Towards inventive design through management of contradictions

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Abstract

Consumption of innovative products is continuously growing and this has a major impact on industry: the need to rebuild design potential is strongly felt both in terms of human skills and methodological expertise. The question behind the challenges regarding this situation can be summed up as follows: are the tools and methods developed during an era in search of quality optimization still appropriate in the context of the needs of innovation era? Two fundamental aspects make us think this is not the case: the gap between the rate of requests for human creativity and its actual capacity [1]; and the gap between the scopes of knowledge required in view of the level of technical object's complexity and the inherent cognitive abilities of a collective human group within a given organization [2].

In our paper, we would like to introduce that the fundamentals brought by TRIZ (theory of inventive problem solving) [3] and its extension OTSM-TRIZ [4] can become a large part of the answer to this situation. After expressing the limitations of traditional design approaches, two elements will be exposed: the initial mode of representation of the design problem as a net of contradictions and its advantages and the fact that within OTSM-TRIZ, the orientations of the design actions are constructed both in accordance with the laws of engineering system evolution and the specific requirements imposed by the industrial situation. A case study conducted in collaboration with Thales regarding a ground-based radar design will also be partially presented to illustrate practically the efficiency of such a contribution.

Keywords:
TRIZ, OTSM-TRIZ, Inventive design, Complexity, Contradictions, Network

1 INTRODUCTION TO NEW CHALLENGES FOR A RESEARCH IN DESIGN

1.1 The “eras” of industrial challenges

It is universally acknowledged that our industry crossed, over its history, several eras characterized by tendencies [5]. They are also influenced by social evolutions, nature and lead organizations to necessary evolutions [6]. The era which we entered from now on near a decade and that succeeds quality era, is the era of innovation. Our aims in this article are not to define innovation, nor even to give our own definition to it but to contribute to one of its characteristics: the necessity to raise inventiveness of design activities of companies [7].

1.2 Complexification of technical objects

One of the obstacles to design activity towards inventive practices is in our sense linked to modes of representation of technical systems. A large amount of contribution participate in the optimization of its formalism, its computerization, its sequencing but only few become attached to the difficulties of breakthroughs introduction, those which bring important changes in the inventive character of designs results. Besides this, the necessity to manage difficulties is increased when complexification of the technical object is effective [8] [9] [10]. It imposes not only a formalism of representation but also to assist designers by making easier for them the access to knowledge located beyond their fields of competence. There, a paradox of design appears: the mode of representation of technical object must be simple to be understood and managed by designers and complex to be exhaustive in its representation.

1.3 The necessity for modes of representation to evolve

Observing functional analysis with regard to innovation

A large amount of companies are still led to optimize the quality of their products, process and services, task which has already assumed by the era of quality. Under this era, were born an impressive quantity of tools and methods aiming at structuring the nomenclature of objects while being easily manageable in quality processes. Functional analysis does not make exception to this and is a flagrant example. This tool has a vocation to give a clear and structured representation of the technical system's functionalities when observing it, inseparable task of the constitution of initial requirements of a design process. But a question that we are tempted to settle is the following: Is functional analysis an instrument adapted to a mode of description which would aim at initiating an inventive step of breakthrough [11], as it is imposed now within innovation era?

Our analysis of expectations of inventive design leads us to express three points expressing that functional analysis may not be ideal when seen as mode of representation of the object in an inventive objective:

- An inventive mode of design imposes to go beyond the need to satisfy customer's requirements but also to verify that the dynamic of chosen evolution is in accordance with laws characterizing the evolution of the technical object [12].
- It is necessary, to bring changes in an object, to formulate and to solve contradictions which stands in the way of his evolution.
- The formulation of a contradiction imposes a system analysis at various levels of observation of the object (Supersystem, System, Subsystems, Elements, Name of the feature, Value). Besides, modes of representation of the complexity of links between these contradictions must also be represented, to lead a consistent management of these contradictions.

