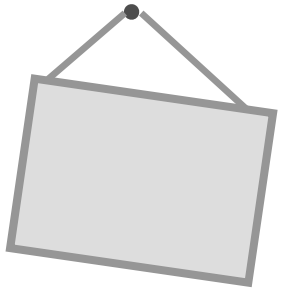
USIT Case Study 4. Picture Hanging Kit Problem



References:

[1] Source: Ed Sickafus (Ford Research Lab. & Ntelleck): "Unified Structured Inventive Thinking: How to Invent", Ntelleck, 1997, pp. 439-442;
"Picture Hanging Kit Problem", Japanese translation: Toru Nakagawa, "TRIZ Home Page in Japan", Mar. 23, 2001

[2] Introduction: "Commentary on "The Picture Hanging Kit Problem"", Toru Nakagawa, (Discussion by Ed Sickafus), "TRIZ Home Page in Japan", Jul. 31, 2001 (in Japanese); Aug. 23, 2001 (in English)

[3] Introduction: "A New Generation of TRIZ" , Toru Nakagawa, 1st TRIZ symposium in Japan, Sept. 1-3, 2005, at Shuzenji; "TRIZ Home Page in Japan", Sept. 20, 2005 (in Japanese and in English)

[4] Description of this case study:
"USIT Manual", Toru Nakagawa, May, 2015 (in Japanese), Jun. 2015 (in English);.
"USIT Case Study (4) Picture Hanging Kit Problem", Toru Nakagawa (OGU), May 15, 2015 (in Japanese), Jun. 8, 2015 (in English)

USIT Case Study 4. Picture Hanging Kit Problem

Introduction: Outline and Significance of this Case Study

The present case study was originally described by Dr. Ed Sickafus, the developer of USIT, in his USIT textbook in detail.

The problem is: "A picture is hung on a wall in a typical way by using a nail, a string, and two hooks, but it is apt to be tilted afterwards. Improve the ordinary picture hanging kit, so as the picture not likely to be tilted."

At a seminar to high school students he talked this case study, and then elaborated it in the textbook.

Nakagawa has been using this case study frequently at seminars as a nice exercise easy to understand.

I translated this case study (of 30 pages) in the USIT Textbook into Japanese [1], and later reorganized the case into 40 slides and wrote the introduction and posted it in my Web site [2]. On the English version of this introduction, Sickafus wrote a discussion [2].

Furthermore, with the trigger of the article [2], we reorganized all the solution generation methods of TRIZ and USIT into a unified system of the USIT Operators, and explained how to use the Operators by applying them in the present case study [3].

In the description of the "USIT Manual", this case study is used as a consistent example of application [4].

In this manner, the explanation of the present case study is evolving together with the development of USIT in Japan. So please try not to be stuck to the old ways of representation.

A standard USIT Case Study on a familiar problem, easy to understand for everybody and yet deep in thoughts.

USIT Case Study 4. Picture Hanging Kit Problem

Table of Contents

[Case 4. Picture] Step 1. Define the Problem (1) Preparation: Training Project

In the Real World, raise an issue and prepare for a (Training) Project of problem solving

(1) Preparation: Training Project for mastering creative problem solving method

Situation: Solving problems creatively is a basic capability which is desirable to be mastered widely from students to engineers and the general public, But actually very few percentage of people have had enough training of it yet.

Target: To set up training programs of creative problem solving, where TRIZ/USIT methods are applied to familiar problems, for a wide range of people.

Project Training projects of group practices in schools/universities, companies, and society, etc.

Activities: Making groups of about 5 persons and carrying out group practices on common problems.
(In the training, it is often necessary to have a few cycles of lecture/practice/discussion.)

Team: About 5 persons per team.
No particular request of members for using this Case Study as the problem to solve.

Theme: The problem in this Case Study is familiar for everybody.
Some basic knowledge of the balance of forces and torques may be desirable.

The present Case Study may often be used as a standard example in lectures and training seminars of USIT

[Case 4. Picture] Step 1. Define the Problem (1) Preparation: Training Project

Setting of the problem situation

According to Sickafus in his USIT Textbook,
the following situation is supposed to start this case study:

There was a company selling picture frames and picture hanging kits.

The present picture hanging kit is composed of:

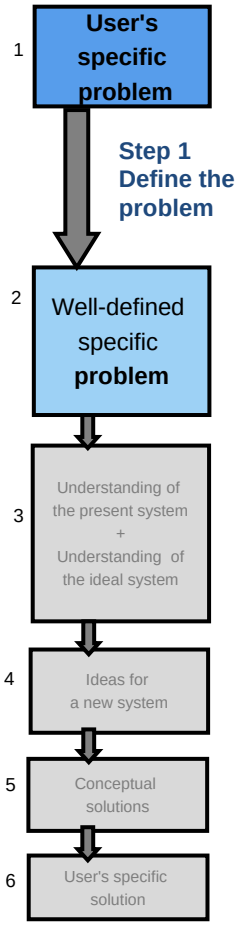
A nail, a string, and two screw eyes

It was decided:

**To develop some new method of hanging pictures,
especially where the picture won't tilt afterwards.**

The catch copies (or targets) are:
"a picture frame that aligns itself",
"get it right, and it stays

[Case 4. Picture] Step 1. Define the Problem (2) Clarify the problem situations



Through the group discussion, the problem is made clear.

Step1: Define the Problem (in the USIT standard template)

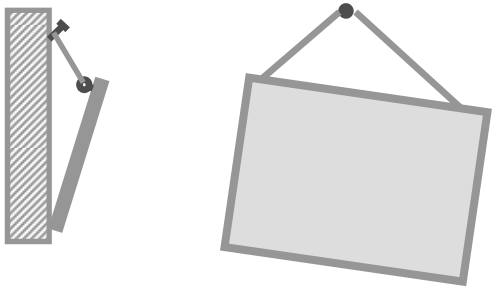
(a) An unwanted effect:

A picture is hung on a wall in a typical way by using a nail , a string, and two hooks, but it is apt to be tilted afterwards without knowing.

(b) Task statement:

Improve the ordinary picture hanging kit (with a nail, a string, and two hooks), so as the picture not likely to be tilted

(c) Simple sketch of the problem situation:



Drawing the sketch is important to understand the mechanism of the system/problem.

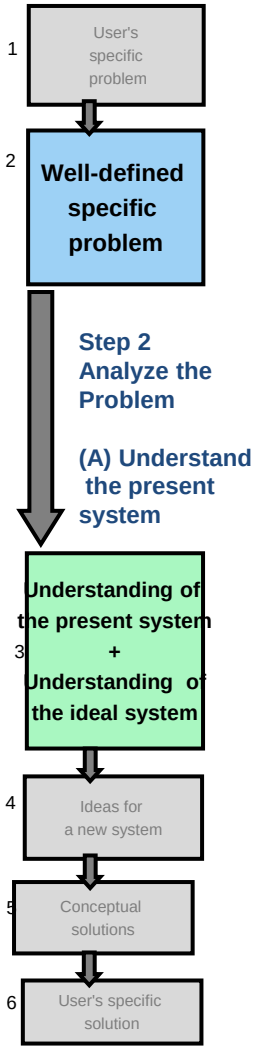
(d) Plausible root causes:

In case of vibration from the wall,
the string slips on the nail and the picture frame is tilted .

