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The article shortly presents the results of forecasting research carried out at the laboratory 'Show Sin' as workshop training on the subject 'The technical systems evolution and forecasting'. The Director of the Laboratory Yury Danilovsky. E-mail: UR7@mail.ru The Scientific Supervisor Voluslav Mitrofanov. E-mail: mitrofanovvv@mail.ru

### The forecast of the ballpoint pen evolution

(the shortened version of the educational program: Forecasting of the evolution of technical systems. The electronic edition of the Laboratory 'Show Sin', 2003, Saint Petersburg, Russia) [1] (This work can be ordered separately)

- 1. The contents of the forecast.
- 2. The method of this forecast development.
- 3. By-products of the procedure of forecasting research.
- 4. The appendix: two diagrams of TRIZ philosophy, nomographic formalization of the pen as a technical system.

#### 1. The contents of the forecast

The object of the research was "a pen". We considered it as a various group of technical systems capable to carry out the function of changing physical and chemical properties of a data carrier: ballpoint pens (1), jelly ink ballpoint pens (2), pencils (3), fountain pens (4), felt-tip pens (8), brushes (6) and eventually, the computer (7). Table 1 unites all the possible concepts of such writing devices. The letter 'E' with a numerical index corresponds to the predicates in the description of the functions of the studied system and its elements. Some comments on the table are given further, meanwhile, we start with the description of the forecasted concepts.

- 1.1. The market of the objects (1) (6) in the near future (5 10 years) will not diminish, because among the predicates of the "Source" of the studied technical system we see E116 – to take pleasure in the process of creating beautiful signs, such as letters, lines (E316, E616, E2616, E2716) and figures of different colors on white paper at very insignificant expenses (E1516, E1616) and immediately (E15). Such composition of predicates will be achieved by the main competing TS (by computers) in the evolution of technical realizations of the formulated function very much not soon. This period is approximately equal to the change of two generations, i.e. 40 years.
- 1.2. The tendency of transition to a micro level in the development of "the working agent» of the studied technical system will continue. The tendency has existed for approximately 35 years from the moment of occurrence of the first ballpoint pens (transition from the principle of the forward movement of the working body to the rotary movement: the capillary channel ended in the surface of the nib of a fountain pen and was replaced with a ball, the "ball" of a jelly ink ballpoint pen has smaller geometrical sizes, than the "ball" of the ballpoint pen  $_{E121} \rightarrow _{E27}$ ;  $_{E811} \rightarrow _{E911}$ . The tendency of the transition to micro level may result in a new type of information carrier «electronic paper»  $_{E121}, _{E122}$ ). In addition, this tendency will manifest in the appearance of a manually operated device  $_{E113}$  for the electronic paper, which, with the help of electrostatic  $_{E613}$  or mechanical principle  $_{E213}$ , will allow "to write" on it by means of

removing of the substances of the data carrier  $_{E13}$ . A pen, specially conceived for the electronic paper will allow to write on the electronic paper very soon, within the period of 3 – 5 years.

