“Logical Enhancement of ASIT”

TAKAHARA Toshio
takahara-t@m.ieice.org

0. Preface

After TRIZ (the acronym for “Theory of Inventive Problem Solving” in Russian) was developed, many articles have been issued [1] and many improvements including ASIT (the acronym for “Advanced Systematic Inventive Thinking”) [6-8] have been made on TRIZ. The systematical theory of TRIZ and these excellent achievements were fundamentally based on the combination of theoretical approach and “bottom-up” or empirical approach from the beginning. This approach constructed today’s main background of TRIZ and its improvements.

In previous papers, after discussion on “technology” and “institution” in human life, I made clear the position of “object” especially “process object” in problem solving [2]. And I considered the way the human being behaved in life relating with “technology/institution” and the role of “process object” and “system object” [3]. These two former articles described the situation around the human behavior and object.
In this paper, on the basis of formal contents of object, I try to enhance ASIT using “top-down” approach. Related examination on the relation between “the 40 principles” of TRIZ and the “Enhancement of ASIT” is also given.

1. “Technology”/ “institution” and “object” [2,3]

In the area of operation on the outside world “technology” born by the “technical means” or “technical system” and “institution” born by “common notion” or “institutional system” are made and made use of.
We have five phases as to the affecting direction between “technology/institution” and the human being.

1) “make” phase
2) “manage” phase
3) “use” phase
4) “affect” phase
5) “be affected” phase

An “object” is everything to be selected and decided to solve a problem or to design something. Thus we can grasp that “object” is not only “system object” in space domain consisting of the element of technological system or institutional system to make but also “process object” in time domain consisting of the element of process of system action or human action. [2]
“System design” is simply to decide the contents of “system object” or to solve a “system problem”.
“Process design” is simply to decide the contents of “process object” or to solve a “process problem”.
The relation between applied areas, three phases of “technology and institution” and objects are in table 1. [3]

Table 1 Applied area, three phases of “technology and institution” and objects [3]

Area	Phase	Domain			Used Object		Changed Object	
		Batch	Semi-real-time	Real-Time	System	Process	System	Process
Technical	“Make”	X (usually)			X	X	X	X
	“Manage”		X		X	X		X
	“Use”			X	X	X		(X)
Institutional	“Make”		X (usually)		X	X	X	X
	“Manage”		X		X	X		X
	“Use”			X	X	X		(X)
Personal	“Make”		X (usually)			X		X
	“Manage”		X			X		X
	“Use”			X		X		(X)

2. Function and structure of object

After examining the situation around the human behavior and object [2,3], I give an outline of “structure” and “function” considering formal contents of “object” which have statics and dynamics.
In general “object” itself has
1. Statics: Attribute and
2. Dynamics: Property to change.
Between objects and between attributes, there are
3. Static relations and
4. Dynamic relations which include
4.1 Causality and
4.2 Interaction. [4,5]
A viewpoint of human being or institutional system specifies the “granularity” of “object”. “Granularity” is time range, space range and level of abstraction. [4]

“Object” has “attribute”(in broad sense).
An “attribute”(in broad sense) consists of quality attribute and quantity attribute.
A “state” is the attribute that can be easily changed.
An “attribute”(in narrow sense) including “ability” is the attribute that can not be changed easily. [4]
As the difference between “broad” and “narrow” is relative, so the difference between “state” and “attribute”(in narrow sense) is relative. It is a viewpoint of the interest of concerned people that fix the separating line between “state” and “attribute”(in narrow sense).

Example: From the viewpoint of taking a bath, “water level of a bathtub” is a “state”, and “shape of a bathtub” is an “attribute”(in narrow sense). In this case this “attribute” is almost impossible to change. In general “attribute”(in narrow sense) can be changed though it is relatively hard to do so.
From the viewpoint of tools to solve the problems it is important whether the situation is easy to change or not. Especially in the case of solving a “process problem” human being or institutional system (such as company or government) change “state” to reach the

"soft" solution more often than in the case of solving "system problem" (such as making a technical invention) which has a main problem to solve "hard" by changing structure or attribute of entity.

