# USIT Case Study:
# A Mom's Bicycle for Safely Carrying Two Children


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## Abstract

This is a report of USIT Case Study obtained recently at a two-day USIT Training Seminar instructed by Nakagawa and brushed up afterwards. We heard TV news: "Though the current Road Traffic Law prohibits carrying two children on a bicycle, the National Police Agency has suggested, on the strong requests from mothers, to modify the law to approve it if bicycles are improved to do so safely". Hence we have chosen this problem. The USIT process of problem definition, analysis, and solution generation performed during the training seminar is reported here together with some discussions on the process and enhancement afterwards. The five-member non-specialist group has obtained an overview of the problem and has proposed a conceptual solution with two child seats in front.


## 1. INTRODUCTION

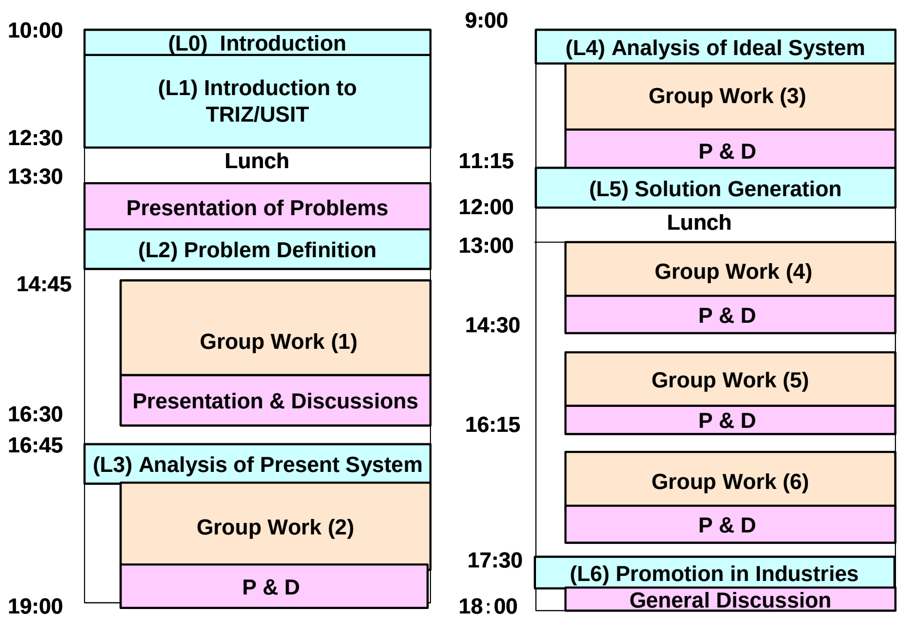
We are interested in the methodologies of systematic innovation and creative problem solving. TRIZ (Theory of Inventive Problem Solving) [1, 2] provides a large system of such methods and knowledge bases, while USIT (Unified Structured Inventive Thinking) [3, 4] developed under the influence of TRIZ gives a concise process of creative problem solving. For mastering such a methodology of problem solving or creative thinking, reading textbooks and listening seminars are usually not enough and training and practices in real jobs are necessary and effective.

Case study reports, but not success stories, are useful to learn if they are written objectively and vividly how the problem solving and thinking process actually has proceeded in some training or practices. The main values of such case studies do not come from difficulty of problems or novelty of solutions but rather from the descriptions of the thinking process which can be learned and practiced later by the readers. The present paper intends to be such a case study of USIT method applied to a real problem by a group of engineers in a training seminar.

The present case is based on the results of the 2-Day USIT Training Seminar conducted on March 7-8, 2008 in Tokyo and enhanced through email discussions afterwards. The way of conducting the 2-day training is similar to the one reported earlier in Nakagawa [4 - 6]. The present case was done in an open-entry multi-company situation. Engineers who were interested but still novices in

TRIZ/USIT took part in the training seminar instructed by Nakagawa. As shown in the agenda in Fig. 1, after an introductory lecture on TRIZ and USIT for 2 hours, group practices of solving 3 real problems in parallel were carried out along the standardized USIT process.

**Fig. 1 Agenda of 2-Day USIT Training Seminar**




The problem handled here was suggested by Nakagawa to the seminar participants. The trigger was TV news broadcasted 3 days before: "Even though it is often seen mothers riding a bicycle carrying two children, strictly speaking it is prohibited by Road Traffic Law in Japan. On strong requests from mothers, National Police Agency recently suggested a possibility of modifying the law so as to permit the bicycle riding with two children if bicycles are improved to do so safely." This problem was one of several alternatives proposed to 16 participants. 5 partcipants selected this problem and formed an instant team, while 11 others selected two other real engineering problems brought in by participants. By virtue of the open nature of this problem, we can report this case study in a frank manner.

During the training seminar, Nakagawa served as the instructor of the USIT process for all the three groups who were working on different engineering problems in parallel. The instructor gave some advices from time to time during the group practice sessions and some more during the group-presentation and discussion sessions. Since the bicycle problem was familiar with all the members, it was almost unnecessary for Nakagawa to explain about the problem situations and background knowledge. The 5-member group worked together by discussing, writing ideas in Post-It Notes, drawing diagrams, classifying ideas, etc., without having any formality of leadership in the group. Contents and results of group practices were documented with Post-It Notes posted on big sheets of papers, and were recorded as photos.

A case study report was first written down by Sudo by filling in a template provided as a part of the seminar text. The template has the feature of describing four categories separately, i.e., (a) raw documents (i.e., the photos) obtained in the group practice, (b) additional explanation how the group thought and worked during the group practice, (c) comments and discussions expressed during the discussion sessions in the seminar, and (d) further comments and notes obtained after the training seminar. The report was passed to the group members and the instructor via email, and was enhanced by adding some more thoughts and figures for discussion. Nakagawa, Sudo, and Sakata contributed mostly. We obtained in early July a new concept of bicycle carrying two children in front of the rider. We presented the case study [7] in September at Japan TRIZ Symposium 2008; a poster presentation was given both in Japanese by Sudo and in English by Sakata.

In mid July we noticed the activities of Japan Bicycle Promotion Institute (JBPI) [8] for supporting the development of prototype bicycles for the present purposes. And in November in the Netherlands Nakagawa found bicycles having a boat-like structure containable two children in the front. We will discuss our solutions in relation to these findings.

In the present paper we are going to describe this case study along the USIT process of problem solving. The process is stream-lined as Problem definition, Problem analysis (of the present system and then of the ideal system), and Solution generation. The enhancements of the results of the training seminar by later revisions and discussions are described explicitly.