- <sup>1.3.</sup> The jelly ink ballpoint pen will undergo trimming according to the Law of the increasing ideality  $_{E214}$ . It will write for a longer period due to the simplification of its design: the outer body will be trimmed off and the inner refill will be turned into both the bigger ink container and the outer body.
- 1.4. The graphite pencil has a resource to the further development on the mechanism of transition from the forward movement to the rotary type of movement of the working body ( $_{E17} \rightarrow _{E27}$ ) due to the change of the aggregative state of graphite from  $_{E59}$  (a firm body) to $\rightarrow _{E69}$ (particles of a firm body). A powerful resource for such a change is the property of graphite  $_{E416}$  to be removed easily from the surface of the paper, and its low cost  $_{E1816}$ . 'A liquid' pencil is expected to appear (see [1]). It will have the properties of a felt-tip pen: to leave lines of different width.
- 1.5. The outer design of the systems (1) (6) can change a little towards better ergonomics  $_{E314}$  (the resource of development here is far from being exhausted) and  $\{_{E117} _{E517}\}$ , rubber overlays will become more comfortable, and the property of a pen not to be lost before we use it  $_{E3616}$  will ever be implied by the designers. It, most likely, will be shown in occurrence of a plenty of pens with some "amusing" properties  $_{E3316}$ , capable "to chirp, "whistle", give flashes of light and so on.
- 1.6. Certainly, there will be writing tools (1) (4), combined with other technical systems: according to one of the most powerful evolutionary laws, the Law of increasing ideality  $_{E110} - _{E510, E16} - _{E376}$ . It is an infinite line of evolution: the ballpoint pen + a ruler, the ballpoint pen + a watch, the ballpoint pen + a calendar, the ballpoint pen + the device for measurement of amount of sugar in blood, etc.
- 1.7. Transition to the super system has begun lately, and it is necessary to expect changes in «a pen 7 » computer, within a rather close time interval of 5 7 years. It will be possible, not to use the keyboard, «it will write to your dictation ». We may expect changes in the design of monitors: they « will lay on the table » and will perform the function of the writing paper.
- 1.8. Mobile phones will gain new options of notebooks with the possibility of manual input of short notes and drawings and the ability "to remember" the images. It is connected to very "strong" predicate E2816 to remember written for the subsequent renewal of an inscription (for duplication, and sending the correspondence). Association of a computer and mobile phone as the device, performing the function of a ballpoint pen, is a very probable line of evolution because of the obvious directing of powerful money flows into that area.

#### 2. The methods of this forecast development

2.1.The authors operated the categories and logic tools of TRIZ: the 12 Laws of technical systems development, the four mechanisms of performance of these laws, the 40 methods of technical contradictions resolving, the Ideal Final Result, undesirable effects, contradictions, functional - cost analysis. The authors also used some additions to the above mentioned methods and tools: some tools of mathematical logic, the algebra of statements, nonlinear programming, multiple-valued logic, algebra of indistinct sets, ideology of synergetrics, QFD, structural and functional analysis. The additions to the conventional set of TRIZ tools allows to apply the<u>TRIZ philosophy</u> as the total <u>of all</u> heuristic methods for obtaining plausible judgments about the evolution of technical systems. The total of all listed methods and approaches, generalized in the works of the laboratory of innovative research "Show - Sin" for the last 13 years, and conditionally named the TRIZ philosophy, introduces some additional categories: the information system, logical-probabilistic flow model of a studied phenomenon, the structuring of informational fields, and also bases on regular teaching work with various auditoriums (see the

video collection « 24 hours of psychological training on the philosophy of TRIZ», Y..Danilovsky, V.Mitrofanov, D.Shevchenko, C-Petersburg, 2003). All these circumstances allow to transfer the highly effective research (and reasoning) technologies to such objects, as « a phenomenon of realization of human demands», «career projecting as information system» and many other things. We consider the Philosophy of TRIZ as a unity of all possible heuristic methods which allows to realize the interdisciplinary approach in solving any kind of task including forecasting.

- 2.2. Working out the forecast, we moved along the algorithm constituted by 7steps, which are to be followed both one after another and concurrently:
- 2.2.1. Information pumping. We reviewed all known devices fixing and saving information for the period of the evolution of the technical systems; There are 63 items in our collection of pens, pencils, markers, clay plates, birch-tree bark, office paper and so on and forth.
- 2.2.2. Creation of the component model of the studied object in accordance with the law of the Completeness of the parts of the TS:



The formation of all predicates for the description of any known realization of the studied function. The predicates are used to make the descriptive formula (« the formula of a pen ») which looks as a matrix or a multy column table which has 19 predicates, the total capacity of the set of parameters of the description -144.