The limits of brainstorming regarding complexity

The actual approach which consists in supporting inventive initiatives in a process of design using brainstorming (we shall qualify it as "divergent" at least in its first stage) has as main objective to issue a maximum of ideas so that they constitute a sufficient statistical population allowing to launch successive sorting (here we can speak about convergence) isolating the idea the most in accordance with the initial requirements of the project [13]. The sorting of these ideas are, either simple filters blocking ideas considered harebrained, or filters blocking ideas not allowing to assume data's placed forward in the requirements of the projects. The issue of these successive sortings is to restrict ideas to the most appropriate of them, to prioritize them to have alternatives opportunities of development more or less in rupture with the present state of knowledge of the company. It is then up to the decision-makers to choose the alternative which will be in accordance with their own strategy.

Such process drives to two obvious limits:

- Chosen direction is *–de facto-* led by ideas issued during creative sessions and therefore relies on an unpredictable process of exploitation of knowledge of individuals and at no moments allows us to guarantee that chosen direction is the optimum one.
- The exhaustiveness of the collected ideas relies only on competences and knowledge of individuals having participated in the sessions of creativity. Thus, it is impossible to guarantee that the statistical spectrum of issued ideas contains the one leading to the best possible resolution in the given situation.

We shall therefore sum up this paragraph by this postulate: the implementation of a divergent design process supported by brainstorming and functional analysis does not allow guaranteeing that directions of design are ideal in the sense of inventiveness. Because of this, expenses engaged to iterate on the basis of the unsatisfaction of acquired results (whether it is by prototyping actions and tries, by calculations or R&D) put the firm in a logic of trial and errors, costly for the profitability of its R&D, so as for the man/hours expenses that are engaged.

2 GROUNDINGS OF TRIZ AND OTSM?

OTSM is a further development of Classical TRIZ meaning in its Russian acronym "General Theory of Powerful Thinking" (In Russian "Obschajia Teorjia Silnogo Mishlenia"). This acronym was proposed by Altshuller based on his analysis of the fact that more and more people start to use TRIZ-based problem solving tools to analyze problems beyond the scope of engineering. Some of those attempts were quite efficient, therefore Genrich Altshuller proposed his followers to develop their research in the direction of a transformation of Classical TRIZ into two ways:

- A general approach for solving not typical (creative) problems
- Attempts to enhance the powerfulness of the thinking regarding problem analysis and synthesis of a solution.

This research has been started by Nikolai Khomenko in 1985 and now the results of the research are used for coaching problem solving sessions aimed to treat complicated not typical multidisciplinary problematic situations. OTSM based tools and methods are taught at INSA-Strasbourg in their program of Advanced Master of Innovative Design.

Here is a short description of several key points about both these theories and about some of tools that are based on them.

2.1 Grounding hypothesis of Classical TRIZ

We have historical evidence that first attempts to develop efficient tool for solving non- typical problems took place at the same time both in Ancient Greece and China: between 400 and 300 years B.C. [Encyclopedia Britannica].

During these thousand years a lot of stereotypes appear about ways of solving non-typical problems. All of them survived in our mind and we assume this as the most difficult barrier to learn Classical TRIZ. In order to efficiently use this theory it is necessary to overcome cognitive obstacles and stereotypes about complicated problem solving. In the next section, the main idea in order to start to overcome these stereotypes will be expressed.

2.2 How to narrow research area of solutions without lots of trials and errors?

In reality Classical TRIZ has both tools for convergent and divergent thinking. TRIZ based technologies are dedicated to control "uncontrollable" creative imagination. They follow this goal: "understand the deepest root of a given problem and eliminate (or overcome) it".

As history of TRIZ have already expressed, Altshuller investigated hundred thousands of patents, history of technological system evolution and most published known scientific discoveries appearing in encyclopedia and collected state of the art publications. The result of this research was a set of methods and tools designed to solve real and complicated problems. The very first attempt in 1949 was successful beyond expectations and allowed Altshuller and his colleague Shapiro (both 23 years old at this time) to obtain a winning prize in competition with experienced inventors and researchers. This experience stimulates Altshuller to teach people to use his methods and improve it during two decades of iterations. In 1975, the first appearance of TRIZ acronym after the formulation of a theory recognized as a system of methods for complicated problem solving was published.