## 2. PROBLEM DEFINITION

### 2.1 Background of the problem

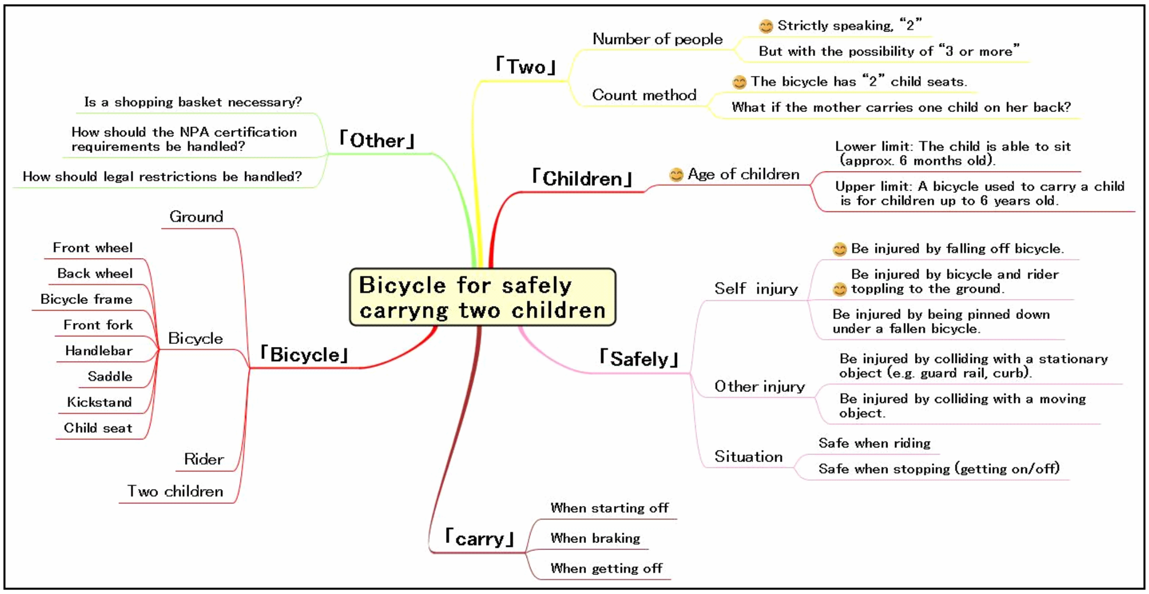
The current Road Traffic Law [9] in Japan has the regulations [9] that two-person riding on a bicycle is allowed only when the second person is of age 6 or less and that three-person riding is prohibited even for children of age 6 or less. But actually it is commonly seen that mothers ride bicycles carrying two children for taking them to nursery schools, kinder gardens, shopping stores, etc. For this purpose child seats are sold separately and may be attached to ordinary bicycles or bicycles specially designed for two-person riding. Carrying their two children on a bicycle is quite necessary for mothers everyday, and hence the safety regulations in the Law are commonly violated. The TV news on March 3, 2009 told that the National Police Agency has recently suggested a possibility of changing this regulation so as to keep the safety of children and mothers by improving bicycles. We also noted later that the Law also has the regulations on the maximum length (190 cm) and width (60 cm) of 'ordinary' bicycles for running on public roads.

### 2.2 Sharing the problem and examining the scope

In problem solving with USIT, it is usual that some people bring in the problem which they want to solve. Then the person explains the problem situations and suggests the scope of the problem at the start of problem definition stage. However, since the present problem was brought in just as a topic triggered by the TV news, the seminar group started their discussion with the aim of sharing the problem and examining the scope.

Sudo, a patent attorney in a prefabrication house building company, naturally led the discussion. He wrote the topic title at the center of a big sheet of paper and asked the members to clarify the implications of each word and wrote them in a manner similar to the Mind map [10]. In about 20 minutes the group obtained the diagram as shown in Figure 2. (Note the figures shown in the present paper are close to the original hand-written ones but refined later more or less.)

**Fig. 2. Mind Map for sharing the problem and its scope**




Some of the implications found and agreed by the members were as follows:

- Children: of age from about 6 months to about 6 years; this implies the weight up to about 25 kg.
- Safely: In the event of self-incurred injury, two cases are noticed, i.e., children falling off the bicycle, and children falling down together with the bicycle. These cases may occur when the rider is getting on/off the bicycle and also the rider is slowly riding or going to stop.

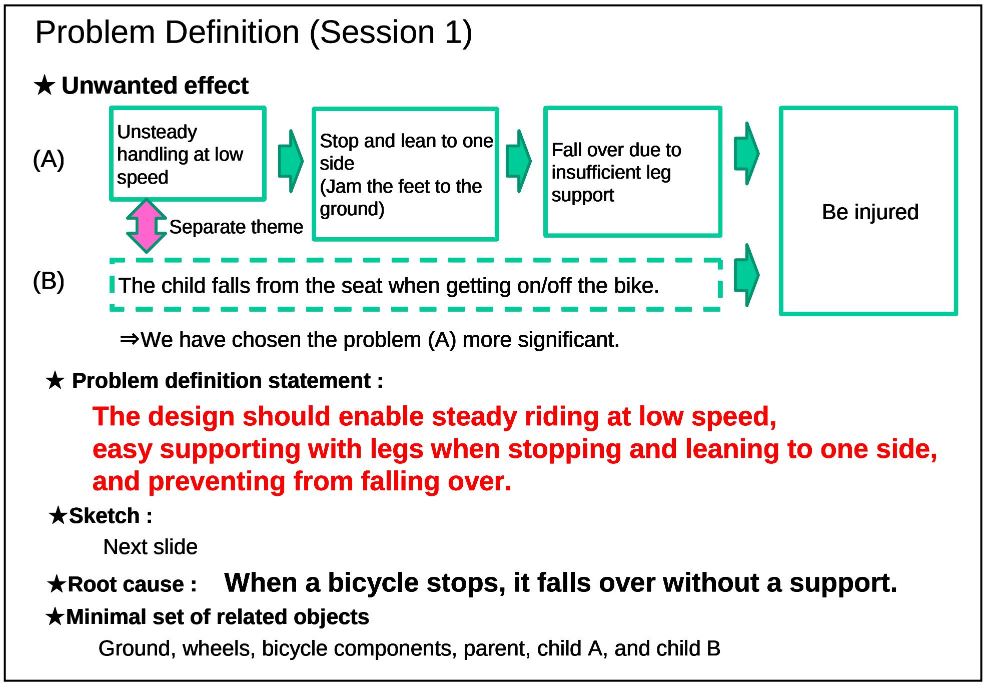
With these discussions, the team decided the two points of basic strategy:

- Bicycle: Focus on ordinary two cycled ones, but include the use of stabilizer wheel attachments and three-wheeled cycles.
- Do not impair the convenience of a standard bicycle.

## 2.3 Problem definition

Then the group went on to the discussions of the five items for problem definition as requested by the USIT. The following figure reproduces the statements of discussions obtained in the Seminar. The five items shown with ★ in Fig. 3 are to be clarified through the discussion.

**Fig. 3. Problem definition**




(a) Unwanted effect: USIT process starts with the clarification of 'what is unwanted in the current problem situation'. The group discussed two scenarios of getting injured and chosen the scenario (A) shown in Fig. 3.

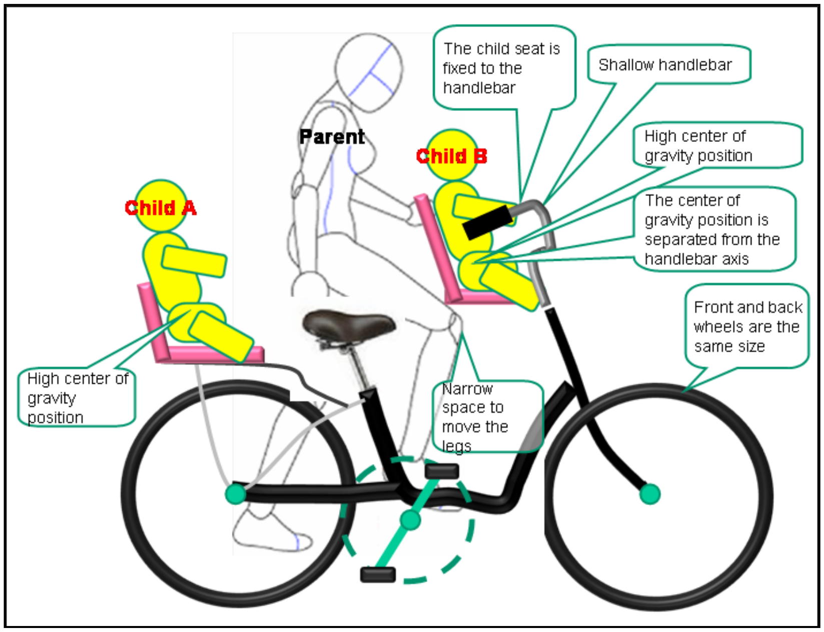
(b) Problem definition statement: This should state the task or goal of eliminating the unwanted effect. We want to develop a new design of a bicycle on which a mother can safely carry her two children. Thus we set up the design task as: "The design should enable steady riding at low speed, easy supporting with legs when stopping and leaning to one side, and preventing from falling over."

