and EHs

Assuming that one should reveal the existence of a relation between a parameter and a formulated hypothesis of evolution, this has the consequence for some links to be obviously relevant and some others dependent of user's interpretation.

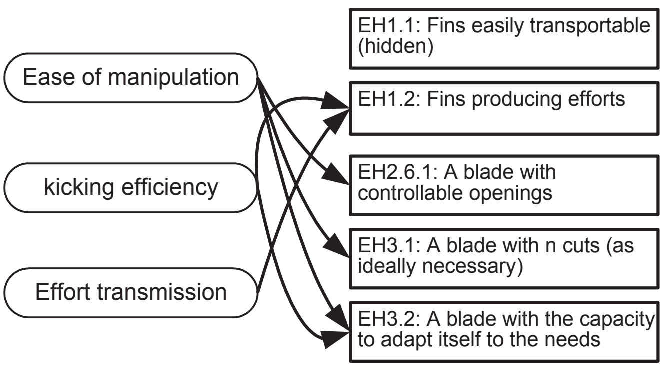

Figure 12: Linking Eps with EHs

Weighting contradictions

If we take into consideration all previous steps: Weight of each EP and AP; coefficient for accordance with laws; predominant laws according to maturity status, we obtain the following contradiction ranking.

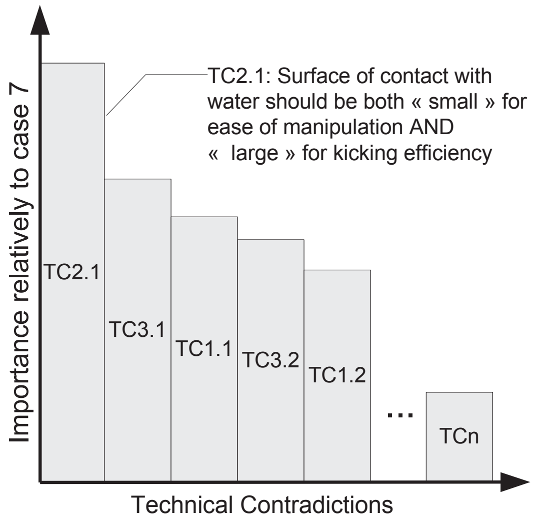

Figure 13: Linking Eps with EHs

Analysis of student's proposed Inventive Concept

After identification of the predominant contradiction, classical TRIZ tools have been used for resolving the confliction requirements with a non-compromised orientation of reflexion.

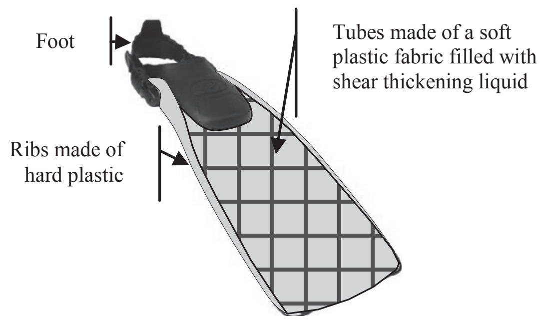

Figure 14: Concept of tubular shear thickening fins

The concept of tubular shear thickening fins is a truly inventive concept, rated level 4 since there are no-existing in wieldy distributed and produced product in industry are working based on this principle (only prototypes, patented fabrics, dampers in truck industry,…). As a possible additional effect regarding this solution, the variability of hardness evolution [27] can be harmonized with the evolution of the kicking efficiency when starting the agitate fins. From TRIZ viewpoint, we can state that laws 7, 8 & 3 are progressing resulting in Law 4 (Ideality) improvement.

4. Discussions

In the treated subject of this article, we wanted to emphasize that LESE, as they have been disclosed and presented by Altshuller several decades ago, were aiming at being fully integrated within the scope of TRIZ's theory usage. Up to now (as we can read through available written and published materials) we have only found contributions either aiming at clarifying the existing laws (descriptive contributions), re-interpreting these laws or trigger designer's imagination with a usage of these laws (using them associated with crispy illustrations) to predict a "brainstoriented" portrait of what will the system look like in the future.

By observing the tendencies of practiced methods and tools built on TRIZ, we can also state that ARIZ presents a decreasing usage when in industrial context. Therefore exposing those who didn't took time to study, in the frame of TRIZ BoKn, either ARIZ or Standards, not to really benefit from the most predominant axiom of TRIZ.

This paper was aiming at proposing a possible use of LESE, within the context of a contradiction choice (ranking). The effect of our approach, declined in form of a procedure teachable and usable, was tested among 103 engineering students of the fifth year (less than a semester from graduation) divided into 7 different engineering disciplines. During the first test (85 students – 23 projects), laws usage leading to relevant results was less than 30%. After having learned our approach within the context of their courses, the second test (103 students – 33 projects) showed us that relevant usage was increased up to 75%. This encourages us to ever improve our approach and observe its possible perspectives.

A first obvious limitation resides in the lack of accuracy of the developed method. We can explain this statement by observing that what we are targeting is at the crossroads from human and engineering disciplines. If the second is easy to manage in terms of accurate formalism, the first is often qualified as "science of imprecise" [28 moles]. The next developments will nevertheless aim at reducing the zones of imprecision of our approach.