2.2.3. Cause –effect study of the function 'to fix information'.



- 2.2.4. The study of the genealogical model. The stages of the function performance were allocated along 'a time line' and each stage is 'unwrapped' in the diagram of the sequence of all technical realizations of each stage.
- 2.2.5. The structural research of the function as an information flow.
- 2.2.6. Revealing and structurization of all discovered undesirable effects of the function performance along "the time line". The total of the revealed undesirable effects is 126. Structurization of the groups of the undesirable effects according to their hierarchical importance to estimate the problem burden of the 19 predicates.
- 2.2.7. Comparison of nomographic formalization of the model with the 12 laws of TS evolution and the 4 mechanisms of the laws of evolution. Deployment of the function of quality of the studied TS. Increase in capacity of set of parameters of the description of 19 predicates from 144 up to 183. Mental experiments with the tool of the nomographic formalization of the model.

#### **3.** By-products of the procedure of forecasting research

The forecasting method shortly described in the article is a part of a big educational program on the main aspects of TRIZ. The series of seminars were given for groups of different ages and educational backgrounds. Group discussions, following the way of reasoning suggested in the algorithm, as well as nearly all traditional TRIZ techniques gave rise to an especially creative atmosphere which induced increase in the creative functions of intelligence. As a result, on each of 7 stages of the forecasting research, new technical decisions arose essentially for the studied TS, and not only for the ballpoint pen. The students obtained new concepts of application of the same principles in new areas, such as children's painting, show business, polygraphy, landscape design, etc. As the result of the forecast, « 34 new solutions likely to be realized in the near and farther future were conceived. The full descriptions of the 36 solutions are given in [1] where it is also shown what way they arose.

	iographi				mitai
Working	g agent 2		Re	esults	
$E^1$	$E^2$	$E^3$	$\mathrm{E}^4$	$\mathrm{E}^{5}$	$E^6$
The surface	The substance	Surface	The shape/	The speed of	Accompanying
of	of the surface	changing	dimension of	the inscription	systems
	of	mechanism	the inscription	appearance	
1paper	1paper	1. Removing	1. Flat	1. Instant	1. Ruler
2stone	2stone	2. Adding	2. embossed	2. Time delay	2. Compasses
3metal	3metal	3. Changing of	3. concave	3. Event	3. Pointer
4plastic	4plastic	physical and/or	4. 3-	dependent	4. Protractor
5 ceramics	5 ceramics	chemical	dimensional	delay	5. Sharpener
6glass	6glass	properties	5. Embedded		6. Erasure
7clay	7clay				7. Penknife
8CD	8CD				8. Paper clip
9sand	9sand				9. Glue
10 ground	10ground				10. Note book
11air	11air				11. Tape-measure
12electronic	12electronic				12. Curvometer
paper	paper				13. Lighting
					14. Letter
					templates
					15. Number
					templates
					16. Figures
					templates
					17. Thermometer
					18. Clock
					19. Pressure
					meter
					20. Timer
					21. Lighter
					22. Reference
					book
					23. Desk
					24. Window
					25. Walls
					26.Toy, knick-
					knackery, flower
					27. Fishes
					28. Plume
					29. Barometer
					30. Sugar in
					blood
					31. Medicine
					32. Stimulating
					emanation M
					33. Acoustic. A
					34. Thermal T
					35.Chemical C
					36.Electrical E
					37. Magnetic M