The three axioms of TRIZ were proposed to solve the key problem mentioned above and to be a basis for scientific methodology of non-typical problem solving:

1. First axiom: Laws of technological system evolution do exist. Technological systems evolve not randomly but according objective laws of evolution. This law does not depend on human. These laws should be discovered and used in order to develop efficient methods of problem solving. The better solution is a solution that is done in accordance with these laws.
2. Second axiom: Contradiction must be overcome. Technological systems evolve not randomly but they have to overcome contradictions. In order to get breakthrough idea we should find a way how to overcome contradictions. Good solution must overcome contradiction.
3. Third axiom: Problems must be solved in accordance with peculiarities of each specific case. Problem could not be solved in general. Each specific problem must be solved in accordance with restrictions of the specific problematic situation. Good solution is a solution that involves as less new resources as possible. Ideally problem should be solved just using existent resources.

These three fundamental axioms can be expressed as statements accepted as true consequently from the observation of tested hypothesis. They constitute the scientific background for Classical TRIZ. In addition to these three background ideas, a model of problem solving process was proposed. Altshuller named it ARIZ and this theoretical model was constantly developed and improved until 1985.

2.3 Main tools based on Classical TRIZ

Altshuller's ARIZ

A better understanding of problem solving process drove the evolution of ARIZ as a method for non-typical-problem solving. The four assumptions of ARIZ framework are the following:

- Assumption 1: Before starting to solve problems, we should investigate the problematic situation and build a model of this problem according to the axioms of TRIZ.
- Assumption 2: The model of the problem must appear as a more general description of the problematic situation.
- Assumption 3: This general description should reveal the hidden analogy with previous experience or transform description of the problem into the form of a typical solutions using a frame proposed by TRIZ's System of Inventive Standards (76 typical solution for most typical inventive problems).
- Assumption 4: As soon as general description appears, it is necessary to feed-back with the initial situation and develop a specific solution for this specific situation. In order that a general solution is implemented by using only resources available in this specific situation.

During history of TRIZ evolution several generation of ARIZ were proposed. They have been systematically improved by Altshuller and tested many times by a lot of researchers and students who actively cooperated with him in this task. The used way to develop the robustness of this tool designed to solve non-typical problem was then to use theoretical background and test the method by real practice.

To summarize, ARIZ is a program of activities dedicated to understand deeper the root of a problem and to eliminate or overcome it. It integrates into a coherent system, all main methods of Classical TRIZ so as efficient methods to overcome mental inertia. ARIZ is also respectful to TRIZ's first axiom (laws of technical system evolution) and help to find and overcome a contradiction that make problem difficult to solve. It is also oriented to use available resources in a specific situation.

Altshuller's System of Inventive Standards

A generalized description of a problem that could be assumed by ARIZ, usually structures the reformulation of the non-typical problem into a general description. This form of problem can be placed in front of a solution that exists in data base of a system of Inventive Standards organized as a set of rules.

Initially, there were five Inventive Standards as Altshuller named them. Years after year, he collected throughout his investigations, the most interesting and inventive solutions and describe them as more generally as possible. There were several generation of Inventive Standards System: 5,18, 28, 50 and finally 76 in the latest version. The way how these standards were organized evolved as well. The more Standards were discovered and expressed, the more efficient their organization as a system was assumed. Today, the system of Standards is organized in accordance with Altshuller's Laws of engineering system evolution (see TRIZ's axiom 1). That is why we can use this system not only to find a solution but also to develop it further accordingly to the Laws of technical system evolution. The generic frame of a standard is formulated in the following form:

If a general description of problem is [described model]…

Then use the general description of a solution [standard inventive way to be solved]…

The combination of ARIZ and System of Inventive Standard Solution has already helped to solve a huge amount of worldwide problems. As a logical result to this, the more problems are solved the more complicated new problems appear in front of us.

