Keynote Lecture

TRIZ シンポジウム 2005
The First TRIZ Symposium in Japan
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A New Generation of TRIZ

Toru Nakagawa
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The First TRIZ Symposium in Japan
September 1, 2005
Shuzenji, Izu

Outline of Talk

"Innovation" in technologies is crucial for industries today.

For achieving innovations, we need philosophy and methodology for "Creative Problem Solving".

TRIZ has developed such a set of methodology, containing:
Philosophy, Thinking ways, Knowledge-bases,
Software tools, Training/Education, etc.
TRIZ has been penetrating into western countries,
but still meets much difficulty.

We need a new generation of TRIZ; simpler and more effetcive.
USIT will meet such needs, I believe.

TRIZ/USIT can lead the practices of technical innovations.

Overview of TRIZ

(a) Philosophy: Recognition of evolution of technical systems and Philosophy in the thinking ways
(b) Methods: Methods and procedures for creative problem solvin
(c) Knowledge bases: A system of knowledge organized for better utilization of science and technology
(d) Software tools: Realization of knowledge bases and methods
(e) Practices: Training of engineers, industrial practices, services, school education, etc.

Historically, these have been constructed via bottom-up through the analysis of patents, etc.

This lecture discusses in the order of (a) --> (c)(d) --> (b)
for better understanding of the overview and
for clarifying the problems in the practices of TRIZ.

(1) Philosophy of TRIZ

Essence of TRIZ:

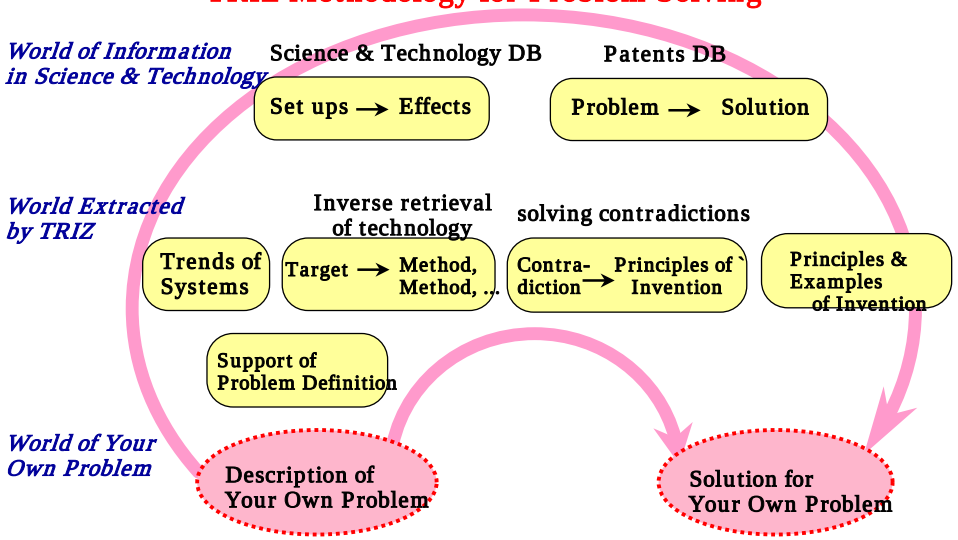
Recognition that
technical systems evolve
towards the increase of ideality
by overcoming contradictions
mostly with minimal introduction of resources.

Thus, for creative problem solving,
TRIZ provides with a dialectic way of thinking,
i.e.,
to understand the problem as a system,
to make an image of the ideal solution first, and
to solve contradictions.

Toru Nakagawa at TRIZCON2001, March 25-27, 2001

(2) Knowledge Bases of TRIZ

TRIZ Methodology for Problem Solving



TRIZ Knowledge Bases and Software Tools

Classical TRIZ: Genrich Altshuller and his followers

Analyzed a huge number of patents and
constructed a system of knowledge bases.

→ In 1990s: Emigrated to USA and made software tools

Knowledge bases working smoothly on PCs.
TechOptimizer (Invention Machine), etc.

In 2000 - 2003: Darrell Mann and CREAX (Belgium)

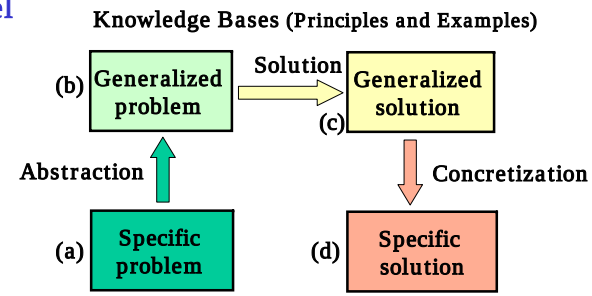
Analyzed all the US Patents granted since 1985 till present
by using Altshuller's approach and
Revised the whole TRIZ knowledge bases.

Textbook: "Hands-On Systematic Innovation"
Data book: "Matrix 2003"
Software tool: 'CREAX Innovation Suite'

(3) Methods of Problem Solving in TRIZ

Basic Principles/Models of Problem Solving in TRIZ

1. Generalization model



2. Understand the problem as a system.
3. Make an image of Ideal Solutions first.
4. Formulate the Contradictions and solve them.

TRIZ (+USIT) Ways of Thinking:
(1) Understand the Problem as a system

- Think over the System of Problem, and focus the probelm to solve.
- Consider the super- and sub-systems of the technical system of problem, and examine the past, present, and future of them (i.e. 9-Windows) on the basis of Trends of Evolution of Technical Systems.
- Analyze the system with respect to Objects, Attributes, and Functions.
- Analyze the Functional relationship of the system, with additional attention to insufficient and harmful relationships.
- Consider the mechanism in the problem system, examine Root Causes (and/or Root Contradictions), and reveal the attributes relevant to the problem. (i.e. Attribute Analysis)
- Reveal the characteristic nature of the probelm and its system in terms of Space and Time.