(c) Sketch: USIT requests to draw a rough sketch of the problem situation of the current system. The group drew a typical bicycle with which a mother carries two children, one in the back seat and the other in the front seat set on the steering handle. Several points of difficulty and trouble are shown in this figure. The child seats are set at high positions; the front child seat makes the handling heavy and unstable; and the leg space is not large enough for pedaling; etc.

(d) Root causes: Next, USIT requests to clarify plausible root causes. The group wrote it as: "When a bicycle stops, it falls over without a support." This statement is simple and clear. Obvious directions of solving this root cause are supporting wheels and tricycles; but such countermeasures spoil the ease of driving at certain speed and cornering. So, we would like to have some good solutions in the framework of bicycles, as much as possible.

(e) Minimal set of objects: USIT requests to list up the relevant objects in the problem system, to minimize the set of objects such that they contain the problem, and to name the objects in generic terms.

**Fig. 4. Sketch of a typical current system, a bicycle for carrying two children**




The group discussions so far in the problem definition were smooth to make consensus, mostly because the problem situations and the demands of solution were familiar to all the members. USIT guided this stage smoothly.

## 3. PROBLEM ANALYSIS

In the Problem Analysis Stage, USIT requests problem solvers to analyze (i.e. to obtain the understandings of) the current system and also the ideal system. The current system need to be understood in the general terms of Objects - Attributes - Functions - Space - Time. For this purpose, USIT provides standard methods of Functional analysis, Attribute analysis, and Space and Time characteristics analysis. With these analysis procedures we obtain the understanding of the mechanism, including the cause-effect relationships, of the current system. For understanding the Ideal system of the problem, USIT provides the Particles Method, which requests to make a clear image of the Ideal system as a goal, and then suggests to imagine desirable behaviors which magical agents (called Particles) should perform and desirable properties which they may have.

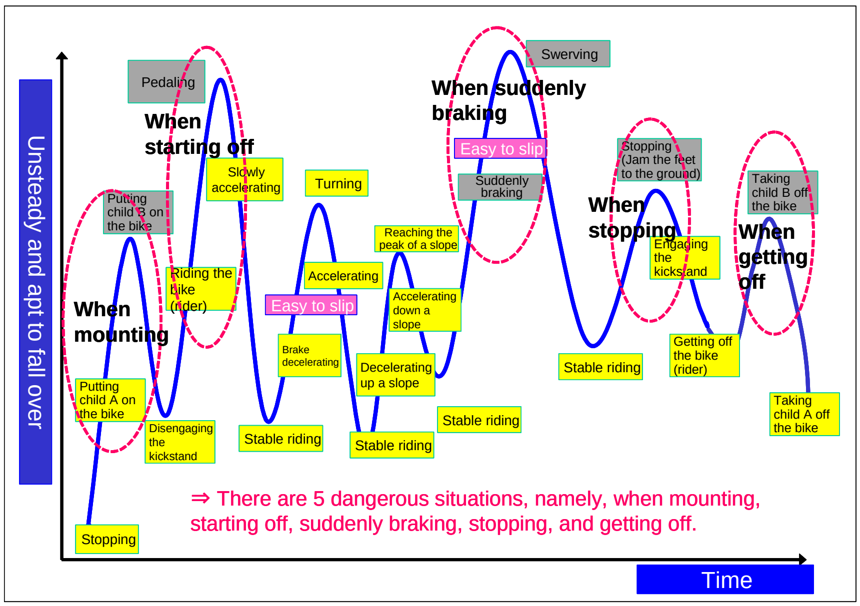
### 3.1 Understanding the Current System

The Problem Analysis stage for understanding the current system was carried out in the first-day afternoon in the training seminar. USIT has three standard methods for the stage for analyzing frm different, compensating angles: They are Functional analysis, Attribute analysis, and Space & Time characteristics analysis, which are often applied in this order, but may be used in different orders. Actually, for the present case, the Instructor advised the group to apply the Time-characteristics analysis first of all, with the intention of making the problem situation clearer in terms of critical timings.

### 3.1.1 Time characteristics analysis

In this analysis USIT suggests to draw some graph of system characteristics with respect to time. Following the suggestion, the group drew a schematic graph as shown in Fig. 5, where the ordinate was chosen to be the degree of being unsteady and apt to fall over., while the x axis was time. Various timings were shown qualitatively in the graph. Five dangerous timings were listed: timings of mounting, starting off, suddenly braking, stopping, and getting off. Thus it was clear that the subsequent analyses should be focused on the problems at these dangerous timings.

**Fig. 5. Time characteristics analysis**



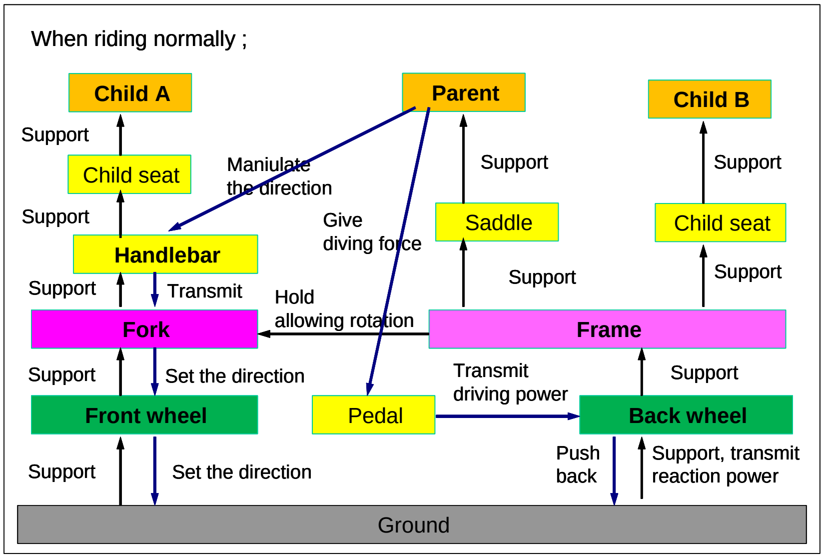

### 3.1.2 Functional analysis

Functional analysis is an important tool in USIT. Functional analysis in USIT intends to clarify the functional mechanism of the current system in its original design, leaving the causal relationship of unwanted effect to be revealed at the next step, i.e., Attribute analysis. USIT advises to select the most important object in the current system and put it at the top of the Functional diagram, and then to draw other objects one by one so as to reveal the intended useful functions.

The group tried to draw the functional diagram but only half finished during the seminar because of spending time in other analysis methods. During the training seminar the group members had the impressions, e.g., 'Drawing the Functional diagram is not so easy especially because USIT has particular guidelines to put the more important objects at the higher positions', 'Functional diagrams are rather complex and do not reveal new findings', and hence they were not well convinced with the usefulness of the Functional analysis in the present case.

In the present case, the functional diagram should have two children and parent at the top, and the bicycle frame, wheels, etc. at the lower positions. The diagram shown in Fig. 6 was drawn after the seminar and refined recently. It shows the functional relationships of various bicycle components. The diagram is particularly complex because the child in the front seat is held on the handlebar which is held to the frame allowing rotation.

