ISSN (Print): 2077-7973
ISSN (Online): 2077-8767
10.6977/IJoSI.201409_3(2)

International Journal of Systematic Innovation

VOL.03, NO.02
September, 2014

Published by the Society of Systematic Innovation

Opportunity Identification & Problem Solving

ISSN (Print): 2077-7973
ISSN (Online): 2077-8767
10.6977/IJoSI.201409_3(2)

The International Journal of Systematic Innovation

Publisher:
The Society of Systematic Innovation

Editorial Office:
The International Journal of Systematic Innovation
6 F, # 352, Sec. 2, Guanfu Rd,
Hsinchu, Taiwan, R.O.C.
e-mail: editor@systematic-innovation.org
web site: http://www.IJoSI.org

International Journal of Systematic Innovation

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10.6977/IJoSI.201409_3(2).0001
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Designing a Multi-Color Display Adhesive Thermometer Based on the TRIZ Systematic Innovation Method

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Abstract

The electronic thermometer model presented in this paper has two unique features, first it is easily attachable to a spot and second it provides a continuous readout of temperature by a method combining visual and digital signals. It is derived from TRIZ Su-Field analysis and is termed a Multi-Color Display Adhesive Thermometer. It is mainly intended for use with sick children. It has been featured in many exhibitions, gained a Silver and two Gold Medals, and has been patented in the USA, China and the R.O.C. (Taiwan).

Keywords: Awards, Su-Field analysis, Continuous readout, Multi-Color Display Adhesive Thermometer.

1. Introduction

1.1 Motivation of the Research

Existing electronic thermometers (for instance the aforesaid three types) have a common flaw. They are unable to attach to the surface of a measured individual or article for showing the temperature at any time, only allowing single measurement of the temperature, where each use calls for a repeat of a like procedure (repeated resets, repeated approach of the measured target, and repeated holding of the thermometer). There is a demand for showing temperature at any moment, which can currently only be met by the sophisticated monitoring systems of some medical organizations, and all the aforesaid prior art electronic thermometers do not have this requirement available. Therefore, a thermometer of a novel structural combination absolutely needs to be invented to meet such usage. Note, the ability of the thermometer to stick to the measured individual for showing the body temperature at any time is most demanded by parents with young and small children. Young and small children will occasionally be sick, and this definitely requires some time (a couple of days) to rest for an earlier recovery. Currently, their parents attend to them day and night and must measure their temperature repeatedly to know if they are getting better. Such efforts by parents that have already looked after their sick children for a long time causes significant fatigue. The inventor deeply understood the suffering of the parents, motivating him to offer a thermometer that sticks to the measured individual, for showing the body temperature directly. Moreover, it can further show the temperature situation on the surface of the thermometer through a number and color generator, providing the caretaker with better control over the measured temperature. In the same measure, this thermometer can also be applied to the measured location of an article or a place once the temperature is demanded for observation at any time.

1.2 Field of the Invention

The present invention relates to thermometers which can attach to the surface of a measured individual or article for showing the temperature at any time

1.3 Description of Prior Art

As regards the drawbacks of the traditional mercury thermometers, electronic thermometers have gained in popularity because of the following well-known advantages: highly assured safety, short measuring time and handy viewing readout. Conventional electronic thermometers appear in various forms, for instance, a popularly seen electronic thermometer, where its front is provided with a sense unit, is placed in some part of the human body (mouth, armpit or anus) of the measured individual, to sense the temperature, and the sensed temperature is read from a display unit located outside the human body. Another electronic thermometer, also named an ear thermometer, has its cone-shaped sense unit inserted into the ear of the measured individual for sensing the temperature, and the readout is shown in its display unit. Aside from the aforementioned two electronic thermometers, there are many different types. For instance, for some organizations or places (kindergartens, schools or department stores) that are prone to contagious diseases, a forehead thermometer is used to aim at the forehead of someone entering to scan and read the body temperature within a short distance, enabling the identification of potential fevered persons of temperatures over 37.5°C, for further affirmation or elimination, the said infrared forehead thermometer is categorized as an electronic thermometer.

2. Literature Review of TRIZ Su-Field analysis model

Su-Field analysis is a modeling approach in TRIZ for analysis and innovation in product systems. Standards are the most effective method for providing a graphical model of a problem. Su-Field modeling of a technical system is performed in the operating zone, the area where the core of the problem exists (Clarke, 2005).

Su-Field analysis is a basic concept used to refer to a technical system and the process of assessing its completeness and effectiveness. Recognized as one of the most valuable contributions that TRIZ has to make, Su-Field analysis is used not only for modeling systems in simple graphics and identifying problems, but also for improving systems with standard solutions. A Su-field model can represent a system, a process or a subsystem. It can be constructed step by step by comparing a problem with a similar one in a corresponding category and applying the suggested solution. It is a process that makes problem-solving easy.

The model normally consists of two substances and a field, as shown in Figure 1. The term S2 represents an object that needs to be manipulated, and S1 represents a tool that acts upon S2. Either or both substances can be a simple, single component or a complicated, large system with many components, each of which can also be explained by individual Su-Field models. The field is the energy required that will enable the interaction. The states of substances can be in typical physical forms (e.g., gas, liquid and solid), interim forms or composite forms (e.g., aerosol, power, porous). Likewise, the field can refer to any one of a broad range of energy sources, be they mechanical, electrical, magnetic, gravitational, chemical, biological, thermal, acoustics, or optics.

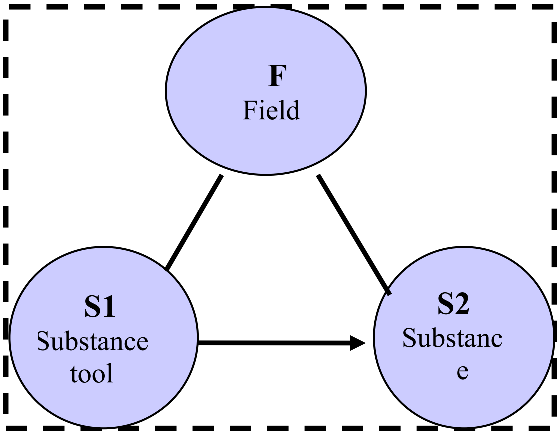

Fig.1. Basic Substances-Field Triangle Model

Genrich Altshuller and his colleagues, the creators of TRIZ, graphically represent a Su-Field model as a triangle. This is a simple and ingenious way to explain a technical system. Given the assumption the field is generated by a hidden substance, the triangle can be simplified into a dumbbell shape with the field indicated above the arrow and the relationship indicated beneath the arrow, as shown in Figure 2. There are four main types of relationship between the substances: useful impact, harmful impact, excessive impact, and insufficient impact. Among these relationships, useful and harmful interactions are the most common.

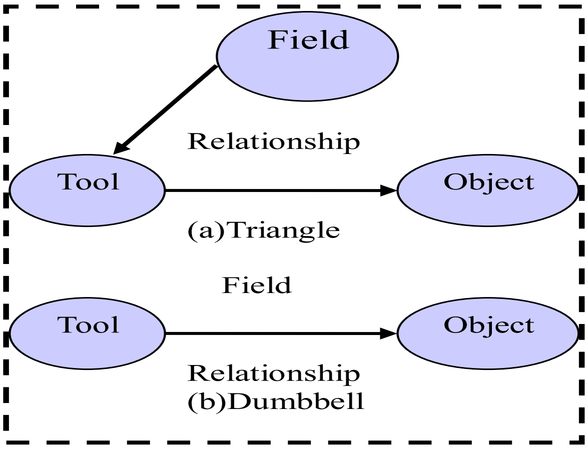

Fig.2. Basic Triangle and Dumbbell Su-Field Model

(Mao, et al 2007)

The Su-Field model is a fast and simple analytical tool for identifying problems in a system and for providing insights that help with the evolution of the system. Once a model is created, Su-Field analysis is used to determine if any of the three elements of the model is missing, or if there are any undesired effects in the system. Then, the analysis indicates the direction for improving the system. A complex system can be modeled using multiple, connected Su-Field models. Generally, there are four types of basic Su-Field models: (1) an effective complete system, (2) an incomplete system that requires completion or a new system, (3) a complete system that requires improvement to create or to enhance certain useful impacts and (4) a complete system that requires the elimination of some harmful or excessive impacts. (Terninko, 2000; Mao, et al 2007)

A series of articles began in the February 2000, issue of the TRIZ Journal, with a tutorial article about the Seventy-six Standard Solutions and the Class 1 problems and solutions. Class 2 appeared in the March, 2000, TRIZ Journal, Class 3 appeared in May, Class 4 in June, and Class 5 in July (Terninko, J., Domb, E., Miller, J. ,2000a; 2000b; 2000c; 2000d; 2000e). There are some applications in articles about the Seventy-six Standard Solutions (Shen, C.L.,2012; Chen, Y.Y.,2012; Hou, Y.H.,2012)

3. Innovative Concept for a Continuous Temperature Measured Device

3.1 Problem Description

Prior art electronic thermometers nowadays (for instance the aforesaid three types) have a common drawback, which is none can be attached to a spot on the body - or on an object - to give a continuous readout of temperature. What they all involve is an operation, a set of procedures, to measure a single moment's temperature. The procedural steps, repeated for each operation, are: set or reset the thermometer, place it on the required spot, hold it in place, and then inspect the readout.

3.2 Requirement Analysis

Note, the need for a thermometer that can be affixed to the body is one that is felt particularly important among parents caring for sick children. A period of care always includes the time the patient needs to recover and rest and the carer will want to monitor progress throughout by continuous temperature taking. The carer equipped to have continuous oversight of temperature has better control of a situation and can react accordingly as, for example, when deciding to treat a sudden rise in a child's temperature with antipyretics.

3.3 Function Analysis

The purpose of Function Analysis is to identify the key problems. The problem to be analysed, described in 3.1 and illustrated in Figure 3, is the thermometer cannot provide continuous readout of the temperature of a sick child. Thus, the function of the traditional thermometer, i.e., that is, the ability to measure and display temperature only at a single moment, is insufficient.

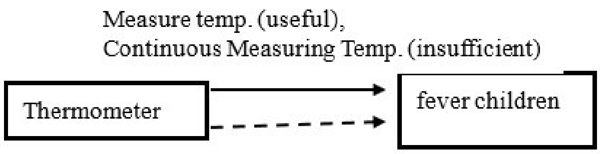

Fig.3. Function Analysis shows no traditional electronic thermometer can give a continuous readout of the temperature of a sick child

3.4 Applying Standard Inventive solutions

The algorithm for applying Standard Inventive Solutions is as follows: (Lin, Y.J., 2011; Ikovenko, S., 2010).

(1) Describe the key problem

Figure 3 shows no traditional electronic thermometer can give a continuous readout of a sick child's temperature, but only a measurement for a given moment. That moment, and each subsequent moment decided on, requires a set of measuring procedures (i.e., set or reset the thermometer, place it on the required spot, hold it in place, and then inspect the readout).

(2) Listing Interacting Components

In step 1, list all the substances and fields and the interactions relating to the problem. Then, the key problem is the existing electronic thermometer is not able to give a continuous readout of a sick child. There are two substances; the sick child and the thermometer. The field is thermal.

(3) Creating a Su-Field model

A Su-Field model of the engineering problem is created. Figure 4 illustrates the construction of a TRIZ Su-Field analysis model, which is based on Function Analysis. There are two substances in the model. The sick child is represented as an objective substance termed S2, and the thermometer as a tool substance termed S1. The thermal field, that is, the temperature of S2 (the sick child) delivered to S1 (the thermometer), is termed T. S1 detects S2 is insufficient information. Figure 4 depicts the model of the problem.

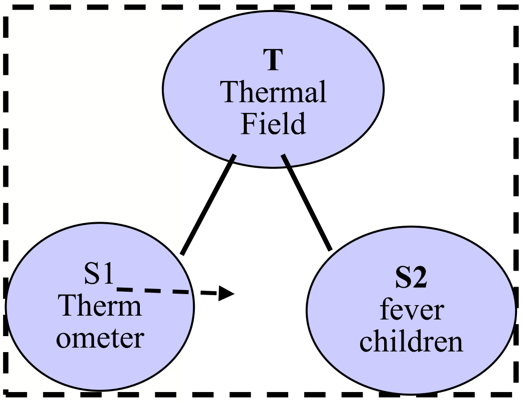

Fig.4. Model of problem for Situation in which Continuous Measuring of a Child's Temperature is lacking

(4) Solution in the model

Write the standard inventive solution applicable for solving the problem

As for the Standard Inventive Solution 4.5.1 of Su-Field analysis, the solution provided by the model is a transition to bi- and poly-systems. If a single measurement system does not give sufficient accuracy, use two or more measuring systems, or make multiple measurements.

(5) Creating a new Su-Field Model

This paper uses the method (i.e., Standard Inventive Solution 4.5.1 of Su-Field analysis) to introduce two new substances into the model and thus creates a new Su-Field Model of the engineering problem. The Standard inventive solution identified in step (4) is then applied. Introducing two New Substances, i.e, the "adhesive material" S3 and the "multi-color display" S4. With regard to the Standard Inventive Solution 4.5.1, Figure 5 shows the solution provided by the model is to introduce an external complex Su-Field. As a result of this introduction, S3 and S4, S1 and S2 are brought into continuous contact and multi-color display. Given the caring parents can continuously know the temperature of a sick child, they are better able to decide on treatment.

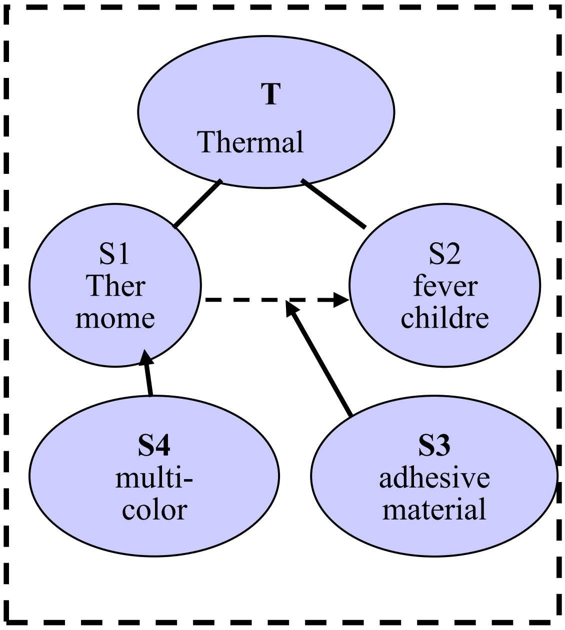

Fig.5. Model for Solution to Situation in which there is no Continuous Measuring about a child's Temperature.

(6) Describe the solution

The solution is described for implementing the created Su-Field Model.

The adhesive material makes it possible for the thermometer to be continuously attached to the sick child and for the display unit with number, color change to signal temperature changes as they occur. A Multi-Color Display Adhesive Thermometer was designed.

4. Present Achievements

4.1 Multi-Color Display Adhesive Thermometer Design

To achieve the foregoing objects of the present invention, the techniques adopted and the achievable functioning are described in detail with reference to the following preferred exemplified embodiments and the accompanying drawings, which help in thoroughly comprehending the present invention.

Figs. 6 and 7 illustrate the general picture of the Multi-Color Display Adhesive Thermometer, which comprises a three-part display unit, attachment unit and sensory unit [thermometer]. The display and sensory units are joined horizontally in the form of a rectangular parallelepiped with the display unit uppermost and face-up, along with a sound generator and a switch (in the preferred form of a thin-film switch). The sensory unit is lowermost and face-down. The area of the uppermost part is larger than that of the lower part, with the difference forming a rebated edge. The rebate allows the parallelepiped to sit in the opening of the flat pad by pressing to fit and that fit is helped by the edges of the opening having a covering of adhesive.

The surface that does the sensing is face-down on the part of the skin where it is affixed. When the power is switched on, the sensory unit measures the temperature and conveys the result to the display unit, signalling it in two ways. As can be seen in Fig. 6, the first signal is visual, given in digital form (e.g., 36°C, 37°C, 38°C, 39°C or 40°C --etc.) on the screen on the left while the second signal is a Multi-Color Display, provided by the status sound generator on the right.

This nature of the Multi-Color Display signal is designed to vary according to temperature. For instance, a temperature below 37°C might be displayed by a green light, a temperature between 37°C ~ 39°C by a yellow light and a temperature over 39°C by a red light.

The parallelepiped is brought into contact with and held in place at the desired spot by a holder, i.e., the flat adhesive pad. At its center, this pad has a rectangular opening, the edges of which have an adhesive covering. There is also an adhesive covering on the underside of the pad. The thickness of the lower part of the parallelepiped and the pad are roughly the same.

During assembly, the indented edge of the parallelepiped (the combined display and sensory units) is firmly press-fitted into the opening of the flat pad and the adhesive round the opening helps the close fit. The adhesive side of the pad, i.e., the down-facing side, is shielded by a temporary protective strip to prevent air contact. When ready for use, simply tear off the protective strip and attach the pad by its adhesive side to the desired spot on the skin of the patient, say to the forehead.

The protective strip can be either a single full-length one attached at one end of the flat pad or two half lengths attached one at each end of the pad, with an overlap in the middle. In the example illustrated here (Fig.7), the type of strip is two half lengths, but the full length, or even a strip divided in other ways, would serve the design just as well.