9-Windows Method (Outline of an application example)

	Past (10 yrs ago)	Present	Future (in 5 yrs)
Super-System	⑥ Society systems at higher levels Telephone network system	③ Society systems at higher levels Mobile phone network system	⑦ Keywords of future society Future information technology and network systems
System	④ Telephone Other devices whose functions have been brought into the mobile phone	① Mobile phone Other devices possibly relevant in future (including Notebook PC)	⑧ Mobile information & comunication device "i-base" (pocketable) (wrist-watch type, pen type, card type, accessary type)
Sub-System	⑤ Basic functions of telephone Various usages of telephone	② Functions of mobile phone	⑨ Functions of "i-base" Functions of smaller-sized devices

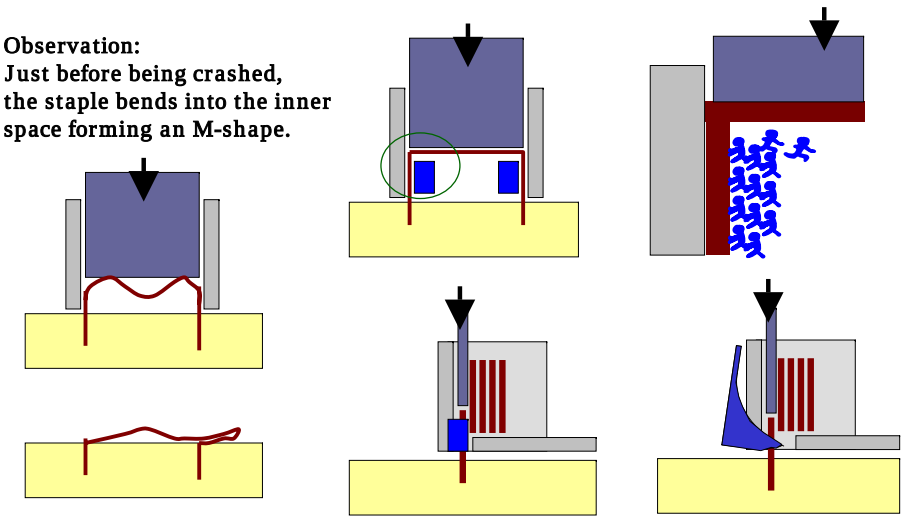
TRIZ (+USIT) Ways of Thinking: (2) Make an image of Ideal Solutions first

- Think over the System of Problem, and focus the probelm to solve.
- Consider the super- and sub-systems of the technical system of problem, and examine the past, present, and future of them (i.e. 9-Windows) on the basis of Trends of Evolution of Technical Systems.
- Analyze the system with respect to Objects, Attributes, and Functions.
- Analyze the Functional relationship of the system, with additional attention to insufficient and harmful relationships.
- Consider the mechanism in the problem system, examine Root Causes (and/or Root Contradictions), and reveal the attributes relevant to the problem. (i.e. Attribute Analysis)
- Reveal the characteristic nature of the probelm and its system in terms of Space and Time.

Toru Nakagawa & Kazuaki Kamiya (2004)

SLP (Smart Little People) Modeling
Application example: Preventing a staple from being crashed

Observation:
Just before being crashed, the staple bends into the inner space forming an M-shape.



TRIZ (+USIT) Ways of Thinking: (3) Formulate the Contradistions and Solve them

- Formulate the problem as a Technical Contradiction, where improving the system in one aspect worsens in another aspect, and solve the contradiction by using Inventive Principles recommended with the Contradiction Matrix.
- Formulate the problem as a Physical Contradiction, where requirements exist in the opposite directions in an aspect of the system, and solve the contradiction by using the Separation Principle and Inventive Principles recommended through it.

Methods to Solve Contradictions
(= Biggest contribution of TRIZ to science/technology)

Physical Contradiction: opposite requirements in one aspect of the system

➡ Apply the Separation Principle. Able to find solutions surely.

(1) Examine the requirements to separate them
with respect to Space, Time, or any other condition.
(2) For the separated situations,
find separate solutions satisfying each requirement.
(3) Then, find a way to use the solutions in combination.

➡ A break-through is necessary at the Combination stage (3).
Apply some Inventive Principles.
Refer to Mann's textbook HOSI or "Matrix 2003".

➡ A nice case study: 'Water-saving Toilet' by Kyeong-Won Lee (Korea).

TRIZ Case Study of Solving a Physical Contradiction: 'Water-Saving Toilet'

by Hong Suk Lee and Kyeong Won Lee (Korea), TRIZ Journal, Nov. 2003.

Task: Reduce the amount of flashing water necessary for the toilets.
-- Needs over the world.

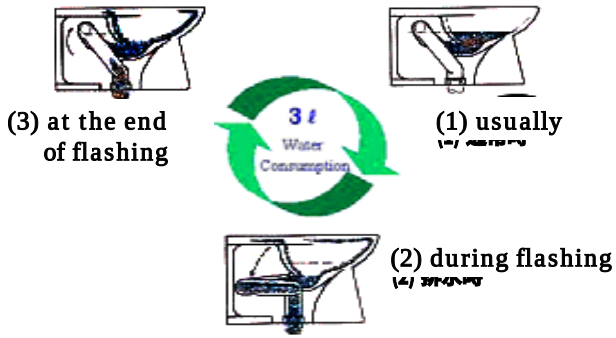
Current problem: For flashing the waste, water of 6 to 13 liters is used.

Analysis: S-pipe is necessary to block the bad odour from coming up, and is effective for flashing all with the ciphone effect.
S-pipe is not disirable for reducing the amount of flashing water.

Physical Contradiction: S-pipe is required to exist and not to exist.

Separation Principle: Separable in Time:
Required to exist -- during most of the time except flashing
Required Not to exist -- during the time of flashing

Solution: Instead of the rigid S-shaped pipe,
a flexible plastic tube is used and is lowered during flashing.



(3) at the end of flashing

(1) usually

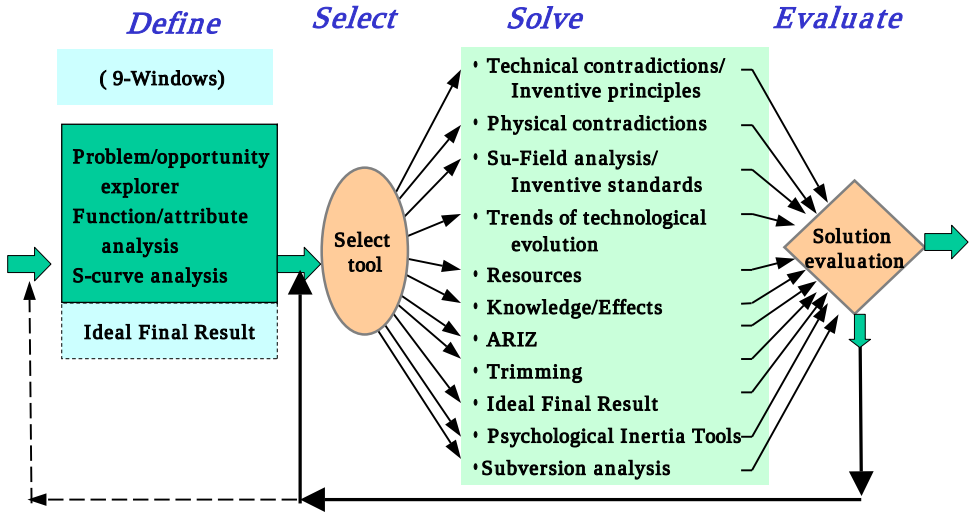
(2) during flashing

Results: Flashing with only 3 liters of water

Implementation: Experiments of usage, maintenance-free, durability, etc.
The amount of water is adjustable to environments and regulations.