**Fig. 6. Functional analysis: Parent carries two children on a bicycle**



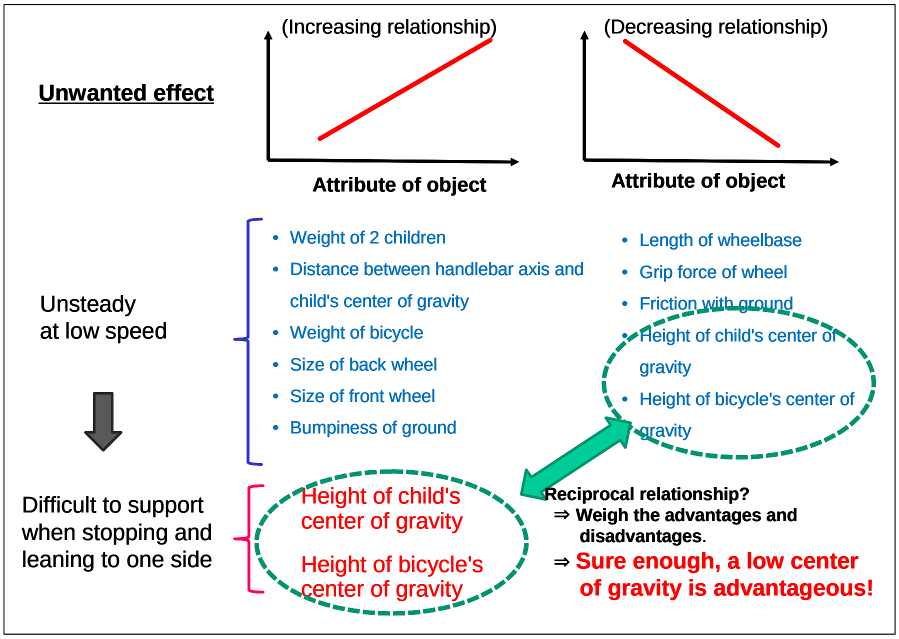

However, once the diagram was completed as shown in Fig. 6, it was well understood. In the diagram the upward arrows show the functions to 'support' the parent and the two children on a structure having two wheels, while the downward arrows represent two functions originated by the parent, i.e., 'give driving force' and 'manipulate the direction of driving'. As you will read later in this paper, an important direction for improving our solution concept after the seminar was to support the child sheet A (in front of the parent) with the bicycle frame itself, instead of the handlebar or the fork shaft. This conceptual direction, even though coming to our mind via different route, can be seen quite natural for improving the functional relationships in Fig. 6.

### 3.1.3 Attribute analysis

USIT uses Attribute analysis to reveal causal relationships which either cause/enhance or prevent/reduce the unwanted effect in the current system. For the purpose USIT uses a graphical representation as illustrated in Fig. 7. The ordinates of the two preset graphs are taken to express the degree of the unwanted effect, while the abscissa are chosen as various attributes of various objects in the current system. An Attribute, in the sense of USIT, is a category, not a value, of property of an object. The problem solvers are requested to list up various attributes of relevant objects one by one and to classify them either having enhancing/increasing or reducing/decreasing relationship with the unwanted effect expressed in the ordinate. The graphs may be regarded just qualitatively. If you find any attribute which behaves in a particular way, you should list it up and pay special attention to it.

Fig. 7 was made by the group during the seminar.

**Fig. 7.  Attribute analysis**

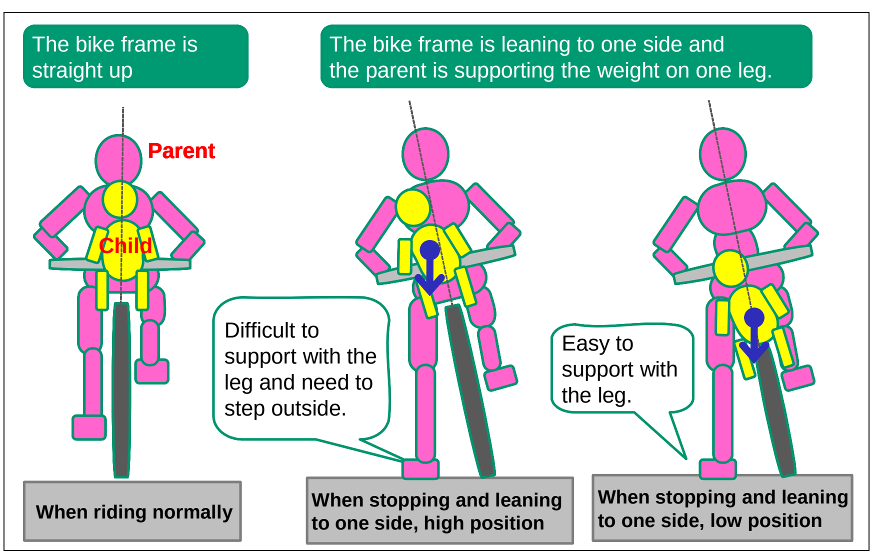



An issue which needed special discussion in the seminar group was the effect of the height of child's center of gravity. There was an argument that the high position of center of mass is more suitable to manipulate a bicycle, running even at a very low speed, with the handle operation. On the contrary, when the bicycle stops and is leaning to one side, the high position of the center of mass (of children) causes a larger problem. Even though the latter case was regarded more important in the group discussion, some members were not so convinced during the seminar.

### 3.1.4 Space-characteristics analysis

For clarifying the effect of the position (height) of the children, a drawing was made after the seminar (Fig. 8). This is a front (or back) view of the bicycle together with a parent and a child.

**Fig. 8. Effect of the high and low positions of the child at a critical timing**



When the parent rides the bicycle normally (see the figure left), the height of the child position is not a matter. The two other scenes capture the critical timing when the bicycle stops and the parent is trying to support the weight of the bicycle and children with her one leg. If the child is at a high position, its weight is loaded more on the parent's leg and even outside of the foot position, causing the difficulty of supporting. On the other hand, if the child is at a low position, the child's weight can be supported easily. Since this drawing shows the most critical timing of injury, we have been definitely convinced to choose the lower position of children on the bicycle.

During the training seminar the group discussed on this issue only with the side views of bicycles, just like the one in Fig. 4. The front view shown in Fig. 8 was much more persuasive. This is a simple but good example of seeing a system from another (appropriate) standing point. This drawing may also be regarded as an application of Space-characteristic analysis in USIT, where the characteristic nature of the system with respect to Space is to be revealed with some appropriate graph/drawing/figure/etc.

## 3.2 Understanding the Ideal system

USIT requests us to obtain the understandings of the Ideal system for the present problem. In the 2-Day Training Seminar this stage was performed in a session on the second-day morning by use of the Particles Method.