2.4 General ideas of OTSM

As more efficient TRIZ based methods appeared, more people start to use them for problems incrisingly growing in complexity.

Then some attempts to use TRIZ to solve non-engineering problems have been observed. At the same time TRIZ-experts started to use the tools to solve complicated networks of problems. The results of these new investigations were not systematically successful. As a consequence, appears a new subject for research: the necessity to answer to the following questions:

Why TRIZ methods are able to solve different kinds of problems? How can we increase their efficiency? How can we teach TRIZ users with no engineering background? What are the peculiarities of new and more complicated problems proposed by industry to TRIZ experts?

The Idea about further development of classical TRIZ appear in the middle of 70's. In the middle of 80's, Altshuller encourage his followers start to develop OTSM as he named future development of TRIZ. One of the authors of this document has started his research and posed the key problem of OTSM in a form of Contradiction:

In order to be universal, rules of problem solving methods should be as general as possible. But the more general rules of problem solving are, the more general and useless to be practical the solution will be.

As an answer to this, the rules must be specific in order to be able to solve a specific problem. But the more specific they are the less universal they are.

This exclusive circle add an even stronger stereotype: It is impossible to develop universal tool efficient enough for solving an infinite variety of problems.

When this contradiction has been stated as a key problem for a universal method of problem solving, TRIZ provided us (using elements from its body of knowledge) the direction to a solution for this contradiction:

Each rules must be general this will make them universal, but the system of rules should be organized in the way that, all together applied as a system, these rules could be helpful to find a specific solution of a specific problem.

Another research problem about OTSM development was the following: The more complicated the problematic situation is, the more important the amount of contradiction exists. After the recognition of these problems, the use of ARIZ to solve them one by one appears less and less relevant. One more key problem of OTSM has then been formulated:

How can we reduce the amount of problems to be solved in order to solve networks of problems constituted of at least several hundreds of them in an initial situation description, assuming that this amount can even grow during the problem solving process?

Today, after this research has started twenty years ago, in the frame of OTSM, several research findings have been found, so as for some other theoretical problems. A new model of problem solving process has been developed: a fractal model for solving complicated non-typical problematic situation was proposed. This Fractal model includes as a sub-model proposed by Altshuller. This "E.N.V. model[1]" was taken from Artificial Intelligence to uniformize the description of various elements of systems and developed further to fit the needs of OTSM problem solving process. A set of OTSM Axioms has then been developed; it shows the restrictions of an efficient application OTSM based tools for problem solving. Some other theoretical models were also proposed and approved by Altshuller in 1997.

2.5 Main OTSM based tools for problem solving.

In accordance with Fractal Model, an initial problematic situation should be presented as a network of problems. OTSM based tools have been built in order to tackle such situations. There are four main OTSM based technologies:

4. New Problem Technology - dedicated to settle a new problem.
5. Typical Solution Technology – dedicated to test opportunity to solve problem or get partial solution to the problem by using TRIZ and OTSM typical solutions and techniques.
6. Contradiction Technology – based on Altshuller's ARIZ and helpful to get solution or at least set of partial

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[1] E.N.V is an acronym for Elements, Name of the feature and Value.

solutions as well as understand deeper the root of a specific sub-problem of a problematic situation.

7. Problem Flow Technology – helpful to handle flow of sub-problems that appear during problem solving process and for the synthesis of final concept solutions of partial solutions concept.

These four main technologies have been proven through an important amount of practices. And as a result of their evolution and further development, we could say that OTSM appear today as a tool to organize problem solving process for interdisciplinary complicated problem solving and a language for various kind of knowledge representation that belong to different areas of human activities.

These peculiarities are also helpful to collect, present, store and use knowledge of a company for further application and decision making process. As well as to be used in order to develop strategy and tactics to drive the evolution of a company and its product, to organize and coordinate cooperation inside and outside a company.

OTSM still evolves and also aims at developing new theoretical models useful for creation of new tools so as the improvement of previous ones.

The next section will be dedicated to present how, within the framework of OTSM, a proposition can be made to face the problematic of a network of problems. The proposed case study will feature a simple example of an application of some of OTSM elements.