"System object" can take "action". An action is taken by "system object" via process or a "process object" itself. And both "system object" and "process object" have attributes.
"Action" can change
1) "attributes and/or states" of the object itself,
2) "action and/or attributes and/or states" of the other object,
3) static relations between "attributes and states" of the object itself, and
4) static relations between "attributes and states" of object itself and those of the other object. [5]

A "function" is the "positive meaning" of "object" to the outside world. To be positive or not positive depends on the practical viewpoint of concerning human being or institutional system.
"Object" has a "positive meaning" to the outside world when
1) its action itself is useful or
2) its action makes a useful "attribute" or "state".
"Action" is a dynamic relation between object and the outside world or human being. So this "action" is said to have a dynamic function to the outside world or human being.
All the other "relations" between "state"/"attribute" to the outside world/ human being is static ones having a direction of "state"/"attribute" of object to the outside world/ human being. Though these relations are static, through this relation the "state"/"attribute" of object affects the outside world or human being. In this sense "state"/"attribute" is said to have a static function to the outside world or human being.

A "structure" is the whole things that consist of elements and relations between them. A set of "objects", either they are "system objects" or "process objects", have the structure of "objects".

3. Problem solving tool

To reach a solution, we can operate "object", "structure", "function" and "attribute" as follows.
"Object" itself can be added, removed or changed.
"Structure" as relation between objects can be changed.
"Action" as a function can be added or removed. Note 1
"Attribute" can be added/activated, removed/deactivated or changed.
"State" can be changed.
From the opposite side, the same things are described as follows.
An operation to "add" is either to "add object", to "add action as a function of object" or to "add/activate attribute" in problem solving tools.
An operation to "remove" is either to "remove object", to "remove action as a function of object" or to "remove/deactivate attribute".
An operation to "change" is either to "change structure of objects" or to "change attribute". Note 1
As a "structure" consists of elements and relations between these elements, to "change structure of objects" is either to "replace object" or to "change relation between each objects".

These are shown in table 2.

Table 2 Operation on “object”

	Operation		
	Add	Remove	Change
Structure			X
Object--	X	X	X
--Function--Action	X	X	Note 1
--Function--Attribute (broad sense)	X	X	X
--(State)			X

Note 1: There is a logical possibility of changing “action”. But I leave it as it is, because changing action can be realized by changing attribute of object in most cases and if necessary by combination of deleting and addition of action.

A sole “action” is treated as that of “system object”. If we treat a series of “actions”, each “action” is treated as an element of “process object”.
We must pay attention that “object” involves “function” (action or attribute) and “attribute” in broad sense involves “attribute” in narrow sense and “state”.
Table 3 shows the relations between five phases of “technology and institution” and using or changing operation on “object”.
In “manage” phase and “make” phase we actively construct or change systems by using existing object and changing its object. But “manage” phase can construct or change process object only.
In “use” phase we make use of existing systems by “action” of existing process object and can change “state” of object.
In “affect” phase we can change or destroy not intentionally operations of “object”.
In “be affected” phase we does not use nor change any operations of “object”.

Table 3 Five phases of “technology and institution” and operations on “object”

Phase	Operation on object				
	Structure	Object	Function		
			Action	Attribute	State
“Make”	X	X	X	X	X
“Manage”	X	X	X	X	X
“Use”			X		X
“Affect”	(X)	(X)	(X)	(X)	(X)
“Be Affected”					

After logical examination of the “structure”, “function” and “attribute”, I try to enhance ASIT using “top-down” approach to obtain “Enhancement of ASIT (ASIT+)”.
According to the former preparations, operation of “Enhancement of ASIT (ASIT+)” should be as follows shown in table 4 compared with ASIT. The terms of “Enhancement of ASIT (ASIT+)” are following that of ASIT [6,7] when possible.
ASIT’s “The Closed World Condition” (“The inventive solution world does not introduce new

kinds of objects that do not appear in the problem world." [8]) is very strict and powerful, therefore it is maintained here. In "ASIT Compared to Scamper for Devising New Products" by Richard Kaplan, Roni Horowitz replied to Richard Kaplan, "The Closed World condition forces the developers to invest their intellectual efforts in areas they would otherwise neglect. In this respect, the Closed World condition does not only restrict but also broadens the scope of the search". [9]

In table 4 we can
#1 add "object" using multiplication tool *1,
#2 add function of existing "object" using unification tool *2,
#3 remove "object" using object removal tool *3,
#3+ remove "function" using function removal tool *3+,
#4 change "structure" of "object" using division tool (including the case of changing object using "breaking symmetry" tool) *4,
#4+ replace "object" using object replace tool *4+,
#5+ change attribute of "object" using uniform attribute change tool *5+,
and/or
#5 change attribute of "object" using breaking symmetry tool *5.
(We need to check symmetry in space, in time or group symmetry. [8])
Here,
*1: Multiplication: Solve a problem by introducing a slightly modified copy of an existing "object" into the current system or process ([6-8]: I slightly changed the formulation of [6,7] to apply to both system object and process object).
*2: Unification: Solve a problem by assigning a new use to an existing "object" [6-8].
Case 1: adding an action
Case 2: adding/activating attribute or state. Many examples of activating attribute are shown in [10].
*3: Object Removal: Solve a problem by removing an object from the system or process and assigning its action to another existing object ([6-8]: I slightly changed the formulation of [6,7]).
*3+: Function Removal: Solve a problem by removing function of existing object from the system or process.
Case 1: removing an action
Case 2: removing/deactivating attribute or state
*4: Division: Solve a problem by dividing an object and reorganizing its parts (including the case of changing object using "breaking symmetry" tool) [6-8]. Note 2