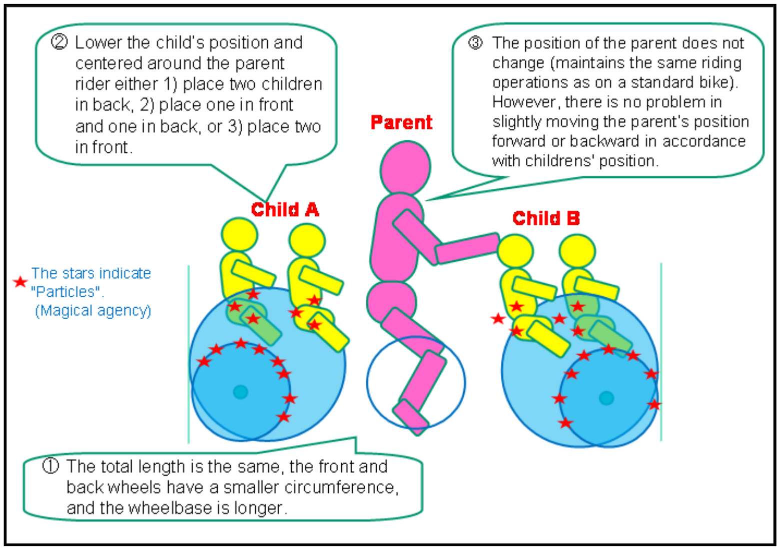
### 3.2.1 Make an image of the Ideal system

In the Particles Method, USIT requests us first to make an image of the Ideal system for the present task and to sketch it. On this request, beginners often think "We cannot draw such an image of Ideal system because we do not find solutions yet". But Ed Sickafus, the developer of USIT, tells us "Try to draw the image of the Ideal result without drawing any means to achieve it". In the Problem definition stage, we have made a Problem statement which declares our goals or our tasks to achieve. Thus the Ideal system here is the image of the result that the goal is achieved. Even though we do not know any means to achieve such a result, we should be able to make a clear image of the final result.

In the present case, our goal is 'A mom's bicycle for safely carrying two children'. Thus our Ideal system should be: An Ideal Bicycle on which a mom can carry her two children safely. This is clear in the verbal form. But USIT requests us to draw a sketch of its image. In the training seminar, the group members tried to draw various sketches of 'an ideal bicycle'. But they found the task rather difficult. Even though they could sketch some nice design of a bicycle, it would just be an example of possible solution, whose feasibility and performance need to be examined later. The image of the Ideal system must not be a concrete but an abstract image of the bicycle design.

Among the drawings in the seminar, there was an 'unfinished' drawing. It showed the parent, a child in front, a child at back, a pedaling space, and two wheels, only; no bicycle body including the frame, handle, fork, pedal, seats, etc. were drawn yet. After the seminar the unfinished drawing was refined as shown in Fig. 9.

**Fig. 9. An image of Ideal system**




The intention of the drawing is explained in the figure. (1) The front and rear wheels have smaller diameters, the total length is the same, and the wheelbase is longer, in comparison with the current standard bicycles. (2) To lower the children's positions and to place two children around the parent rider either (a) both two in back, (b) one in font and one in back, or (c) both two in front. (3) The position of the parent may be adjusted slightly depending on the children's positions. It should be noted that this figure is abstract in its nature and can represent an Ideal system. One can imagine many different designs of bicycle frame, seats and supports, handlebar, driving mechanism, etc. You may also imagine tricycles by doubling either front or rear wheel. As a matter of fact this drawing can cover most of the solution concepts we have found later.

### 3.2.2 Apply the Particles, the magical agents

Then USIT suggests to compare the sketch of the Ideal system with that of the current system and to put the x marks at the places where there are differences. In Fig. 9, the current system is shown with larger wheels. Thus the x marks are placed at the smaller wheels and at the seat positions of children.

In USIT these x marks are now regarded as the 'Particles', i.e., the magical agents which can perform any desirable behaviors and can have any desirable properties. They may be any substances and/or any fields in the sense of TRIZ. Supposing such magical agents, we may ask them to perform any desirable behaviors and may imagine them having any desirable properties. After expressing such desirable behaviors and desirable properties in the following sub-stages of understanding the Ideal system, you may go ahead to think of ideas to realize them next, in the stage of Solution generation.

### 3.2.3 Desirable behaviors of the Ideal system

During the seminar the desirable behaviors of the Ideal system were written down in the form of AND/OR tree diagram (Fig. 10) as recommended in USIT. At the top of the tree diagram, the goal statement of the current problem was set, and was broken down into statements of desirable behaviors. As shown in Fig. 10, the group described the desirable behaviors mostly while driving the bicycle at some speed or still moving at very slow speed. If we would redraw this diagram with the present understanding, the branch of 'Easy to return to a stable position by using the leg when the bike is leaning to one side' would be enhanced.

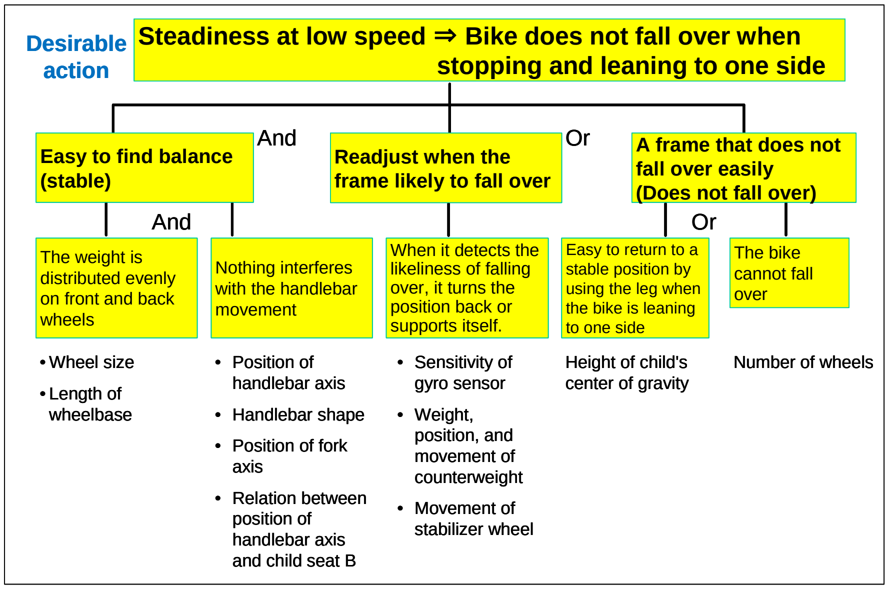



**Fig. 10. Particles Method: Desirable behaviors and desirable properties of the Ideal system**

### 3.2.4 Desirable properties of the Ideal system

The desirable properties of the Ideal system were thought of and listed at the bottom half in Fig. 10. At this stage, USIT recommends the problem solvers to list up as many and different properties as possible which may be desirable, without criticizing their feasibility, effectiveness, etc. Such properties may trigger ideas of solution in the next stage, i.e., the Solution generation stage.

## 4. Solution Generation

After performing the Problem definition and Problem analysis, we now come to the third, and last, stage in USIT, i.e., the Solution generation stage. In the 2-Day USIT Training Seminar, this stage was carried out in the second-day afternoon in three sessions, i.e., (1) Free idea generation, (2) Generalizing and systematizing the solution ideas, and (3) Building conceptual solutions.

### 4.1 Free idea generation

During the stages of Problem definition and Problem analysis, it is usual that group members have already come up with various ideas of solutions and thought of different approaches to the solutions. Thus, in the USIT Training Seminar the members were advised to write down all such ideas one after another. Each idea should be written in a Post-It Note; the idea should include a sketch or a rough drawing, some naming/keyword, brief explanation, etc. Group members wrote such ideas individually for 20-30 minutes and then showed them one by one to the group with brief explanation. Being stimulated with other members' ideas, members were encouraged to write associative ideas.

This process was carried out smoothly as usual because the problem analysis stage of USIT had already prepared much understanding of the reasons of unwanted effects, possible candidates of functions and attributes to be improved, desirable behaviors and desirable properties for a new system, etc. The ideas actually generated in the present case are shown in the figures in the next subsection.