2.6 Convergence: from a network of contradictions towards a portrait of an ideal solution

All design acts are carried out as cognitive acts encouraging the designer to solve a contradiction introduced by his act. This essential notion in TRIZ stipulates that the contradiction symbolizes the obstacle which has to be understood and solved to enable the technical system to evolve in keeping with the laws. While cognitive reflexes often drive designers to a compromise solution, Altshuller purports that compromise does not arise from an inventive approach and that to move in the direction of inventiveness, a designer must refuse compromise despite his psychological inertia to solve the dilemma posed by the contradiction. The level of complexity involved in designing a technical system implies that a network of contradictions should be built up in order to place the designer face to face with the challenges he has to raise.

Then, the contradiction network helps the designer to build a model of the problem in order to reduce its complexity. A set of guiding factors must then be designed for this network to enable the designer's problem-solving actions (or possibly his choices) to be directed towards an inventive approach, bearing in mind the company's strategy problems.

3 DRIVING THE DESIGN ACTIVITY USING A NETWORK OF CONTRADICTIONS

3.1 Network constitution

In this paragraph we offer a method for representation of the complexity of a problem “contradiction oriented”. Most of the representation modes are “functionally oriented” or oriented ”morphology of the object”, but very few provide (when modeling) a clear representation of problems. That's why the model which we offer proposes to carry these essential notions:

- represent an association of parameters linked to the object: as a network;
- provide a representation of links between these parameters: the internal links of this network;
- point out influences of the values of a parameter’s evolution: the nature and the directions these links are taking;
- Facilitate the management of the network (its evolution): the graphical representation (mostly its visual aspect).

Rules concerning its constitution could chain themselves following this pattern:

1. Extract expression of problems from the engineers responsible of the study, by constituting a group including all individuals carrying the knowledge (people from every field concerned by the technical system in question)

2. Isolate, during these expressions, the key words implicating the ontology of the model to be constructed.

3. Clarify the model by completing its form using additional questions aiming at reaching an exhaustive representation

4. Verify the model with the members of the group and improve/correct possible errors/forgotten elements in representation/perception of the problem.

Semantic rules

Some semantic rules must now be established. The diversity of the typology of parameters concerned in the problem representation imposes a consistent ontology in order to represents a parameter so as to carry all elements included in its formulation. The following table specifies the semantic definitions of used terms:

Active parameter	Parameter which provokes possible changes in evolution of its values and whose management remains controlled by designers
Evaluation parameter	Parameter which has values influenced by the result of an evolution of values of one or several active parameters
Influence	Characterize the relating influence of a parameter in comparison with its network
Value (A and opposite of A)	Characterize the state of a parameter in the limit of its values
Element	Part of a decomposition of the studied system having a sense with regard to the key parameters of network
Parameters contradiction	Association of an active parameter, and the couple of evaluation parameters influenced positively by the evolution of its opposite values
Macro-network	Group of contradictions linked between them and covering exhaustively the whole fields implicated in the initially stated problem
micro-network	Reduced group of contradictions restricted and pruned by directives of specific conditions linked to problem
Subsequence	Relative influence between two evaluating parameters leading to the fusion of these last

Table 1: Vocabulary used in the representation

Rules of representation

Modes of presentation must be graphically comprehensive, iterables, instantiables and allow the management of this network. We offer therefore to establish certain rules allowing visualizing the interrelations of contradiction's belonging to several domains of parameters expressed in a micro-network.

The Yin-Yang symbol (understood here in the sense of its graphical representation) carries, in our approach, the idea of representing a heart of a contradiction, the starting point of the birth of two oppositions (here applied to the parameters of a system) and of their influence on other centers. From these active parameters, and the states of their values, directions are initiated (at the same time positives and negatives) towards other evaluating parameters [16].