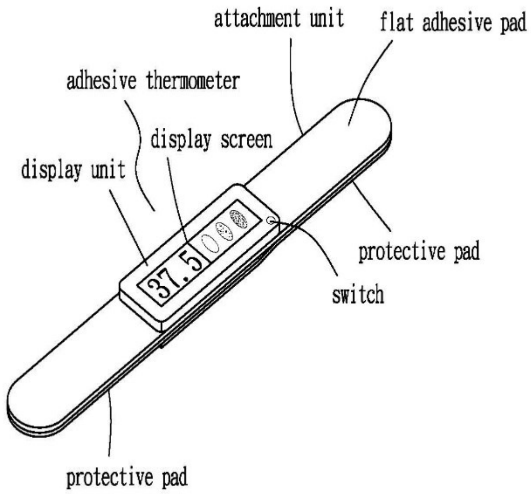

Fig.6. Exploded view of Multi-Color Display Adhesive Thermometer

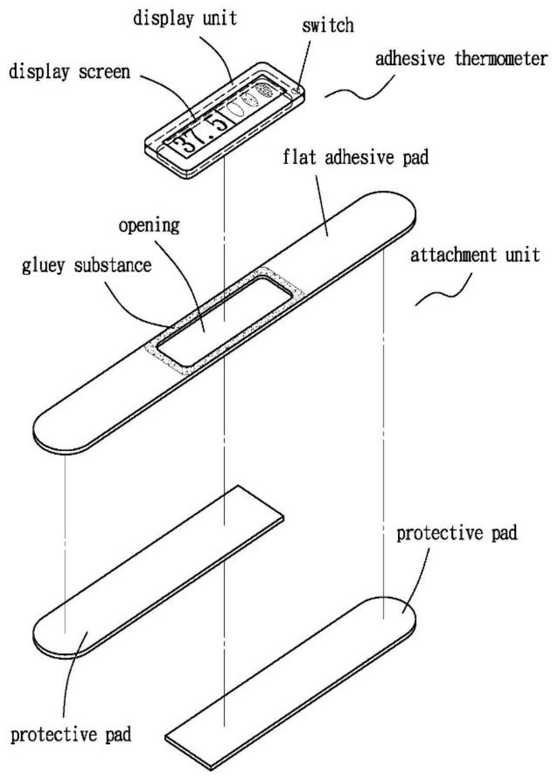

Fig.7. Decomposed view from Above of the Multi-Color Display Adhesive Thermometer

The combined display unit/sensory unit/attachment unit parallelepiped, shown in Figs. 7, is assembled at the factory stage, as shown in Fig 6, and wrapped and sealed airtight, ready for use. The parallelepiped is provided with electric power (e.g., by a thin battery cell) and an on/off switch to operate the units. The preference is for a somewhat concave switch to prevent unwanted contact with other surfaces.

4.2 Awards

The device has featured in many exhibitions and has earned the following awards: 1. Silver Medal at the "2012 Moscow International Salon of inventions and innovation technologies" (Please see Figure 8). 2. Gold Medal at the "ANDI Invention Awards 2012". (Italian Exhibition of Inventions) (Please see Figure 9). 3. Gold Medal with mention at the "2011 5th International Warsaw Invention" (Please see Figure10).

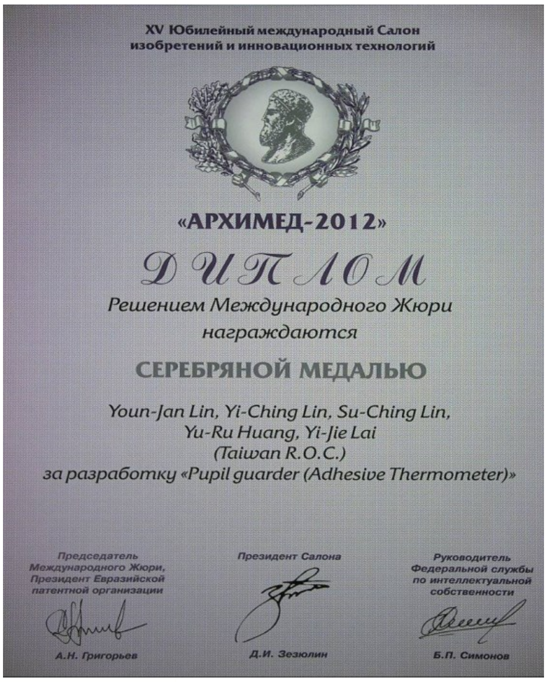

Fig. 8. "2012 Moscow International Salon of inventions and innovation technologies". Silver Medal Awarded

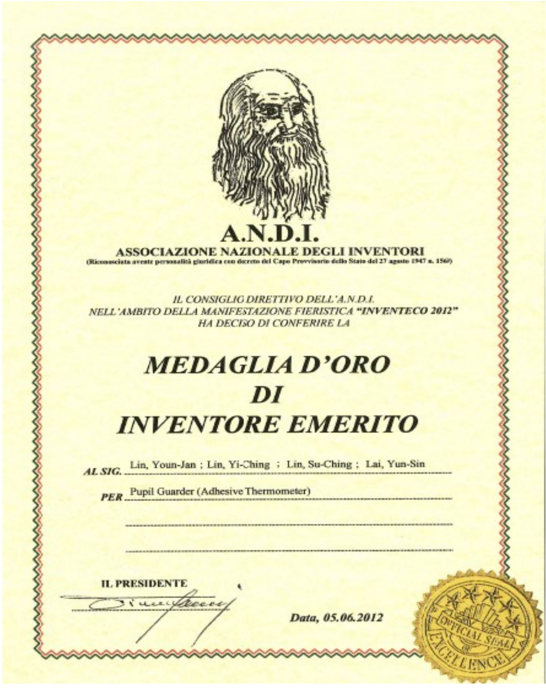

Fig. 9. "ANDI Invention Awards 2012". (Italian Exhibition of Inventions) Golden Medal Awarded

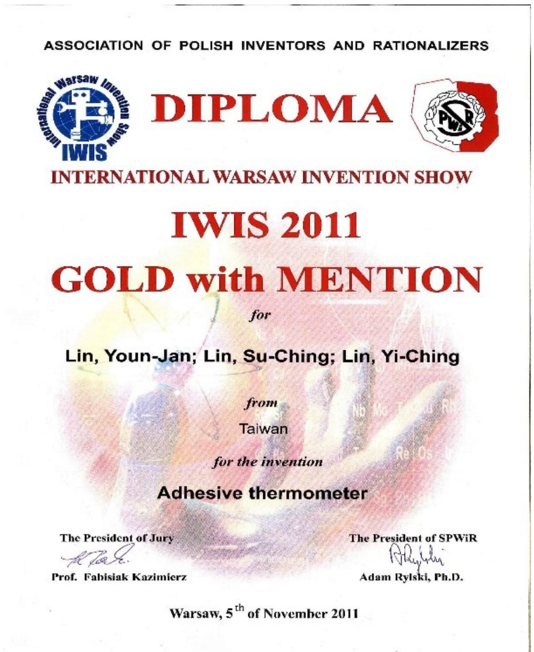

Fig. 10. "2011 5th International Warsaw Invention". Gold Awarded with me

5. Conclusions and Suggestions

Traditional electronic thermometers to date suffer a common drawback. It is not possible to apply them to a spot on a surface to be measured - be that to the skin of a person or the surface of an object – and obtain a continuous readout of temperature. The restriction is they can only give a moment –in-time readout, with each moment-in-time requiring a set of repetitive procedures. Young children will from time to time fall sick and require care at home – perhaps for days - by parents who might wish to take their temperature frequently.

In this study, the TRIZ Su-Field analysis model I construct has two substances. The sick child is represented by the objective substance termed S2, and the thermometer is represented by the tool substance termed S1. The thermal field, which is the temperature delivery from S2 to S1, is termed T. S1 continuously measures that S2 is providing insufficient information, and therefore the attached material S3 and multi-color display device S4 are introduced between S1 and S2. With S3, a continuous connection is made between S1 and S2 and with S4, a multi-color display is made between S1 and S2

Parents can know the temperature of their child at any time. Thus informed, the parents can treat the sick child accordingly.

For instance, a temperature below 37℃ might be displayed by a green light, a temperature between 37℃ ~ 39℃ by a yellow light, and a temperature over 39℃ by a red light.

This thermometer, an innovative design, integrates Su-Field analysis, Inventive Principles 32 color change.

The device consists of a multi-color display adhesive thermometer for affixing to a place on the skin of a person or the surface of some object to give a continuous readout of temperature in both digital and Multi-Color display forms. It comprises a sensory unit, a display unit and an attachment unit. The display and sensory units are joined horizontally to form a rectangular parallelepiped, the first on top of the second. The attachment unit consists of a sanitized adhesive pad which is the holder for the parallelepiped. The underside of the pad is covered with a temporary protective strip. In use, the protective strip is torn off and the pad is then applied to the desired location to sense the temperature. The display unit receives the temperature and signals it in two ways, by a visual signal (numerals) and an auditory signal (bleeps).

The display and sensory units may be safely reused within their lifetime, but the attachment unit must be disposed of after each use and replaced.

The invention has been patented under the name Adhesive Thermometer in the following jurisdictions: in the US as no. 8,061,891 B2; in The People's Republic of China as no. ZL 200810226181.4; in the R.O.C (Taiwan) as no. I377047. It has featured in many exhibitions and has gained a Silver and two Gold Medals.

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Youn-Jan Lin is a Professor of Ming Hsin University of Science & Technology(MUST) in Taiwan. He has taught in MUST since 1996.

He earned his PhD degree from the Department of Civil Engineering, National Taiwan University in 1995. He has licenses of PE in Hydraulic Engineering, Tour Leader of Chinese language, and etc. He is teaching in the Institute of Management. His areas of interests include Systematic Innovation including TRIZ, Green hotel, and Hot spring hotel. He received the “Greatest Teacher’s Award”, the highest honor recognizing the national most outstanding faculty from the Private Education Association in 2006. He got 46 patents and his inventive devices have featured in many exhibitions and has earned 45 awards, for example, as follows: 1. Most popular query prize at the “2006 Taipei International Invention Show and Technomart” in the National Science Council Exhibition Hall. 2. Golden Medal at the “2010 Moscow International Salon of inventions and innovation technologies”. 3. Gold Medal with mention at the “2011 5th International Warsaw Invention”. He was awarded “Lifetime Achievement of Invention” and “Pride of the Nation Inventor” that are co-awarded from Taiwan International Invention Award Winners Association and Golden State University of USA in 2009. He was one of Elastic Salary Prize Winner for Special Outstanding Talent in 2011 in the field of “Design, Cultural innovation, Hospitality and Leisure”, awarded by Ministry of Education.

Teaching Disadvantage as an Appearance of Contradiction in Basic TRIZ Education

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(Received 19 July 2014; final version received 31 December 2014)

Abstract

In order to simplify realizing main categories of TRIZ and shorten the learning curve for basic TRIZ education, a new instrument is suggested. This instrument is based on the concept of disadvantage (DA) as a shortened and easier understandable form of physical contradiction. We suggest a new classification of DA that are generalized in five groups depending on the kind of critical resource of a system: Substance, Field, Time, Space, and Function, with total 30 typical DA. By analyzing the data about 5000 known inventions that came to the market, we have found most typical inventive principles, standards and trends known in TRIZ that are frequently used for overcoming each type of DA. The new tool links typical disadvantages to corresponding principles, standards and trends. Our practical experience of TRIZ education (in the form of coaching) demonstrates that the students better realize the studied TRIZ tools (trends, principles, standards), faster find the solution, and resolve greater percent of problems; therefore, the education becomes shorter and more effective.

Keywords: TRIZ, disadvantage, contradiction, principles, trends, standard solutions

1. Background

One of the main problems in TRIZ education is too long learning curve caused by considerable conceptual difference between TRIZ and classical engineering disciplines. In particular, this difference appears in the TRIZ concept of contradictions in technical systems.

All main instruments of classical TRIZ (inventive principles, standard solutions, ideal final result, trends of engineering systems evolution, ARIZ) are based on general concept of contradiction in a Technical System (TS). TRIZ operates with several kinds of contradictions; among them, the most usable are Technical Contradiction (TC) that describes undesirable consequences of improving TS (if we do something with the system then we improve A but inevitably worsen B), and Physical Contradiction (PC) that describes opposite requirements to the same parameter of TS (the value of parameter P should simultaneously be big to achieve desirable result C and small to achieve desirable result D).

At the same time, our experience and experience of our colleagues demonstrates that the students, especially outside of the former USSR, and specifically in the Eastern Asia (Korea, China), hardly accept this concept that is in strong contrast with educational and even mental paradigms that dominate in these countries.

Indeed, in the Eastern and, with some stipulations, Western universities the future engineers study the Technical Systems (TS) as holistic objects that work in the prescribed manner, in order to satisfy some or other human need for which they have been developed, e.g. transportation, communication, protection from something, etc. This model does not consider the existence of any "contradictions" in the system. As a result, the TRIZ teachers (trainers, coaches, facilitators) may spend a lot of time trying to teach students the concept of contradiction, but be not much successive.

On the other hand, our experience demonstrates that if we present the same concept in a little bit different form, by changing the term "contradiction" for "disadvantage" (DA), most of students easily realize the key points of this concept. Indeed, for any engineer it is self-obvious that any technical system, from the simplest hand instruments to such large and complicated ones as a spacecraft or superliner, has some or other disadvantages, and their overcoming is usually the main task of a real-world engineering project. Thus, thinking in terms of disadvantages looks natural and does not cause mental abruption.

In this paper, we use the term "disadvantage" as a synonym for "undesirable effect". With the term "disadvantage", we underline the practical focus of TRIZ instruments: to get a competitive advantage, to make a new or improved system better than its previous variant; in other words, to suggest something that satisfies objective requirements to a system, not somebody's desires.

The above-mentioned word replacement changes nearly nothing in essence, as far as, according to the main positions of classical TRIZ, any disadvantage in the system is a consequence of some or other contradiction, and it can be reduced to this contradiction. The problem, in our opinion, is psychological: in a typical TRIZ educational program, the term "contradiction" appears too early, without proper background. Below, we suggest the concept of disadvantage as a key point of such preliminary education.

We have to note that nearly all programs of TRIZ education were originated from the USSR/Russia and became adopted (in most cases, implicitly, without any special stipulations) to the Russian mentality and specific educational system. In particular, for most of Russian (and former Soviet) engineers, contrary to their Western and especially Eastern colleagues, disadvantage in a system is so much "natural" phenomenon that it does not require special education. Another significant difference between countries concerns basic education: up to very recent years, Russian students of any specialty learned a special course of dialectics where the term "contradiction in a system" was one of the key points. Thus, for Russian students, learning "contradictions" looks quite natural and does not need any preliminary steps, whereas outside of Russia the situation is something different.

Thus, we suggest the concept of disadvantage-oriented education as a first, preliminary step to deep understanding the main TRIZ categories. At the same time, we found this approach quite sufficient for explanation and basic practical use of such TRIZ tools as inventive principles, basic trends of engineering systems evolution (TESE), and some of standard solutions. And after that – not before! – explanation of the term "contradiction" as a mechanism of "functioning" these, basically already known, instruments does not cause mental abruption by students.

Below, we suggest a new educational instrument that we widely use in our classes of basic TRIZ education: a handbook of typical disadvantages.

2. Prior art

The problem of shortening the "learning curve" is not new in TRIZ. The founder of TRIZ Genrich Altshuller made much effort to make basic TRIZ education faster and more efficient. One of the first attempts in this direction caused the development of the worldwide-known Contradiction Matrix (Altshuller, 1973 & 1999). The author analyzed many descriptions of the inventions and suggested the most popular inventive principles that were used to resolve technical contradictions with the same type of conflicting parameters. This instrument was then criticized many times (mostly, on the sidelines) for low practical efficiency, but up to now it remains one of the most popular TRIZ instruments available for beginners. A new version of this instrument was suggested in (Mann, 2004) where the list of conflicting parameters was extended for total 50 items.

Other classical tool that was developed with the same goal (to shorten the "learning curve") was a set of standard solutions (Altshuller, 1975 & Bukhman, 2014). The idea of this instrument was to simplify the use of rather complicated instrument, ARIZ, for the most typical problems that often have similar solutions. This tool also includes a classification based on Substance-Field modeling.

Standard Solutions and Inventive Principles are internally connected with each other. In (Domb et al., 1999), their relationship is described and tabulated: for each of inventive principles, the authors specified one or more standard solutions that use this principle. Essentially, the mapping table suggested in (Domb et al., 1999) can be considered as a new classification of standard solutions.

Similar solution was suggested by Fedosov (2009) to simplify teaching the concept of function: the author compiled a "handbook of elementary functions" that covered the majority of practical situation requiring functional analysis. Then, a rather complicated and error-prone procedure of formulation of particular functions was replaced for selection of proper function from the list. Similar idea was suggested in (Kynin & Priven, 2013).

If we try to integrate the basic ideas suggested in these and many other papers, we can formulate the "mainstream" of suggested solutions as follows:

(1) Specify the category which learning is difficult ("function", "contradiction", etc.);
(2) Suggest a new classification of this category basing on its key element ("conflicting parameter" for TC, "substance-field model" for standard solutions, etc.);
(3) Suggest a simple way of attribution of a particular problem to a corresponding class of this classification;
(4) For each class of the suggested classification, specify one or more typical (popular, frequently used) instruments that effectively work with this class of problems.

In this paper, we apply the same general strategy to disadvantages.

3. Relationship between disadvantage and physical contradiction

The concept of disadvantage is not somewhat foreign for TRIZ. The use of all known versions of inventive algorithms (ARIZ-85, ARIZ-CMBA, AVIZ, etc.) start from the description and definition of some "inventive situation" in terms of some or other inconvenience in the prototype, unsatisfactory complexity of performing the function, too high cost, etc. All of these issues characterize disadvantage of the existing system as the first, basic category to be analyzed. Then we convert the description into the "language" of parameters and build a TC for understanding of the causal link of this DA. Afterwards, we built a model of PC as a new heuristic single-parameter model where the DA is considered in the form "a parameter P should be big (for something) and small (for something else)". Then we build the next heuristic model of the DA on the base of concept of Ideal Final Result (IFR), with two key phrases: (1) my new system contains some "X-element" that causes disappearing the DA, and (2) the new system prevents the DA itself, without special intervention. The solution of this "equation system" (finding a common solution for all of these models) helps a solver to focus his/her thinking to search for a solution as some image, "portrait" of possible solution that overcomes the initial DA.

As follows from the above reasoning, the DA is a key category in the process of the development of a new TS, as far as the concept of DA is used in some or other way in all instruments of classical TRIZ: in TC, PC, IFR, standard solutions.

Basing on this general understanding, we suggest a rather simple classification of the most "popular" typical DA that force a solver to find a new inventive solution of a problem.

We have to notify that G. Altshuller tried to do something very similar in the Appendix 1 to ARIZ-85C (Altshuller, 1985 & Marconi, 1998) where he described 11 typical models of conflicts. Unfortunately, our experience shows that practical use of this classification in TRIZ education is rather difficult: the students very often confuse different kinds of conflicts, improperly determine their "sides", and, as a result, just "draw a picture" instead of understanding the nature of the conflict.

Again, we see the probable reason of this difficulty in psychology: the mentally negative word "conflict" is inconvenient and needs replacement. In our opinion, much more convenient and habitual language uses no "conflict" but "parameter". Such approach significantly simplifies education.