Here we need a comment. Theoretically speaking, the tool of USIT in the stage of Idea generation is the System of USIT Operators [4]. The USIT Operators were derived by reorganizing all the solution generation methods in TRIZ, including 40 Inventive Principles, 76 Inventive Standards, and Trends of System Evolution, etc. It has 5 main operators and 32 sub-operators. The USIT main operators are: Pluralization of objects, Dimensional change in attributes, Distribution of functions, Combination of solution pairs, and Generalization of solutions. All the sub-operators have simple guidelines and a lot of application examples. Thus applying USIT Operators is not difficult for USIT practitioners, but is not practical for trainees in the seminar. It takes time for a USIT student to master the USIT Operators just as for a TRIZ student to actually use the 40 Inventive Principles. For these reasons, USIT Operators were taught in the Training Seminar, but were not explicitly used in the group practice.

## 4.2 Generalization and systematization of solution ideas

Then in the next session, the group members were advised to generalize the solution ideas and to systematize them into a hierarchical diagram of solution ideas. (Note: this is the direction of the USIT Operator: Solution Generalization.) In the present case study, the group built three sets of tree diagrams viewed from different aspects.

### 4.2.1 Solution ideas grouped with the timing

First, many solution ideas were built into a hierarchical diagram with the consideration of the timing of effective usage. This diagram was an extension of the tree diagram, Fig. 9, obtained in the Particles Method. Three dangerous timings were treated, i.e., when starting off (or driving at a low speed), when braking, and when getting off (or getting on). Since some solution ideas were found useful at multiple timings, the solution ideas were regrouped in Fig. 11 into 5 general solutions, i.e., (a) light pedaling, (b) a frame that does not easily lean to one side, (c) a frame that does not fall over when stopping and leaning to one side, (d) a handlebar that can become immovable, and (e) improved kickstand. Some more detailed ideas were listed in Fig. 11. The group marked the circles and triangles in Fig. 11 after evaluating the effectiveness of the ideas (see section 4.3).

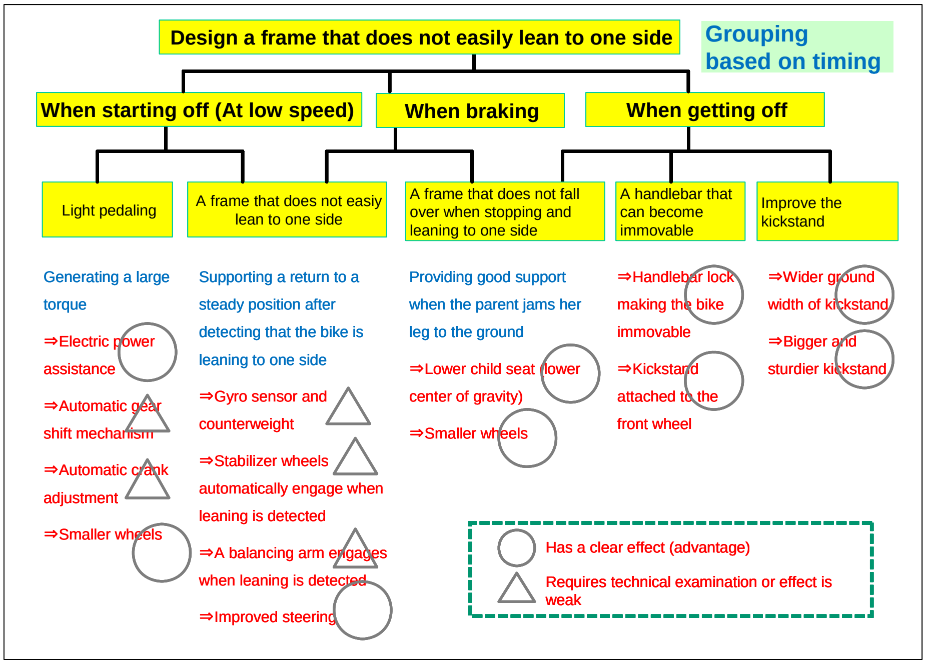



**Fig. 11. Solution ideas (1) grouped with the timing of effective use**

## 4.2.2 Solution ideas grouped with the positions of the child seats

As shown in the figure of the Ideal system, Fig. 9, one of the main focus of our attention was how to locate the two child seats at lower positions. Various possible arrangements were naturally grouped in Fig. 12 into three cases, i.e., (a) 2 in the back, (b) 1 in the back and 1 in the front, and (c) 2 in the front.

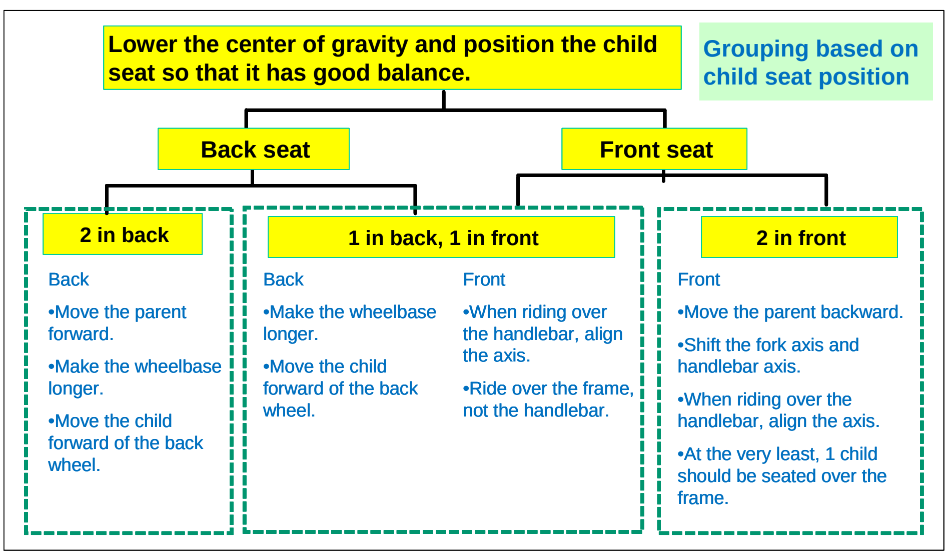


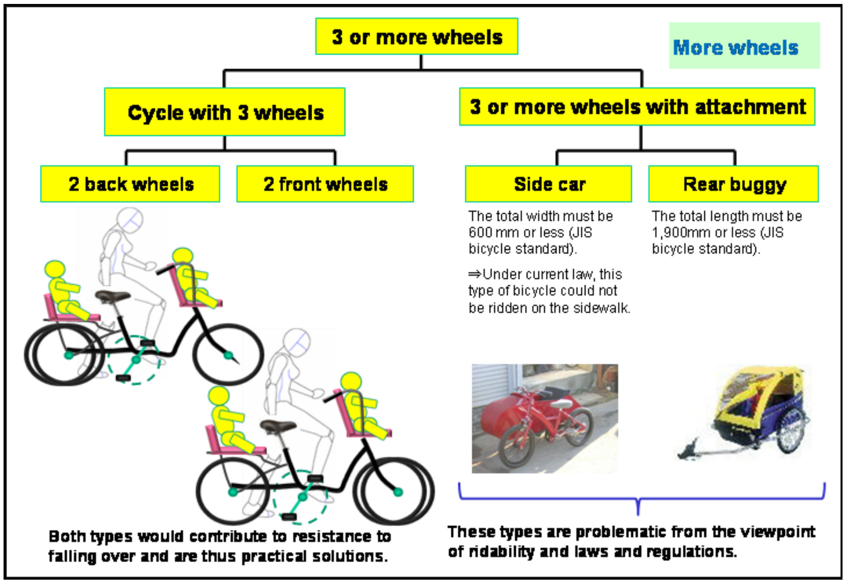

**Fig. 12. Solution ideas (2) grouped with the positions of the child seats**

The main issue here was how to locate or support the child seat in the front of the parent. The conventional way is to attach a child seat on the handlebar; this causes a heavy load for handling and uneasiness for the child. A new way recently developed commercially is to place the child seat on the top of the fork shaft of the front wheel; this partly reduces the load for manipulating the handlebar and also the uneasiness for the child. The seminar group thouht it desirable to support the child seat directly by the frame in the front position, but no good idea was obtained during the seminar.