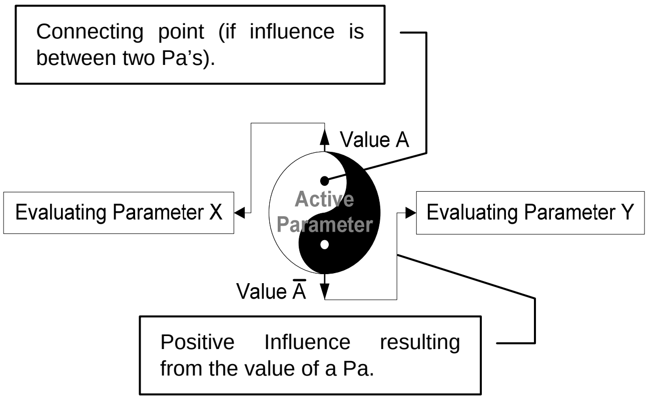

Figure 1: Representation of a Pa and its influences on Pe's

3.2 Driving of a network

To evolve in coherence with the model of convergence proposed by OTSM-TRIZ, we established rules of managing a network of contradictions. These rules have as objective to reduce a macro-network in a micro-network allowing easing a formulation of key problem to be solved. Let's remember that the sense of a "key problem" must be understood here only in the sense of a problem towards which converges mutual interests:

1. The monitoring of specific terms imposed by the situation;
2. The coherence in the evolution of the studied system with the objective laws which this system obeys.

Modes of driving the network are of three types:

Driving oriented "centers of importance": Network reduction passes by the priorisation to the most solicited evaluating parameters; at the same time by the active parameters and by subsequence.

Driving oriented "evolution": The analysis of the logic of systems evolution often reveals obstacles to this evolution. These obstacles, in the preliminary stages of formulation, are still only embryos of contradictions but lead, at the stage of convergence, to focus on parameters resulting from these obstacles.

Driving oriented "resources": The mode of instantiating contradictions states that a list of resources should be established for every contradiction. The resource appearing most often in these lists (the most commonly present in the active parameters) becomes centre of preference. This last is logically carried by an element of the system (more than by the others) and induced therefore to converge on the parameters of action carried by this element.

4 CASE STUDY OF A GROUND-BASED RADAR: THE M3R OF THALÈS

4.1 Summary of M3R's project

On the implusion of DGA[2], M3R technology[3] acts as preamble in the development of future radars of air defense enlarged to active antenna. They will allow to discern, to follow and to indicate in systems of interception (batteries of missiles) of classical air targets such as planes or drones, but also ballistic missiles. The realization of this demonstrator, M3R served, for one of its sub-problems, frame in the spreading of the contribution offered in this article.

Initial situation shows a group criterions considered important by the responsible of the project and several directions are initiated to collect ideas allowing, case by case, to treat the evoked problems. Our collaborative work aimed at implementing a mode of representation of the situation in order to understand influences of a network of active parameters influencing evaluating parameters. Expected results are to converge towards a physical contradiction in order to proceed to its resolution using a classical problem solving method.)

Illustration 1: Situation of one of the latest radar generation: Master A

4.2 Network of problems representation

After the establishment of a team constituted from the persons possessing the knowledge linked to the study. It was possible to set up, using a synthesis method, their problem in the form of a macro-network (see figure 2). The constitution of this network allowed several reformulations of contradictions; they constituted a determinant factor for the added value of the employed method. These successive reformulations became a guarantee of a good understanding of the situation and provided mutual confidence within the engineers of Thalès to evaluate the relative importance of the challenges of each technical data.

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[2] DGA is the acronym of the french Direction Générale de l'Armement.