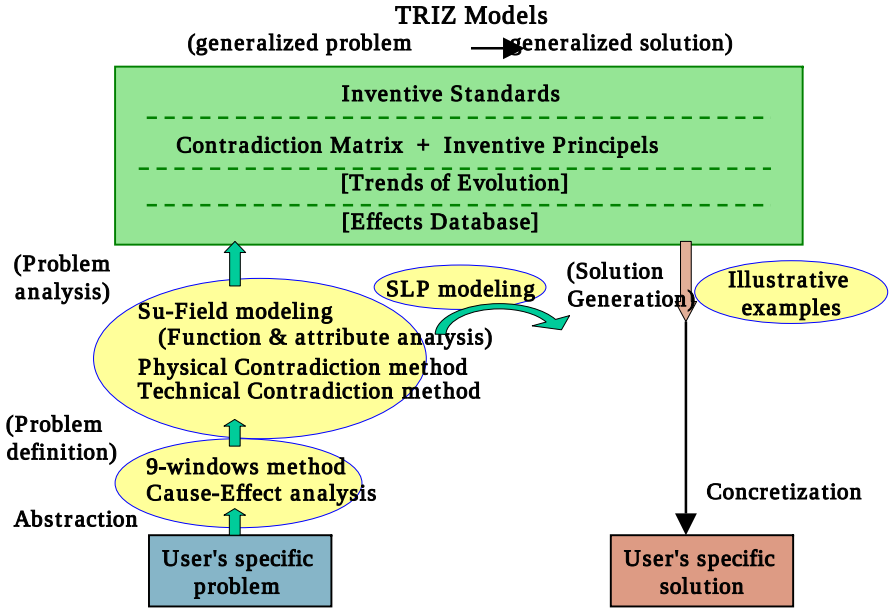
Overall Procedure in TRIZ [Flowchart]

(in the modernized form by Darrell Mann)



So many methods, so complex procedure.
Can we and should we learn them all? -- Learn one by one. (Mann)

Overall Structure of TRIZ Problem Solving [Data-flow diagram]



TRIZ in the traditional way:

Principal Models for Solution Generation request their own analysis methods (for abstraction):

- Contradiction Matrix → Inventive Principles
- Su-Field analysis → Inventive Standards
- ARIZ (for formulating Physical Contradictions) → Separation Principle

Separate analysis methods provide insufficient and narrow understanding of the problem.

→ The solution process is confusing and not effective enough.

The lack of a clear overall structure in TRIZ is the root cause of the "TRIZ slow-penetration problem".

Let's reconsider the essence of TRIZ:

Penetration of TRIZ in industrial practices is slow
not because TRIZ is poor,
but because TRIZ is so rich.

Darrell Mann has expalined TRIZ easier to understand
but has not made TRIZ easier or simpler to apply.

Instead of handbook-type knowledge in TRIZ,
we should better learn the essence of TRIZ.

→ Essence of TRIZ is simple!!! (See it in 50 words.)

We need a simple and effective process for problem solving.

→ That's USIT !!!

USIT ("Unified Structured Inventive Thinking")

Developed by Ed Sickafus (at Ford) (1995 -)

Refined in Japan

Simplified and unified from TRIZ ⇔ "USIT Operators"
A system of solution generation methods
(Nakagawa, Kosha, Mihara, 2002)

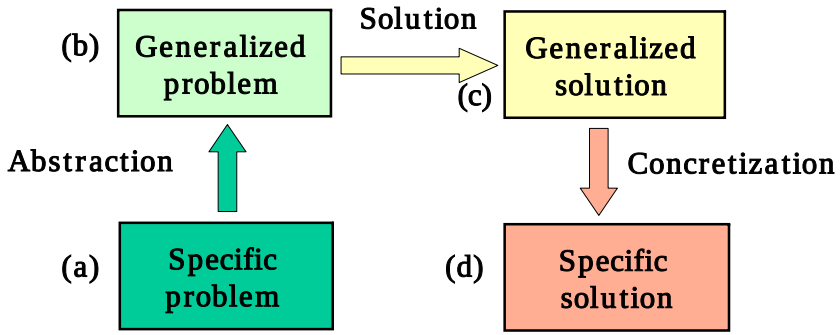
Clearly defiened, effective process ⇔ Clear overall structure "6-Box Scheme"
Define the problem,
Analyze the problem, and
Generate solutions.
A new paradigm for problem solving
(Nakagawa, 2004)

Readily applicable to real industrial problems
for obtaining conceptual solutions.

Do not depend on the use of tables, handbooks, or software tools.

Re-examine the Basic Scheme for Problem Solving:

Basic Four-Box Scheme for Problem Solving

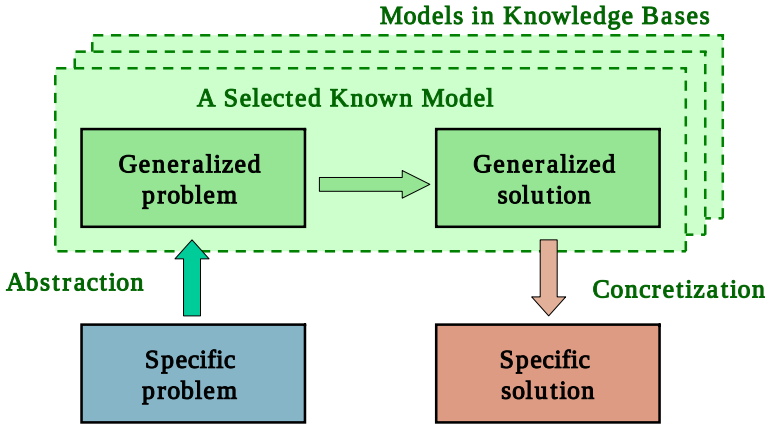


? Contents of these boxes depend specifically on the fields, models, and problems; thus are not explainable any further in general terms.