### 4.2.3 Solution ideas having 3 or more wheels

The root cause of the present problem is well known as 'When a bicycle stops, it falls over without a support'. Thus it would be a natural solution direction to explore the possibilities of having 3 or more wheels within the framework of a man-power driving. The group also examined the solutions in this direction, as shown in Fig. 13.

**Fig. 13. Solution ideas (3) having 3 or more wheels**




The solutions of tricycles, having either two rear wheels or two front wheels, were found practical. Such solutions can be seen commercially, mostly for senior people to carry baggage. The known demerits of such solution is less operability especially in cornering.

## 4.3 Building conceptual solutions

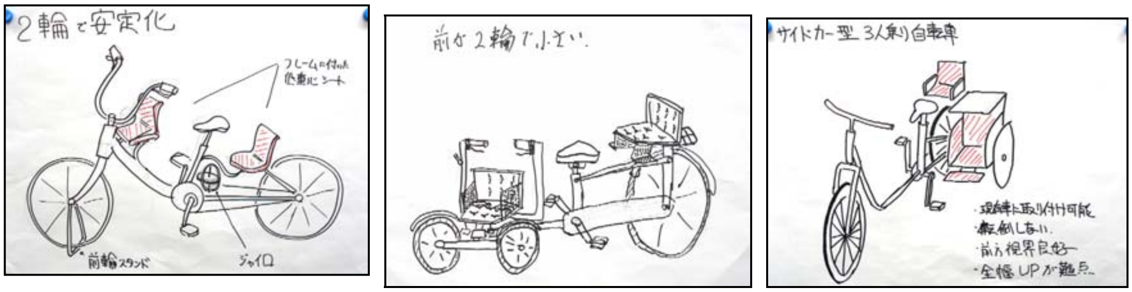
In the third session of the Solution generation stage, the group was advised (a) to quickly evaluate the solution ideas obtained so far, (b) to select several most promising solution ideas, and (c) to draw sketches of conceptual solutions built around the core ideas. (Usualy, the criteria for evaluation in (a) are a combination of effectiveness/usefulness, feasibility, novelty/uniqueness, economy, etc.; the weights of different criteria should be chosen properly depending on the intention of the problem solving in real cases.) In the present case, effectiveness, feasibility, and uniqueness were regarded as the main criteria.

### 4.3.1 Raw conceptual solutions at the end of the seminar

Within the limited time of about one hour, the seminar group worked out three conceptual solutions. Fig. 14 shows the original drawings of the three solutions. The first one is a basic-type bicycle with a front child seat fixed to the frame and installing a gyro for mechanical stabilization.

The second and third solutions are tricycles.

**Fig. 14. Raw conceptual solutions at the end of the seminar**

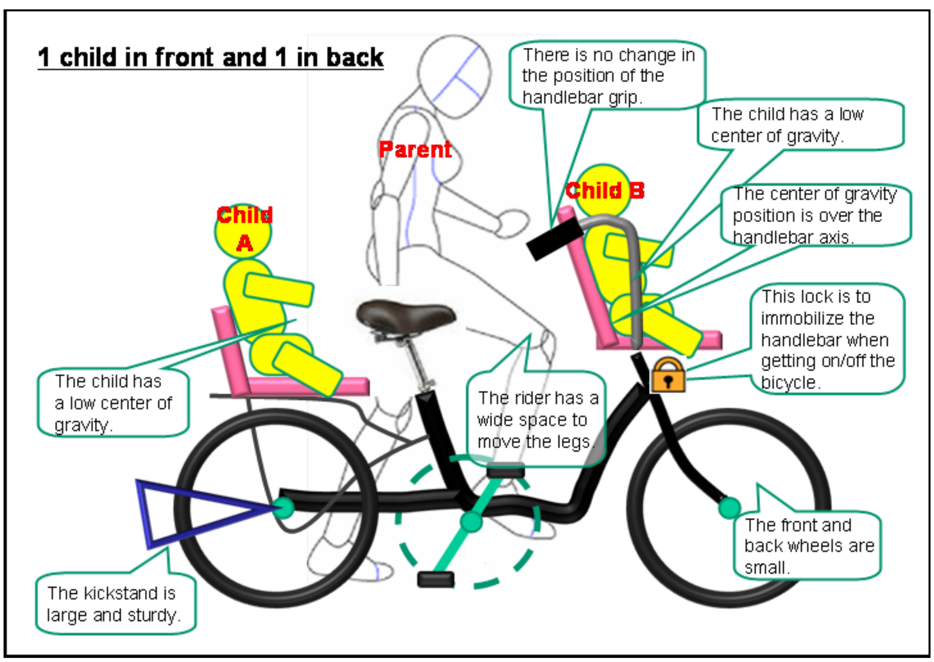



Frankly speaking, nobody was satisfied with the results obtained at the final stage of the training seminar. No new and effective solutions seemed to be produced by a group of non-specialists, even after a two-day workshop of group practice with USIT which provided good understandings of the problem. Thus we wanted to refine the solution ideas further while writing down the case study documents later.

### 4.3.2 A feasible conceptual solution

One trial was the refinement of the current system by introducing several ideas which appeared to be feasible and also effective especially at the critical timings. The sketch in Fig. 15 was thus obtained in a month after the seminar.

**Fig. 15. A feasible conceptual solution; improvement of the current system**




In this solution, the scheme of '1 child in front and 1 in back' is chosen because it seems best balanced and well established. Placing the child seats at lower positions while maintaining the operability of bicycle were the main points of consideration. The front child seat was chosen to set on the top of the fork shaft, following an up-to-date commercial design. A mechanism was introduced for locking the handlebar while getting on/off the children on the bicycle.

The ideas introduced in Fig. 15 seemed to be feasible and effective, and hence good for improvement. However, we understood that each component ideas might not be new.

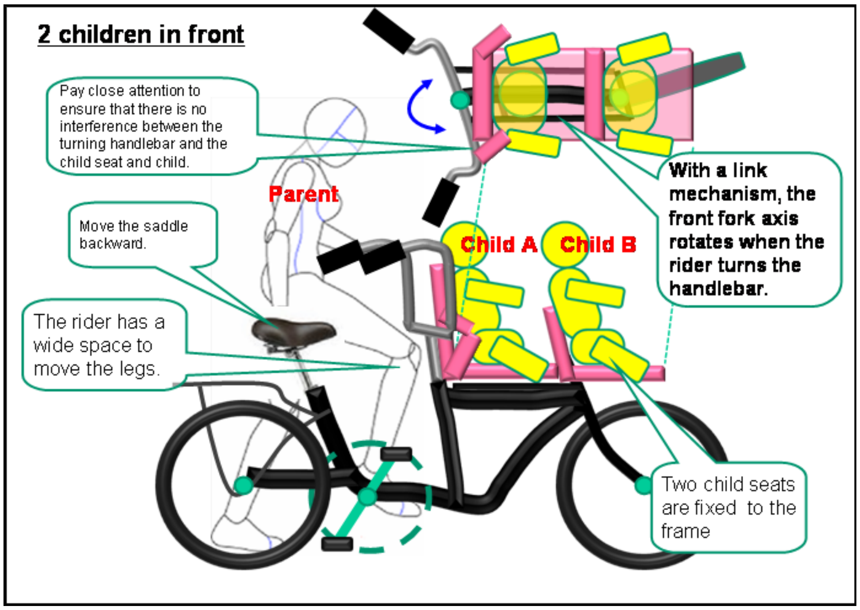
### 4.3.3 A new conceptual solution: separation of handlebar shaft from fork shaft

As mentioned in 4.2.2, a demerit of the front child seat in the current typical solution (Fig. 3) and also in the improved design (Fig. 15) was understood to be the fact that the child is moved/rotated whenever the handlebar is turned. This makes the handle manipulation heavy and unstable. Thus we thought it much desirable to support or fix the front sear directly to the frame of the bicycle. However, as seen in Fig. 14 for example, a primitive design may cause the difficulties of too narrow space for parent legs for pedaling and of interference of the handlebar with the child seat and child. Due to such apparent difficulties, we had not seen before a design of front child seat fixed to the bicycle frame.