(e) A minimum set of relevant objects:

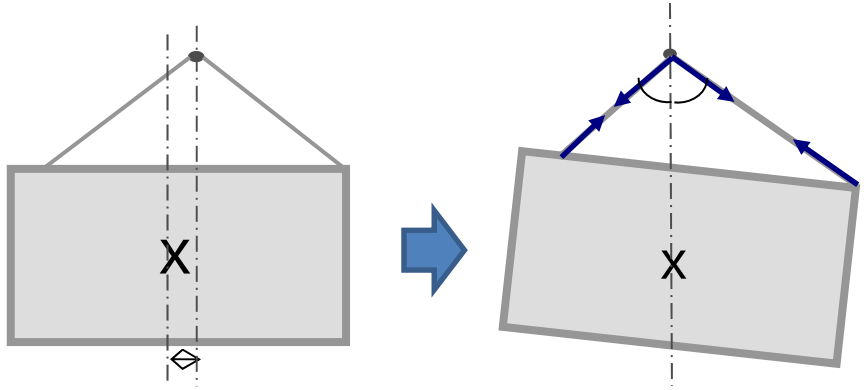
A picture frame (including the picture, frame, glass, etc.), a nail, a string, two hooks, and wall

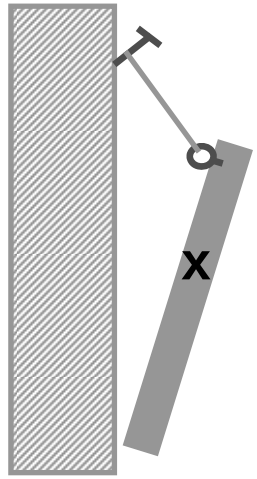
[Case 4. Picture] Step 2: Analyze the Problem (A) Understand the present system



(A1) Understand the Space Characteristics

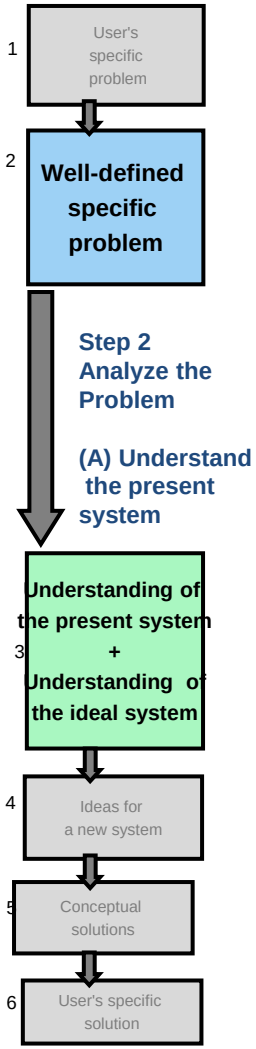
In this problem, the spatial arrangement (e.g., tilting) is the results of the balance of forces and torques. Thus it is essential to examine and understand the mechanical relationships correctly.



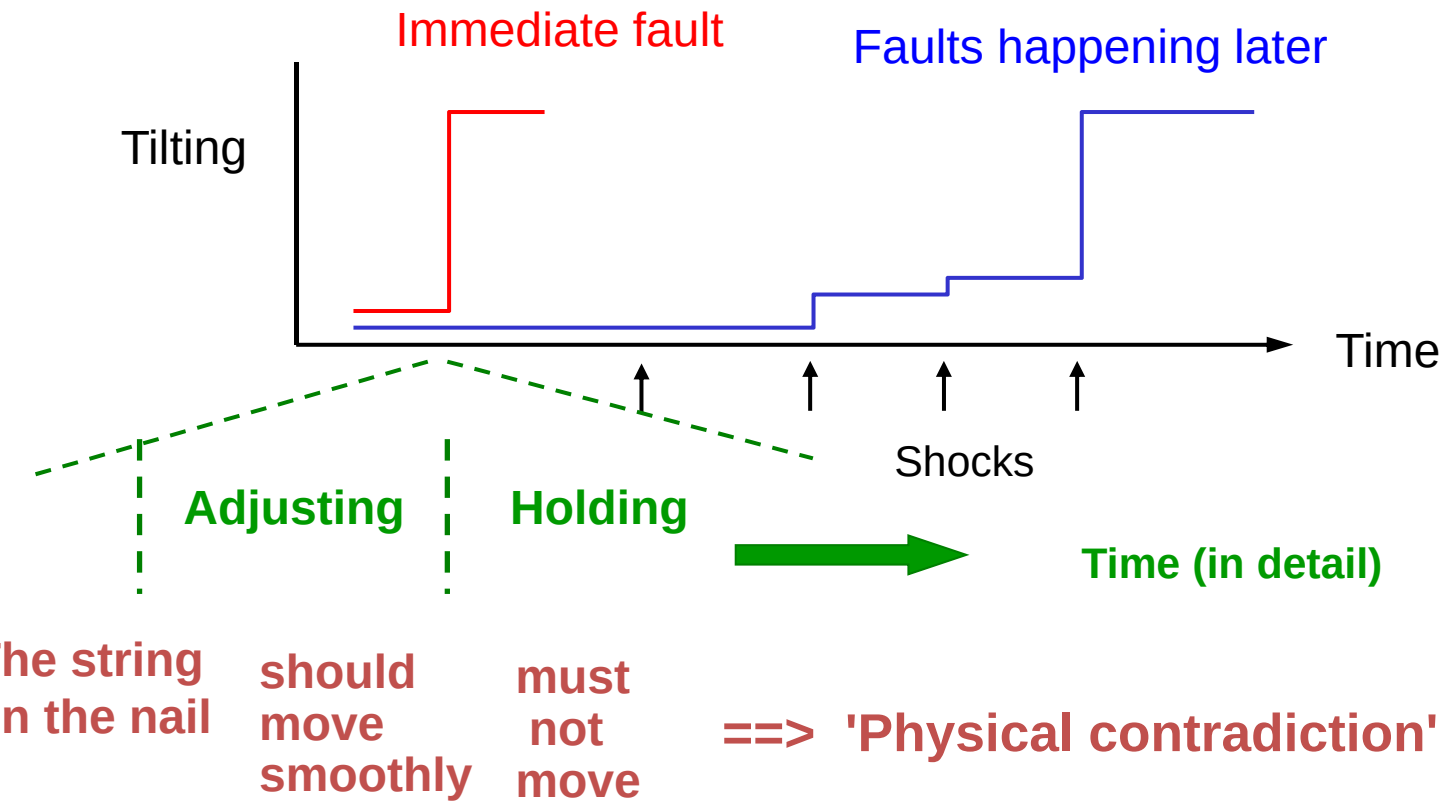


When we adjust the frame in the horizontal position, the center of mass of the frame must be located just below the nail. Otherwise, due to a torque the string slips at the nail and the frame will be tilted.