Four-Box Scheme Using Models in Knowledge Bases

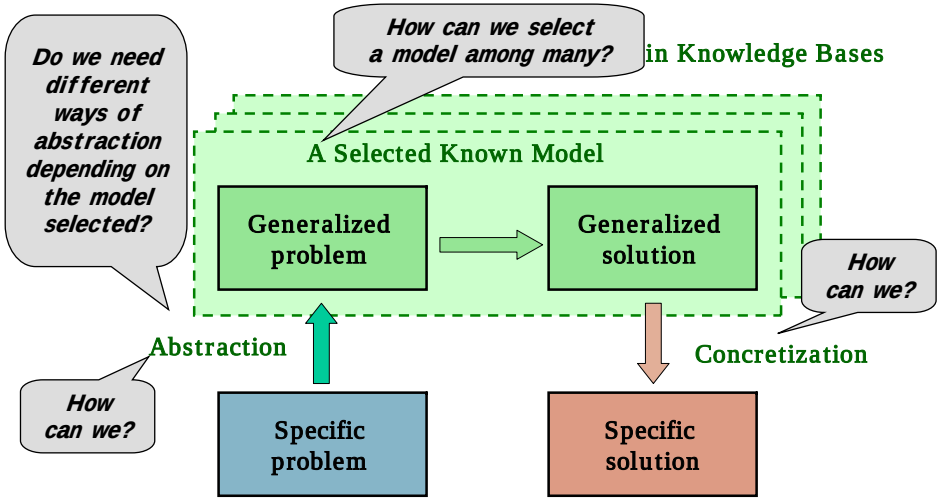
[Analogical Thinking]

Basic scheme in TRIZ (in reality)
= Basic Scheme in many other scientific/technological methods



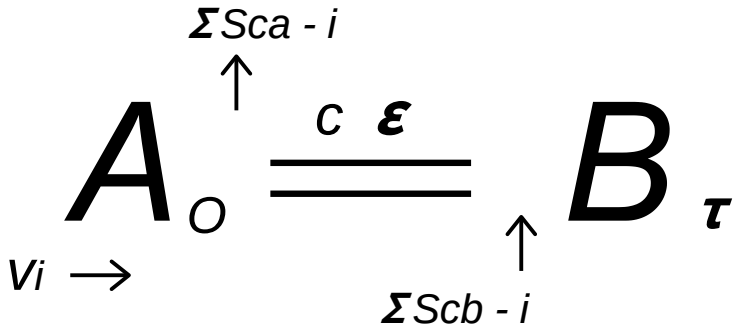
Four-Box Scheme of Problem Solving with Analogy

TRIZ (in reality) and many other scientific/technological methods



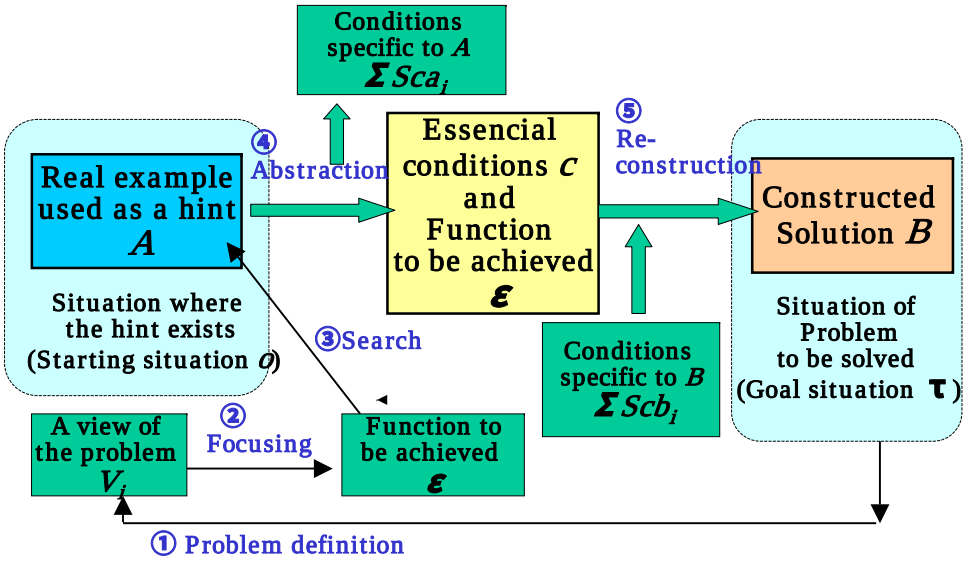
Equivalent Transformation Thinking Developed by Kikuya Ichikawa

A big source of Creativity Study in Japan
Tried to go further than analogical thinking

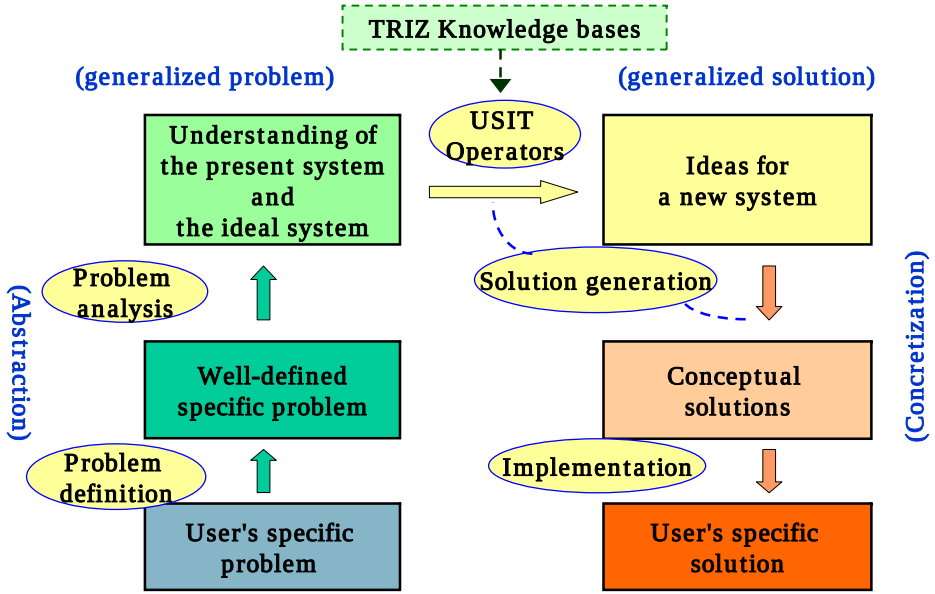


Overall Structure of Equivalent Transformation Thinking

(Toru Nakagawa, Jul. 2005)

