The functional - resource approach to the forecasting of technical systems evolution

A fragment from the book "Evolution of technologies", Chapter « Graphic and numerical methods based approach to forecasting tasks solving »

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TRIZ as a scientific discipline develops according to the laws of dialectics first put forward by Hegel: from phenomenological ways of study of technical systems to measuring procedures. Any creator of new technology (and new goods or services) would be interested in his product following the brilliant destiny of many of goods - champions of sales, like the paper clip or the ball point pen or the bentwood chair, or the car 'Volkswagen Bug', which were the champions both in the volume of sales and in the market life period.

The methods of formalization of objects of research suggested below may become the first step in creation of analytical methods for measurements of potential success of an innovation. Such "device" (analytical procedure) is impossible without the application of principles of causality, historicity, generality {universality} of dialectic materialism.

The professional forecasting analytical procedures developed and successfully used by our laboratory in TRIZ consulting, are complex and labour consuming. For example, the method of the construction of the given technical system's evolutionary spectrum contains 22 lines, each of which describes 5 basic evolutionary conditions and shows full adequacy to all known laws of development of technical systems. Another method, the method of construction of the functional - resource diagram is not that exact, but is simple and at the same time profound enough. The constructed model rests upon a number of simplifying assumptions, which are necessary to use:

1. Material-field resources sometimes are the cause of a TS (TS stands for Technical System) development; sometimes they are consequences.
2. Function, in the context of TRIZ, is a complimentary addition to material-field resources and simultaneously is in the dialectic contradiction with them.
3. Function as the actualized requirement sometimes is the cause of the TS development, sometimes is a consequence.
4. To describe the space of material - field resources, it is necessary, but not enough to use 3 measurements (fig. 1).

4.1. The line of change of a substance aggregate state of the Working Body (Line ?)

4.2. The line of change of topology of movement of the Working Body and its elements as a resource of the TS development (line D)

4.3. The line of change of the nature of the fields, capable to provide the Working Body functioning as a resource (Line F)

The difference of this way of formalization from known (? ? ? ChE? , introduced into practice by Boris Zlotin, much respected by us) consists in the expanded interpretation of the letter of M

- a mechanical field. We relate both muscular fields of living origin, and mechanical properties of acoustic fields as belonging to the 'M' group. We also introduce an additional evolutionary condition "MICRO" which now includes not only the fields of phenomena of micro levels, but also properties of a phenomenon of distribution of information fields as C. Shannon understands them (C. Shannon).

5. To describe the space of functions, it is necessary, but not enough to use 3 measurements:

5.1. The line of change of the level of complexity of ideality regarding operations with the denominator (the sum of functions) - line I (ideality), where I = {ΣF} / {Σ $}

The difference of our approach to the standard understanding of the mechanism Mono - Bi - Poly consists in different interpretation of the notion of 'mono'; association with antisystem; poly-system as n≥2; « complex system » as association of two Working Agents of different field nature, which are not considered as antisystems in relation to each other, and «a new mono-system », which is considered to be an evolutionary state that causes clearly revolutionary changes in the nature of fields, topology of movements or change of physical conditions of substances in the Working Body of the system.

5.2. The line of change of the level of complexity of the Working Body dynamicity (Line C). It is a well-known trend in TRIZ: the monolith, the hinge, a lot of hinges elastic links and fields which here are designated by the term ' flows of substance - field resources', meaning oscillations and the wave phenomena.

5.3. The line of change of dimension of result of the Working Body performance function (Line R). It is also a known trend supplied with 5-th evolutionary condition after the condition "volume" - « volume constituted by dots ». It is a thorough analogue of the concept « new mono».

6. We cannot offer any strict argumentation to the introduction of so-called '5-th evolutionary condition'. However general success (good adequacy) of the pentagonal models constructed by us for objects complex for study, such as phenomena of a conflict, sales, road and transport incidents, emergency deployment of vertical cylindrical tanks for mineral oil, and also intuitive preferences, allow us so to apply the 5th evolutionary condition and the models based upon this scheme .