For example, it is very easy to describe the disadvantage of a pencil in the form: "long use of a pencil causes pain in fingers of an arm that holds it". After some analysis, we could formulate a TC that connects the time of use with some characteristics of the pencil itself, i.e. its hardness, and then move to a PC where this second parameter (hardness) is used: "hardness of pencil should be big to save the shape of pencil and small to avoid causing the pain in fingers".

Operating with the parameter "hardness" simplifies the search for a proper solution. However, to come to this "secondary" parameter we need considerable time and effort. At the same time, if we come back to the source formulation we can see that it already contains some parameter: time of use. In fact, we can rewrite this formulation in the form of PC: "time of use should be big (to write the required text or draw picture) and small (to prevent the pain in fingers)".

The experienced TRIZ specialists often call such PC-like formulas derived from the source problem formulation as "proto-PC" or "initial PC". The general recommendation is not to try to resolve this "proto-PC", as far as the information about the problem is often insufficient, and continue the analysis to formulate the "proper PC" (in our case, concerning the hardness of pencil). The same recommendation can be derived from the text of ARIZ (Altshuller, 1985) where the initial formulation should be transformed to a TC and only afterwards to a PC. Reasoning about "erroneous" intension to resolve PC without formulating TC can be found, for example, in (Goldovsky, 2014) where the author underlines limited application of such simplified approaches. We completely agree with the last statement and consider only the situation of basic TRIZ education within very limited time (1-2 working days for the course), as far as such time limit was specified by very many our customers.

Analysis of about 5000 inventions realized in the commercially successful products showed some essential relationships between the kinds of parameter mentioned in a "proto-PC" and particular TRIZ instruments (principles, trends, standard solutions) that typically allow resolving the problem. For example, the problem of expendable substances (that we can rewrite in a "parametric language" as "too high consumption of substance") is very often solved by using the trend "transfer to Super-system": pen transforms to computer (eliminating the ink), oven transforms to electric cooker (eliminating the fuel), etc. In other words, problems with similar disadvantages often have similar solutions.

Note that similar idea is indirectly used in the Functional Oriented Search (see e.g. Litvin, 2005): if a problem is properly formulated in the "language of parameters" then (after translation to the "language of functions") it is possible to find a solution in some far enough domain area and use its operation principle to improve the source system. In other words, there is a rather high probability to find similar (working!) solutions for systems with similar disadvantages initially formulated in terms of the same parameters.

Below, we describe a new instrument that integrates significant parts of our knowledge about DA and their connection with the instruments of classical TRIZ. Not using the term "contradiction" directly, this approach indirectly gets the students to understanding of the essence of this term, so that its further explanation appears "painless" and mentally appropriate.

4. Use of classical TRIZ tools in connection with typical disadvantages

As it was stated above, to practically use the idea of "similarity by disadvantage", especially in basic TRIZ education, we need some simple and convenient classification; in our case – the classification of disadvantages.

Earlier (Danilovsky, 2011), we suggested a new classification of disadvantages basing on the use of five general categories that are widely used in TRIZ: time, space, field (energy), substance, and function. This classification contained 36 typical DA. However, our experience in TRIZ consulting and education shows that six of them have never appeared in our projects (we tried to apply this approach backdating to several hundred previous projects). Thus, we consider reasonable to exclude these six types of DA from our classification to reduce the "information noise".

The suggested classification is presented in Table 1. This classification was derived empirically and, therefore, does not pretend to be complete. However, it covers an overwhelming majority (about 80%) of real-world problems that we resolved last time.

Table 1 List of 30 typical disadvantages.

##	Description
Substance	
1	Undesirable substance
2	Disposable substance
3	Low productivity of using substance
4	Low usable energy of substance
5	Need to remove substance
6	Insufficient control of substance flow
Field	
7	Undesirable field
8	High weight
9	High energy consumption when using
10	High energy consumption when preparing to use
11	High energy consumption when switching
12	Many moving parts
Space	
13	Big size when transportation
14	Big size when storing
15	Improper shape
16	Trivial shape (and color)
17	Small distance of useful action
18	No mobility
Time	
19	Short life time
20	Long time of charging
21	Small resource of autonomous work
22	Long preparation to use
23	Long operating time
24	Long learning curve
Function	
25	Needs correction function
26	Excessive level of function
27	Insufficient level of function
28	Insufficient additional functions
29	Insufficient reliability
30	Requires additional system

In the Table 2, we summarize the results of our analysis of about 5000 inventions realized in commercially successful products concerned different industries: household appliances and housewares (about 1700), car and machinery (about 1500), little consumer things and toys (about 800), chemistry and agriculture (about 350) and others (the rest).

Table 2 Most popular TRIZ tools recommended for overcoming the disadvantages specified in Table 1.

DA ##	Trends	Standard solutions (Altshuller, 1975)	Inventive principles (Altshuller, 1973)
1	Ideality MATCEM Harmonization	2.2.5, 3.1.5, 5.1.1.1, 5.1.3	2, 9, 10, 11, 22, 23, 24, 31, 34, 38, 39
2	Supersystem Macro-micro Ideality	3.2.1, 5.1.1.1, 5.1.3	13, 28, 35, 36, 25
3	MATCEM Conductivity Ideality	1.1.1, 1.1.4, 1.1.5, 2.2.2, 2.2.4, 3.2.1, 5.2.1, 5.2.2	9, 14, 18, 34, 38
4	MATCEM Macro-micro Ideality	1.1.2, 1.1.5, 2.3.1, 5.3.1	35, 36, 38, 39
5	Harmonization Supersystem Macro-micro	1.1.6, 3.1.3, 3.2.1, 5.1.3	1, 5, 6, 9, 10, 14, 16, 25
6	Completeness Harmonization Dynamization	1.1.3, 2.3.3, 5.2.3	1, 2, 3, 7, 15,13, 19, 20, 24, 25,31
7	MATCEM Macro-micro Harmonization	1.1.5, 1.1.6, 1.1.7, 1.1.8, 1.2.2, 1.2.3, 1.2.4, 1.2.5, 3.1.3, 4.5.1, 4.5.2, 5.1.1.1, 5.2.1, 5.3.3, 5.3.4	1, 2, 3, 7, 11, 17, 24, 35, 40

DA ##	Trends	Standard solutions (Altshuller, 1975)	Inventive principles (Altshuller, 1973)
8	Dynamization Supersystem Harmonization	1.2.2, 1.2.4, 5.1.1.1, 5.1.4	8, 15, 28, 29, 30
9	Supersystem Macro - micro Ideality	2.2.2, 3.1.1, 3.2.1, 5.2.1, 5.3.2, 5.3.5	35,36,12,28, 1
10	Completeness Conductivity Dynamization	2.4.1, 3.1.5, 5.1.1.1, 5.2.1, 5.4.1	9,23,15,17
11	Ideality Conductivity Supersystem	3.1.5, 5.2.1, 5.4.1	12,15,17,10,25,23
12	Macro – micro MATCEM Conductivity	1.2.2, 1.2.4, 3.1.5, 3.2.1, 4.1.2	9,10, 28,30, 35, 36, 26,13
13	Dynamization Ideality MATCEM	2.2.4, 3.1.2, 3.1.5, 5.1.4	7,15,17,28,29,30,35
14	Dynamization Harmonization Supersystem	2.2.4, 3.1.5, 5.3.1	7,18,17
15	Harmonization Dynamization Ideality	2.2.4, 3.1.2, 5.1.4	2,3,4,7, 15, 19, 23, 23, 28.
16	Ideality Supersystem Harmonization	2.2.4, 3.2.1	32,26
17	Completeness MATCEM Supersystem	3.1.1, 3.1.4, 5.2.2	19,20,22,8,23,28,35
18	Supersystem Dynamization Ideality	5.1.4, 5.4.1	2, 17,15,13
19	Harmonization Ideality Dynamization	1.2.3, 1.2.4, 3.2.1, 5.1.1.1	9, 10, 3, 29, 30,39,40,34
20	Harmonization Ideality Dynamization	2.2.4, 5.3.5, 5.1.1.1	1,10,12,7,18,23,34
21	MATCEM Macro - micro Ideality	3.2.1, 5.3.5, 5.4.1, 5.5.1	28,35,36,19,20,12
22	Supersystem Macro - micro Ideality	1.2.2, 1.2.4, 2.2.4, 2.2.6, 3.1.2, 5.1.1.1	10, 1,2,7,23,25
23	Completeness Dynamization Supersystem	1.1.1, 1.1.5, 1.1.8, 2.2.4	14,18,21,7,15,17, 2,9,10
24	Supersystem Completeness Dynamization	2.2.4, 2.3.1	25,13,20,17,2
25	Ideality Supersystem Dynamization	2.3.1, 2.3.2, 2.1.2, 2.2.3, 3.1.3, 4.3.2, 4.3.5, 4.4.2, 4.5.2	6,25,20,24,23,2,28
26	Harmonization Ideality Completeness	1.1.3, 1.1.5, 1.2.4, 5.1.1.1	19,25,23
27	Conductivity Completeness Dynamization	1.1.1, 1.1.3, 2.1.2, 2.2.2, 2.4.11, 4.2.2, 4.4.1, 5.1.2, 5.4.2	12,20,14,18,21,28,22,23,15,13
28	Ideality Completeness Supersystem	2.2.1, 3.1.1, 3.1.3, 4.2.1, 4.3.1, 4.4.1, 5.3.1	6,20,32,25
29	Completeness Dynamization Ideality	1.2.1, 1.2.2,1.2.3, 2.2.3, 2.4.3, 2.4.8, 3.1.1, 4.4.1, 5.1.1.1, 5.4.1	5,2,12,19,20,23,24,25,33,38,39,11
30	Ideality Harmonization Dynamization	1.1.3, 2.1.1, 2.2.3, 3.1.1, 3.1.4, 4.1.2, 4.2.1, 4.2.2,4.2.3, 5.1.1.1, 5.2.3, 5.4.1, 5.5.1	25,20,28,12

The table describes the instruments that get the tips how to come to these solutions from previous state of the system.

Like other tools of this kind, the suggested mapping does not pretend to be complete but suggests the recommended tools. The names and descriptions of inventive principles and standard solutions are omitted to save space.

5. Practical application

The suggested map of disadvantage overcoming tools was used in numerous educational courses and showed positive results. Our students were able to attribute particular problems to one or few of 30 typical DA after about just an hour of study. The use of the suggested principles and trends was available to beginners, right after learning corresponding tools. Standard solutions appeared not as easy in use, but in the basic (1-2 days) educational courses we did not even try to use them, as far as this instrument requires high enough qualification of a solver.

When explaining the procedure, we faced some common questions that students frequently asked. The discussions allowed students to better understand the essence of the inventive problems and, in fact, prepared them to learning next topics.

For example, a very frequent question concerns the choice of one of multiple disadvantages in the same system. For example, in the glasses they found three disadvantages: big size when transportation (#13), small distance of useful action (#17) and trivial shape (#16) – so, what to select? Our answer was: "*Which of them you consider the most harmful or uncomfortable?*", preparing them to the subsequent topic "Ideality".

Another situation. For an asphalt compactor, a student determined the disadvantage as "too small weight" that he could not find in Table 1 – but found the opposite term "high weight" (#8). Could he use it instead? Our answer was: "If small weight is a disadvantage, *don't you know how* to make the machine heavier? *Do you need new* *invention* for that?" After obvious answer "Of course not!", the students found a real disadvantage: "insufficient function" (#25). This procedure indirectly stimulated students to distinguish inventive problems from routine, easy-to-solve tasks and, therefore, to specify the real problems that include contradictions.

Now let us present one example of the students' work.

a **b** **c**

Fig. 1 Ideas of simple, cheap and always-with-you home night vision system
a: essence of problem (too dark room); **b:** use of the trend of completeness (adding a light source to an existing al-ways-with-you system); **c:** idea based on the principle #18 (use of mechanical vibration: switch of the light with under-floor/on-floor vibration sensor that detects waking-up).

The task was formulated as "to suggest idea of simple and cheap home night vision system that is always with you at night", with the physical contradiction (that was assumed although not sounded): *light should be bright to be visible, and it should be dim to allow sleeping*. The students attributed the disadvantage *of* the prototype system to the type 27 "Insufficient level of function". By using the instruments recommended for this type of DA they suggested several ideas; two of them are presented in Figure.

We have to note that, although this instrument was planned to use only in educational projects, in fact we also used it in our own projects as an auxiliary instrument. An example is presented in (Danilovsky & Ikovenko, 2014).

6. Conclusion

Our experience of teaching TRIZ in different countries demonstrates the critical need in much accelerating the basic courses of TRIZ. By analyzing possible causes of "long learning curve" problem, we came to a conclusion that most of existing educational programs are implicitly adapted to the specifics of Russian educational system and use some specific features of Russian mentality, which simplifies TRIZ education in Russia but complicates it in other countries and cultures. In particular, serious difficulties are permanently observed when teaching the concept of contradiction that is especially inconvenient in the Eastern countries.

To overcome this difficulty, we suggest the use of disadvantage as a key term, prior to learning the concept of TRIZ contradictions. Our reasoning is based on the strong relationship between disadvantage and contradiction as an outward manifestation and its internal cause. This relationship itself is well known in TRIZ, and it is well known that for inexperienced people, disadvantages are mostly much easier to formulate than contradictions.

However, practical use of this very basic concept in real-world TRIZ education required some additional instrumental support. As a supporting tool, we suggest a new classification of typical disadvantages (DA) accomplished with the "map" that connects each type of DA with particular instruments of classical TRIZ: principles, trends and standard solutions.

Basing the introductory course of TRIZ on the concept of disadvantage, instead of contradiction, considerably simplifies learning the above-mentioned tools of classical TRIZ (principles, trends and standard solutions) and does not cause psychological abruption by the students. By using this approach, the students are able to use these tools in their own practice from very beginning, without spending much time for learning the mentally "foreign" (for many of them) idea of contradictions.

Then, after students get some practical experience of the use of new instruments, it is much easier to explain them how these instruments work internally; this is a good time to teach them the concept of contradictions as a theoretical explanation of what they already can do in practice and why it works.

Thus, finally we get the same result (the students learn the concept of contradiction and try to use the instruments that help to overcome them), but without such undesirable effects as psychological abruption and long learning curve.

As a "side effect", the suggested method became effective in our own projects as well: it allowed saving some time when searching for the simplest solutions. An example of such solution is described above.

We believe that the suggested approach not only facilitates learning the classical TRIZ tools (trends, principles, standard solutions) but also allows better understanding of basic concepts of TRIZ.

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10.6977/IJoSI.201409_3(2).0003
D. D. Sheu, M. H. Tsai / Int. J. Systematic Innovation, 3(2), 16-31 (2014)

Systematic Organizational Conflicts Identification and Resolution Using Perception Mapping and Function Relationship Analysis

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Abstract

This research proposes a set of methods to analyze the relationship between people's perceptions and organizational goals and ultimately to identify and solve complex organizational conflicts using modified TRIZ Perception Mapping, Function Relationship Analysis, Solution Directions, and Business Inventive Principles. Organizational perceptions are usually fuzzy and obscure, making it difficult to detect conflicts in them. However, they may cause friction between colleagues and create significant negative impacts on organizational performance. This research proposes an augmented perception analysis and links organizational perceptions with phenomena and performance indices to form a function relationship diagram which enables a structured unequivocal identification of conflicts within an organization. TRIZ (Theory of Inventive Problem Solving) tools such as Cause Effect and Contradiction Chain Analysis (CECCA), Solution Directives, and Inventive (Business) Principles can then be used to locate root conflicts and resolve complex organizational problems.

Contributions of this research include:

(1) Enhancing Perception Mapping Method. An "Inhibit" relation is added to the existing "Lead to" relation. With the additional relaxation of a one-to-one relationship to multiple-to-multiple relationships and the introduction of organizational phenomena/performance indices into the perception map, this method is able to clearly identify organizational conflicts in a structured way. Objective logical reasoning instead of subject feelings can now be used to identify conflicts in complex perception relationships in organizations.

(2) Enabling us to link individual perceptions to organization performances through Function Relationship Diagram. It helps us identify which perceptions are causing performance problems, thereby allowing us to solve the root cause problems. It also helps us to locate the conflicts between people’s perceptions, enabling us to resolve or prevent friction.

(3) Adopting structured application of TRIZ technical tools such as CECCA, Solution Directives, and Business Inventive Principles on solving fuzzy business problems.

Keywords: TRIZ, Perception Map, Conflict identification, Conflict Resolution, Function Relationship Diagram.

1. Introduction

1.1 Background and Motivation

In today’s world, most organizations are not embedded with cohesion which meets the expectation of the entrepreneur; rather than the entire benefit of the organization, members of each department usually put much emphasis on the goal and benefit of their own department. Thus, members from different departments have different thoughts, different goals, and diversified interests. The above differences result in internal conflicts to certain degree; hence, the whole performance of the organization is undermined.

This research mainly strengthens the Perception Mapping methodology of Darrell Mann. It probes the different requests and thoughts of members from different departments from a humanistic viewpoint and investigates whether these differences have influences on performance. This approach distinguishes and manages internal conflicts of the organization on a whole.

1.2 Research Purpose

There are three main purposes of this research:

(1) To provide a structured method to analyze the relation between different perceptions in an organization and the performance of said organization: In the past, the solutions to management problems are usually determined by the experiences and intuitions of a few strategy personnel instead of a structured and systematic method that measures the relation between

the problem and external effect factor. Therefore, this research proposes a systematic and structured method to analyze that how different perceptions in an organization influence the performance of said organization, then uses the result as a standard to distinguish conflicts within the organization, and finds possible solutions.

(2) To distinguish different types of conflict in an organization and find out key conflict via (Cause-Effect and Contradiction Chain Analysis；CECCA):

a. The conflict between perception and performance of the organization
b. The conflict between perceptions
c. The conflict between performances of the organization

(3) To find out possible solutions to solve the conflict of an organization via systematic tools and methods provided by TRIZ.

d. Function Relationship Analysis: Solution Directives
e. Engineering contradiction: Contradiction Matrix and Inventive Principles (Business)

Users can find out the trigger solution of solving conflict of organization step by step and convert trigger solution into specific solution based on the type of the problem.