[Case 4. Picture] Step 2: Analyze the Problem (A) Understand the present system

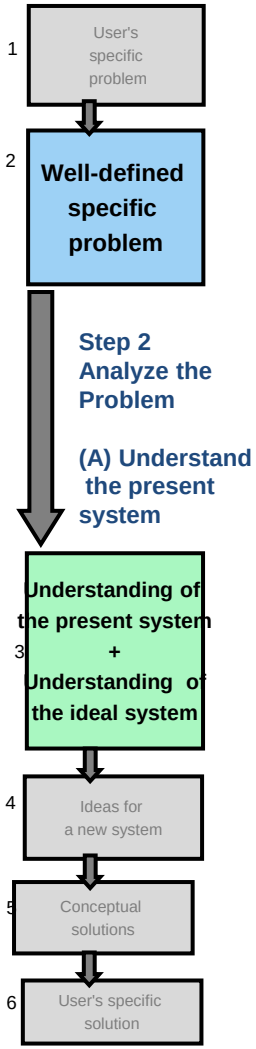


(A2) Understand the Time Characteristics



"Requirements while adjusting and requirements while holding the frame are different."
-- This is a very simple observation everyone knows, AND YET it is found to be the essence of the present problem.
The recognition of this contradiction will give an important effect on the solution process and on the evaluation of the solution concepts.

[Case 4. Picture] Step 2: Analyze the Problem (A) Understand the present system



(A3) Understand the Attributes (properties)

The table here is easier to understand than Sickafus's QC graphs

Attribute = Category of properties

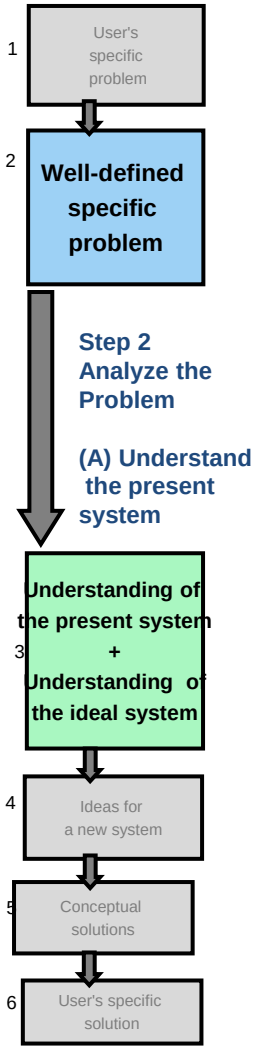
List up the relevant attributes as much as possible and understand the mechanism

==> Enhance the understanding of the plausible root causes and prepare for the idea generation

Unwanted effect of this problem = Frame's easiness to tilt

Object	Attributes which increase easiness of picture frame tilting	Attributes which decrease easiness of picture frame tilting	Attributes irrelevant to the easiness of picture frame tilting
Picture frame	Offset of the center of mass from just below the nail., Asymmetry of shape & weight		color, width, length, thickness, weight
Hooks	Offset from the symmetric positions	adjustment of positions	
String	Slipperiness	Friction of string with the nail	Thickness, length, color
Nail	Slipperiness on the surface	Friction with the string, angle	Material, length, thickness
Wall	Vibration of wall	Friction with the frame bottom	Color, oldness

[Case 4. Picture] Step 2: Analyze the Problem (A) Understand the present system



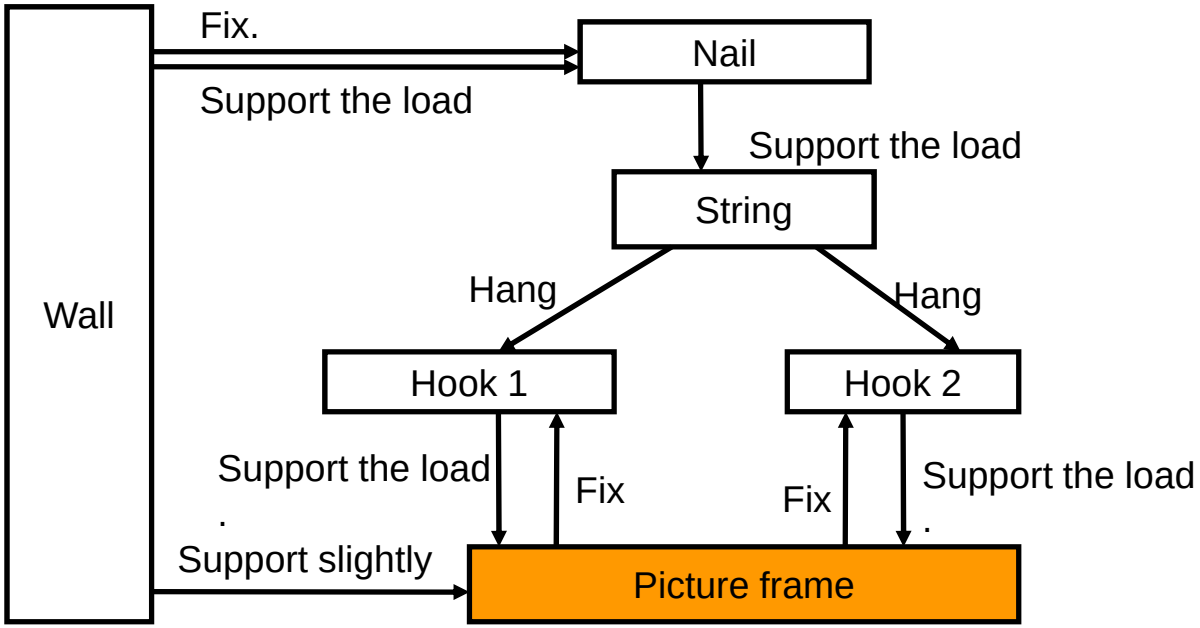
(A4) Understand the Functional Relationships

Terms related to the Interactions between objects:

- **Action** (or Function in a wider sense) **:** The interaction is viewed as a work from one object to the other.
- **Function (in a narrow sense):** Action regarded useful
- **Harm:** Action causing bad results (for people)

Depending on the problem, a same system can be viewed in different aspects and hence with different functional relationships.