7. Constructed 3 + 3 measured space DAF - « space of resources » and ICR - « space of functions » are coordinated among themselves by pairs: D ↔ R; I ↔ F; C ↔A, which are found to be both in the state of the dialectic contradiction and at the same time are mutually complimentary.

All stated is represented in fig. 1. Two important remarks are pertinent:

1. The idea to combine two spaces according to the principle of known diagrams by A. Minkovsky, which is an application to the Special Theory of relativity: as two cones with the common top - "a sand-glass structure", appeared on the professional TRIZ workshop 'TRIZ in business' given by ? . and L.Sibirjakovies (13 - 17.07.03) where the model of a 3-dimensional business - space was considered as the diagram of evolutionary conditions .

2. Currently, in the Russian speaking Internet space, a very actively discussed topic is so-called «Bartini's cryptogramm». R. Bartini was a Soviet aircraft designer of the 40’s of the last century who outstripped the constructive ideas of his contemporaries to no less than 50 years. This charismatic and mysterious personality can be compared to the scale of the person and merits of Nikolo Tesla. The magnificent mathematician and physicist, R.Bartini, in his last works of the 60’s, wrote about 3+3 dimensional image of a certain elementary cell of space, which can be considered as a wave and as a rotating oscillator, which is alternately a drain and a source. TRIZ, from our point of view, is a complex

synthesis of science and art (e.g. like architecture). Therefore we regard the art of making analogies while constructing models in TRIZ as appropriate.

Fig. 2 presents the examples of functionally - resource diagrams of an evolutionary chain of different technical systems intended for fastening two metal surfaces: a groove of dry friction, a rivet, a bolt, a screw, soldering, glue, electrode welding. A curious observation is a certain symmetry of graphic constructions in both spaces. All these technical systems are "long-livers". Might this symmetry be a graphic indication of success of a system? Study of these objects has allowed us to make one more curious observation concerning the ratio of numerical values of the measured degree of development (complexity) of the system.