2. Literature

2.1 Perception Mapping

Perception Mapping Method is a method which can identify opportunities and solve problems via analyzing the interrelation between perceptions. Darrell Mann (2007) presents Perception Mapping Method methodology as follows: Throughout interview, the perception of relevant department members can be known; the different perceptions can be linked by "lead to" relationship and become "Perception Mapping." Users utilize Perception Mapping to distinguish three kinds of chain modes—loop, collector, and conflict chain—and give them different weight. With the weight, the user can rank those perceptions and recognize those perceptions and their importance to the problem. Users then adopt Contradiction Matrix and Inventive Principles to find out the trigger solution of conflict by the distinguished conflict chain and convert the trigger solution into specific solution which deals with the problem.

2.2 Process (in Detail)

The following 8 steps are the detailed progress of Perception Mapping Method:

(1) Define the problem: Define the questions which needs to be answered related to the specific problem. Because the perception of members in each department is necessary, the questions must be designed in a Q&A mode.

(2) Inquire and obtain the perception of members of related departments for the specific question and number each perception.

(3) Find out the affected perception (effect) for each perception (cause) and marked the number of perception (effect) in Lead To column to show the "lead to" relationship between these two perceptions, as in table 1. The "lead to" relationship here means it will happen "Always" rather than "possibly".

(4) Compare whether or not the conflict exists between the perceptions in pairs. If the conflict exists, mark the number in Conflict column as in table 1.

Table 1. Perception Mapping Table

Node	Perception	Lead To	Conflict
A	Perception_1	C	
B	Perception_2	D	
C	Perception_3	B	E
D	Perception_4	C	
E	Perception_5	D	C

(5) Connect all perceptions according to lead to relationship by directional arrow to get a Perception Mapping Diagram.

(6) Analyze the Perception Mapping Diagram and explore the Conflict chain / Collector point / Loop chain mode between the perceptions.

- Conflict chain: If the conflict exists in two perceptions, the chain between these two perceptions is a Conflict Chain. Note: a Conflict Chain emphasizes the fact that the conflict exists between two perceptions instead of the direction of the arrow of the Conflict Chain. The Conflict Chain in figure 1 shows that there is conflict between A and B but it doesn't mean that the conflict exists in perception C. The chain only reveals that there is conflict between A and B and the arrow between A and B is not directional.
- Collector point: Collector point means that numeral perceptions lead to this perception and this perception is affected by numeral perceptions.
- Loop: Every perception will finally goes back to the original perception after it moves to next perception according to the direction of the arrow; this chain means Loop. There must be at least one Loop in

Perception Mapping Method; however, the number of node and Loop is not limited.

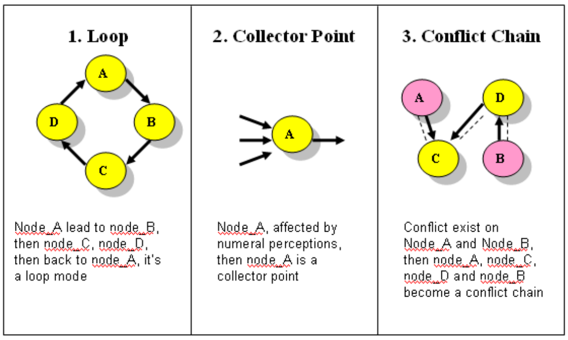

Fig. 1. Loop / collector point / conflict chain modes

(7) Provide different weights for the three chain mode defined in step (6):

- Loops: 4 score, every node in Loop is 4 score.
- Collectors: (n-1) score, n means the number of arrow which connects to the node and Collector is (n-1) score.
- Conflict Chain: 3 score, if there is conflict between two nodes, these two nodes can get 3 score respectively.

(8) To solve the two perceptions of conflict point in Conflict Chain, the corresponding trigger solution can be found via Contradiction Matrix & Inventive Principles; users can find out the corresponding specific solution based on the trigger solution.

2.3 The Advantages and Disadvantages of the Perception Mapping Method

The advantages of Perception Mapping Method:

(1) The invisible perceptions can be converted into visible logical figure and the relationship between the different perceptions can be clarified.

(2) Communication becomes easier because the perception and attitude can be understood by Perception Mapping Method.

The disadvantages of Perception Mapping Method:

(1) It can only describe the positive relationship between the perceptions of members of different departments, but not the negative one.

(2) It can only subjectively distinguish the conflict and mark that the conflict exists between these two perceptions; however, it cannot distinguish the conflict point directly by figure.

(3) The potential reason of the conflict caused by perceptions cannot be explained without structuring the perception.

2.4 Function Relationship Analysis

Function Relationship Analysis is a problem-solving method. John Terninko (1998) proposes that the "function" is not only a function but also "Anything users want to achieve …", probably an event, action …etc. It disassembles a problem into functions and assorts them into useful/harmful functions and then connects those functions by cause-effect relationship to make a "Function Relationship Diagram (FRD)". By analyzing those useful and harmful functions, the contradiction problem can be addressed. Next, use "Solution Directives" to find the trigger solution of the contradiction problem and then provide the proposal to improve and solve the problem.

Function Relationship Analysis describes problem through Function and Relationship, and Function and Relationship are illustrated below:

(1) Function: Function can be an action, progress, operation, situation and an execution. It can be presented by a verb or verb phrase. Functions are assorted into two types: useful and harmful; they are distinguished by their form and color. Function is displayed by Box figure and illustrated by words.

a. Useful function: The green rectangle Box is used to represent useful function in system, as figure 2.

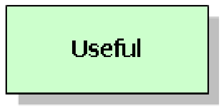

Fig 2. Useful function

b. Harmful function: The red rounded rectangle Box is used to represent harmful function in system, as figure 3.

Fig. 3. Harmful Function

c. Contradiction: The yellow rectangle is used to represent the function which is both useful and harmful, as figure 4.

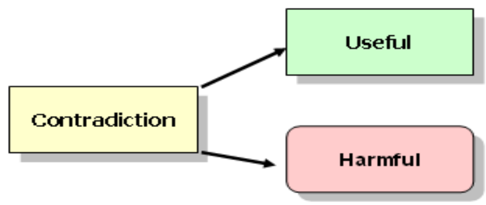

Fig. 4. Contradiction Function.

2.5 Relationship:

Relationship is used to connect two function boxes and illustrate the relativity between them; it can be assorted into "lead to" and "inhibit", as in figure 5.

(1) Lead to Relationship means that when function of origin point of the arrow increases (decreases), the function of arrow point increases (decreases) simultaneously; it is an obverse relationship. Lead to can be classified into useful Lead to or harmful Lead to; if the function of arrow point is connected with a useful function, it is a useful Lead to; if the function of arrow point is connected with a harmful function, it is a harmful Lead to.

(2) Inhibit Relationship is represented by an arrow with a vertical. It means that when function of origin point of the arrow increases (decreases), the function of arrow point decreases (increases) simultaneously; it is a reverse relationship. Inhibit can be classified into useful Inhibit or harmful Inhibit. If the function of arrow point is connected with a useful function, it means that a useful function is inhibited; it is a harmful Inhibit. If the function of arrow point is connected with a harmful function, it means that a harmful function is inhibited; it is a useful Inhibit.

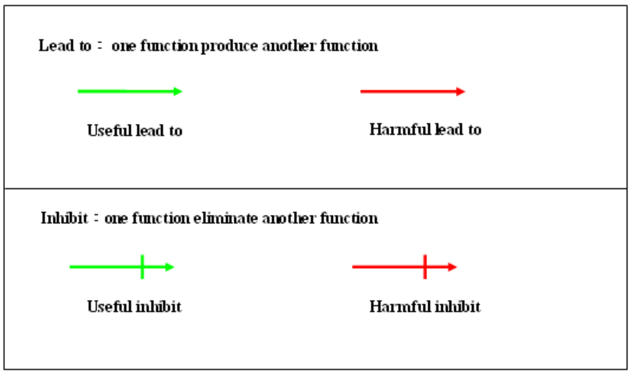

Fig. 5. Lead to / inhibit useful vs harmful relationship symbol.

(3) Function and Relationship Type Permutations: The following 8 types of situation are produced by permuting and combining Function and Relationship (as in figure 6). Relationship can be classified into two types: Lead to and Inhibit.

There are two types of useful Lead to in Lead to Relationship: (1) Useful function creates useful function. (2) Harmful function creates useful function, but the harmful function here is a contradiction function because a harmful function creates a useful function. There are two types of harmful Lead to: (1) Useful function creates harmful function but the useful function here is a contradiction function because a useful function creates a harmful function. (2) Harmful function creates harmful function.

There are two types of useful Inhibit in Inhibit Relationship: (1) Useful function inhibits harmful function. (2) Harmful function inhibits harmful function; the former harmful function is a contradiction function because harmful function creates useful function: Inhibit harmful function. (2) Useful function Inhibits useful function; the former useful function is a contradiction function because useful function inhibits another useful function. (2) Harmful function inhibits useful function.

Throughout the above 8 combination, whether there is contradiction or not in the Function Relationship Figure can be clearly defined.

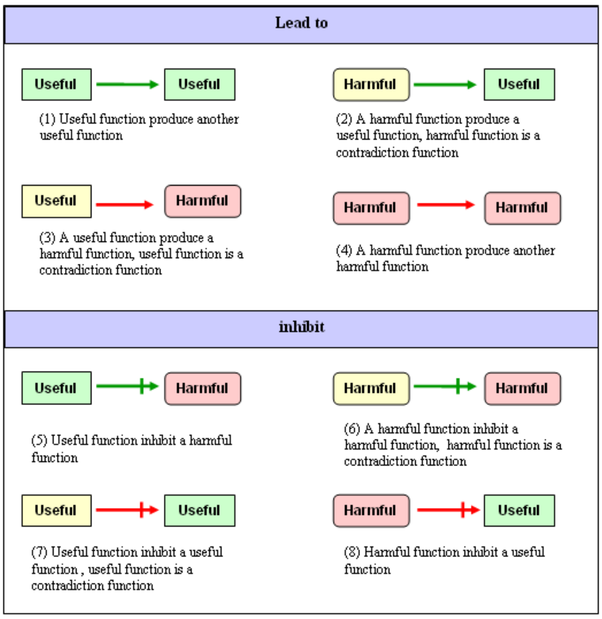

Fig. 6. Lead to / inhibit useful vs harmful relationship permute

(4) Solution Directives:

The useful function/ harmful function/contradiction function in system can be distinguished via Function Relationship Diagram; the different Solution Directives module is provided for useful function/ harmful function/contradiction function respectively. The Solution Directives is provided for users systematically; thus, users can find out the specific solution corresponding to the problem. The instruction of solution of useful function/ harmful function/contradiction function will be illustrated respectively below.

a. Guidelines for Useful Functions:

The improvement plan should be presented for the useful function in the system according to the following methods: (a) Provide useful result. (b) Do not provide any harmful result. (c) Any other function should not provide useful function previously. (d) Do not be affected by harmful function. (Refer to figure 7)

Useful Solution Directives Guideline

- Find an alternative way to provide the useful function
  - Useful function could be:
    - Produce useful function
    - inhibit harmful function
- Avoid provide any harmful function
  - Harmful function could be
    - Produce harmful function
    - inhibit useful function
- No prior function should be required
- Not influenced by other harmful function

Fig. 7. Useful Solution Directives Guideline.

b. Guidelines for Contradiction Functions:

The improvement plan should be presented for the contradiction function in the system according to the following methods: (a) Useful function should exist; if useful function produces useful result, the useful function relationship should exist. (b) If useful function produces harmful result, the useful function relationship should not exist and should be eliminated. (Refer to figure 8)

Contradiction Solution Directives Guideline

- Useful function should be remain, if it produce useful function
  - Useful function would be
    - Produce useful function
    - inhibit harmful function
- Useful function should be remove, if it provide harmful function
  - Harmful function would be
    - Produce harmful function
    - Inhibit useful function

Fig. 8. Contradiction Solution Directives Guideline.

c. Guidelines for Harmful Functions

The improvement plan should be presented for the harmful function in the system according to the following methods: find out an alternative way to eliminate, reduce or prevent other harmful conditions before providing harmful function. (Refer to figure 9)

Harmful Solution Directives Guideline

- Find an alternative way to reduce, eliminate or prevent harmful function result
  - Harmful function result
    - Produce harmful function
    - Inhibit useful function
- Avoid provide harmful function In an harmful situation

Fig. 9. Harmful Solution Directives Guideline.

(5) Function Relationship Analysis: Advantages and Disadvantages

The advantage of Function Relationship Analysis is that it converts engineering problem into functions and it can utilize useful/harmful function to help users to find out the key problem. Moreover, it provides corresponding instruction of solution and systematical method to find out the trigger solution.

The disadvantage of Function Relationship Analysis is that it is usually applied to analyze the engineering problem rather than complicated management problem. Hence, this research intends to apply Function Relationship Analysis to management problem. Use perception/phenomenon/performance of human to replace the original function elements, then describe the relationship of perception/phenomenon/performance by relationship, and analyze the conflict which is produced by different perception of human for the organization performance. Then adopt the Solution Directives provided by Function Relationship Analysis to find out the solution for conflict.

3. Research Method

This research mainly intensifies the Perception Mapping Method of Darrell Mann. With this structured method, the perception appeal structure of members of different organizations and how the appeal activities establish interactive relationship with performance can be explored. Then connect the relationship between perception appeal structure and performance to find out (1) the conflict between perception and performance, (2) the conflict between perception and perception, (3) the conflict between performance and performance. Then utilize the tool Cause-effect and Contradiction Chain Analysis provided by TRIZ to find out key conflict and adopt (1) Function Relationship Analysis: Solution Instruction, (2) Engineering Contradiction: Contradiction Matrix & Inventive (Business) Principles to find out the trigger solution. Thus, users can find out the specific solution of solving organization conflict via trigger solution based on the problem.

3.1. Preliminary Definitions:

Perception, phenomenon, and performance are defined respectively as follows.

Perception: It means "appeal and opinion toward things". The perception of human decides his/her ways of solution. Different people have different appeal/opinions; their ways of doing things are different either.

Phenomenon: It means "a series of events or a situation of facts produced to achieve the goal which is set by perception". Whereas Perception is an internal thought which is hard to be observed, phenomenon is an external event or a situation of fact which is visible. Therefore, people's perception can be understood by observing the external phenomenon, such as interactive relationship.

Organization Performance: It means "the result of members in organization striving to achieve the expected goal from the organization. It will be measured and evaluated as the criterion of reward and punishment". For an enterprise, the most important thing is to pursue the highest organization performance, achieve the intended operating goal, and enhance competitiveness of the enterprise. Most of the activities of an enterprise are created for its core managerial task: improving performance. By providing methods of improving, reasons that affect organization performance can be located to improve performance successfully. This research investigates how perception affects organization performance by combining perception and performance, then find out the reason of abating performance, and provide solutions to improve organization performance.

3.2. Research Process:

The study process is divided into four phases: (1) Problem Description, (2) Perception Analysis, (3) Conflict Identification, and (4) Conflict Solution as shown in Figure 10.

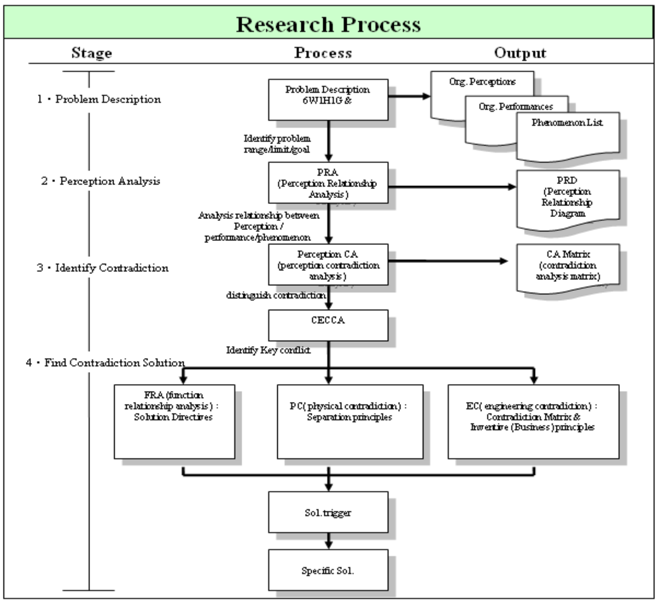

Fig. 10. Research Process

Description: the main purpose is to confirm the range of the problem. Users can use 5W1H1G question method to define problem, limit and goal. The "Organization Performance Form", "Organization Perception Appeal Form" and "Phenomenon Observation Form" can be used to record the perception, phenomenon and performance of members of related departments.

Phase 1: Problem Description. The main purpose in phase 1 is to confirm the range/limit/goal of the problem; a problem well put is a problem half solved. Thus, this phase is essentially important because it lays a solid foundation for the following phases.

Phase 2: Perception Analysis. Phase 2 gives an overview of how Perception Relationship Analysis (PRA) makes use of diagram tool to connect perception, phenomenon, and performance to accomplish Perception Relationship Diagram (PRD). PRD can be used for the next phase to distinguish conflict.

Phase 3: Contradiction Identification. It mainly analyzes how many times inhibit relationship happens from perception to performance via Perception Relationship Diagram to decide whether perception produces useful or harmful effect. Useful/harmful effect is used to find out (1) conflict between perception and performance, (2) conflict between perception and perception, and (3) conflict between performance and performance. Cause-effect and Contradiction Chain Analysis is used to find out the key conflict. Conflict solution is expected to be located in the next phase.

Phase 4: Conflict solution. After finding out the trigger solution by TRIZ tool, users can convert trigger solution into specific solution. In this case, the following TRIZ tools are adopted: (1) Function Relationship Analysis: Solution Directives (2) Engineering contradiction: Contradiction Matrix and Inventive (Business) Principles.

The four phases are illustrated below:

(1) Problem Description: Phase 1 is Problem Description. The main purpose in this phase is to confirm the range of the problem. Users can use 5W1H1G question method to define the problem, limit and goal. The following

"Organization Performance Form" (Table 2), "Organization Perception Appeal Form" (Table 3) and "Phenomenon Observation Form" (Table 4) can be used to record the perception, phenomenon and performance of members of related departments.

