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### The Contribution to TRIZ by the Inventor Schools in the GDR

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#### Abstract

On the basis of an analytical scheme developed in [1] the analysis of the theoretical heritage of the inventor school movement in the GDR is continued in more detail. We provide an analysis of the tension between theoretical-methodological positions and productive-practical dynamics in the short time of the boom of the GDR inventor schools in the 1980s and describe the most important theoretical results from the inventor school systematics.

*Keywords: inventor schools in the GDR, ProHEAL methodology, ABER matrix.*

### 1 Inventor Schools as an Example of a Socio-Technical Development

In [1] – using an ARIZ-like approach to socio-technical analysis – an analytic scheme was proposed to describe and reflect the development of the inventor school movement in the GDR as a specific form of TRIZ practices in their contradictory dynamics. This analytical scheme, that can also be applied to other TRIZ practice contexts, considers TRIZ as part of the inventive system within the given society model. The idea to apply TRIZ's analytical and methodical concepts to the historical analysis of TRIZ itself is inspired by the essay [11], that outlines the general potential of applying TRIZ to the analysis of contradictory societal processes.

In the context of the well-known 9-fields approach the application of such a methodology to the history of the inventor school movement in the GDR must first adequately apply system modeling to identify and model the correct place of the inventive system on the one hand in relation to a more general social supersystem and on the other hand in relation to appropriate subsystems. In a first approximation the structures of the inventive system are in tense conflicts with the socio-political system as *supersystem* and with the economic-productive system as *subsystem*. In the course of this analysis, in [1] three components of the inventive system are identified that are significant for the analysis of the inventor school movement,

- the theory of Systematic Heuristics according to Müller (SH),
- the potential left over from the short theoretical and practical boom of cybernetics in the years 1965-1974 in the form of persons trained in dialectical, contradiction-oriented thinking (DC) and
- the personal and structural potential of the *Honoured Inventors* (“Verdiente Erfinder”, VE) – a system of ideal and material gratification of invention achievements, existing in the GDR since 1952.

These components show different dynamics over time, which is, compliant to TRIZ theory, taken in [1] as reason for remodeling. After a substance-field swap, the inventive system is no longer regarded as *unit of modeling* (“substance”), but as a *mediation* (“field”) between the relational structures between the socio-political and inventive systems (1) on the one hand and between the inventive and the economical-productive system on the other hand, thus considering those initially relational structures now as units of modeling (“substances”).

Such *substance-field swaps* as basic remodeling principle play a minor role in the current TRIZ practice, although such a transition from verbs (to designate relational aspects, “fields”) to nouns (“substances”) is essential and far-reaching in philosophy representing a common abstraction principle. An obstacle to apply this principle comes from an *immersive* system notion that is widespread in TRIZ practice and reduces the relationship between the supersystem and the system to a simple inclusion relation. Such an approach insufficiently takes into account that modeling is not concerned with the real-world systems themselves, but with *descriptions* of such systems, that necessarily require abstractions and reductions. Due to the relative autonomy of the forms of movement of the socio-political and inventive systems in our context, a hierarchization of system levels can only be used to a limited extent, but on the other hand does no more play a prominent role in a *submersive* system notion. Hence, we consider the three systems (socio-political, inventive and economical-productive) as independent to a certain degree<sup>1</sup> and do not reduce the relationships between them to a pure embedding. This concept is described in [1] in more detail.

Furthermore, in [1] we discussed, to what extent such an approach – the consideration of the inventor schools in particular and of TRIZ in general as a *mediation structure* between the poles of two social relation areas, on the one hand TRIZ as theory (1) and on the other hand TRIZ practices (2) – is necessarily reductionistic. Such a reductionism results from the consideration of the areas (1) and (2) as “substances”, thus suppressing the analysis of their *inner* contradictions in favour of focusing on the contradictions and forms of movement within the field of tension *between* TRIZ theory and TRIZ practice.

In this essay such a problem access is granted as given. In [1] we considered more closely the period from 1960 to 1990 that can clearly be divided into three phases (1960<sup>th</sup>, 1970<sup>th</sup>, 1980<sup>th</sup>) with different emphases at the level of the supersystem. Such gradual changes at that level are manifested in significant *structural* changes at the level of the inventive system. In this essay, the period of the inventor schools of the 1980<sup>th</sup> will be analyzed in more detail. We refer to [2] for detailed information about the inventor school movement in the GDR.