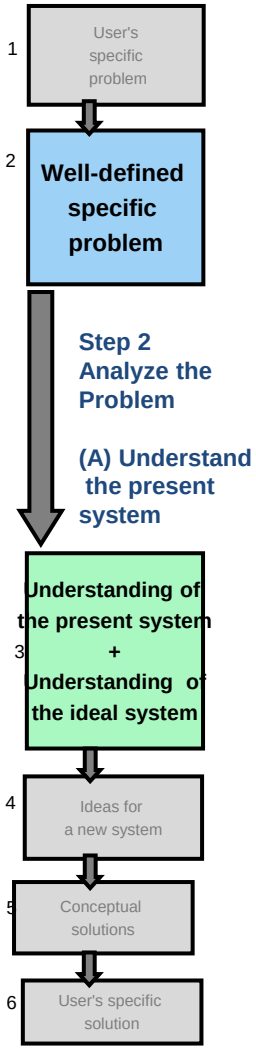
Thus, **the functional diagram below is NOT suitable for the present problem.**



On the arrangement/tilt of the picture frame (and its adjustment and holding), no information is available in this diagram.

[Case 4. Picture] Step 2: Analyze the Problem (A) Understand the present system

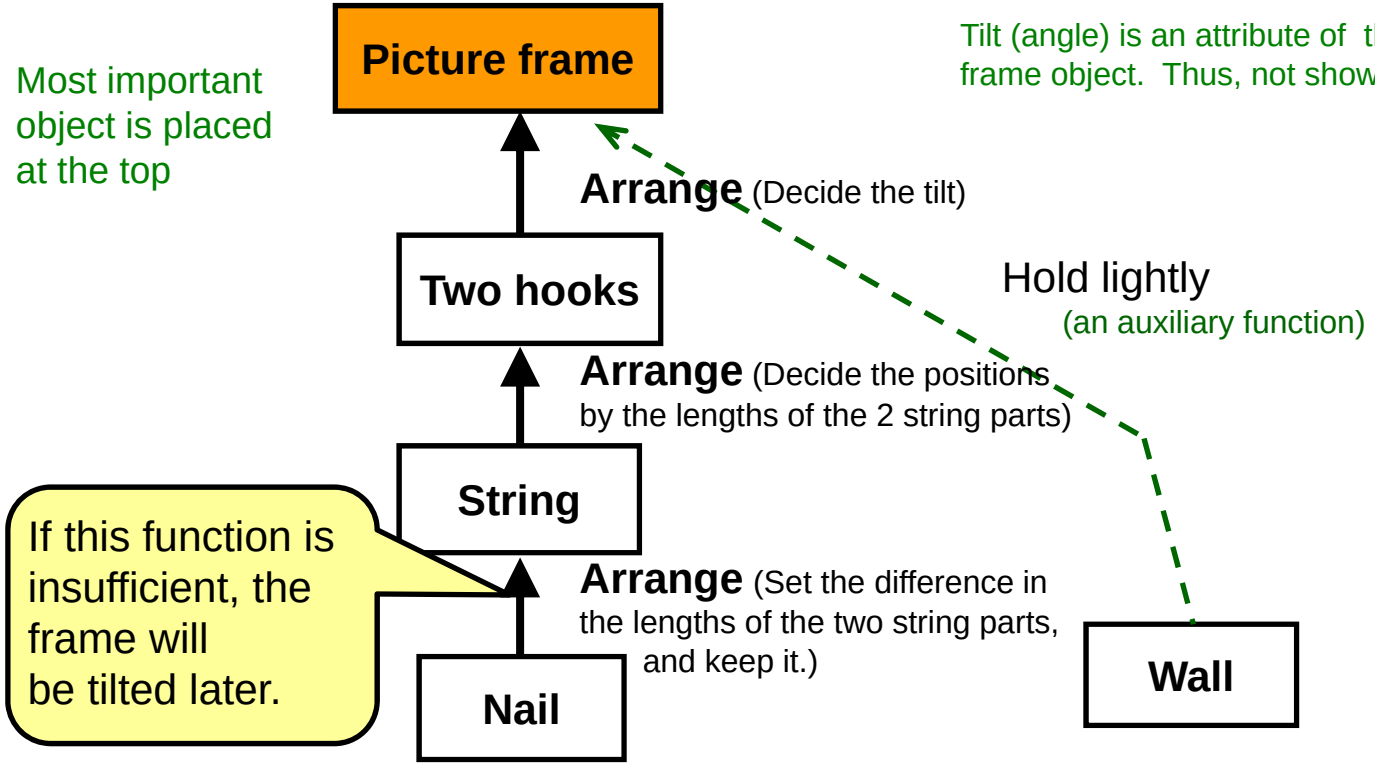
(A4) Understand the Functional Relationships (continued)



Clarify the mechanism and designer's intention of the present system for holding the frame without tilting.

The USIT way of Functional diagram

Most important object is placed at the top

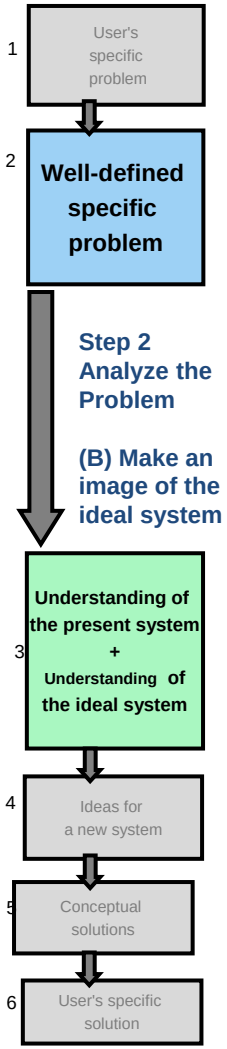


Tilt (angle) is an attribute of the picture frame object. Thus, not shown here.

Auxiliary functions are drawn in broken lines.

Harmful or insufficient functions may be commented explicitly, if significant.

[Case 4. Picture] Step 2: Analyze the Problem (B) Make an image of the ideal system



(B1) Consider the Ideal system with Separation Principle (Altshuller's method)

Formulate the problem in terms of the Physical Contradiction:

==> While adjusting the picture frame,
the string **must move smoothly** on the nail;
While holding the picture frame after finishing the adjustment,
the string **must NOT move** on the nail.

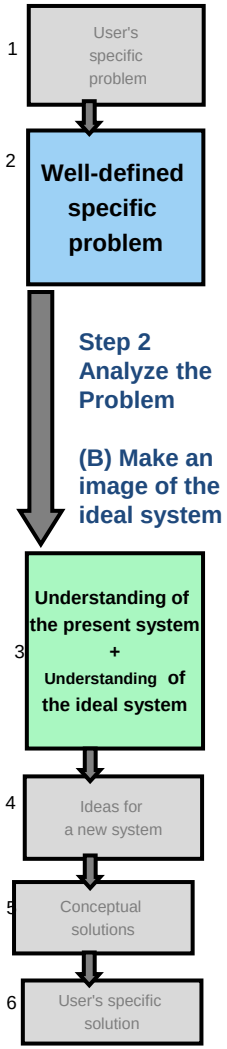
==> This is a case of Physical Contradiction, separable in time

State the Ideal solution overcoming the Physical Contradiction by use of the Separation Principle (in case of separable in time):

==> The string **moves smoothly** on the nail
while adjusting the picture frame, AND
the string **DO NOT move** on the nail
while holding the picture frame after finishing the adjustment,

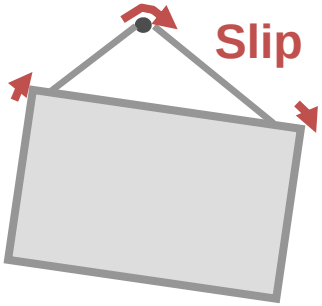
.