Note 2: It seems to be that there is a logical possibility of changing structure by not dividing an object. But I leave it as it is. This is a matter of dealing with "granularity".

*4+: Object Replace: Solve a problem by replacing or substituting existing "system object" or "process object" with adding "system object" or "process object" obtained by multiplication.
In "ASIT Compared to Scamper for Devising New Products" by Richard Kaplan, Roni Horowitz replied to Richard Kaplan, "ASIT does not allow substituting at all because of the Closed World principle". [9] [3]
But in "Enhancement of ASIT (ASIT+)" "Object Replace" tool is added which is to "replace

or substitute existing object with adding object obtained by "multiplication". This enables the principles such as "Principle 26: Copying" in "the 40 principles" of TRIZ to apply to the object, while keeping "the Closed World condition".

*5+: Uniform Attribute Change: Solve a problem by changing attribute uniformly.

*5: Breaking Symmetry: Solve a problem by changing a symmetrical situation into an asymmetrical one [6-8].

(hatched parts are added to ASIT)

Table 4 Operation of tools and objects

Classification		The name of tool	Case	Apply to	
				ASIT	Enhance-ment
Add	Add Object	Multiplication: introduce a slightly modified copy of an existing object into the current system or process		X	X
	Add Function	Unification: assign a new use to an existing object	Add action	X	X
			Add/activate attribute/state	X	X
Remove	Remove Object	Object Removal: remove an object from the system or process		X	X
	Remove Function	Function Removal: remove function of existing object from the system or process	Remove action		X
			Remove/deactivate attribute/state		X
Change Note 1 (above)	Change Structure	Division: divide an object and reorganize its parts Note 2		X	X
	Replace Object	Object Replace: replace or substitute existing object with adding object obtained by multiplication			X
	Change Attribute	Uniform Attribute Change: change attribute uniformly			X
		Breaking Symmetry: change a symmetrical situation into an asymmetrical one		X	X

x : available

Newly added tools are as follows.

Function Removal Tool

Object Replace Tool

Uniform Attribute Change Tool

As compared with ASIT's five tools, "Enhancement of ASIT (ASIT+)" has eight tools.

The logical “top down” approach makes “Enhancement of ASIT (ASIT+)” applicable to all kinds of operations. In fact these three tools seem to be useful in some cases. But these additions are not combined with the empirical basis. So I must call “Enhancement of ASIT (ASIT+)” tentative at this time. And “Enhancement of ASIT (ASIT+)” itself can be extended to be more generic, but in this article it keeps strict restriction and power of ASIT; at the same time it obtains some logical exactness.

An important thing is that ASIT can also be seen along the lines of the logical approach, and can extend smoothly to “Enhancement of ASIT (ASIT+)”, which is the feature of ASIT and “Enhancement of ASIT (ASIT+)”.

4. The 40 principles” in TRIZ and ASIT/ Enhancement of ASIT (ASIT+)

The relations between “the 40 principles” [11,12] of TRIZ and ASIT [3] / Enhancement of ASIT (ASIT+) are shown in table 5.

Table 5 shows the following fact.

1. As compared with ASIT that covered 32 principles, Enhancement of ASIT (ASIT+) covers all “the 40 principles”. It may be said that “the 40 principles” are reorganized into eight categories in Enhancement of ASIT (ASIT+).

2. The principles that ASIT does not cover are as follows.

Principle 26: Copying
Principle 27: Cheap short-living objects
Principle 28: Mechanics substitution
Principle 29: Pneumatics and hydraulics
Principle 30: Flexible shells and thin films
Principle 31: Porous materials
Principle 38: Strong oxidants
Principle 39: Inert atmosphere

The reason that ASIT eliminates these principles was shown in [9]. [3]

3. Newly added three tools cover the principles as follows. (See Note 1&2)

Function Removal Tool: 2
Object Replace Tool: 9
Uniform Attribute Change Tool: 12

The two principles involved in Function Removal Tool are the same as that of Object Removal Tool.