## 2 Inventor Schools – a Refinement of the Analysis

In the last section we described our approach to analyse TRIZ history in its movement forms of tense relation between TRIZ theory and TRIZ practices. In this approach TRIZ theory and TRIZ practices act as *poles* of an exchange relationship between the different area of conflicts in (1) and (2). This analytical approach was used in [1] already to explicate a rough pattern of *theoretical* contributions of the inventor schools to the further development of TRIZ, attributing the component VE to the pole of TRIZ practices, whereas the components SE, DC, and also the system of TRIZ approaches in a strict sense are attributed to the pole of TRIZ theory. This analysis will now be deepened.

The pole of TRIZ practices in that setting definitely needs to be supplemented by the practices of the *specific inventor schools and their participants*. In order to clarify the dynamics of this context, we cite a longer quote from [3] that describes the typical inventor school situation (translated from German by HGG):

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<sup>1</sup> Such an independence is part of an abstraction process in system analysis that puts a frame of separation on the complex interdependencies of the “real world”. Such an by its very nature *reductionistic* abstraction process can be considered as the core of the substance-field approach in TRIZ, see [1] for details.

“The EKO (‘Eisenhüttenkombinat Ost’) hosted the first inventor school in 1982/83, in which I participated. In this context, within the KDT company section, a working group ‘inventor activity / creativeness’, headed by Dr. Papert, was founded in April 1983. Members of this working group were preferably graduates of the inventor school. The tasks will be reported below.

Trainer of the first inventor school was Dr. Herrlich from Leipzig, himself a Honoured Inventor and a leading coach of inventor schools. The training rooms were outside the company. The goal was to familiarize the participants in a place far away from the living and working area with the invention methodology in a focused and undisturbed manner and to let them work. The motto of the inventor schools was: ‘Experienced inventors train future inventors’.

At the end of the first week, the participants had to process the identified information deficits of subject-specific and IPR-specific nature until the second week of training. In the final work after the second week, patentable solutions should be realized. Each graduate had to formulate an implementation concept for this purpose.

Participants should in any case handle an actual operational task from the company with the objective of a patentable solution. Thus it was clear that already existing collectives, preferably with their leader, should take part in the inventor schools. However, this also required that the engineers came up with demanding topics. With the implementation of inventor schools, there were demands on the topics that had to be dealt with, that often made the difference between claim and reality in the area of company research clear. ...

Basically, it should be noted that the college and technical college engineers were very open-minded about the invention methodology and after completing the inventor schools were very motivated to work on the tasks. Unfortunately, the topics often did not have a level that would have made scientific and technical excellence possible. Here compromises had to be made in relation to the actual concerns of the inventor schools. ...

The inventor schools were supplemented by the mediation of mathematical-statistical experimental design and evaluation and separate courses and commercial offers for computer-aided inventions. Own materials came from the district center of innovators (“Bezirksneuererzentrum”) in Suhl, that among other things also carried out courses on computer-aided inventions. This technical support had not obtained practical importance in the company.”

For further analysis it turns out that the personnel tableau has to be divided into two categories – the *coaches* and the *participants*. For the participants the solution of specific economic-technical tasks was in the foreground, for the coaches the *problem-related mediation of suitable methodologies*. [2:13] lists a considerable number of such coaches.

The elaboration and fixation of such methodologies in handouts and the consolidation of a corresponding *mediation system for methods* represents an independent challenge that was addressed only selectively in the short time of existence of inventor schools and was essentially limited to the preparation of handouts and their (under real socialist conditions difficult) publication and distribution.

The first approaches towards an *independent methodological work-up* can be found in the dissertations [4] by Linde at TU Dresden and [5] by Herrlich at TH Ilmenau. Further effort to work up the methodological heritage of inventor schools, such as [2], [6] or [7-9], took place only after 1990, at a time when the springs of inventor schools TRIZ practices already dried up and the systematization was only possible in retrospective form.

To play back these experiences in the *further development of the TRIZ corpus* itself not only such a systematization is required, but also appropriate personnel and structural framework conditions, i.e. a sufficiently efficient academic context. The corresponding systematizations in [2], [4] or [6]

represent at best a beginning of such an assembly, a systematic merge of the theoretical heritage of the inventor schools with the theoretical development of TRIZ in the last 30 years is still pending.

In this short analysis, within the inventive system we have identified four roles and three communicative interconnections, that further structure the inventive system as a major mediating link between (1) and (2). These are the roles of *participant*, *coach*, *leading coach* and *master* as well as the mediation relationships on the levels

- (a) of practical methodology (coaches – participants),
- (b) of further development of the methodological mediation structures (a qualification system of coaches by leading coaches as well as the embedding of such a training in the academic educational structures) and
- (c) of further development of the academic foundations of these innovation methodologies.