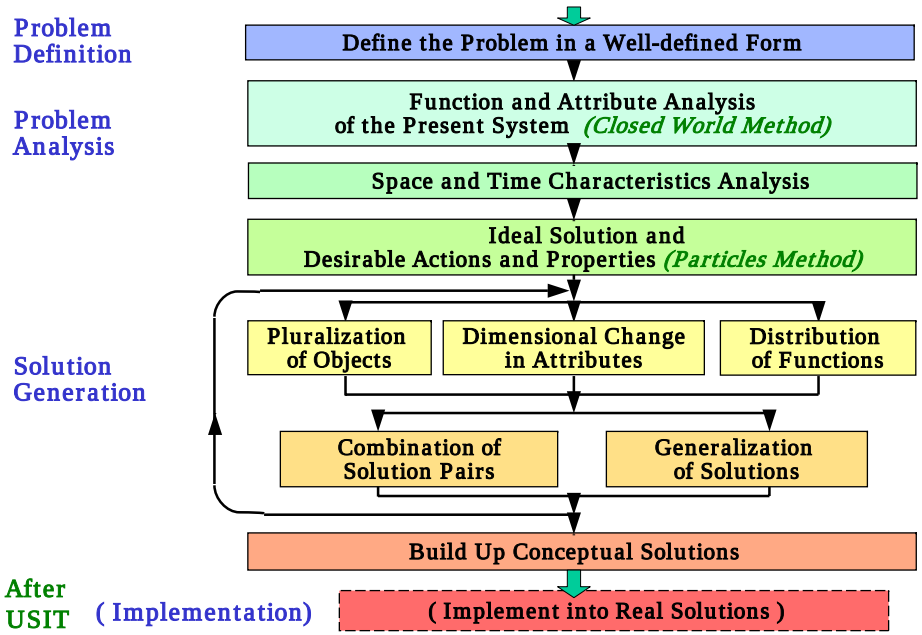


Overall Structure of Problem Solving in USIT



USIT Procedure [Flowchart]

[T. Nakagawa, Mar. 2005]



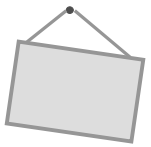
Usage of USIT: Example: "Picture Hanging Kit Problem"

Problem Definition Stage: Well define in the follwing points:

(1) Undesirable effect: The picture frame is apt to tilt sometime later.

(2) Problem statement: (in 1 or 2 lines) Improve the picture hanging kit, which is currently composed of a nail, a string, and two

(3) Simple sketch of problem situation



(4) Plausible root causes Offset of the center of mass of the frame, vibrati

A frame, two hooks, a string, a nail, and wall

(5) Minimum set of relevant objects:

USIT: Problem Analysis Stage

(T. Nakagawa, Dec. 2004)

Analyze the current system
(Closed-World Method)

- Draw a diagram of functional relationships
  (Functional Analysis) (Closed-World Diagram)
- List up the attributes relevant to the problem
  (Attribute Analysis) (Quality Change diagram)

Analyze the Space and Time characteristics

- Space and Time Analysis

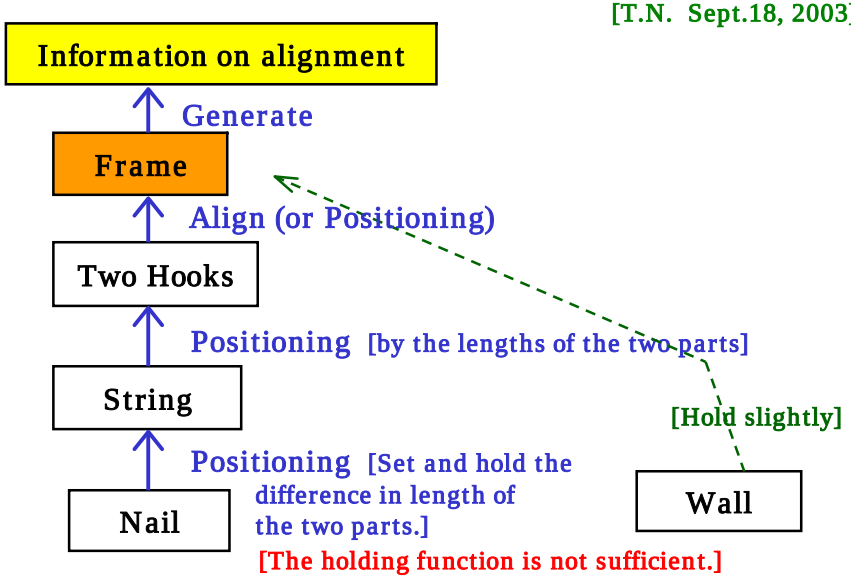
Analyze the image of ideal systems
(Particles Method)

- Make an image of the ideal solutions, first.
- Draw the Particles (supposed to be magical agents)
- Describe actions desirable to be carried out by the Particles
- List up properties desirable for the Particles.

Functional Analysis in USIT

Picture Hanging-Kit Problem

[T.N. Sept.18, 2003]



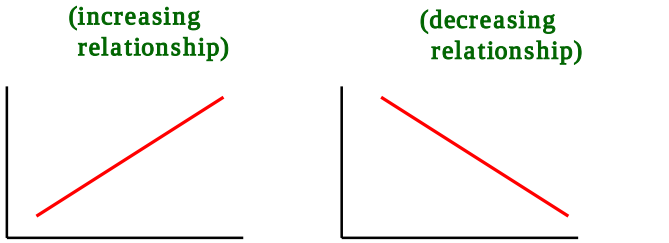
Attribute Analysis in USIT

Qualitative Change Graphs

for Picture Hanging Kit Problem

Unwanted effect:

tilting of the frame



frame: offset of the center of mass
frame: asymmetry in the shape

hooks: offset from symmetric position

wall: causing vibration

Wall/frame bottom: friction

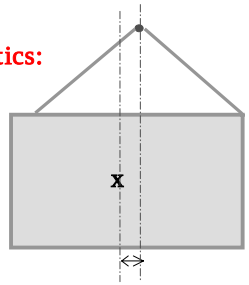
nail/string: friction

hooks: location adjustment

Space & Time Analysis in USIT

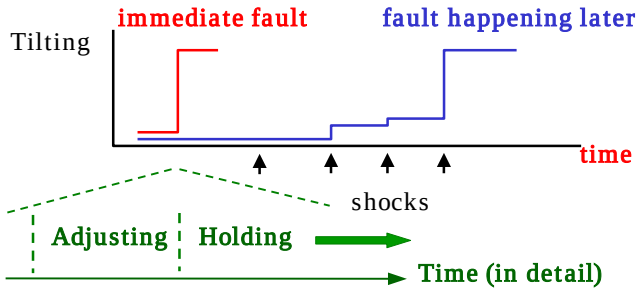
Picture Hanging Kit Problem

Space Characteristics:



Offset of the frame's center of mass from the vertical line below the string is the main cause of the problem.