Among the nine principles involved in Object Replace Tool, eight principles are covered only in Enhancement of ASIT (ASIT+).

The twelve principles involved in Uniform Attribute Change Tool are nearly equal to that of Breaking Symmetry Tool. The differences are in

“Principle 04: Asymmetry”, “Principle 07: Nested doll” and “Principle 33: Homogeneity”.

We can easily understand the reason for these differences, which are shown as follows. “Principle 04: Asymmetry” and “Principle 07: Nested doll” are apparently for Breaking Symmetry Tool and not for Uniform Attribute Change Tool. “Principle 33: Homogeneity” is also apparently for Uniform Attribute Change Tool and not for Breaking Symmetry Tool.

Table 5 The 40 Principles of TRIZ and ASIT/Enhancement of ASIT (ASIT+)

The 40 Principles of TRIZ	type of principles					type of tools (ASIT/ASIT+)							
	abstract structure	abstract function	concrete structure	concrete function	physically specific	*1 Multiplication (adding object)	*2 Unification (adding function of existing object)	*3 Object Removal	*3+ Function Removal	*4 division	*4+ Object Replace	*5+ Uniform Attribute Change	*5 Breaking Symmetry
Principle 01: Segmentation	x	x								x			
Principle 02: Taking out			x	x				x	x				
Principle 03: Local quality	x	x				x						x	x
Principle 04: Asymmetry	x	x											x
Principle 05: Merging	x	x				x							
Principle 06: Universality	x	x					x						
Principle 07: "Nested doll"			x	x						x			x
Principle 08: Anti-weight			x	x		x							
Principle 09: Preliminary anti-action				x		x							
Principle 10: Preliminary action				x		x							
Principle 11: Beforehand cushioning				x		x						x	x
Principle 12: Equipotentiality					x	x							
Principle 13: "The other way round"			x	x						x			
Principle 14: Spheroidality - Curvature			x									x	x
Principle 15: Dynamics	x	x				x				x		x	x
Principle 16: Partial or excessive actions				x								x	x
Principle 17: another dimension	x	x				x				x			
Principle 18: Mechanical vibration					x	x						x	x
Principle 19: Periodic action				x								x	x
Principle 20: Continuity of useful action				x		x	x						
Principle 21: Skipping				x								x	x
Principle 22: "Blessing in disguise"				x		x	x						
Principle 23: Feedback		x				x				x			
Principle 24: "Intermediary"	x	x				x							
Principle 25: Self-service		x				x	x						
Principle 26: Copying			x	x							x		
Principle 27: Cheap short-living objects			x								x		
Principle 28: Mechanics substitution			x								x		
Principle 29: Pneumatics and hydraulics					x						x		
Principle 30: Flexible shells and thin films					x						x		
Principle 31: Porous materials					x						x		
Principle 32: Color changes				x								x	x
Principle 33: Homogeneity	x	x				x						x	
Principle 34: Discarding and recovering			x	x			x	x	x				
Principle 35: Parameter changes			x	x								x	x
Principle 36: Phase transitions					x	x							
Principle 37: Thermal expansion					x	x						x	x
Principle 38: Strong oxidants					x						x		
Principle 39: Inert atmosphere			x								x		
Principle 40: Composite materials			x								x	x	x

ASIT: *X,
ASIT+: *X+*X+

Note: "Object" contains both "system object" and "process object".

5. Conclusion

I gave the outline of "structure/function/attribute". And I reconsidered the problem solving tools from the viewpoint of "system/process object" and "structure/function/attribute".
On this basis I drew the outline of a tentative framework of "Enhancement of ASIT (ASIT +)". Afterwards related examination on the relations between "the 40 principles" of TRIZ and ASIT/Enhancement of ASIT (ASIT+) was also given. It may be said that "the 40 principles" of TRIZ were reorganized into eight categories in "Enhancement of ASIT (ASIT+)".
The previous Issues [2,3] and this article formed a series of issues, which drew the basic outline of the problem solving tools or thinking tools to be discussed in future.

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About the Author

TAKAHARA Toshio received his B.E. degree in electric-communication engineering from Waseda University, Tokyo, Japan in 1968. He joined FUJITSU Limited where he mainly engaged in river management as a design engineer and a consultant. Before retiring an affiliated company of FUJITSU in 2002, he engaged in quality management concerning ISO9001 for a few years. In the study of quality management and design method at the affiliated company of FUJITSU, he met TRIZ in 2001.

His today’s interest includes culture theory, design method and problem solving tools.

His e-mail address: takahara-t@m.ieice.org
His homepage URL: http://www.geocities.co.jp/WallStreet/2744/ (almost in Japanese)