While the systematic heuristics (SH) reached a wider spread in the 1960s starting from the academic system (c), the inventor schools as well as Altshuller's approaches at Soviet times remained in its core outside academia, as Thiel [10] explains for the academic recognition of [4] in greater detail.

### 3 Theoretical Approaches within the Inventor School Systematics

With ProHEAL (“Programm zum Herausarbeiten von Erfindungsaufgaben und Lösungsansätzen”) [10] and WOIS (“Widerspruchs-orientierte Innovations-Strategien”) [6, 10] two theoretical versions of the inventor school methodologies have been elaborated in more detail.

Common to both approaches is that compared to Altshuller's original, where the potential of *administrative contradictions* is not considered systematically, the *technical-economic* problem field is considered as a separate level, in which “the relation between products, goods and purposes” [2:57] have to be explored in more detail. Such a perspective nowadays is experiencing a renaissance, especially in the area of agile approaches, since it is increasingly counterproductive to leave the requirements analysis to the management and to limit the responsibility of the engineering and technical personnel to the realization of previously specified requirements. This potential is already highlighted in Part 3 of [2] entitled “Perspectives of Inventor Schools in the Market Economy”.

Similar to ARIZ, these three *levels of contradiction* are operationalized in a *path model*. The “problem areas in the path model of inventive methodology” [2:106] are identified on the one hand as mediation between different levels of detail of the problem analysis and on the other hand stem from the contradictory nature of different levels of conflict.

On the *technical-economic level*, the technical-economic problem situation is developed in a person- and process-related analysis as the conflict of objectives between potential needs in the sense of a requirement analysis and the (technological) state of the art. As result of this level of analysis listed in [2:59] one obtains

- the *technical-economic goal* of the innovation project,
- the *basic variant* of a process and/or product innovation that meets demand in a technological sense,
- the *critical functional area* in the multi-dimensional optimization space of this basic variant,
- the *technical-economic contradiction* (TEC), that stands in the way of an optimal design and dimensioning of the basic variant.

[2] continues: "If it is not possible to derive a basic variant from the state of the art that can be optimized in terms of the technical and economic objectives, then there arises an *inventive problem*. The solution of the TEC is then the goal of the invention", on which the further analysis has to be focussed.

If a basic variant is found, then the *techno-technological level* is entered, in which all facts are to be analysed, "that concern the technical system of the basic variant, its structure, function, its behaviour and its immediate technological environment." [2:60] As result of this level of analysis one obtains

- the *ideal technical subsystem* in the critical functional area of the basic variant that solves the TEC,
- the *unwanted effects* as undesired technically disadvantageous effects of the ideal subsystem on the functional behaviour of the basic variant,
- the *critical range* in the functional structure, to which the causal correlation of the ideal subsystem and the undesired effects extend,
- the *technical-technological contradiction* (TTC), that stands in the way of the attempt to eliminate or suppress the undesired effects by varying the functional principle of the ideal subsystem.

[2] continues: "If the technical subsystem with the alternative functional principle for the critical functional area of the basic variant can be found without a significant undesirable accompanying effect, then an *invention* is present as a solution of the TEC. Due to the heuristic approach, this often turns out to be a *clever simple solution* ('*raffiniert einfache Lösung*' – REL) in the low-tech sector, that in the best case requires only application-specific testing. ... If the solution is not achieved in this problem field level, then from the previous analysis the problem may be formulated as a *precise invention task*, that includes the TTC as well as a solution strategy tailored to this contradiction. This amounts to defining the harmful natural law in the critical area of the functional structure and replacing it with an alternative known active principle", that is to be analysed in more detail on the third problem field level.

On this *technical-natural-law problem field level* "all circumstances come into consideration, that concern the operating principle, the conditions for its technical use as well as its theoretical and experimental foundations. The considerations are model- and event-driven and determined by relations between fields, factors and effects." [2:60] As result of this level of analysis one obtains

- the *ideal operating principle* in the critical effective range of the functional structure in the sense of the solution of the TTC,
- the *harmful natural law* that opposes to unfold the ideal operating principle,
- new *technical-constructive boundary conditions* in the critical range of action that suppress the effect of the harmful natural law,
- the *technical-natural-law contradiction* (TNC), that prevents a deployment of the ideal operating principle by varying the technical-constructive boundary conditions in the critical range.