Time Characteristics:

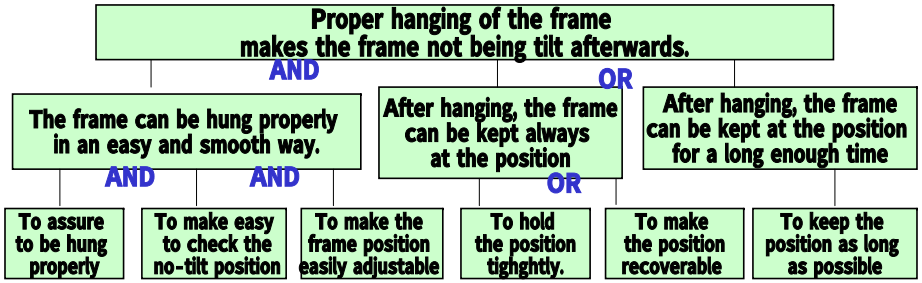


Analysis of Ideal Systems in USIT

Picture Hanging Kit Problem

Particles Method (Action & property diagram)

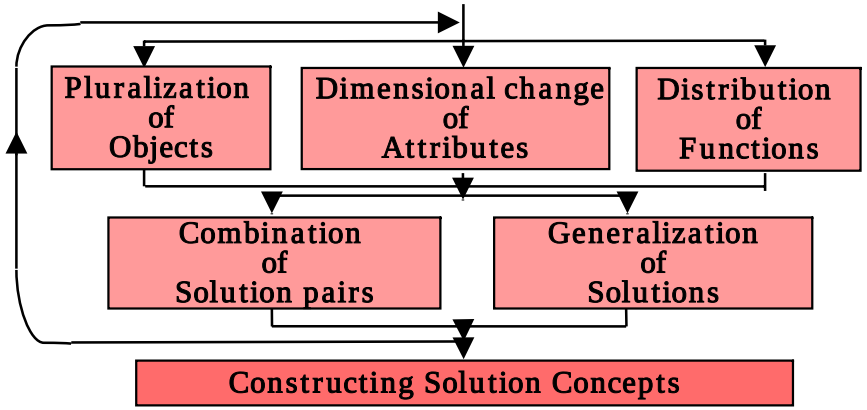
Desirable actions:



Desirable properties:

- Lengths of the two parts of the string
- Offset of center of mass
- Adjustment at the hook
- Support by the wall
- Automatic adjustment
- Horizontal position of the frame
- Vertical position of the frame
- Smoothness of the nail surface
- Smoothness of the string surface
- Freedom of adjustment
- Fixing the string at the nail
- Strength of fixing
- Adhesion
- Pressing to fix
- Recovery power
- Elastic
- Self adjustment
- Electric magnet
- Friction
- Roughness of the nail surface
- Pressure
- Strength of holding
- Preventing shocks

Solution Generation in USIT: "USIT Operators"



The five solution generation methods (i.e., USIT Operators) are operated onto their possible operands, as shown in their names.

The USIT Operators are applied repeatedly in any order.

USIT Solution Generation Methods: USIT Operators

Nakagawa, Kosha, Mihara (2002)

(1) Object Pluralization Method

a. Eliminate
b. Multiply into 2, 3, ..., ∞
c. Divide into 1/2, 1/3, ..., 1/∞
d. Unify
e. Introduce or modify ⟺ KB
f. Introduce from the Environment.
g. From solid to powder/liquid/gas

(2) Attribute Dimensionality Method

a. Deactivate a harmful attribute
b. Activate a useful attribute ⟺ KB
c. Enhance a useful or suppress a harmful attribute
d. Introduce a spatial attribute or vary in space
e. Introduce a temporal attribute or vary in time
f. Change the phase or the inner-structure
g. Attributes at the micro level
h. Properties of the system as a whole

(3) Function Distribution Method

a. Reassign to a different Object
b. Divide the compound Functions and assign them separately
c. Unify multiple Functions
d. Introduce a new Function ⟺ KB
e. Vary the Function in space, use space-related Functions.
f. Vary the Function in time.
g. Detection/measurement Function.
h. Enhance adapting/coordination/control
i. With a different physical principle

(4) Solution Combination Method

a. Combine functionally
b. Combine spatially
c. Combine temporally
d. Combine structurally
e. Combine at the principle level.
f. Combine at the super-system level

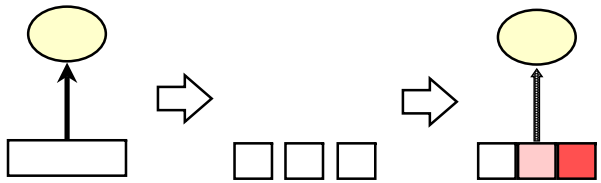
(5) Solution Generalization Method

a. Generalize/specify
b. Hierarchical system of solutions

(1c) Divide the Object (into 1/2, 1/3, ..., 1/∞).

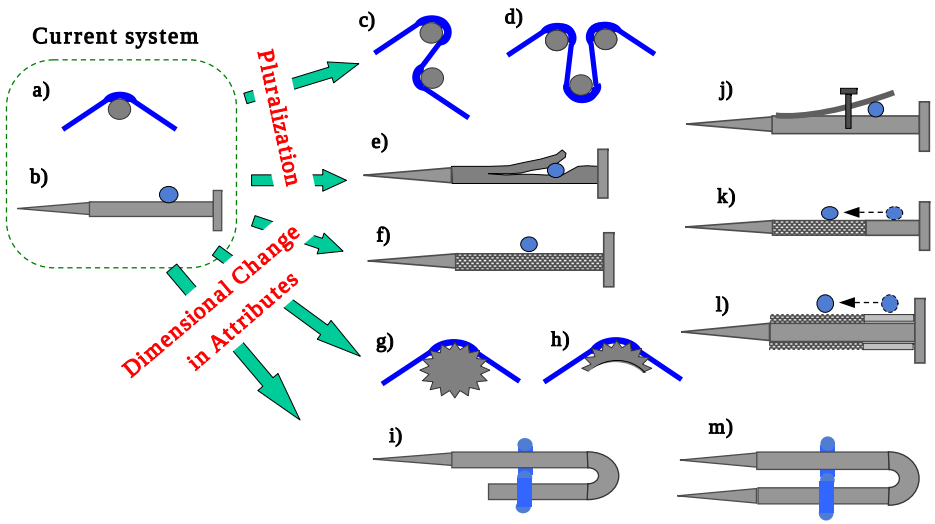
Divide the Object into multiple parts (1/2, 1/3, ..., 1/∞),
modify the parts (slightly,
or differently for different parts),
and combine them for using together in the system.

P1 Segmentation
P2 Taking away
P3 Local quality
P15 Dynamicity



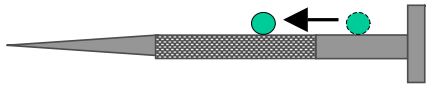
Examples of Application of USIT Operators: (Part)

Picture Hanging Kit Problem. USIT Operators are applied to the nail.