[Case 4. Picture] Step 2: Analyze the Problem (B) Make an image of the ideal system

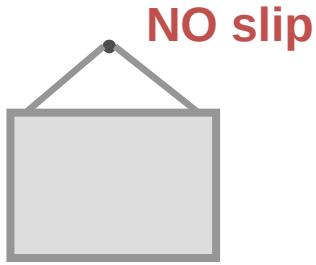


(B2) Consider the Ideal system with the Particles Method (Sickafus's method)

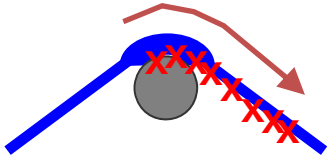
(a) Sketch the present system



(b) Sketch the ideal system (as the result of achievement)

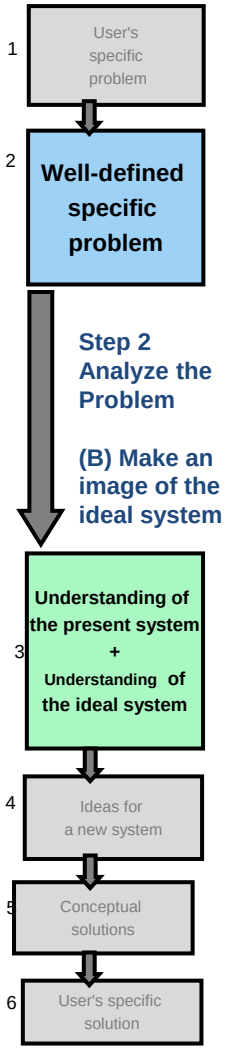


(c) Draw x marks at the places of any difference between (a) and (b): Call x marks 'Particles'.



The Particles are supposed to be magical things/fields which can have any property and can make any behavior.

[Case 4. Picture] Step 2: Analyze the Problem (B) Make an image of the ideal system



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(B2) Consider the Ideal system with the Particles Method (Sickafus's method) (Continued)

(d Desirable behaviors

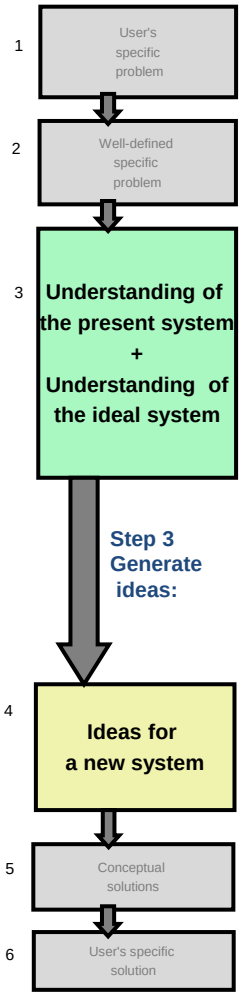
Not Ideal but practical goals

- Once the frame is hung correctly, it never tilt or hardly tilt afterwards
  - AND
    - When we set the frame, we can adjust the frame smoothly at the correct position
      - AND
        - correctly with no tilting
        - AND
          - Sense of no tilting
          - Easy to adjust the tilting
    - OR
      - Once the frame is set, it never tilts for a long time
        - OR
          - Hold the frame at no tilt position tightly
          - Tilting returns at the no-tilt position
      - Once the frame is set, it hardly tilts for a long time
        - Hold the frame at no tilt position

(e) Desirable Properties

- Lengths of string in two parts
- Balance of the center of mass
- Hook adjustment
- Wall support
- Auto-adjusting
- Horizontal degree of the frame
- Vertical degree of the frame
- Smoothness of nail
- Smoothness of string
- Degree of freedom of adjustment
- Fixing the string at the nail position
- Strength of the fixing
- Clinging
- Fixing to the wall
- Resilience
- Elasticity
- Automatic adjustment
- Electro-magnet
- Friction
- Roughness of nail surface
- Pressure
- Strength of holding
- Vibration suppression

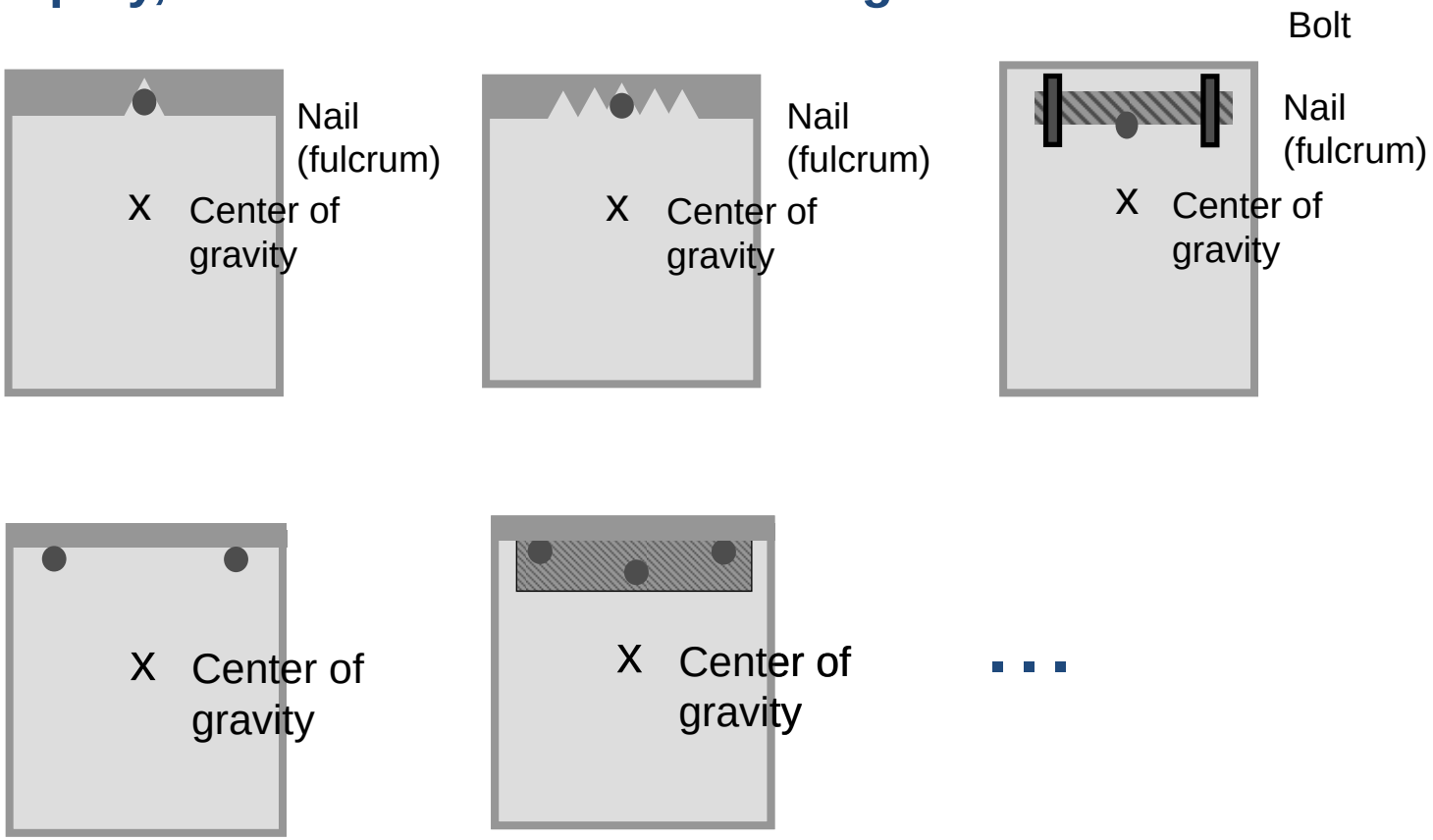
[Case 4. Picture] Step 3: Generate Ideas (1) Write down the ideas stimulated by the analyses