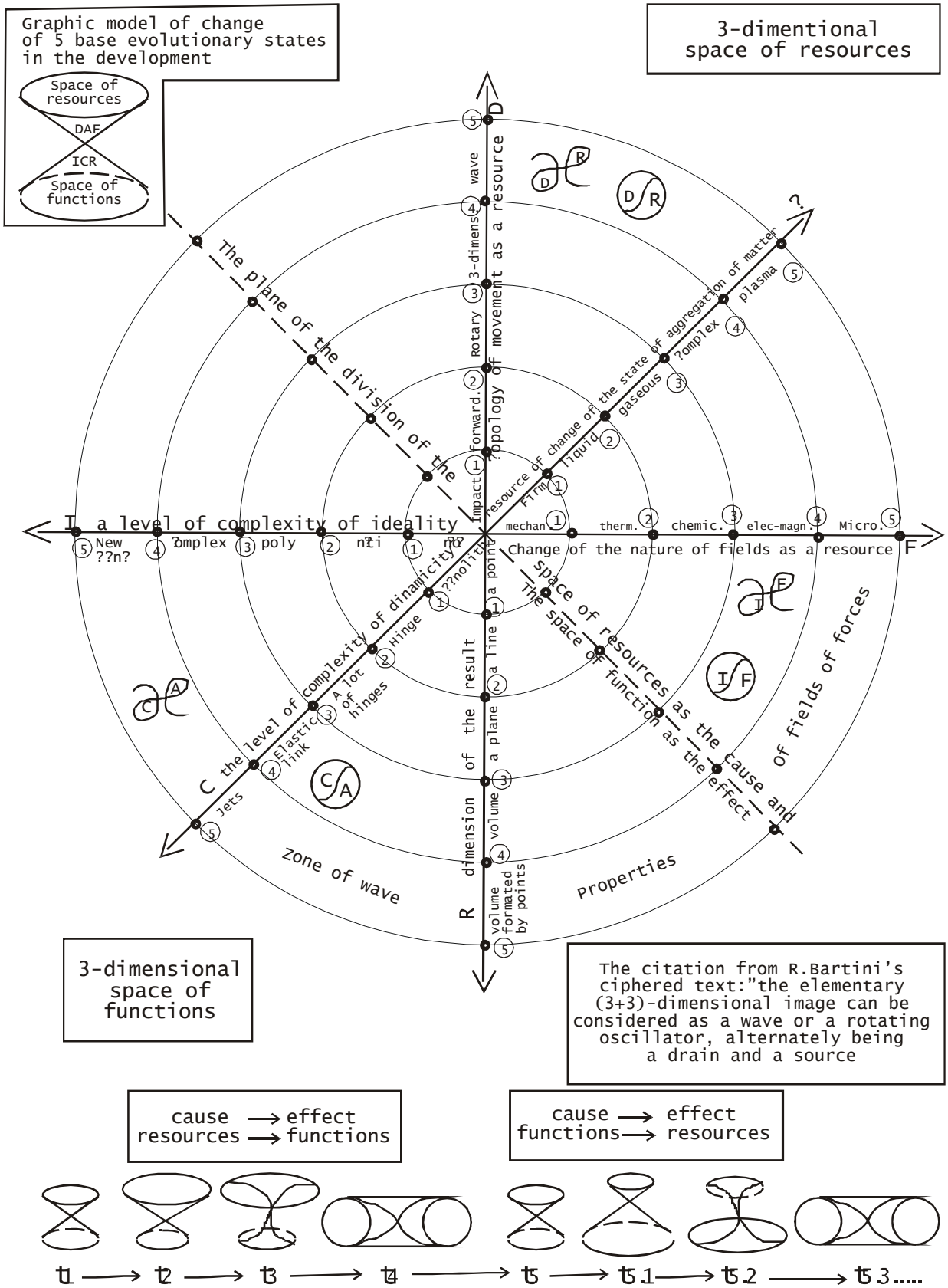
There is an impression of coherence of changes of numerical values of a degree of development of the system with Fidius' number (« gold section ») and its derivatives, that can be the basis for construction of a new hypothesis in the field of laws of development of technologies and for revealing new, not known earlier, laws. Thus, designing a new technical (or business) system, it is possible to measure its evolutionary potential to compare it with the potentials of a corresponding evolutionary chain (all historical precedents of performance of the main function of this system) which makes it possible to receive a certain well-reasoned judgment about the degree of innovative risks. Certainly, it is only « a vector of search » which can reveal a trend of the parameter "the beauty" of the process of the given technical system evolution.

Conclusions:

1. For high-grade application of the method of functional - resource diagrams it is necessary to collect an imposing bank of cases of their construction for evolutionary chains - i.e. to create « the Directory on evolution of technical systems» as a well-formalized set of maximum number of evolutionary scripts.
2. The procedure of the analysis of the diagram of a specific system will be organized as a procedure of comparison with the scripts from "the directory" that can be easily transformed into corresponding software of forecasting purpose.
3. Such methodological approach realizes principles of historicity and causality at the level of measuring procedure and allows connecting achievements and advantages of TRIZ to other forecasting means, for example, 6 Sigma or synergetics, which will make any researcher more acute and versatile.

Coming in future issues:

We hope to publish 35 training games for mastering of the method of forecasting on the basis of evolutionary spectra in one of the nearest issues.