A case of solution

Picture Hanging Kit Problem



This idea can be generated in five different ways in USIT:

(a) Object Pluralization Method

Divide the Nail Object into halves, change the smoothness of the two parts, and use them in combination.

(b) Attribute Dimensionality Method

Change the values of the Smoothness Attribute in parts of the Nail.

(c) Function Distribution Method

The Adjusting and Holding Functions of the Nail are re-assigned to different parts of the Nail.

(d) Solution Combination Method

The solution of making the Nail smooth for easier adjustment and the solution of making the Nail rough for better holding

are combined in space by dividing the Nail.

→ are combined in time. [This interpretation of the idea is most important.]

Multiple ways of generating an idea = Redundancy in USIT Operators for making the application easier.

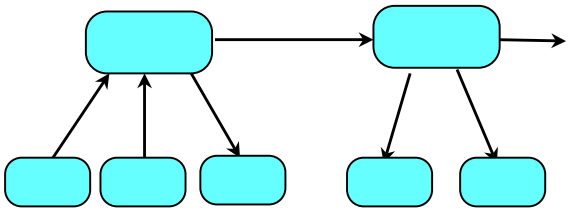
(5a) Generalize/specify the solution for associative thinking.

Replace the technical/specific terms in a solution with plain/generic terms, form a plain solution template, and then obtain new specific conceptual solutions in an associative way.

H18 Generification

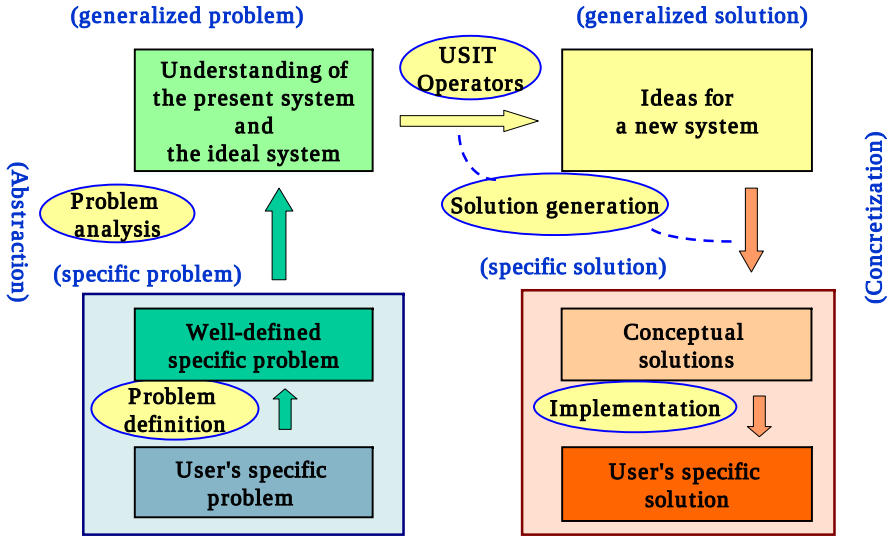
H19 Solution templates

Heuristics by Ed Sickafus



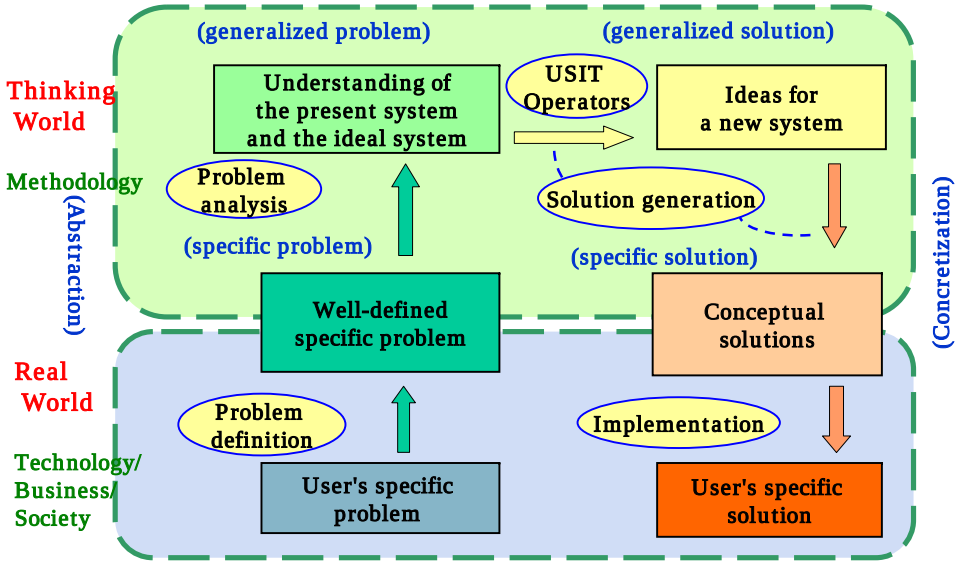
New Scheme of Creative Problem Solving (6-Box Scheme in USIT)

Implication (1) Refinement of the basic 4-Box Scheme



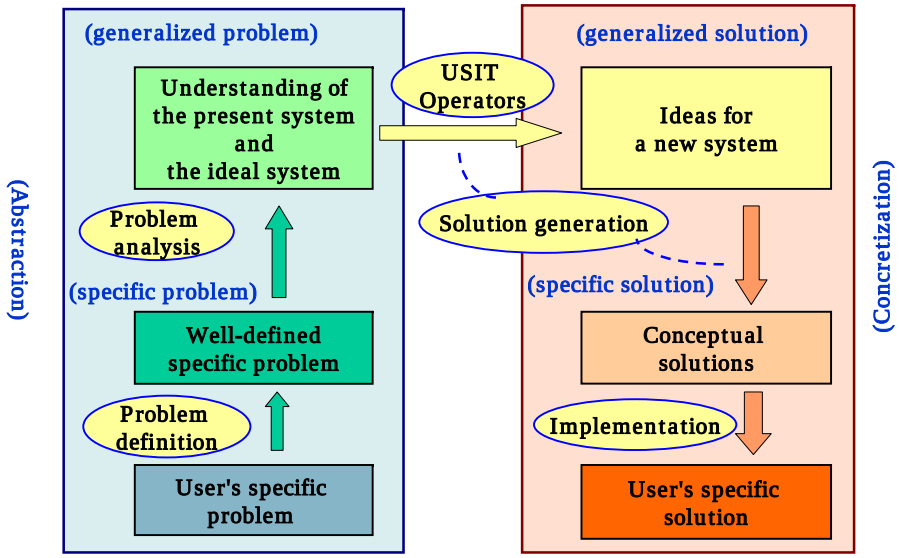
New Scheme of Creative Problem Solving (6-Box Scheme in USIT)