[3] M3R stands for Radar, Mobile, Multifunctional & Modular

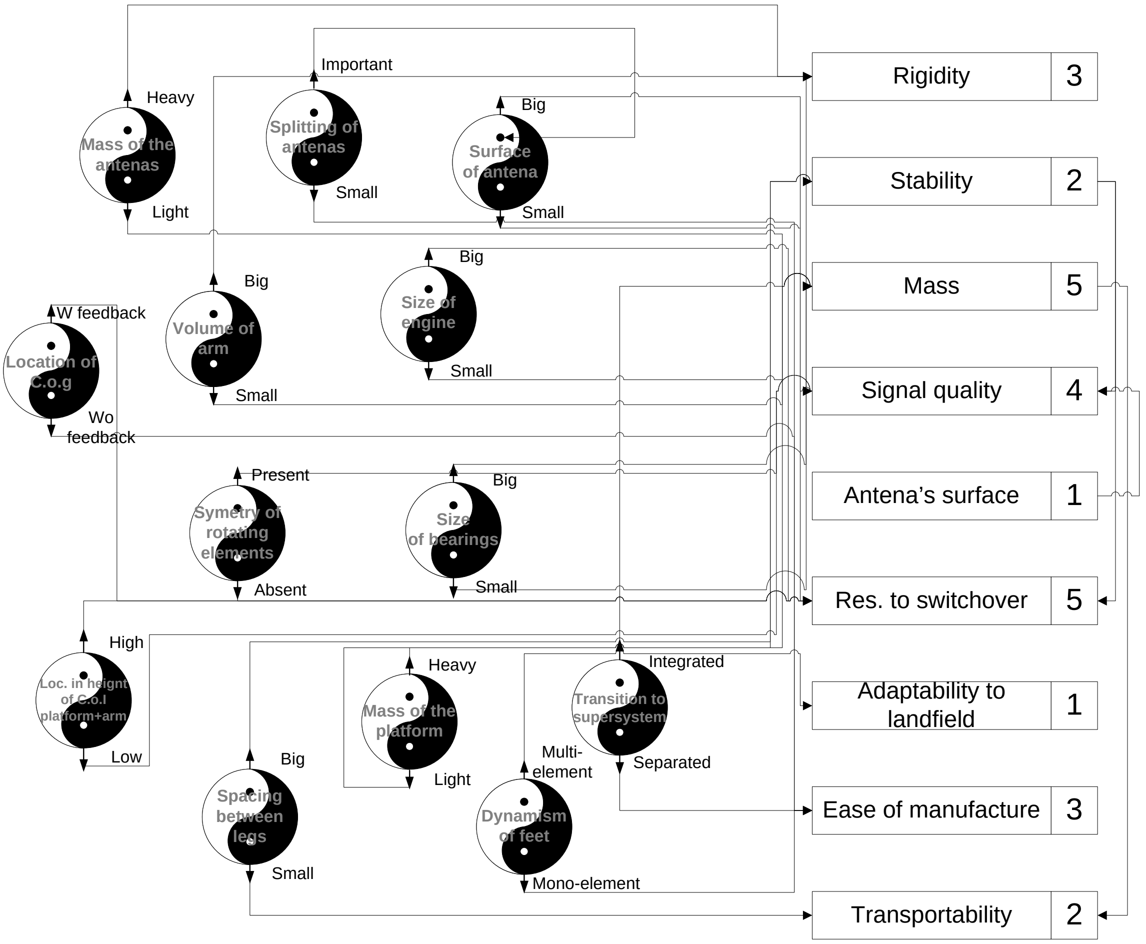

Figure 2: Representation of the macro-network linked to M3R problem

4.3 Used modes of convergence

In our case, the mode of convergence used to deal with this macro-network was by "centre of importance". After a first pruning of this network in eliminating the centers of contradictions implying elements provoking important modifications in the structure of M3R, we managed the rest of the reduction by balancing centers of importance and their subsequences. The result lets appear two contradictions as being the most influencing the problem. These last, were then treated by solving methods of classical TRIZ. Once these main contradictions were brought to evidence, the method allowed us to define two different types of solutions:

- Solutions coming from the TRIZ databases use: for instance the use of a structure in Releau's triangle alloying better results regarding the compromize between mechanical resistance available space regarding the feet of the antenna.

- Solutions coming from the use of resources: for instance, the use of the antenna's feet as elements for transportation, or else, the use of the mass of iso containers mass (traditionally only used for transportation purposes) to ensure the stability of the antenna when functioning.