Table 2. Org Performance Form

Question：what performance could be measure or evaluate the issue and list by each unit concerned ?	
Dept.	**Performance Factor**
Unit_1	performance_1
Unit_1	performance_2
Unit_1, Unit_2	performance_3
Unit_2	performance_4
Unit_2	performance_5
Unit_3	performance_6

Table 3. Org Perception Appeal Form

Question：what perceptions could solve or improve the issue ? please list them.		
Dept.	**perception**	**Desc**
Unit_1	Perception_1	
Unit_1	Perception_2	
Unit_2	Perception_3	
Unit_2	Perception_4	
Unit_3	Perception_5	

Table 4. Phenomenon Observation Form

Question：What phenomenon/event/situation will be accrued when perception perform ? Please list them.		
Dept.	**phenomenon**	**Desc.**
Unit_1	phenomenon_1	
Unit_1	phenomenon_2	
Unit_2	phenomenon_3	
Unit_2	phenomenon_4	
Unit_3	phenomenon_5	
Unit_3	phenomenon_6	

(2) Perception Relationship Analysis: After finishing describing the problem, the purpose of phase 2 is to introduce how Perception Relationship Analysis method use diagram tool to combine perception, phenomenon and performance to complete Perception Relationship Diagram. Two diagram tools are used in Perception Relationship Analysis method: Element and Relationship. Perception Relationship Analysis method is to connect each element by relationship and form a Perception Relationship Diagram. Element, Relationship and Perception Relationship Diagram are illustrated below:

Element:

It can be classified into three types: Perception, Phenomenon, and Performance. Perception Relationship Analysis is used to clarify the relationship among these three types of elements. Element can also be assorted into "Useful Element" and "Harmful Element". Useful element refers to like-event for the department; harmful element, dislike-event.

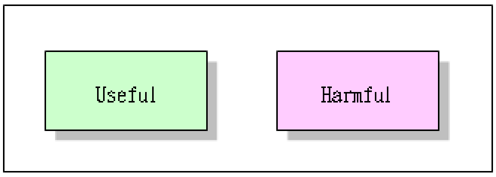

Fig. 11. Useful vs Harmful Element

- **Relationship:**

Relationship is used to describe the interaction between two elements. There are two types of description: lead to description and inhibit description; they are shown as an arrow. The original point represents the affected element (cause) whereas the end point represents the affected element (effect).

Lead to relationship means that element of cause and effect is cyclical; that is, they increase and decrease simultaneously. Inhibit relationship means that element of cause and effect is countercyclical; that is, one element increases (decreases) when the other decreases (increases).

Lead to relationship is assorted into two types: "useful lead to" and "harmful lead to". "Useful lead to" leads to events which the organization wants, displayed in green; "harmful lead to" leads to events which the organization does not want, displayed in red.

Inhibit relationship is assorted into two types: "useful inhibit" and "harmful inhibit". "Useful inhibit" inhibits events which the organization does not want, displayed in green; "harmful inhibit" inhibits events which the organization wants, displayed in red.

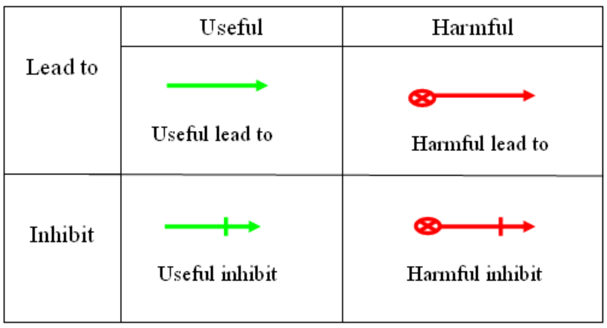

Fig. 12. Lead to/ Inhibit Useful vs Harmful Symbol

Perception Relationship Diagram

The Perception Relationship Diagram is used to illustrate the relationship diagram which is constructed by perception and performance; it uses relationship to connect the structure of perception, phenomenon and performance (as shown in figure 14). Through observing the interactive relationship between perception and performance, the gradually perception-changing events illustrate: (1) how perception of humans affects organization performance, and (2) whether the interactive relationship between perceptions of humans in different departments enhances or weakens organization performance.

Therefore, perception of humans becomes a series of invisible phenomenon rather than just exists in the imagination phase. In addition, it can be connected to organization performance; the rise/fall of performance can help users observe: (1) which perception is useful to some performance or (2) which perception causes some side effect to other performance to weaken the performance.

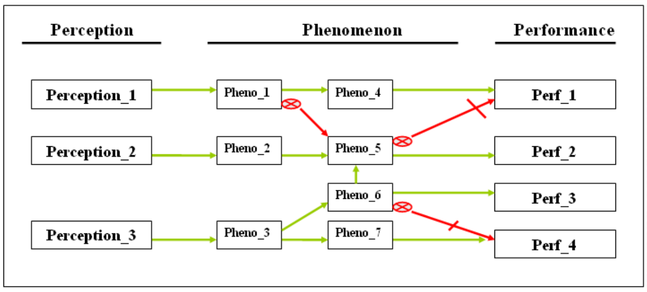

Fig. 13. Perception Relationship Diagram

An example: How to Increase Operating Revenue of a Fixed Network Company is shown in the Perception Performance Diagram in Figure 14. It shows how Perception A (Increase customer volume to increase market share be the target) pursues (1) **Customer volume increase** to facilitate (2) **Sales volume increase** and achieves the goal of (P1) **Increase Operating revenue**. Yet, (1) **Customer volume increase** also precipitates (3) **Increase in Service Demands** and (4) **Increase in Maintenance Levels**, suppressing the effect and performance of (P2) **Total Quality improvement.** Due to a lack in increase of salesmen numbers, a demand for increase in service in this case will result in a decrease in quality of service.

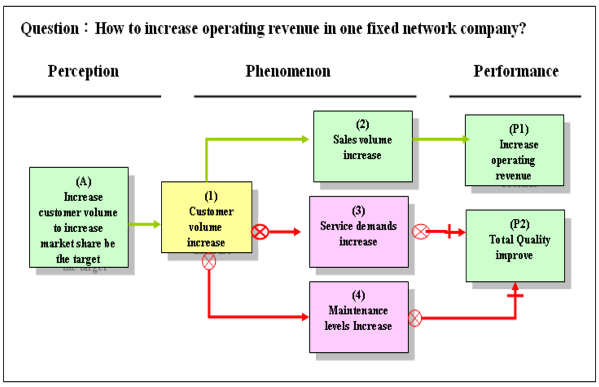

Fig. 14. Perception Relationship Diagram

3.3. Perception Contradiction Analysis

The perception, not the phenomenon, is the control factor. To find all the reasons behind organization influence and provide improvement methods to achieve the purpose of improving organizational performance, observation of the contradiction between perception and performance is necessary in order to determine the inefficiencies of said perception. The performance of the organization will be improved by improving the structure of the perception.

- Contradiction Types

The contradictions between perception and performance can be classified into four kinds: (1)Contradiction From Perception to Performance, (2) Contradiction Between Different Perceptions, (3) Contradiction within Performance(s), and (4) Physical Contradiction Within Perception.

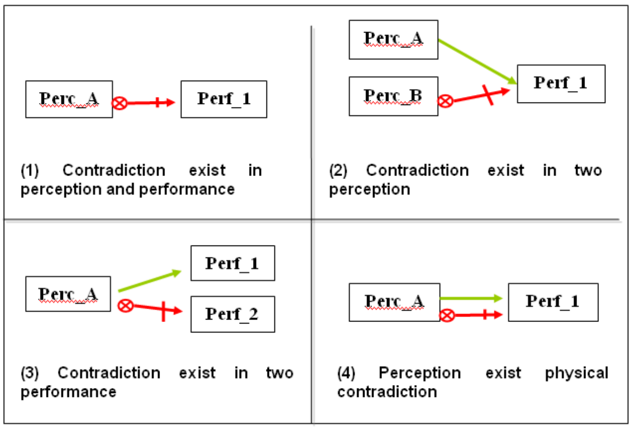

Fig. 15. Contradiction Type

- Contradiction Analysis Matrix

Contradiction types can be determined through the Contradiction analysis matrix. First, one must use the Perception Relationship Diagram and observe the trajectory of Perception to Performance. If there is an odd number of inhibition, mark with a minus (-) sign. If there is an even number (including zero) of inhibition, then mark with a plus (+) sign. Through observation of all inhibitory relationships arising from each perception of achieving performance, one can complete a Contradiction analysis matrix. This is demonstrated in Figure 16.

performance / Perception	(P1)	(P2)	(P3)	(P4)
A	−		+	
B	−		+	
C	+		−	
D		+	−	−
E		+	−	
F			−	+
G	−/+		−	+

Fig. 16. Contradiction Analysis Matrix

Through the Contradiction Analysis Matrix, we can determine four types of contradictions:

- **Conflict between Perception and Performance**: From the viewpoint of the Perception, if a "+" is present, it signifies the lack of conflict between the perception and said performance. If a "-" is present, it signifies the presence of conflict. If there is no "+" or "-" present, then there is no relationship between the perception and performance.
- **Conflict between Perception and Perception**: From the viewpoint of the Performance, one "+" and one "-"between two Perceptions represents the presence of a conflict between the two.
  - Observing from Performance P1, the "-" and "+" signs between Perceptions A and C show the conflict between each other.
- **Conflict between Performance and Performance**: From the viewpoint of the Perception, a "+" sign and a "-" sign between two Performances illustrates the presence of a conflict between the two.
  - Observing from Perception F, the "-" between it and Performance 3 (P3) and the "+" between it and Performance 4 (P4) demonstrates the conflict between these two Performances.
- **Physical Conflict within Perception**: From the viewpoint of the Perception, if a "+" and "-" appear in relation to the same Performance, it signifies that there is a physical contradiction within the Perception's approach to the Performance.
  - Observing from Perception G, its "+" and "-" in relation to Performance 1 (P1) shows that Perception A would create a physical conflict on Performance 1.

In an organization, it is not easy to notice the conflicts between human perceptions and organizational performances. But through the "Contradiction Analysis matrix," one can, in a structured and systematic method, help user recognize "Contradiction between Perception and Performance," "Contradiction between Perception and Perception," "Contradiction between Performance and Performance," and "Physical Contradiction within Perception."

▪ Cause-Effect and Contradiction Chain Analysis

Use of the Contradiction matrix can locate the many potential conflicts between perceptions and performances, but not all conflicts need to be focused on. Rather, it is more effective to locate the key conflict(s) and focus on resolving that conflict to solve the grand problem. To further streamline this process, this research puts the conflicts determined by the Contradiction Analysis matrix in a Cause-Effect and Contradiction Chain Analysis to locate key conflict(s) and design corresponding counter-strategies. As Ill. 18 illustrates, "(1) Target Disadvantage" refers to the weakened performance factor. Using the Perception Relationship Diagram, one works backwards from the impaired performance to track any unfavorable factors. Once unfavorable factors have been found, one then continues working backwards to trace the perception(s) that produce these unfavorable factors; such perceptions are the major unfavorable factors behind the respective weakened performance. (2) If postulating backward from these key unfavorable perceptions creates a positive effect, then these perceptions are termed "key conflicts." If not, then they are termed "target disadvantage." (3) Through Darrell Mann contradiction matrix and inventive (business) principles, one can determine specific parameter for all the elements of the cause-effect and contradiction chain. (4) One can resolve the conflict by improving and worsening parameters to address the corresponding inventive principles.

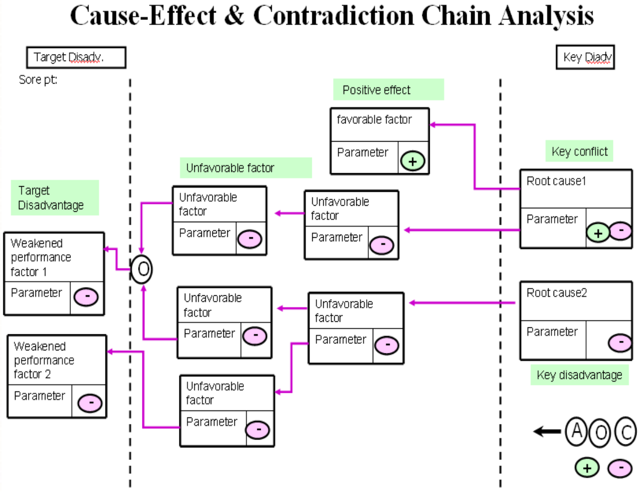

Fig. 17. Cause Effect and Contradiction Chain Analysis

▪ Searching for Conflict Resolutions

The Cause-Effect and Contradiction Chain

Analysis enables discovery of the key conflict(s) of a problem. Using the tools offered by TRIZ—(1) Function Relationship Analysis: Solution Directives (2) Engineering contradiction: Contradiction Matrix and Inventive (Business) Principles—one can determine the trigger solutions and corresponding specific solutions to the key conflicts as shown in Figure 18.

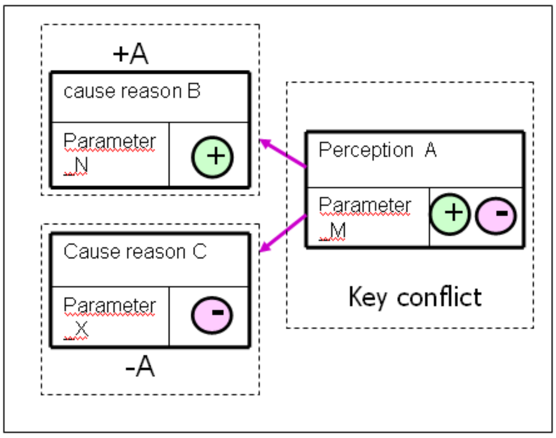

Fig. 18. Solution Directives

◆ **Solution Directives Guide: Trigger Solutions**

The solution guide enables the user, in an interrogative manner, to analyze solutions to the key conflicts and infer trigger solutions to the key conflicts. The method works as follows:

✧ Solution Guide 1: Fully satisfy "Positive Effect (+A)" and eradicate negative effects.

➔ Raise positive effects to the state of largest scale, and eliminate the production of negative effects.

✧ Solution Guide 2: Fully eliminate "Negative Impact (-A)" and maintain positive effect.

➔ Prevent the occurrence of negative effect and achieve the gains of a positive effect.

✧ Solution Guide 3: Eradicate A and provide positive effect methods.

➔ Remove A, locate other methods that offer positive effects, and thus prevent the occurrence of the negative effect.

✧ Solution Guide 4: Make the negative effect insignificant, obtuse, or directly remove it.

➔ The negative phenomenon is irrelevant to A element, so switch to eradicating all components and units that observe such phenomenon.

Specific Solution: User locates trigger solution through the problem-solving index, and targets problem requirements to find suitable solutions.

▪ **Engineering Contradiction: Contradiction Matrix and Inventive (Business) Principles**

In 2002, Darrell Mann stated that the business contradiction matrix involves using improved and worsened parameters to locate conflict points, and then utilizing corresponding inventive principles to achieve possible and tangible solutions.

✧ Use improved and worsened parameters to locate inventive principles in the contradiction matrix, and determine trigger solutions from the inventive principles.

✧ Specific Solutions: Find solutions to problems through their corresponding trigger solutions.

3.4. Case Study

Based on the backgrounds of an individual case [7], a fixed network company has, at countless times, set up its strategic objectives to increase operating revenue, business scale, and engineering units, with an emphasis on each department's methodology to achieve these goals. In order to meet the company's strategic objectives, the marketing department has proposed increasing clientele and sales figures to achieve the goal of increasing revenue. The engineering unit has, on the other hand, proposed elevating internet and service quality as a means of increasing clientele and, thus, sales.

Table 5. Org Performance Form

Question：How to raise marketing income and record the related performance factor.	
Dept.	**Performance Factor**
Engineering dept	Total quality improve
Sales dept	Increase operating revenue
Engineering, Sales dept	Increase employees satisfaction
Engineering dept	Increase productivity
Sales, Engineering dept	Improve quick response

(1) Problem Description

Use an interrogative manner to obtain relevant perceptions, phenomena, and performances from each department. Questions may be formatted in the 5W1H1G questioning style.

a. Set up required questions: How to increase sales revenue?

b. Record the performances of the relevant units, as Table 5 shows:

c. Record the perceptions from each relevant unit, as depicted in Table 6.

Table 6. Org Perception Appeal form

Question：How to raise marketing income and record the perceptions of the relevant units		
Dept.	**perception**	**Desc**
Sales dept	Increase customer volume to increase market share be the target	Increase customer volume to increase operating revenue
Engineering dept	Reduce the customer waiting time to be the target	Increase quality satisfaction
Engineering dept	Reduce hardware failure time to be the target	Increase quality satisfaction
Engineering dept	Reduce maintenance time to be the target	Increase quality satisfaction
Engineering sales dept	Arise employee morale to increase operation efficiency	To encourage employee then increase service efficiency

d. Record observed and heard phenomena from the interviews, as shown in Table 7.