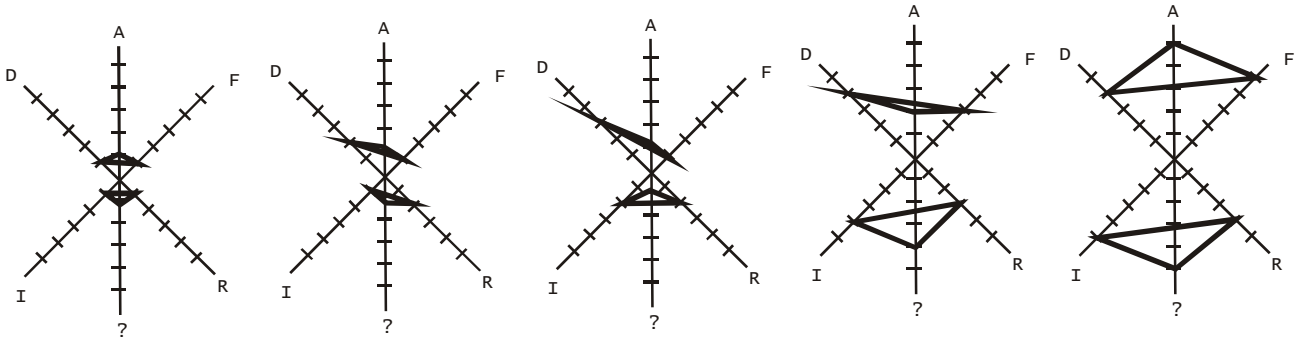


Hypothesis of pseudo-quantum process in the development of technology
from J.Danilovsky, V.Mitrofanov's book "Evolution of technology"

Fig. 1

Graphic models of evolutionary states of technical systems:

$\rightarrow$ $\lambda 1$ [3,3] $\rightarrow$ $\lambda 2$ [4,4] $\rightarrow$ $\lambda 3$ [5,5] $\rightarrow$ $\lambda 4$ [8,8] $\rightarrow$ $\lambda 5$ [14,14]



1. 2. 3. 4. 5.

Matrixes of evolutionary states of technical systems (numerical models):

1. Joints of parts by means of dry friction (groove, dovetail, jount ets)

D	1	0	0	0	0
A	1	0	0	0	0
F	1	0	0	0	0
R	1	0	0	0	0
C	1	0	0	0	0
I	1	0	0	0	0

2. Joint-pin, rivet

D	1	1	0	0	0
A	1	0	0	0	0
F	1	0	0	0	0
R	1	1	0	0	0
C	1	0	0	0	0
I	1	0	0	0	0

3. Bolt, screw

D	1	1	1	0	0
A	1	0	0	0	0
F	1	0	0	0	0
R	1	1	0	0	0
C	1	0	0	0	0
I	1	1	0	0	0

4. Glue, soldering

D	1	1	1	1	0
A	0	1	0	0	0
F	1	1	1	0	0
R	1	1	1	0	0
C	1	0	0	1	0
I	1	1	1	1	0

5. Electrode welding

D	1	1	1	1	0
A	1	1	1	1	1
F	1	1	1	1	1
R	1	1	1	1	0
C	1	1	1	1	1
I	1	1	1	1	1

1.	2.	3.	4.	5.
Degree of the system development 1/? :				
0.2	0.267	0.333	0.533	0.934
Evolutionary potential ? ?:				
148.413	42.521	20.086	6.521	2.918

$\rightarrow$

Where λ - a parameter of the ratio of space of resources and functions def: $\lambda \equiv (\det(DAF); \det(RCI))$,

Where $\det(DAF) \equiv \Sigma(d_i+a_i+f_i)$; $\det(RCI) \equiv \Sigma(r_i+c_i+i_i)$

The evolutionary age as a degree of the lack of development is determined as

$$? \equiv \frac{30}{\det(DAF)+\det(RCI)} \Rightarrow 1 \le T \le 5$$

$\Rightarrow 1/T$ - the degree of the development of the system.

] Evolutionary potential of the technical system

def ?? $\equiv \exp(?)$ (the choice of the exponential function is made from 'more, than general reasons'

Curious observation:

$?_1^{-1} / ?_2^{-1} = 1.333 \approx \sqrt{?}$,

where ? = 1.618, Fidius' number or «gold section», $\sqrt{?}$ = 1.272

$?_2^{-1} / ?_3^{-1} = 1.25 \approx \sqrt{?}$

$?_3^{-1} / ?_4^{-1} = 1.6 \approx ?$

$?_4^{-1} / ?_5^{-1} = 1.751 \approx ?$

Might it be a new, unknown for a while law of development of technical system?

The ways to join metallic parts and some Technical Systems performing this function

Fig. 2