[2] continues: "If the new mode of action can be technically unfolded to the extent necessary for functional performance in the critical area, then an *invention* as the solution of the TTC is present. Since this enters new technical and scientific territory, the solution is usually located in the high-tech field. It requires application-oriented basic research for its verification. ... If a problem solution is not found in this way, then one has to deal with a system-inherent TNC, that questions the development and viability of the system as a whole. As solution strategy one has to search on a suitable, hitherto unknown principle of action or on a fundamental process innovation. Both solu-

tion strategies usually go beyond the framework of a time and financially definable innovation project.”

This methodical framework was condensed to a “Program Sequence to Work out Invention Tasks and Solutions” [2:107-109], in which ARIZ-like process sequences in each of the three operation fields are coupled together via narrow interfaces.

Contradictions of various kinds are to be identified on all three levels, for which a uniform methodological instrument was developed with the *ABER Matrix* as a “strategic tool for contradiction-aware inventions”. [2:62]

On the technical-economic level, this matrix is defined as a *target matrix* with 16 fields to “systematically determine the targeting requirements, conditions, expectations, restrictions<sup>2</sup> (as rows of the matrix) in terms of functionality, economy, controllability, usefulness (as columns of the matrix)”. It serves “to question systematically the actual need for action, the action objectives and the project idea underlying the innovation project. ... The ABER matrix is intended to anticipate all conceivable ‘yes, but’ prejudices to an invention when it comes to putting it into production or on the marketplace.” The technical-economic problem is basically formulated as determining the main variable that, with its variation, causes other significant target parameters to deteriorate to an impermissible extent or to go beyond given limit values.

On the technical-technological level, the ABER matrix is used as a *critical function matrix* with 20 fields to “define the technical-technological innovation goal in the form of the ideal subsystem” by systematically recording the “functional requirements, the design and manufacturing conditions, the technological influences, the natural law restrictions<sup>3</sup> (as rows of the matrix) in terms of operand, operation, operator, counteroperation, counteroperator (as columns of the matrix)” to record the “technical-scientific solution needs” by a functionality-related structure analysis, to define the critical functional area and the interface conditions for the ideal subsystem both structurally and functionally.

On the technical-natural-law level, the ABER matrix is used as an *activity field matrix* with 12 fields for scientific-mathematical modeling to produce a “working hypothesis on the processes in the critical effective range of the ideal subsystem”. It is used to record systematically the “requirements, conditions, insights, restrictions<sup>4</sup> (as rows of the matrix) with regard to technically exploitable effects, technologically to be controlled side effects and accompanying effects, constructively controlled counteractions and lead effects in the functional structure of the ideal subsystem (as columns of the matrix)”. The description of the causal relations between the defined activity field parameters is more complicated. “The problem is still the TTC. The solution goal is now the new active functional principle according to the solution strategy. The solution goal is thus no longer directly oriented to the invention, but primarily based on natural scientific gain, that opens up new spaces of solutions for inventive thinking.” [2:64]

## 4 Conclusions

In this paper, the theoretical heritage of the inventor school movement of the GDR was analysed in more detail. On the basis of an analytical scheme, that was itself developed in [1] with an ARIZ-like methodology, we provide an analysis of the tension between theoretical-methodological positions and productive-practical dynamics in the short time of the boom of the GDR inventor schools in the 1980s. Already at that time it became clear that the broad practical availability of innovation-methodical skills in the engineering and technical area is strongly required for a

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2 In German: **A**nforderungen, **B**edingungen, **E**rwartungen, **R**estriktionen – the source for the acronym ABER, that translates also as “but”.

3 In German another ABER: **A**nforderungen, **B**edingungen, **E**inflüsse, **R**estriktionen.

4 In German a third ABER: **A**nforderungen, **B**edingungen, **E**insichten, **R**estriktionen.

developed industrial society to survive in the worldwide economic competition. The three areas of mediation

- (a) practical methodology as an offer for continued professional education by trained coaches,
- (b) further development of the methodical mediation structures by coach qualification as well as anchoring it in the academic education of future engineers and
- (c) further development of the academic foundations of these innovation methodologies

further structure the inventive social system as a field of tension between the socio-political and the technical-economic social systems, formerly also – and possibly more precisely – identified as a field of tension between *relations of production* and *productive forces*.

In Section 3 essential theoretical positions are referenced, which are rooted in the experiences of the inventor schools of the GDR. [2] as probably the most instructive methodical systematization of these experiences so far is used as a reference. The focus is on the effort to raise this wealth of experience for the debates on the further development of TRIZ theory. A precise classification of these results in the TRIZ theory building with all its winding corridors and rooms requires a more comprehensive processing of this heritage, which is still to be afforded.

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**Communication acceptance:** With the submission of the paper the authors accept to be contacted by MATRIZ representatives for TRIZfest purposes.