Table 7. Phenomenon Observation Form

Question：What phenomenon/event/situation will be accrued by those perception perform？Please list them.		
Dept.	**phenomenon**	**Desc.**
Sales dept	Increase customer volume	Perception (A) Increase customer volume to enlarge market share
Sales dept	Increase sales volume	Increase customer volume will increase sales volume
Sales dept	Operating revenue increase	Increase sales volume will increase operating revenue
Engineering dept	Reduce setup time	Perception (B) Reduce customer waiting time will reduce setup time
Engineering dept	Reduce failure frequency	Perception (C) Reduce hardware failure time will reduce failure frequency
Engineering dept	Reduce maintenance frequency	Perception (D) Reduce maintenance time will reduce maintenance frequency
Engineering dept	Increase network quality level	Reduce setup time/failure frequency/maintenance frequency to increase network quality level
Engineering dept	Increase productivity	Increase network quality level will increase productivity
Engineering, sales dept	Offer performance bonus	Perception (E) Arise employee morale and efficiency by offer performance bonus
Engineering, sales dept	Improve employee operation efficiency	Offer performance bonus s improve employee operation efficiency
Engineering, sales dept	Service quality improve	Improve employee operation efficiency will improve service quality level
Engineering, sales dept	Service demands increase	Increase customer volume will increase the service demands
Engineering, sales dept	Maintenance levels increase	Increase customer volume will increase the maintenance request
Engineering, sales dept	Employee turnover rate increase	Maintenance and service demands increase, make employee busy and turnover rate will be increased

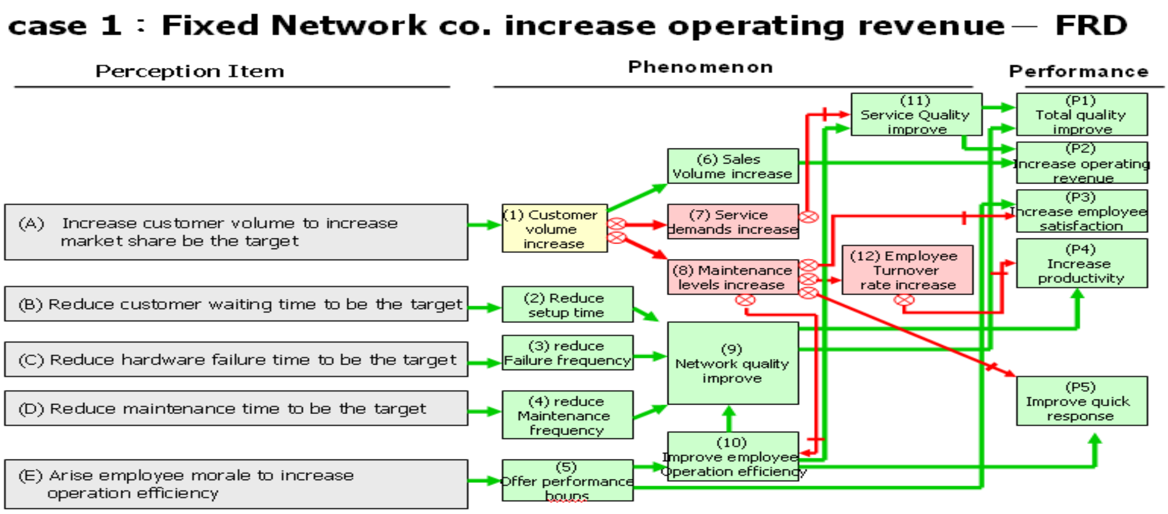

Fig. 19. Fixed Network co. increase operating revenue — FRD

(2) Perception Relationship Analysis

Use the Phenomena Observation Form, Perception Appear Form, and Performance Form to help establish the relationships among and between the elements, and determine if said relations are suppressive or facilitating. The chart also establishes whether the facilitating or suppressive relationships are beneficial or harmful, as Figure 19 shows.

(3) Perception Contradiction Analysis

The Perception Relationship Diagram calculates all the individual occurrences of inhibit relations on the trajectory from perception to performance, and fills in the corresponding contradiction Analysis matrix as depicted in Table.

Table 8. Contradiction Analysis Matrix

Perf / Perc	(P1)	(P2)	(P3)	(P4)	(P5)
A	−	+/−	−	−	−
B	+			+	
C	+			+	
D	+			+	
E	+		+		+

a. Through the contradiction analysis matrix, the following four types of conflicts can be analyzed:

- Conflict Type 1: Conflict arising between perception and performance

Using coordinates to depict the conflict:

(A,P1) (A,P2) (A,P3) (A,P4) (A,P5)

- Conflict Type 2: Conflict between Perception and Perception:

Using coordinates to illustrate the conflict:

(A,B) (A,C) (A,D) conflict with Performance P1

(A,E) conflicts with Performance P3

(A,B) (A,C) (A,D) conflict with Performance P4

(A,E) (D,G) conflict with Performance P5

- Conflict Type 3: Conflict between performance and performance

The conflict depicted as coordinates:

(P1,P2) conflicts with Perception A

(P2,P3) conflicts with Perception A

(P2,P4) conflict with Perception A

(P2,P5) conflict with perception A

- Conflict Type 4: Physical contradiction Inherent in Perception

(A,P2) conflicts with Perception A

b. Cause-Effect and Contradiction Chain Analysis

Use of the contradiction analysis matrix carries out all contradiction in a problem to be determined; using the cause-effect and contradiction chain analysis can help locate key disadvantage. Identification of target disadvantage allows for step-by-step inference of the key disadvantage. “Target disadvantage” in this case refers to weakened performance factors. Use the contradiction analysis matrix to identify the target disadvantage factor, from the viewpoint of the performance factor, and if a “-” is present, it shows the performance is one of the “target disadvantage” factors. Follow the CECCA method and put the weakened performance into the target disadvantage. After that, search all unfavorable factors step-by-step as demonstrated in Figure 20.

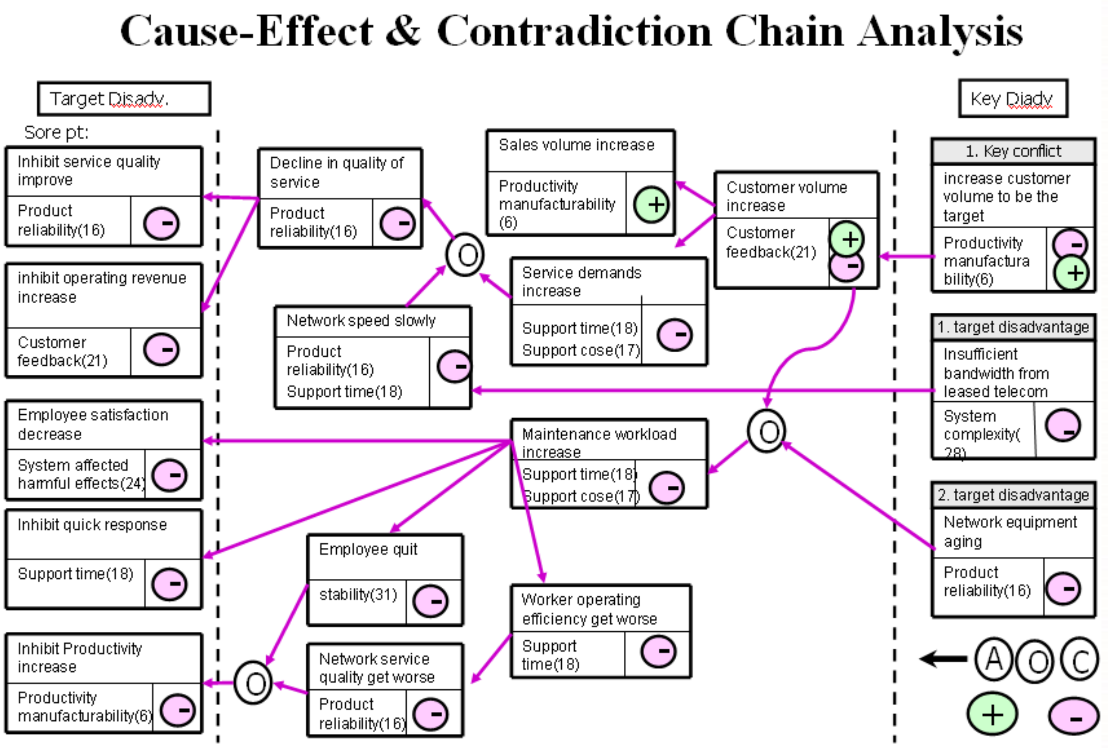

Fig. 20. Cause effect and contradiction chain Analysis

The reason for "inhibit service quality improve" is "Decline in Quality of Service," while "Decline in Quality of Service" is a result of "Service demand increase." "Service demand increase" is a direct product of "customer volume increase," and "customer volume increase" is a resulting phenomenon of the perception "increase customer volume to increase market share to the target."

This trajectory shows that the key disadvantage factor causing "inhibit service quality improve" is "increase customer volume to increase market share to the target." Yet, consideration of whether the key disadvantage factor might also provide positive, favorable factors is also necessary, so as to prevent the eradication of favorable factors in the removal of the key unfavorable factor. If a favorable factor is present along with the key disadvantage factor, then the key disadvantage factor is the locus of the key conflict.

The Cause-effect and Contradiction Analysis thus helps identify one conflict and two disadvantage factors. In this case, the key conflict is the perception "increase customer volume to increase market share to the target," while the disadvantage factors are "insufficient bandwidth from leased telecom" and "Network equipment aging."

(4) Locating Conflict Solutions

- **Disadvantage Factor 1: Insufficient bandwidth from leased telecommunications network inhibit service quality improve**

Specific Solution: Switch to leased fiber-optic network to improve overall network speed, thus reducing occurrences of dissatisfaction over slow internet speeds.

- **Disadvantage Factor 2: Network equipment aging causes increase in maintenance work**

Specific Solution: Replace new and high-stability equipment to lower maintenance workload.

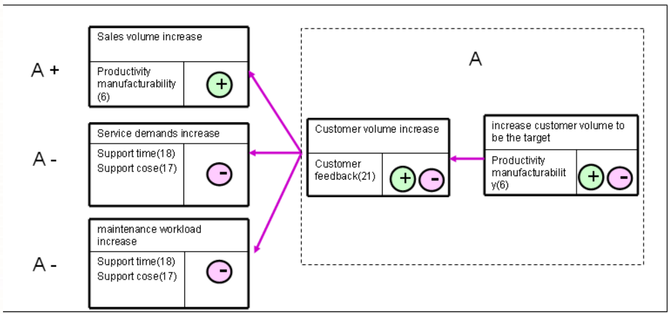

Fig. 21. Key Conflict diagram

- **Solution Index for Key Conflict Point 1: Solution Directives**

(1) Solution Guide1: Fully meets "Positive Effect (+A)", and eradicate negative effect

Solution Trigger: How to fully meet goal of sales volume increase without increasing service Demands

Specific Solution: Simplify the user interface and decrease the level of service needs in spite of an increase in customer numbers. The improvement in quality is not affected.

Solution Trigger: How to fully meet goal of sales volume increase without increasing maintenance work

Specific Solution: Increase internet reliability to lower maintenance workload; quality standards will thus not decrease in spite of rise in customer numbers.

(2) Solution Guide 2: Fully eliminate "Negative Impact (-A)" and maintain positive effect

Solution Trigger: How to eliminate "Service demands increase" and keep providing "Sales volume increase"

Specific Solution: Train employee to be the multi-ability-worker to serve more customers and maintenance jobs and meet company goal of revenue growth.

(3) Solution Guide 3: Eradicate A, and provide positive effect methods

Solution Trigger: How to remove the demand on marketers to raise clientele numbers and provide an alternate method for increasing sales figures.

Specific Solution: Provide high-quality and high-speed fixed-line services, and customers will, through word of mouth, bring in more customers and meet company goal of revenue growth; additionally, install automated voice query services to provide additional means of service through internet and telephone network (not limited to the amount of configurations of service staff) to influence service quality.

(4) Solution Guide 4: Make the negative effect insignificant, obtuse, or directly remove it.

Solution Trigger: How to make the phenomenon of service demand increase unimportant, non-sensitive, or directly remove said phenomenon.

Specific Solution: Increase staff number to facilitate and maintain rising demand for service and maintenance workload without causing decrease in service quality.

Solution Trigger: How to make the phenomenon of increase in maintenance workload unimportant, non-sensitive, or directly remove said phenomenon

Specific Trigger: Utilize fully automated service, thus rendering increasing for service and maintenance workload irrelevant.

▪ <u>**Engineering Contradiction**: Contradiction Matrix and Inventive (Business) Principles</u>

Table 9 Contradiction Matrix

Worsen / Improve	Productivity manufacturability(6)
Support time(18)	**5,6,10,12**
Support cose(17)	**13,10,17,2**

Inventive Principle 5: Merging

Specific Solution: Combine service categories and provide customer service through the call center in maintaining consistency in service quality.

Inventive Principle 6: Universality

Specific Solution: Train relevant staff to be multi-ability-worker and assist other staff members so as to slow down increase in service demand and unfinished business proceedings.

Inventive Principle 12: Remove Tension

Specific Solution: Automate service needs, and eradicate tension from increased rates of service.

Inventive Principle 2: Take Out/Suspension

Specific Solution: Establish voice inquiry service system and leave all easily-resolved service demands/questions to it, so as to lower service load on staff members.

◆ **Physical Contradiction: The Physical Contradiction Between Perception A and Performance P2**

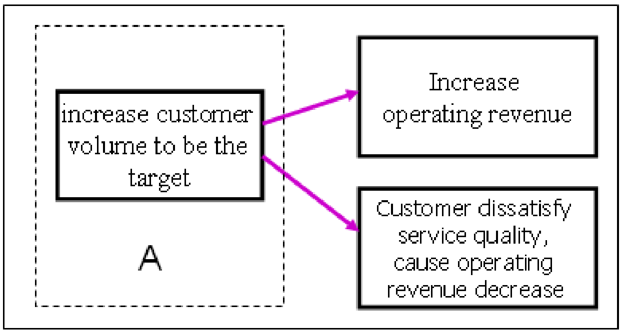

Fig. 22. Physical Contradiction

⌖ Time Separation: When (+A) is required, (-A) is required

Solution Trigger: When +A (the goal to push marketers to raise clientele figures) is necessary, –A (the goal to push marketers to decrease clientele figures) is necessary.

Specific Solution: Increasing clientele figures (+A) is imperative when fixed-line usage is infrequent, using new marketing methods to attract more customers and increase sales revenues. When fixed-line usage is high and frequent, lowering customer numbers (-A) is needed, setting higher fee rate to limit customer usage.

5. Conclusion and Proposals

5.1. Conclusion

This research mainly set out to: (1) Provide a method for analyzing human perceptions by transforming an initially-unseen perspective into a visible phenomenon, then combining the perspective with the performance to observe and evaluate whether the effect of the perspective on the performance is conducive or negative; (2) Analyze the relationships between different perceptions to find any potential underlying contradictions, using the methods provided throughout this research. Through the structured method provided here, seemingly-unrelated perceptions can be expanded together into a series of related phenomena, depicting contradictions that might exist between each other through the links between those phenomena.

The main contributions of this research are:

(1) Strengthening the original Perception Mapping Method, furthering its methodology and application. While original perception mapping can only describe "lead to" relationships between positive effects of different perceptions, the methodology of this research utilizes both "lead to" and "inhibit" relationships to describe positive and negative correlations between perceptions. A description of perception relationships through both negative and positive factors illustrates contradictions between the perceptions more clearly.

(2) By using the combination of perceptions and performances with the "Perception Relationship Diagram," unfavorable factors of the performances can be located and thus improved so as to meet the goal of raising organizational performance.

(3) Expanding the application range of Function Relationship Analysis (FRA): Traditionally, Function Relationship Analysis and Solution Index were mainly applied to engineering-related problems. Few research papers have observed the relevancy of FRA to solve management problems. This research combines Function Relationship Analysis with Perception Mapping to analyze and solve management-related problems.

(4) Traditional Perception Mapping required subjective judgment regarding identification of contradictions; this research proposes a logical inference method based on odd-number and even-number suppression to determine the relationships with no standing contradictions.

(5) Via Cause-Effect and Contradiction Chain to the Perception Relationship Diagram, utilizing the Contradiction Analysis Matrix and Cause-Effect and Contradiction Chain Analysis can assist in further recognizing technical and physical contradictions. Conflicts in management can thus be resolved through Business Inventive Principles and the Principle of Separation.

5.2. Suggestions and Directions for Future Research

(1) While discussing the relationships between perceptions, phenomena, and performances, this research solely described the interactions, no degree of the interactions is discussed. If System Dynamic is applied to the relationships to quantify the degrees of influence between perceptions and performances through simulations, the relative sizes of influence between perceptions and performances can be discerned, allowing the user to concentrate resources on resolving major problems. (Huang, 2005)

(2) Combine the Theory of Constraints with this research to locate core issues and target whether an organization's strategic direction meets required evaluation and execution. The Theory of Constraints poses that a system's constraints usually only exist amongst a handful of links, yet core problems are in actuality those in which constraint factors pose major influence on an entire organizational system's production and performance. By undergoing a set of structured thought processing to infer the causality of the issue and using the graph theory of arborescence to organize that inference, one can unravel the core of the problem. Through a three-stage implementation of strategic thinking, one targets:

a. What to change: Note underlying reasons of the problem using a Current Reality Tree depicting the current status

b. What to change: Many bottleneck problems cannot be remedied immediately with the use of Evaporating Cloud (i.e. Conflict Resolution Diagram) and Future Tree as a result of preexisting paradoxes and contradictions in their requirements. The Conflict Resolution Diagram merely points out the existence of contradictions. Future Trees, on the other hand, are used to test whether desired programs/methods can contribute to the final desired result of the organization.

c. How to change: Using Prerequisite Trees and Transition Trees, confirming all necessary elements of the program, and breaking down details of the actual implementation. (Wang, Yen 2008)

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Systematic Innovation for the Retention and Development of Human Talent

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(Received 6 February 2017; final version received 6 February 2017)

Abstract

In order to build and sustain competitive advantage, the knowledge that a workforce possesses has become an important tactical resource. This perspective means staff retention has become part of any organization's main objectives. Numerous studies have defined management of human talent and organizational performance of this talent. The motivation for this study was to create an inventive solution through systematic innovation of human talent in the beverage industry of El Salvador. In this study, we use systematic innovation to solve retention and development of human talent issues. The guide which is introduced in this thesis may serve as a useful methodology for solving intangible human talent issues. Our findings show that even though systematic innovation has only recently begun to be used to solve business management issues it can still be used to generate ideas or specific solutions on how to solve issues related to retention and development of human talent. The specific solution given by the inventive principles is the creation of an incentive system that can be flexible, by covering not only one product but by adapting to different situations and to many different products.

Keywords: human talent, incentive system, TRIZ, systematic innovation

1. Introduction

Having a system or program to develop and retain human talent is considered to be a competitive advantage in a company (Beechler & Woodward, 2009). Management of human talent involves planning, organizing and developing the capacities of personnel, in order to make them more efficient and achieve both their individual goals and those of the company. To maintain steady development of human talent, it is extremely important to consider programs of induction, re-induction and guidance. This will allow the continued development of staff and generate identification with the organization as well as a constant understanding of organizational changes. Furthermore, to properly develop human talent it is not enough to utilize trainings and inductions, it is also necessary to provide needed resources to employees. As a result, materials and technical resources play an important role in human talent development and leads to success at the organizational level (Chiavenato, 2009). These resources are necessary for the successful development of human talent. However, giving personnel access to these resources does not guarantee optimal development of personnel. Therefore, it is necessary to create a philosophy that supports this.

Systematic innovation is often applied in problem solving, but systematic innovation has limitations; there is a lack of earlier studies on implementation of TRIZ (theory of inventive problem solving) in management incentive systems (Mann, 2007). In other words when you try to optimize a system, systematic innovation contains virtually no mathematical formulae and so if we are trying to answer questions such as "what is the optimum batch size" or "what is the best interest rate?" or "what bonuses should everyone get this year?" or as in this study "what is the ideal amount of economic incentives for the workforce?" then systematic innovation will not help because each person has a different way of thinking, an incentive that works for one person could be a disincentive to another, and this makes it hard to apply an effective incentive system. In this study we will attempt to solve this problem with the use of systematic innovation and, if necessary, modifying it so that it can be adapted accordingly.