## Nomographic formalization of the technical

Working agent 1 Transimission							on
$E^7$	$E^8$	E <sup>9</sup>	$\mathrm{E}^{10}$	$E^{11}$	$E^{12}$	$E^{13}$	$E^{14}$
The type of the working agent movement	The type of working agent field	The physical state of the Working Agent substance	Presence of other working agents	Working agent dynamicity degree	The storage of the substance location and its properties	The way the substance is transported	The presence or absence of the body. The signs of being trimmed
<ol> <li>Forward movement</li> <li>Rotary movement</li> </ol>	<ol> <li>Mechanical</li> <li>Acoustic</li> <li>Thermal</li> <li>Chemical</li> <li>Electrical</li> <li>Magnetic</li> <li>Kohesive</li> <li>Capillary</li> <li>Pneumatic</li> <li>Ejection</li> <li>gyroscopic</li> </ol>	<ol> <li>Paint</li> <li>Paint</li> <li>Ink</li> <li>Solid</li> <li>body</li> <li>Particles</li> <li>of a solid</li> <li>body</li> <li>Particles of a solid</li> <li>body</li> <li>A jet of</li> <li>particles of a solid</li> <li>body</li> <li>Liquid</li> <li>Gas</li> <li>A jet of</li> <li>liquid</li> <li>Gas</li> <li>A jet of</li> <li>gas</li> <li>Foam</li> <li>Dust</li> <li>Ice</li> <li>Particles</li> <li>of ice</li> <li>Vorticity</li> <li>Aerosol</li> </ol>	2.Anti 3.Bi 4.Poli 5.Complex. 6.Nesting doll	2.Hinge 3.A lot of hinges 4.Elastic link 5.Continuity 6.Periodical impact action 7. Porous substances 8. Sphere 9.Transition to microlevel	the system 2.Only the substance of the Working Agent is renewed 3. The storage of the substance of the 1 TS is renewed 4.The storage of the substance of the 2 TS is renewed	2.Mechani- cally. 3.Being forced by the Gravitation 4.Capillary 5.Pnewma- tically. 6.Electro- statically	<ul> <li>1. The body exists as a separate part of the design</li> <li>2. The working agent and the body are inseparably connected. The body is the ink container.</li> <li>3. The body has an ergonomic overlay grip</li> </ul>

## system 'ballpoint pen' as a device for

Engine	Source		Controlling system	
E <sup>15</sup>	E <sup>16</sup>	E <sup>17</sup>	E <sup>18</sup>	E <sup>19</sup>
The moving	The basic idea of the	Not to lose	Not to spoil	The way the ideality
device	result		_	of the conductivity
1 Hand	1 Pleasure	1 Mechanical clin	1 No subsistems	1 Mechanical
2 Electric	2 Not to get tired	2 Hang on a stran	2 Mechanical	(manual) way of
source and an	3 One colored thin	3 An elastic link	forward removing	the additional
electr motor	lines	to the place of use	of the working	systems supply
3.Mechanical	4. Correct	4.A sucker	agent	2. Acoustic
source of	5. Highlight	5.Sticky holder	3. Mechanical	3.Transition to
energy	6. Lines of middle	5	rotary removing	microlevel
4.Thermal	width		of the Working	(electronic way)
5.Chemical.	7. Wide lines		agent	4. Replicating
6.Acoustic.	8. Two colors		4. The principle	
7.Magnetic.	9. Three colors		of the local	
	10.Four colors		quality (protective	
	11. 5 colors		cap)	
	12. 6 colors		5.The principle of	
	13.7 colors		Unification (a	
	14.Colorful		case)	
	compositions.			
	15. $\$ \rightarrow 0$			
	16. \$			
	17. $\$ \rightarrow \infty$			
	18. $L \rightarrow 0$			
	19. L			
	$20. L \rightarrow \infty$			
	21. To change the			
	width of the line			
	22. Mono-			
	23. BI-			
	24. Poll- 25. Eont			
	25. FUIIL 26. Straight lines			
	20. Straight lines			
	27. Regular figures			
	renlicating			
	29 To see			
	30 A decoration			
	31 A gift			
	32. An advertisement			
	33. To entertain			
	34. To frighten			
	35. To type on a			
	keyboard			
	36. Not to look for			

# the creation of information on surfaces



#### Appendix A: The TRIZ Philosophy



About the authors:

**Yury Danilovsky** - pupil of Mitrofanov, the owner more than 50 patents of Russia, the author of a rate « Forecasting of evolution of technical systems », the head of laboratory of innovative researches, the expert on TRIZ since 1991.

**Voluslav Mitrofanov** - the master of TRIZ, the organizer and the rector of the international university of scientific and technical creativity with 1991 for 2001, friend Altshuller, since 2001 - the supervisor of studies of laboratory of innovative researches.

**Denis Shevchenko**: the graduate of the international university of scientific and technical creativity of 2001, the employee of laboratory of innovative researches, the professional translator.