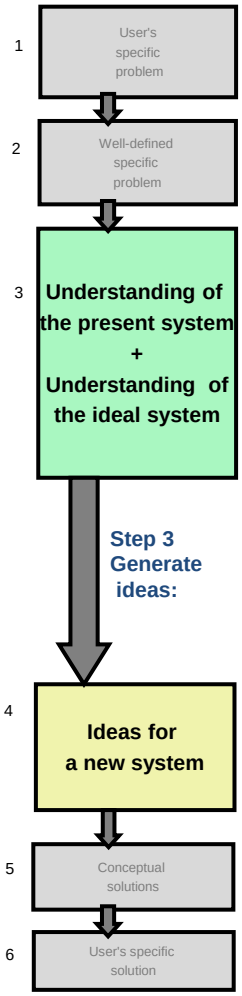
(1) Write down the ideas freely with the stimulation of the analyses

Description by Sickafus in his USIT Textbook [1], as shown in Nakagawa's introductory article [2]

Simplify, and use associative thinking.



[Case 4. Picture] Step 3: Generate Ideas (1) Write down the ideas stimulated by the analyses

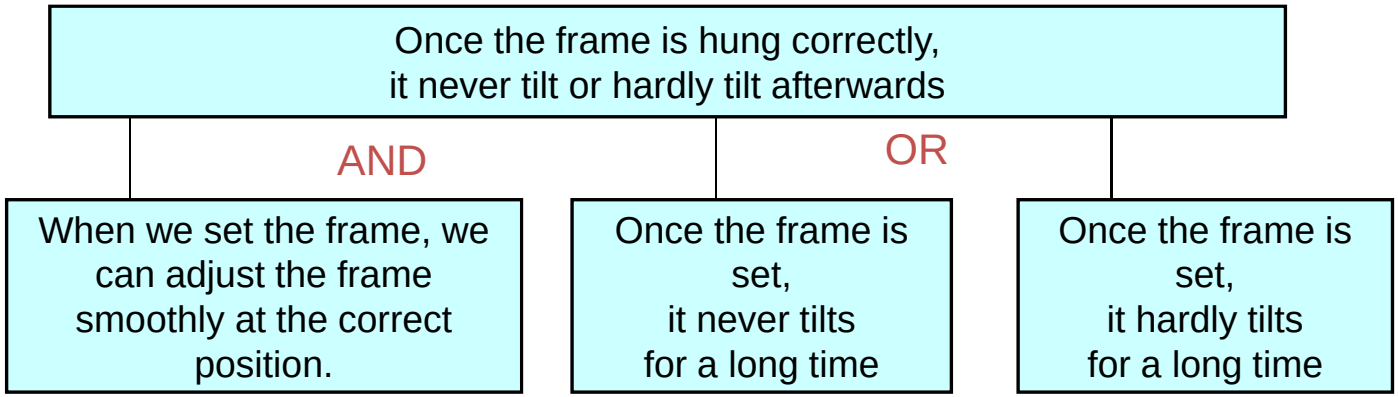


Generate various ideas as much as possible:

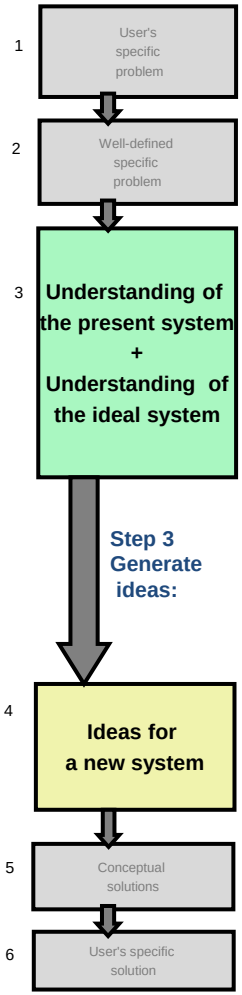
For instance,

- Increase the friction between the nail and the string.
  (Make the nail surface rough; apply an adhesive; ..)
- Use two nails.
- When the adjustment is finished, apply some treatment for fixing or making hard for the string to slip on the nail.
  (e.g., clip, press with a screw, apply an adhesive, etc.)
- Make the frame bottom edge not slip on the wall.
  (e.g., apply a cushion, fix with a double-faced adhesive tape)
- …