Currently in El Salvador there is a very competitive beverage industry. This market is currently undergoing change, and you cannot really predict what will happen in the future due to these constant changes. Organizations need to be prepared for these changes and act accordingly. The best way for a company to be prepared for these events is to have staff that are trained with the appropriate skills that enable them to respond to market events. The sales force in this industry has a hard time with market distribution. They need to have direct contact with retailers, by visiting shops either by scooter or car, and this sometimes can be very dangerous. Consequently the problem is that the sales forces (of "Company P") cannot be retained or motivated to stay for a long period of time and perform to expectations (Abrego, 2011).

In this research we establish and create an incentive system for the development and retention of human talent in organizations dedicated to beverage distribution. First the issues are defined and data is extracted from interviews. The interviews were conducted with ex-employees (ex-sales staff) of "Company P", from the beverage industry in El Salvador. The interviews had the objective of discovering issues encountered by sales staff during their time at Company P, and to find out more information about the current incentive system at the company. After gathering this information we used systematic innovation to solve these issues. The conceptual framework comprises nine steps which essentially follow the systematic innovation problem solving process. We evaluated our results and offer a conclusion and possible further research areas.

2. Methodology and Results

In this part of the study we go into the procedures we used to resolve the issues at hand. We follow the procedures and most of the tools of systematic innovation as found in "Pro-Forma Tools" (Mann, 2007). First we start with "*problem definition*", with the use of information gathered from interviews with ex-employees of Company P. Secondly we apply *"preliminary problem analysis",* which consists of analyzing in a broad way the problem at hand by using tools such as problem hierarchy and the "nine windows" approach. Then we continue with *"Problem modeling and formulation"*. In this step we perform function attribute analysis (FAA) so that we can further understand the system and grasp what each component is doing correctly and what is being done wrong. The next step is *"Contradiction Analysis"*. With the use of the information gathered we apply Root Contradiction Analysis (RCA) to understand the issues in a more specific manner, finding the roots of the problems. After RCA we carry out "*Parameter Analysis"*. With the use of a contradiction matrix we analyze the contradictions isolated in the contradiction analysis and we select the parameters that best relate to these contradictions. Then we create a "Generic solution", with the help of the contradiction matrix and generic solutions from the 40 inventive principles are created. Finally, in the "*Generation of Specific Solutions"* step, we create a specific solution to solve the problem at hand, through the ideas created with the 40 inventive principles and with the knowledge we have gathered from other research and studies.

2.1 Problem Definition and Interviews

The main problem in this case is that because of the unique nature and the needs of the market (where Company P is located), the sales force has difficulties in market distribution. They need to have direct contact with retailers, by visiting their shops either by scooter or car, and this sometimes can be very dangerous. Consequently the problem is companies in the beverage market (such as Company P), cannot seem to retain and motivate their sales force to stay for long periods of time and perform to expectations. Based on interviews done with Company P's ex-employees, the problem is that there is not enough support given to the sales force. They do not receive support materials (such as pop-up materials like pamphlets or posters), or gas money for transportation (sales staff typically use their own transport to visit customers, and they don't get a depreciation expense for their vehicles). This really discourages sales staff. Another factor is that they do not receive incentives to sell new products or products that are not the company's main products, therefore they may reach sales targets for their main products but not for other products offered by the company.

2.2 Preliminary Problem Analysis

Preliminary problem analysis analyzes in a broad way the problem at hand by using tools such as the Problem Hierarchy Explorer and the nine windows. The Problem Hierarchy Explorer is a way of clarifying the space around an originally stated problem definition. The original problem in this case is that the sales department cannot retain and motivate their human talent (sales staff) and because they are not motivated they do not perform to expectations. The reason why we can't solve this problem is because the incentives budget given to the sales department is simply too little to motivate and push the sales staff to improve their performance, and therefore sales staff are always unmotivated because they do not have support materials (pop-up materials, transportation, depreciation expenses, etc.…) to help them improve their sales. This leads to a bigger problem which is that the company is not really a long-term sustainable business, because sales figures are declining, and also their human talent is in a constant state of change because staff quit the company because of low motivation or poor performance. This can be seen below in Figure 1 Problem Hierarchy Explorer for the "retention of sales force".

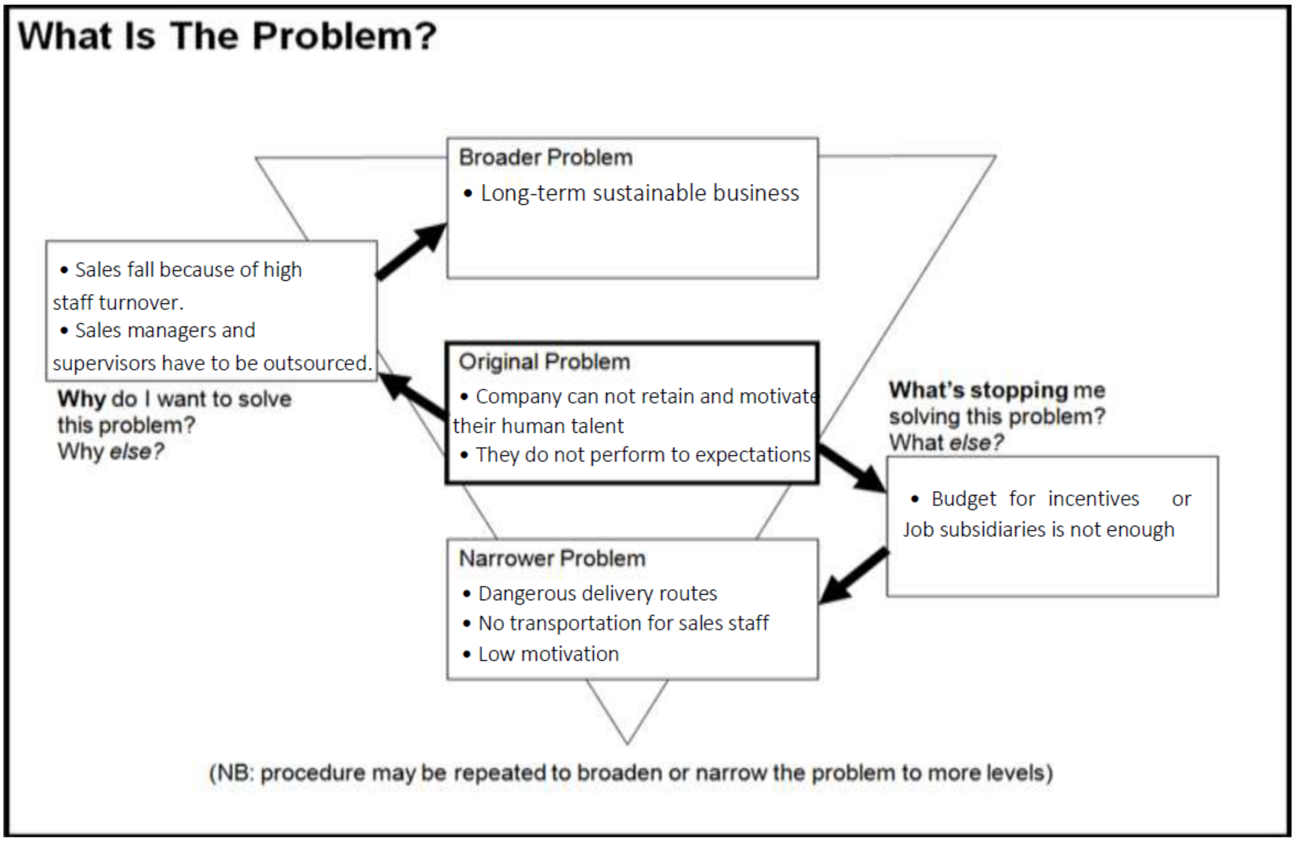

Fig. 1. Problem Hierarchy Explorer for the "retention of sales force"

The Nine Windows tool is used for the identification of resources in and around the system. The general identification of a resource is anything in or around the system that is not being used to its maximum potential. The main point of this tool is to adopt a systematic approach to look for resources. With this tool we analyze a general view of the system and at the same time tangible (things) and intangible (knowledge, people) resources. There are no rules concerning what order to fill the boxes in, or that all boxes have to have something written inside them.

Analysis of around the system, the system and finally subsystems is done by looking into the past, present and future aspects of the entire system, and also by taking into consideration general aspects as well as the tangible and intangible resources of the system, so we can have not only a broad understanding of the system but also a more specific image of it.

Firstly, past system surroundings comprising information such as historical data of cycle profiles and lost customers is useful for the prediction of future demand or trends. In the present system surroundings are customers such as vendors or small shops that purchase beverages for sale to final consumers, non-customers or potential customers, different channels of distribution, and different competitors in the beverage industry. We take into consideration tangible resources that are missing from the system, which is support materials for the sales force. Also we consider knowledge resources which are competitor strategies that are unknown to the sale force. For the future surrounding system these comprise new market trends and channels, new competitors and new customers, which in the case of this study need to be searched for by sales staff instead of by the company providing a list of new or potential customers; and possible transportation collaboration with the company or depreciation cost for sales staff that use their own vehicles.

In the past system (sales model or incentive system) are previous incentive systems, customer histories, databases of lessons learned; this type of information is useful to learn about problems that the company has had before and that could be useful to solve problems in the present or future. In the present system are the current sales team and the current sales model, which in this case lack as a sales force because of unmotivated sales staff that can't reach sales targets because they do not get enough support from the sales department. In the future system are new technologies or new products that might come to the company and a long-term sales workforce that comes with experience and employee loyalty.

Within the system or the sub-system, past constraints are previous staff that have quit the company along with the lost experience they represent, also past processes and lost deals. In the present subsystem, there are sales representatives, procedures, and a lack of technology which in this case forces them to use a paper-based order system leading to the need to have direct contact with the customer. In the future sales could be converted to homework if new technology is introduced, meaning that instead of having a paper-based order system there will be an electronic system which will make things faster and easier, and create the opportunity to achieve sustainable business with sustainable customer relationships. In Figure 2 below is the Nine Windows analysis, where all the parts of the system and all the different constraints can be seen via a more organized approach.

		Past	Present (sales workforce employees/ current customers)	Future
Around System	1	Historical Data, Cycle Profiles, Lost Customers, Exited Competitors	Customers , Non-customers, Channels, Suppliers, Competitors	Market Trends , New Channels , New Customers, New Competitors
	2		No transportation provided to sales force, No support material(Pop Material)	Transportation Provided by the Company
	3		Competitors/ Competitors strategies	Sales projections, Competitor Scenario, planning
System (Sales model or Incentive System)	1	Previous Incentive Systems, Customer History,Databases Lessons Learned ,Trials	Current Sales Team/ Current Sales Model	New Technology, New Products,Experience
	2		Lack Sales workforce	Long term sales workforce, Company Loyalty, Good salesman- customer relationship
	3	Previous business model	Business/sales model(channel)	Market trends, E-commerce
Sub-System	1	Past Staff, Experience, Past Processes, Lost Leads	Sales Representative, Procedures , Structure, Forms/Media, Communications	Home-working, Flexible Models, Autonomy, New Media, Paperless
	2		Lack of technology, Use of paper base orders, Need to have direct contact with the customer	Electronic based orders
	3	Knowledge of customers from the Sales man that left the company	New sales force knowledge of Customers	Sustainable relationships with customer

1= General Analysis
2= Tangible/ Resources Analysis
3= Intangible/Knowledge Analysis

Fig. 2. Nine Windows Analyses

2.3 Problem Modeling and Formulation

In this step we performed a function attribute analysis so we can further understand the system and get to know what each component is doing correctly and what they are doing wrong. The basic function analysis process is conducted in three main stages. In the first stage we began with a definition of the components (elements) of the system. After defining the components we continued with identification of the useful and negative relationships that exist between the various components defined in the first stage.

2.3.1 Definition of Components in the System

+**Sales manager**: In charge of the sales area and tells the chief of sales what actions to take, coaching and mentoring the sales team, developing sales strategies, goals and plans with and for sales team, reviewing sales and marketing information both historical and current, looking at competitors and evaluating, developing strategies with which to compete, communicating the corporate message to sales team, forecasting sales for senior management, working with the marketing department, heading up sales meetings and going on sales calls with team members, meeting the needs of the team and being there for them when needed, and most importantly leading the team and helping individual members succeed.

+**Sales Chief**: Responsible for a sales territory. A territory can be by a state, city, division of the country, among others. The sales chief controls, supervises, advises on actions to take, solves problems, and informs market needs to the sales manager, among others. Also he is responsible for informing staff under his charge of how to manage the territory correctly.

+**Supervisor:** Responsible for supervising a specific area within the sales territory. Supervisors report on and control the sales staff that are under their charge. These sales staff are assigned to the area that the supervisor is in control of.

+**Sales Staff:** Responsible for taking orders from customers. They are important, as they directly communicate with customers and can detect market movement**.**

+**Customer:** He is the person that places orders for sales staff to request product with. They are retailers that sell the products to the final consumer and sometimes they are also the final consumers.

+ **Product**: is simply the plain product that is sold to the customer, in this case the beverages supplied by Company P.

2.3.2 Identification of positive and negative relationships between components

+**Sales Manager - Sales Chief:** The sales manager and the sales chief have a positive relationship with each other when it comes to the manager informing the chief what actions to take, and the goals of the company. In the same way the chief informs the manager what the market's needs are as well as making sales reports. On the other hand they have a negative relationship because the budget which is managed by the sales manager (allocated by higher up management departments) is insufficient to cover incentives or support materials needed for the sales team.

+**Sales Chief – Supervisor:** The sales chief and the supervisor have a positive relationship when the chief overlooks or supervises the work that the supervisor is doing. They also enjoy good communications when the chief informs the supervisor how to handle each part of the territory. On the negative side the sales chief does not solve problems faced by the supervisor, the main problem being keeping sales staff motivated, and because of this they are losing a lot of the sales staff.

+**Supervisor – Sales Staff:** The supervisor-sales staff relationship is slightly positive when it comes to informing sales staff what part of the sub-territory they should handle. However, they have a negative relationship regarding information flows from sales staff to the supervisor. Since there are no service surveys given to customers neither the sales staff nor the supervisor know if they are meeting customer expectations. Another negative relationship is that support materials given to sales staff is missing; there is no pop-up material or transportation rebate given to sales staff, resulting in an unmotivated sales force. This negative relationship results in not enough know how, and an unwillingness to work from the sales force because of lack of support.

+**Sales Staff – Customer:** In the sales staff customer relationship there is a positive relationship when it comes to communication, like the response from sales staff to the customer when the customer places an order. But there is a negative relationship at the same time, because of the fact that the sales staff do not have support materials or do not have enough knowledge about the products and thus do not know how to sell the products or all of the product to the fullest, leading to low order volumes because sales staff are pushed to sell mostly the main product. Since the incentive system of the company is focused only on sales of this main product and not on new products or other products, the result is insufficient orders and failure to reach sales targets. Another negative relationship is that there are no recommendations whatsoever from customers to sales staff, since there are no customer service surveys, so there is no chance for improvement for the sales team.

+**Customer – Product:** The customer-product relationship is positive for some products of the company, mainly for the main product, but for other products or new products it is negative because the sales staff do not have knowledge or support materials on how to sell to the customer therefore the image of the product is discredited and sales are not achieved as expected.

In Figure 3 FAA (Function and Attribute Analysis) below you can see all of the negative and positive relationships between the components of the system.

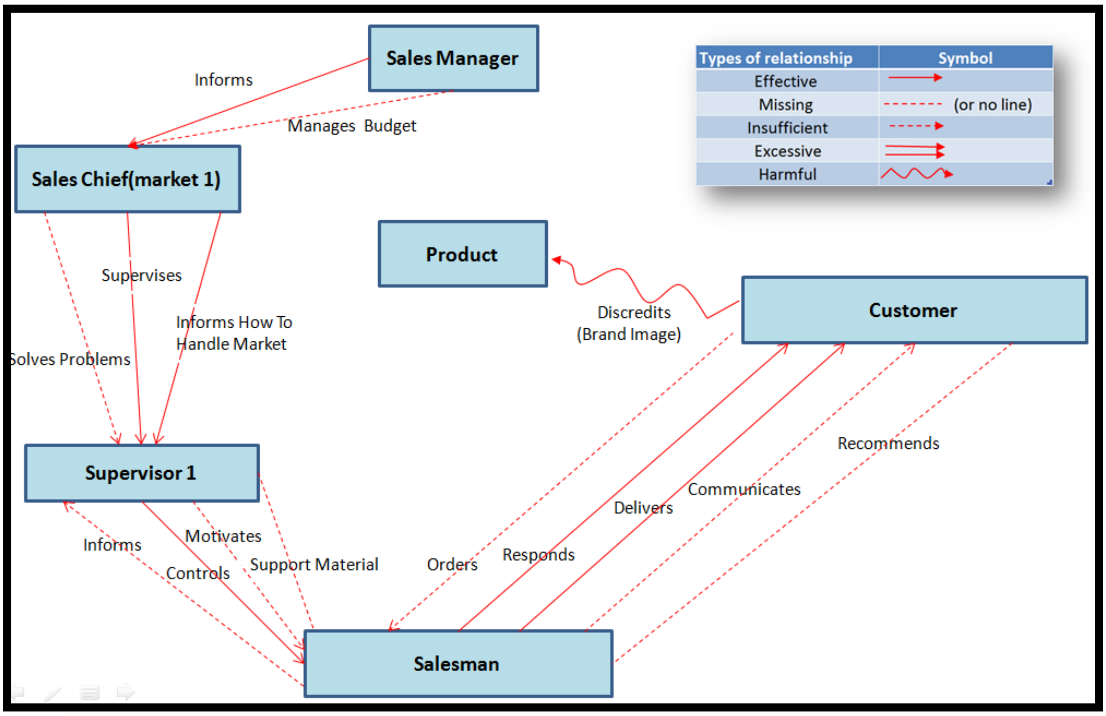

Fig. 3. FAA (Function and Attribute Analysis)

2.4 Contradiction Analysis

With the help of Root Contradiction Analysis problems are determined in a more specific manner. We discover the roots of problems and why things went wrong so that we can both correct them and, more importantly, prevent them from happening again. Based on information gathered we have come up with an RCA. We start at the bottom of the RCA with the roots of the problems and move upwards to the main problem by describing every part of the RCA as shown in Figure 4.