After writing the first case study document we considered this problem seriously. We thought that the root cause of these difficulties was the limited distance between the parent seat and the front wheel in order for the parent to manipulate the front wheel orientation with the handlebar. Thus we reached a new idea of request for 'separating the handlebar shaft from the fork shaft of the front wheel'. The parent should be able to manipulate the handlebar in the ordinary posture, and the manipulation should be transmitted with some mechanism, to the rotational angle of the fork shaft. The separation of handlebar shaft from fork shaft has solved the contradiction!

The new solution concept was obtained in early July, as demonstrated in Fig. 16 in an exaggerated manner of '2 front seats'. Note that the essence of our idea was to fix a child seat to the front part of the bicycle frame and to separate the handlebar shaft from the fork shaft. This allows the space of one, two, or even more child seats in the front part of the bicycle. The scheme of '1 front and 1 back' is also a good implementation of our present solution concept.

**Fig. 16. A new solution concept: separation of the handlebar shaft from the fork shaft**




The merits of the present design are: (a) Child seats are placed at low positions to make the bicycle stable and safe from falling over, (b) Child seats are fixed to the frame and hence children are kept comfortable and safe independent of the handlebar manipulation, (c) Children have clear front view and can be watched by the parent all the time, (d) Handlebar can easily be manipulated without heavy load, (e) The leg space is taken large enough for pedaling, and (f) Baggage may be put at the back deck. Since this design is new in Japan, parents might want to get used to the operation of this type of bicycles. Thus it may be helpful in marketing to introduce the lease system with a test-use period.

## 5. Discussion

### 5.1 Activities of Japan Bicycle Promotion Institute

In mid July 2008, after having obtained our solution shown in 4.3.3, we noticed the activities of Japan Bicycle Promotion Institute (JBPI) in its Web site [8]. They announced a program on April 24, 2008 and called for proposals of prototypes of bicycles for safely carrying two children. They reported on July 8 that JBPI selected 12 proposals among 14 submitted ones and granted some R&D funds to the proposers to develop the prototypes by the end of February 2009. Most of the proposers are bicycle manufacturing companies, larger or smaller, in Japan.

The publicized 12 prototype designs contain various ideas mostly inside and some outside of our thoughts in the present case study. However, they have no ideas of (a) fixing the front child seat to the frame, (b) separating the handlebar shaft from the front fork shaft, and (c) placing two children in the front. In this sense we have found our conceptual solution obtained in the present case study is new and unique in Japan. We would like to have some opportunities of discussion with some people in JBPI and in bicycle manufacturing industries.

## 5.2 Bicycles in the Netherlands

In November 2008 Nakagawa visited the Netherlands for ETRIA TFC2008, and saw a unique type of bicycles. It has a boat-like container for two children between the front wheel and the rider. Mothers were riding the bicycles without any difficulty and the children in the container seemed comfortable and warm in the cold wind. One of such bicycles is shown in Fig. 17. The shafts of the handlebar and of the front fork are separated by about 1.5 m and are linked with a simple cantilever.

**Fig. 17. A bicycle in the Netherlands. (Photo by Nakagawa 2008)**

This design made us realize that there are many different ideas around the world and the ideas we obtained by ourselves were not new in the global scale. But it also convinced us that our own design is mechanically feasible and is operable without difficulty by ordinary mothers.

The boat-like container, however, would not suit in Japanese situations. Without mentioning the legal regulations, it is too long and large to ride on Japanese narrow roads and to park in front of houses, apartments, and shops. Thus we think something close to our idea shown above in Fig. 16 is appropriate.

As for a technology with a long history, such as bicycle technology, it is difficult to propose completely new ideas. However, in the present case study, we have found that even non-specialists can make adequate contributions and that TRIZ/USIT will act as a guide for them.

## 6. CONCLUSIONS

The present paper provides thorough documents of a case study of applying USIT to a real familiar problem. The case study was initiated as a group practice in a 2-Day USIT Training Seminar and later enhanced by email communications among the members and the instructor. With such an enhancement, the present study has obtained a meaningful conceptual solution in a real problem. The way of applying standard methods in USIT is explained in detail both at the level of actual group practice and at a higher level of instruction and later enhancement. Since USIT uses these standard methods in the whole procedure of problem definition, problem analysis, and solution generation, it is useful to master them through case studies. USIT is a simple, unified, and yet effective procedure in the family of the TRIZ methodology.

## REFERENCES


[1] Genrich Altshuller: "Creativity as an Exact Science", Gordon & Breach, 1984. (E)

[2] Darrell Mann: "Hands-On Systematic Innovation", CREAX Press, Ieper, Belgium, 2002. (E)

[3] Ed Sickafus: “Unified Structured Inventive Thinking: How to invent”, Ntelleck, LLC, Grosse Isle, MI, USA (1997). (E)

[4] Toru Nakagawa: 'Extension of USIT in Japan: A New Paradigm for Creative Problem Solving', 4th TRIZ Symposium in Japan 2008, at Laforet Biwako, Shiga, Japan, on Sept. 10-12, 2008 (J & E); TRIZ HP Japan, Sept. 2008 (J & E); TRIZ Journal, Nov. 2008 (E); TRIZCON2009, Woodland Hills, CA, USA, Mar. 16-18, 2009. (E)

[5] Toru Nakagawa: 'Education and Training of Creative Problem Solving Thinking with TRIZ/USIT', ETRIA TFC2007, at Frankfurt-am-Main, Germany, Nov. 6 - 8, 2007 (E); TRIZ HP Japan, Nov. 2007 (E & J).

[6] Toru Nakagawa: 'A System for Preventing from Our Leaving Things Behind -- A Case in 2-Day USIT Training Seminar --', TRIZCON2006: The 8th Annual Conference of the Altshuller Institute for TRIZ Studies, at Milwaukee, Wisconsin, USA, April 30 - May 2, 2006 (E); TRIZ HP Japan, Feb. 2006 (J), Jun. 2006 (E).

[7] Tetsuya Sudo, Hiroshi Sakata, Keiichi Hasegawa, Katsura Hino, Akira Kato, and Toru Nakagawa: 'USIT Case Study: A Mom’s Bicycle for Safely Carrying Two Children', 4th TRIZ Symposium in Japan, Laforet Biwako, Moriyama, Shiga, Japan, Sept. 10-12, 2008 (E & J); TRIZ HP Japan, Jan. 2009 (J).

[8] Japan Bicycle Promotion Institute (JBPI), URL: http://www.jbpi.or.jp/ (J).

[9] For example: http://www.npa.go.jp/bicycle/ (J)

[10] Tony Buzan: “The Mind Map Book”, Penguin Books (1996). (E)


Note: TRIZ HP Japan: abbreviation of "TRIZ Home Page in Japan", Toru Nakagawa, Editor, URL: http://www.osaka-gu.ac.jp/php/nakagawa/TRIZ/eTRIZ/ (in English)