Build them into a hierarchical system

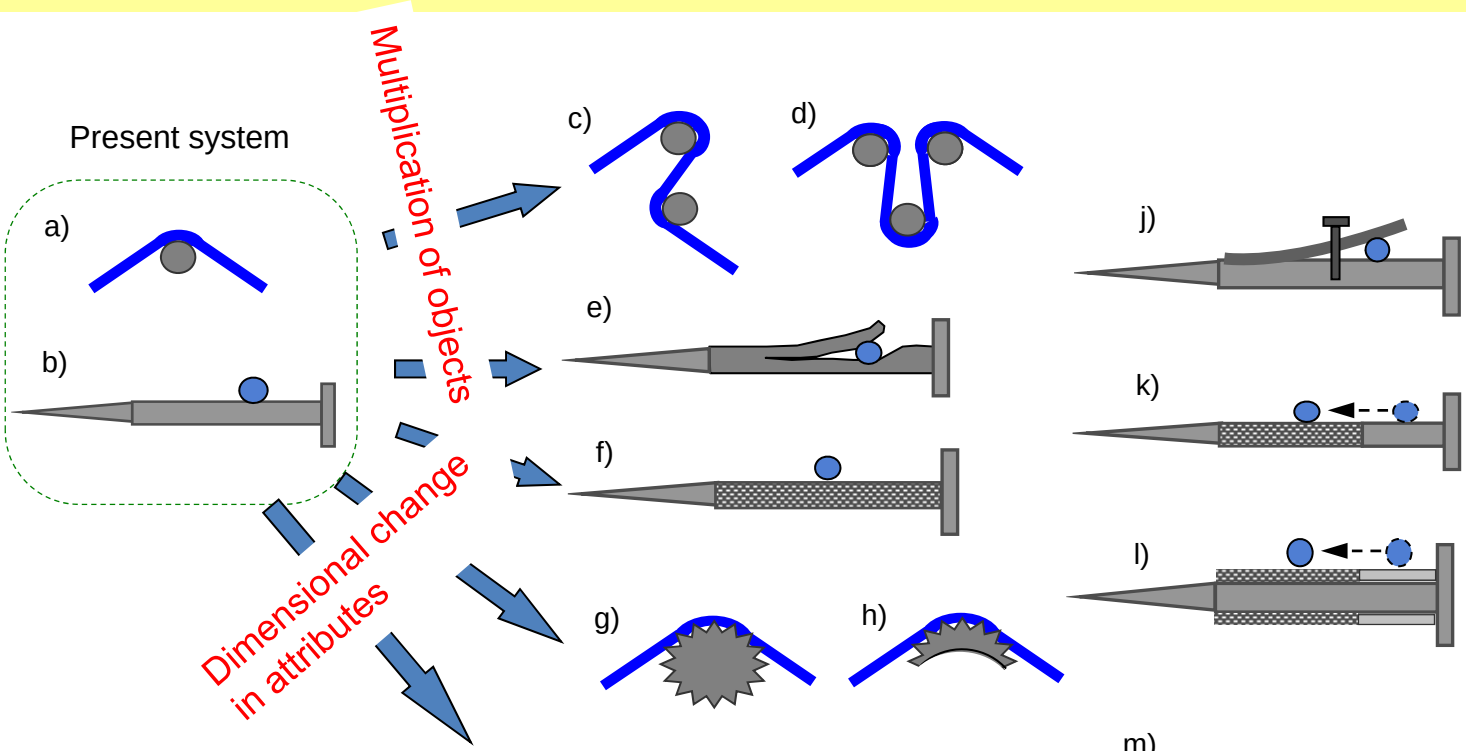


[Case 4. Picture] Step 3: Generate Ideas (2) Apply various USIT Operators intently



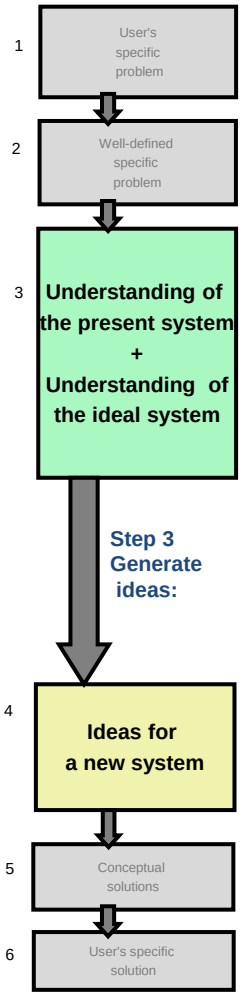
(2) Apply various USIT Operators intently to generate more ideas and extend/improve them further

The USIT Operators are the integrated and reorganized system of all the solution generation methods developed in TRIZ and USIT. (5 main-, 32 sub-Operators)



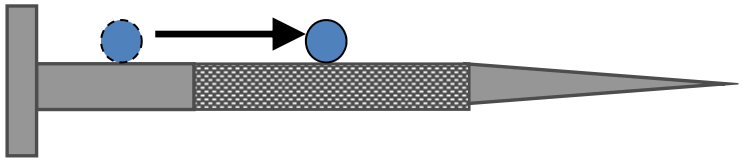
Apply a USIT Operator to any possible target somehow literally, and then think of an idea of making good use of it.

[Case 4. Picture] Step 3: Generate Ideas (2) Apply various USIT Operators intently



An idea can be interpreted in multiple ways of applying USIT Operators:

(Example) Sickafus' Nail



(a) Object Multiplication Method:

Divide the nail into two parts, differ the surface properties and combine them again.

(b) Attribute Dimensional Change Method:

Smoothness attribute of the nail was changed by places.

(c) Function Redistribution Method:

The adjustment and maintenance functions of the nail are allocated to different parts of the nail.

(d) Solution Combination Method:

(d1) Solution Combination in Space:

Solution of a smooth nail and solution of a rough nail are combined by the places.

(d2) Solution Combination in Time:

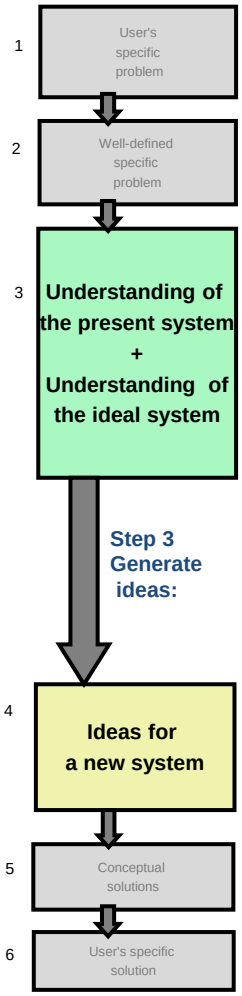
Solution of a smooth nail and solution of a rough nail are combined in time..

An idea can be interpreted in multiple ways of applying USIT Operators

==> Several USIT Operators can derive a solution.

The interpretation (d2) 'Solution Combination in Time' is most meaningful in this case, because it corresponds to **solving the Physical Contradiction by Separation in Time**.

[Case 4. Picture] Step 3: Generate Ideas (2) Apply various USIT Operators intently



(3) Ideas generated by the recognition of the Physical Contradiction

Recognition of the Physical Contradiction has guided us the Ideal solution:

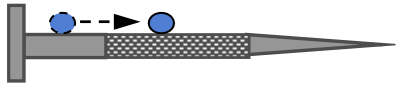
"The string moves smoothly on the nail while adjusting the picture frame, AND the string DO NOT move on the nail while holding the picture frame after finishing the adjustment,"

This guide us to a solution idea, straightforwardly:

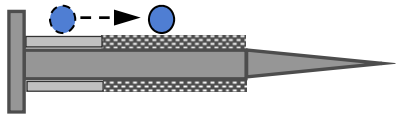
" Just after finishing the adjustment, we should do some operation for making the string do not move (i.e. fixed) on the nail."
Fixing can be done by clipping, pressing, adhesion, pasting, binding, etc.