There are two main roots in this RCA. The first one is that the upper management department give the sales department a really *(8) low budget* to work with, resulting in a positive and a negative effect, or, in other words, a contradiction (contradiction # 1). The positive effect is that since they provide only a low budget it means more profit for the company since they do not have to spend that much sales revenue on a budget for the next year. In other words there is less cost for the company. The negative side of this contradiction is that since there is not enough budget for the sales department the sales management cannot afford to supply *(5) support materials* to their sales team. Support materials are really important to sales staff because they facilitate their work, by making it faster (providing transportation) and easier (by providing pop-up materials allowing them to sell their products in a more efficient way). The shortage of support materials results in another negative impact in the system, *(3) no motivation.* When a sales force is unmotivated it does not sell or perform as expected by the company, resulting in a drop in sales, or inability to retain sales staff *((2) sales staff not retained)*.

The second root of the RCA is that management *(9) focuses only on one main product;* because of this another contradiction comes about as a result (contradiction # 2). On the positive side of the contradiction, because management focuses on only one main product sales staff are able to reach the sales target for that specific product. On the other hand (negative side of the contradiction) because management focuses on only one product they create *(6)(7) an inadequate incentive system or an incentive system without proper objectives*. The inappropriate incentive system creates contradiction # 3, because the sales system is programmed to reward salesman only if they reach the sales target of the main product, they are able to reach this sales target. On the negative side because of this the salesman are *(4) not able to reach sales targets of all products,* resulting in a loss of opportunity for the company to earn more profits.

All of these conflicts or contradictions result in the company being *(2) unable to retain their sales force*, because they are so unmotivated or their jobs are hard to do and they do not have that much support. This is becoming a big problem for the company because it means that it is not *(1) a long-term sustainable business*. If they keep on losing sales staff every 6 to 8 months the experience that the sales staff possess and the money that the company has invested in training these staff goes to waste. Also customer relationships are harmed since there is no stable sales staff-customer relationship. Below is Figure 4 RCA, where it can be seen how these problems move from the roots all the way up to the main problem.

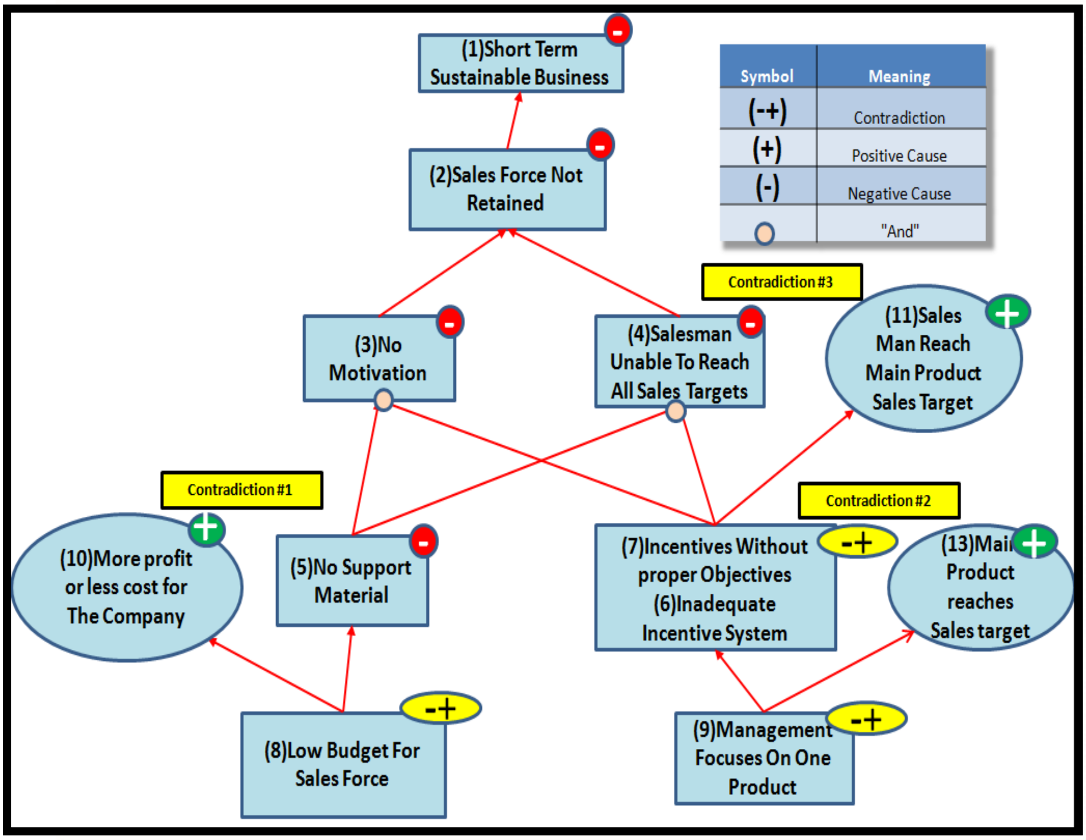

Fig. 4. RCA

2.5 Parameter Analysis

In this part of the process, with the use of the Contradiction Matrix, we analyze each of the contradictions isolated in the Root Contradiction Analysis and we select which of the parameters best relate to the contradictions. Below in Table 1 Contradictions are the three contradictions identified from the RCA, emphasizing what should be improved and what is preventing this improvement from occurring.

Table 1 Contradictions

	Things you would like to improve	→	What's stopping you from doing it
#1	No Support Materials	→	High Cost for the Company
#2	Incentives without Proper Objectives	→	Drop in Sales Profits from Main Product
#3	Sales Staff Unable to Reach All Sales Targets	→	Drop in Sales Profits from Main Product

2.5.1 Contradiction # 1 & its Parameters

Contradiction # 1 is composed of what we would like to improve i.e. "No support materials" and what is stopping this improvement which is "high costs for the company". Based on the Contradiction Matrix we have selected the parameters that in our understanding relate the most to the conflicts in this contradiction. In Table 2 below, the parameters selected for each conflict are shown as well as the possible inventive principles to solve or reduce the problem.

Table 2 Contradiction #1 Parameters

No support materials	***Parameters***	**(1) R&D-Spec /Capability/ Means**	**(7) Production Cost**	**(12) Supply Cost**	**(15) Supply Interfaces**	**(17) Support Cost**	**(19) Support Risk**
High costs for the Co.	**(7) Production Cost**	3,10,35,37		2,5,31,35	3,5,12,35	2,3,10,35	3,10,25,27
	(12) Supply Cost	1,5,6,15	2,5,31,35		1,6,28,38	5,25,27,35	2,10,12,27
	(17) Support Cost	15,25,28,35	2,3,10,35	5,25,27,35	1,5,10,26		14,25,27,35
	(21) Customer Revenue/Demand/ Feedback	7,13,14,22	1,7,13,24	2,13,25,35	13,24,25,39	3,24,25,37	4,7,13,20

2.5.2 Contradiction #2 & its Parameters

Contradiction # 2 is composed of what we would like to improve i.e. "Incentives without proper objectives or an inadequate incentive system" and what is stopping this improvement from being made i.e. "sales profits of the main product". Based on the Contradiction Matrix we have selected the parameters that in our understanding relate the most to the conflicts in this contradiction. In Table 3 below, the parameters selected for each conflict are shown as well as the possible inventive principles to solve or reduce the problem.

Table 3 Contradiction #2 Parameters

7) Incentives Without Proper Objectives (6) Inadequate Incentive System	***Parameters***	**(26) Convenience**	**(28) System Complexity**	**(29) Control Complexity**
Sales Profit from Main Product	**(7) Production Cost**	1,2,25,27	1,2,5,35	3,6,10,25
	(17) Support Cost	1,12,25,26	1,2,25,35	15,19,25,28
	(21) Customer Revenue/Demand/ Feedback	27,28,35,40	1,2,19,25	2,7,25,37

2.5.3 Contradiction #3 & its Parameters

Contradiction # 3 is composed of what we would like to improve i.e. "Sales staff unable to reach sales targets" and what is stopping the achieving of this improvement i.e. "sales profits of the main product". Based on the Contradiction Matrix we selected the parameters that in our understanding relate the most to the conflicts in this contradiction. Table 4 below shows the parameters selected for each conflict as well as the possible inventive principles to solve or reduce the problem.

Table 4 Contradiction #3 Parameters

(4) Sales staff unable to reach all sales targets	***Parameters***	**(7) Production Cost**	**(12) Supply Cost**	**(21) Customer Revenue/Demand/ Feedback**
Sales Profits from Main Product	**(7) Production Cost**		2,5,31,35	1,7,13,24
	(17) Support Cost	2,3,10,35	5,25,27,35	3,24,25,37
	(21) Customer Revenue/Demand/ Feedback	1,7,13,24	2,13,25,35	

2.6 Generic Solutions

In this section, with the help of the contradiction matrix and the 40 inventive principles, generic solutions are created. Each contradiction is analyzed by looking at every row in each of the contradiction tables and taking the most frequent inventive principle as the number one option to solve the problem, because the most frequent inventive principle would be the most likely to create the best generic solution. If the most frequent principle does not create a solution, then the second most frequent principle is examined and so on. If the most frequent principle does not find a solution then we analyze the ones that are not repeated. After analyzing and finding the generic solution of each contradiction, the generic solutions will be analyzed in Section 2.7 of this paper.

In contradiction #1, after analyzing the parameters and the inventive principles related to the contradictions the most frequent inventive principles are: Principles: #3 Local Quality, #5 Merging, #35 Parameter Changes, and # 13 "the other way around". In contradiction #2, after analyzing the parameters and the inventive principles related to the contradictions the most frequent inventive principles are: Principles: #1 Segmentation, #25 Self-service, #2 Taking/Separation. In contradiction #3, after analyzing the parameters and the inventive principles related to the contradictions the most frequent inventive principles are: Principles: #3 Local Quality and #13 "the other way around" (Mann, 2007).

Another option would be that once the new incentive system is completed, ex-employees could be rehired with the offer of an improved contract. The experience that they possess can be recovered and with new or extra incentives they will perform better. The incentive system could self-motivate sales staff since the more they sell the less their

2.7 Generation of a Specific Solution

In this part of the process, after the generation of generic solutions, the ideas given by the 40 inventive principles, and the use of the knowledge we have gathered from research and studies, we create a specific solution to solve the problem at hand. Based on the analysis of the contradiction parameters/generic solutions, the answer to solving this issue is creating a flexible incentive system, with one or more incentives for each part of the sales force system, one which is not only applied to the results of sales of the main product, but one that can also be applied fairly or for each product, adapted in a different way to every different situation, so that no matter what product it is (main-new-old product) there would be some compensation for sales completed if the sales target is reached. For each compensation resulting from sales, part would be as an economic incentive for the salesman, and the other part would be for expenses for support materials or transportation expenses, in other words the more sales staff sell the more economic incentives they will receive and the less expenses they will have, therefore solving the problem of not having any sales support materials. The main idea is that instead of the company giving sales staff money for support materials, they can be compensated with support expenses if they reach sales targets of every product. Instead of giving money at the start for support materials, the company will provide support materials only if they achieve a large percentage of sales or if they reach sales targets, thereby motivating sales staff to do better.
expenses for support materials will be. If ex-employees are rehired they can be part of a new incentive system that will cover all products therefore boosting sales of every product not only the main product. Figure 5 below shows problem/ conflicts and corresponding solutions, in which it can be seen how each principle creates an idea for a specific solution.

Contradiction #	Problem/conflict	Generic Solution	Specific Solution	
1	(+)No Support Material (-)High Cost for the Company	[3]Local Quality [13]'the other way around [35]Parameter changes	• Principle 3: From uniform incentive system to, flexible incentive system. • Principle 13: instead of company providing support material let the salesman earn their support material by selling. • Principle 35: Giving ownership to salesman, make them invest in their own company.	Flexible Incentive System
2	(+)Incentives Without Proper Objectives (-)Drop of Sales Profit from Main Product	[1]Segmentation 25]Self-service	• Principle 1: divide the incentive system in an way that it covers all of the prodcuts the salesman are incharge of. • Principle 25: rehire employees that quit, regaining their experience and making them better with a new incentive system.	
3	(+)Sales man unable to reach Sales target (-)Drop of Sales Profit from Main Product	[3]Local Quality [13]'the other way around	• Principle 3: From uniform incentive system to, flexible incentive system. • Principle 13: instead of company providing support material let the salesman earn their support material by selling.rm incentive system to, flexible incentive system.	

Fig. 5. Problem conflicts and corresponding solutions

2.8 Specific solution for incentive system

An incentive system is a vital part of any sales force and of any company. Besides helping increase sales volume, coverage, customer service, etc., it also helps develop human talent through the direct contact they have with customers. It is necessary to have a system of incentives that is effective and not only benefits the company but also helps with the developing and retention of human talent. The system of incentives that will be offered will be directed to the sales force of companies engaged in the distribution of beverages.

The incentive system that will be proposed consists of different tasks that will help to develop and retain human talent. This system will be to the benefit of Company P and will help them develop and retain their sales force. Every task proposed is essential because it has a specific objective in the incentive system. Below in Figure 6 is the tasks that the proposed incentive system will have.

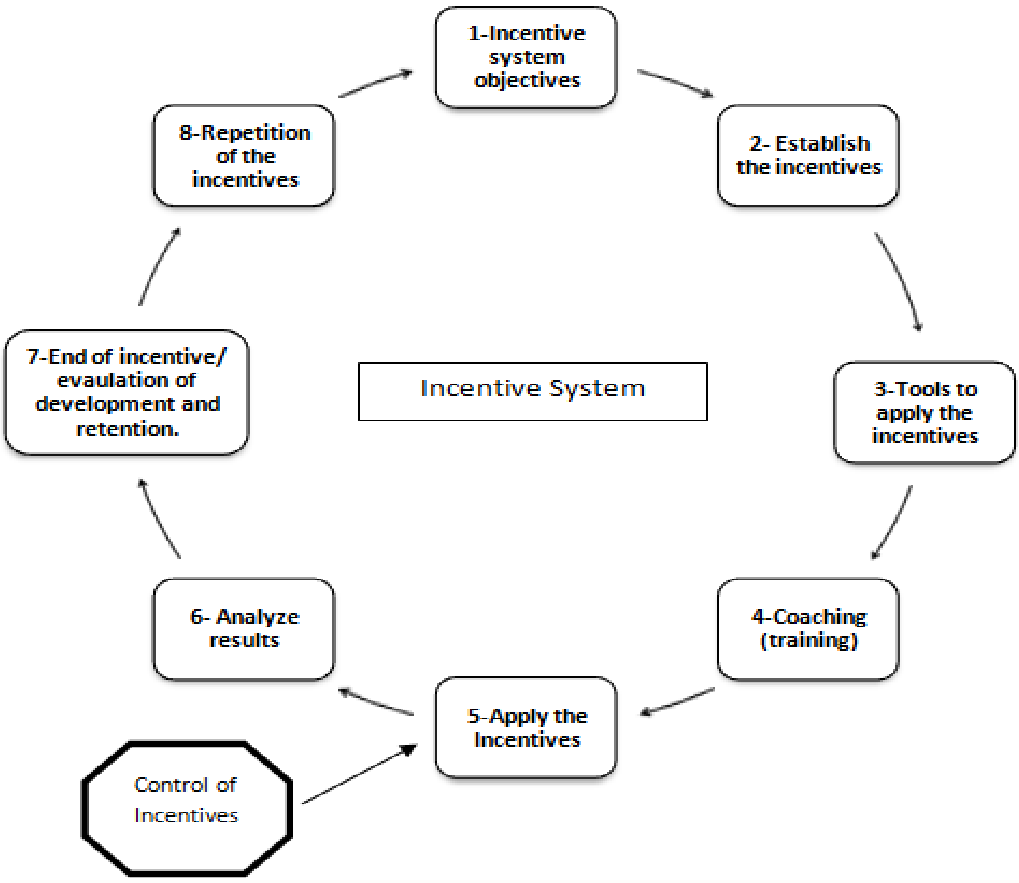

Fig. 6. Incentive system

The incentive system must always be in a state of constant feedback. The feedback will allow the system to maintain the incentives. This means learning to improve every activity by avoiding mistakes that have happened in the past by keeping it in a state of constant improvement. That is, to improve every aspect of activities and to achieve the development of talent within the sales force. The development of human talent gives the company a competitive advantage over the competition. This is because the staff knows their way around and does their work efficiently and effectively. By having different types of incentives, the system is adapted to every single aspect of Company P, including sales incentives, customer service incentives, customer resource incentives, coverage incentives, and clients served incentives, helping to overcome the problems of the company.

3. Conclusion & future research

A good incentive plan is straightforward and predictable. It is easy to comprehend so that staff can link their performance with their pay. It is predictable, so that people can match the work they do to their objectives. A good plan is fair and flexible enough to accommodate new product launches and changeable markets. It is economical, yet competitive. Finally, it meets the needs of both its customers' sales force and the company. Research indicates that broad-based incentive plans can be utilized as a means to encourage both employee performance and productivity (Gordon & Kaswin, 2010). When implementing an incentive plan, several considerations are needed to ensure the plan is successful. However, it is important to note that incentive plans cannot guarantee employee productivity by themselves. They must be tied to effective human resources practices in order to ensure a successful work environment. These include determining appropriate incentive awards, instituting a broad?

In the last few years, TRIZ methodology has been used in several fields. It began to be studied in several non-technical areas such as business, finance etc. (Souchkov, 2007). This study is inspiring because human talent has not been evaluated to the fullest before with systematic innovation, and systematic innovation can be used as a creative tool to design a guide for managers. The major contribution of this paper is to show that human talent is an appropriate area in which to use systematic innovation methodology even though originally systematic innovation was only applied to engineering problems.

Regarding future research, it is recommended that researchers should focus on analyzing this study in terms of different cultures or environments. The fact that this study is applied to a company in El Salvador does not mean that it could not be adapted to a different industry in a different country. Every company has its own "personality" and culture. For an organization to be successful over the long term, its management style needs to be designed depending on its culture. Taking this fact into consideration, incentive systems can be designed or adapted depending on the characteristics of individual companies or the countries within which they reside.

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