Implication (2) Real World and Thinking World



New Scheme of Creative Problem Solving (6-Box Scheme in USIT)

Implication (3) Idea Generation as the Jump



Practices of Training/Applying USIT in Japan

USIT 2-Day Training Seminar in Japan

10:00	(L1) Introduction to TRIZ/USIT
12:00	Lunch
13:00	(L0) Introduction
	(D0) Presentation of Problems
14:00	(L2) Problem Definition
	Problem Definition (Ex 1) Group Work
	(D1) Presentations & Discussions
16:20	
16:30	(L3) Problm Analysis 1
	Problem Analysis 1 (Closed World Method) (Ex 2) Group Work
19:00	(D2) Presentations & Discussions

9:00	(L4) Problem Analysis 2
	(Particles Method) (Ex 3) Group Work
11:20	(D3) Presentations & Discussions
	(L5) Solution Generation
12:15	Lunch
13:15	Solution Generation 1 (Ex 4) Group Work
	(D4) Presentations & Discussions
15:15	
15:30	Solution Generation 2 (Ex 5) Group Work
	(D5) Presentations & Discussions
17:15	
17:30	(L6) Promotion in Industries
18:00	(D6) General Discussion

USIT 2-Day Training Seminar in Japan

First morning (2 hrs): **Introductory lectures on TRIZ and USIT**
1.7 Days (14 hrs): **Group practice for solving problems with USIT**

3 Real problems are brought in and solved by group practices.
Important, un-solved, and clearly definable problems.
Needs technical background knowledge and passion to solve the problem.

15 to 25 Participants: Engineers, staff, managers, etc.
Novices in TRIZ/USIT are welcome.

Groups of 4 to 8 members for practicing each problem:
Bring different knowledge and specialty together. Non-specialists are useful

5 Step-by-step sessions with USIT procedure: Each session has:
Short lecture on the concrete way of the step;
Group practice in parallel (each group solves one problem);
Presentation by the groups to the whole members, for discussion.

Participants can master USIT to the level able to apply it in their jobs.

Serves as the model for trainings and practices in industries.

Open Multi-company Training Seminar

Needs a prior 'Win-Win-Win' agreement by smaller 'Loss-Loss-Loss'

	Win (Win more than ordinary)	Loss (Loss more than ordinary)
(A) Problem Proposer	Solve his own problem by USIT, Master the problem solving method, Obtain the whole results with IP rights including contributions from others, Exclusive rights for 2 years to utilize the results and to develop them further, and to file the patents	Allow public disclosure of the technical contents after 2 years, Take a risk of leakage of information of some degree of company secret
(B) Other participants	Master the problem solving method by real application, Able to report the method and the case studies (including technical details) inside his company, Able to apply the method in his company, Able to publicly report the method	Discarding any rights of his own contribution to the solutions, Duty of non-disclosure of the technical contents outside his company for 2 years, Having no rights of further developing the technical contents of the case for 2 years.
(C) Instructor	Experiences of applying the method to real problems, Rights of improving and publishing the method and its application method, Rights of publishing the case study (including technical details) after 2 years	Discarding any rights of his own contribution to the solutions, Duty of non-disclosure of the technical contents outside his company for 2 years.

How to Use USIT in Industrial Practices

(1) USIT is much easier to learn than (traditional) TRIZ.

➡ Bring up one or several USIT experts in a company,
and then train many engineers in in-house training programs.

(2) USIT fits well for group work.

➡ Joint team of 1-2 USIT experts and 4-8 engineers for problem solving.
USIT experts may lead the discussion or better pose appropriate questions along the USIT process.

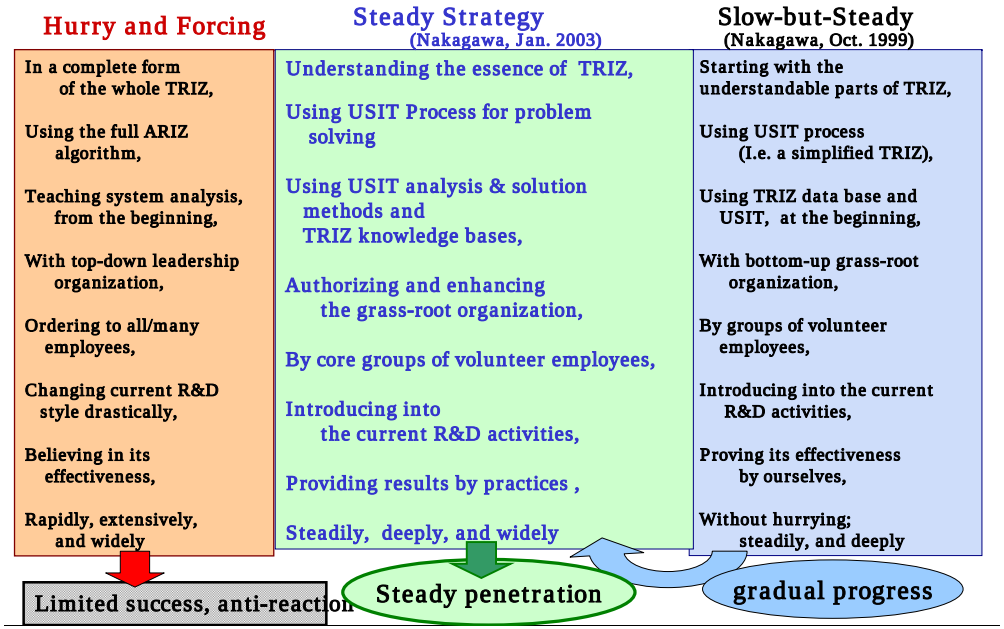
(3) USIT is applicable to real problems to obtain conceptual solution

➡ Apply USIT to real important problems in the company and obtain results.
Introduce USIT in the regular procedures of R&D whenever appropriate.
Selecting problems and implementing USIT solutions must be done in real world.

(4) Use USIT and TRIZ software tools in a comlementary way.

➡ Use USIT in a group as the guiding process of human thinking.
Use TRIZ software tools mostly personally as knowledge-bases.

Strategies for Introducing TRIZ into Industries



Concluding Remarks: Significance of TRIZ/USIT

TRIZ/USIT has provided
A new view and new philosophy of technologies,

Knowledge bases and software tools
powerful for innovation in technologies,

Pracical methods for creative problem solving.
6-Box Scheme in USIT gives
a new paradigm of creative problem solving.
USIT has now become "A New Generation of TRIZ".

TRIZ/USIT will carry
a new movement of innovation in technology in future
(because it has provided the quality improvement movement with a new pillar of technological view).