Some examples of solutions along this guideline:

k)

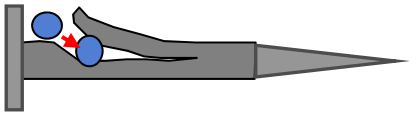


l)

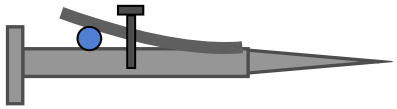


Solutions to make the string hard to move.

e)

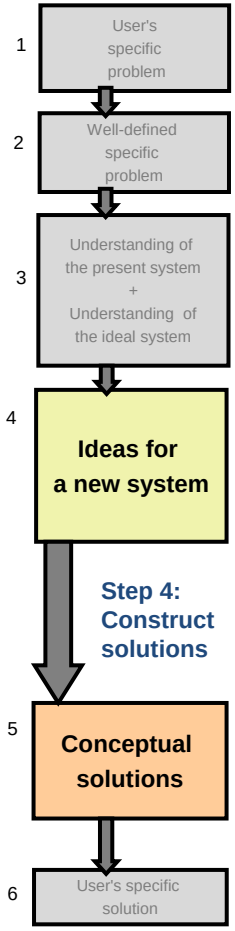


j)



Solutions to make the string impossible to move.

[Case 4. Picture] Step 4: Construct Solutions: (1) Evaluate and select ideas (2) Construct the conceptual solutions



(1) Evaluate and select ideas

In the present case, **"Overcoming the Physical Contradiction, or not"** is the clear and good criterion for the solution evaluation

The string is fixed (or made not to move) while the holding period

= Made never tilt. ==> Good solution

The string has larger friction with the nail while the holding period .

==> made hardly tilt ==> Fair (not quite good) solution

(2) Construct the conceptual solutions

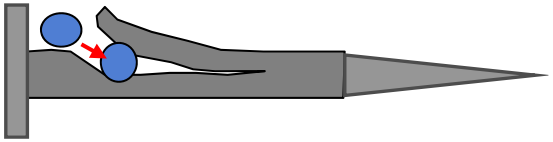
Solution where the picture frame never tilt.

Example:

.

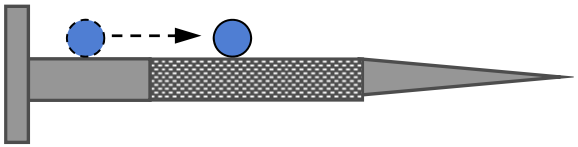
The nail has a slit in its body.
Adjust the string at the ordinary axis part, and after finishing the adjustment push the string forward to set tightly in the slit.
Whenever necessary, after the exhibition, etc., the string may be released by hand easily

e)

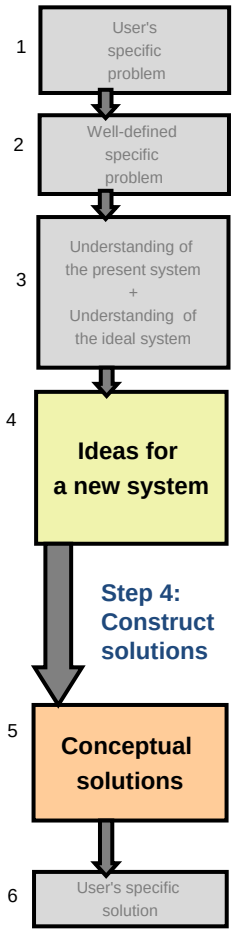


Solution where the picture frame hardly tilt.

k)



[Case 4. Picture] Step 4: Construct Solutions: (3) Report the results



Finalize as a Case Study and Report it. Conclusion as the Case Study.

USIT was applied to a familiar problem "Improve the picture hanging kit so as to make the picture never/hardly tilt" and its process is shown.

This is a standard USIT Case Study, where the USIT process and its representation have been improved many times so far.

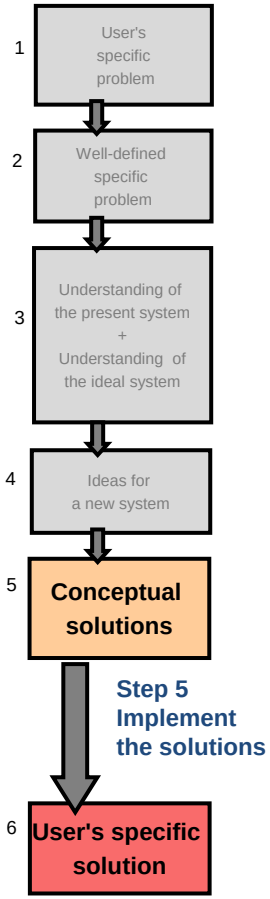
The methods for understanding the present system have been improved in all the aspects of space, time, attributes, and functions.

The methods of idea generation are integrated into the USIT Operators and are demonstrated with the examples in this case study.

These experiences and improvements have been described and reported at conferences and seminars, and posted in "TRIZ Home Page in Japan".

A standard USIT Case Study on a familiar problem, easy to understand for everybody and yet deep in thoughts.

[Case 4. Picture] Step 5: Implement the Solutions : (Real activities in the 'Real World')



In the present case, we have not yet tried any of designing, prototyping, manufacturing, marketing, etc.

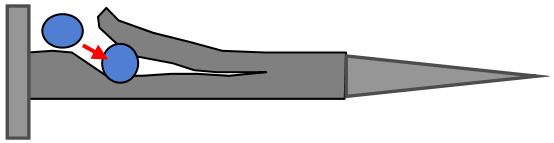
For such a trial, we should select some good solution concepts among the ones obtained in the preceding step.

Especially, an improved nail which has overcome the Physical Contradiction.

Namely, The adjustment of the picture frame can be carried out smoothly,
the string is fixed on the nail after the adjustment,
and the string may be released easily by hand when necessary.

A conceptual solution:

e)



Some items to be examined in the process of implementing the solution:

- Materials (iron, brass, SUS, steel, etc.) and manufacturing methods
- Design and appearance (whole length, shape, shape of the head, color, etc.)
- Shape of the slit part and manufacturing process of the slit part
- Method of installing in the wall (nail of driving type, rectangular nail, wood screw, a bolt, etc.)
- Sales (art supply stores, hardware stores, DIY shops, etc.)

USIT Case Study 4 [Picture] (Overview). Picture Hanging Kit Problem

**A standard USIT Case Study on a familiar problem,
easy to understand for everybody and yet deep in thoughts**

Ed Sickafus and Toru Nakagawa (1997-2005)