A second hypothetic situation that we didn't clarified yet is the fact that our tests have been settled within educational context. Even though we were in the very last period of engineering curriculum, and that the concerned students had already some industrial experience (through their various internships) we did not expose our postulates in a real industrial situation. This will undoubtedly be a very next step in the process of improvement of our approach.

5. Conclusions

As an introduction to this paper, we underlined the existence of a significant amount of research achieved in human sciences related to engineering systems evolution. Altshuller took the problematic from the engineering viewpoint, starting from technical observations and needs. He first considers his goal was to provide the world of inventors with techniques and tools, and that these techniques and tools had to be supported by methods. But to be efficient, they also have to be built upon reliable and statistically relevant amount of observations, analyses and tests in real practice with a measurement of their effectiveness. Later (in the early seventies) after several iteration of tools and methods versions, the statement that a theory must be disclosed as the grounding of Inventive Problem Solving has logically emerged [29].

By formulating the hypothesis that Altshuller's approach and Simondon's philosophy have a lot in common, this article has also the aim to bring together the two approaches to the front scene. Born in different part of the world, visions with such proximity observed from two people that obviously did not new about each other's findings, should at least awake our curiosity and invite us to carefully study this hazardous fact. The situation that Altshuller took the problematic from engineering viewpoint and Simondon from philosophical viewpoint may also finally brings sense to two bodies of knowledge which, insulated in their own context, were often minimized in their respective communities.

Finally, our developed approach is aiming at being an open framework for discussion. We have observed that Evolution Hypothesis have been proven to be helpful in the context of LESE usage, increasing the capacity of engineering students to benefit from a more coherent understanding and usability of some TRIZ elements. By attempting to be a link between parameters and LESE, they also have been a link between MSA and contradictions, therefore, in a smaller scale, contributing to provoke a systemic impact on TRIZ itself.

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Prj #	Designation	# of stdt	T-MUF-O	Law1	MSA	Laws 2 to 9	TC's	EP-EH-LAWS	TCs ranking	Matrix use	Inventive concepts	Level
1	Glasses case	3	+++	+++	++	+	+++	++	YES	++	YES	2
2	Baby seat	4	+++	++	+	+	+++	++	YES	+++	NO	1
3	Gourd	4	++	+++	++	++	+++	+++	NO	+++	YES	3
4	Food drainer	3	++	++	+	+	++	+++	NO	++	YES	2
5	Saddle	3	+++	+++	++	++	+++	+++	YES	+++	YES	2
6	Bicycle’s protection	3	+++	+++	+	++	+++	++	YES	++	NO	1
7	Camelback	4	+++	++	++	+	++	++	NO	++	NO	1
8	Dynamo	3	+++	++	+	++	+++	++	YES	++	YES	2
9	Umbrella	3	+++	+++	++	+	+++	+++	YES	++	YES	2
10	Caddy	4	++	+++	+++	+	+++	++	NO	++	NO	1
11	Hanger	3	+++	+++	++	+	+++	++	YES	++	NO	1
12	Blades of shutters	3	++	+	++	+	+++	++	YES	++	NO	1
13	Drainer for clothes	3	++	+++	+	++	+++	+++	YES	+++	YES	2
14	Climbing blocker	4	++	++	+++	+++	++	+++	YES	+++	YES	3
15	Cutter	2	++	+	+	++	++	++	NO	+++	YES	2
16	Coffee cup	2	+++	++	++	+	+++	++	NO	++	YES	2
17	Meal set	3	++	++	++	+	++	++	YES	++	YES	2
18	Tartinor	3	+++	+++	++	+	+++	++	NO	++	YES	2
19	Kettle	3	++	++	++	+	+++	+++	NO	++	YES	2
20	Vegetables raper	3	+++	+++	++	++	+++	+++	YES	+++	YES	2
21	K-Way	3	++	++	+	+	++	++	YES	++	YES	2
22	Alarm clock	2	++	+	++	+	+	+	NO	+	NO	1
23	Cross-belt	4	+++	++	++	+	++	++	NO	+++	YES	2
24	Fins	3	+++	+++	+++	++	+++	+++	YES	++	YES	4
25	Dustbin	3	+++	++	+++	+	+++	+++	YES	+++	YES	2
26	Cheese Grater	3	+++	+++	++	++	+++	+++	YES	+++	NO	1
27	Back bag	2	+++	++	+	++	++	++	YES	++	YES	2
28	Tripod	3	++	++	++	++	++	++	NO	++	NO	1
29	Helmet	4	+++	++	+	++	+++	+++	YES	++	YES	2
30	Package for cereals	3	+++	+++	+++	++	+++	+++	YES	+++	YES	3
31	Draining wire	4	+++	+++	++	+	+++	++	YES	++	YES	2
32	Ironing table	4	++	+	+	+	+++	++	NO	++	YES	1
33	Corkscrew	2	+++	+++	+	++	+++	++	YES	+++	YES	2

+ : wrong or no use of concept
++ : average use of concept
+++ : appropriate use of concept

Appendix 1: Summary of the second test among 103 students and 33 projects