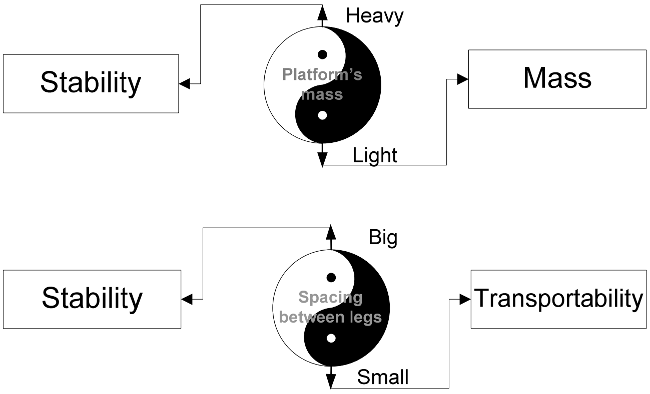

Figure 3: The two contradictions at the heart of the problematic

4.4 Solving process of a contradiction

When the network reduction has reached the state of a prototype of a physical contradiction (sometimes also called conflicting pair), it is then possible to treat the problem using ARIZ 85C. The main goal of ARIZ is to conduct a solving process in a logical way, oriented by fundamental notions of TRIZ like Ideality formulation, physical contradiction formulation, resource uses, and the most logical use of the databases of TRIZ.

In the case of M3R, the most significative result of the solving process led the engineers of Thalès towards a new architecture of radar with significant weight reduction (approximately 30%), allowing a better transportability (from 5 to 3 iso containers) and a better stability under wind conditions in operation.

These results are of importance not only regarding the improvements of the radars performance, but also on the strategy of the company. If a significant stability is proposed by the solution concept, it is also possible to increase the size of the antenna (its surface) allowing reaching a wider range for the radar. So as regarding to the transportability and the weight reduction: If the radar is transportable using lighter and smaller amount of iso containers, it is then possible to reach new marketing targets for the company like offering transportation by helicopter. During the construction of the solutions, the network of contradiction remains a necessary support to guide choices and to drive them in a converging way.

Besides the final outcome concretized by different notions and collected partial solutions (see illustration 2), the first major result of the method reside in the logical guide offered by the network of contradiction to identify contradictions to be solved in priority.

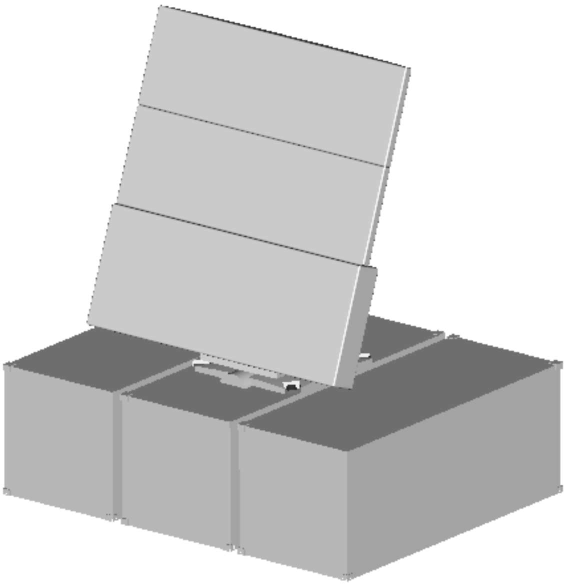

Illustration 2: Solution concept in development

In our case, both contradictions obtained (as shown figure 3) are an essential intermediate result: it allows the creation of rules of formulation for a problem never formulated clearly, and therefore never solved.

5 CONCLUSIONS

5.1 On the use of a network of contradictions in M3R case

As a conclusion to the use of our approach regarding the M3R case, we may conclude around two different aspects. The first one reflects the benefit of the roadmaping offered by the network of contradiction. It has been felt by engineers of the company that compared to their traditional way of conducting the design process, a clear representation of their problems, and a logical way to converge towards a legitimate goal, provided a structurized way of choosing the right problem to tackle. Thus significant R&D time has been saved if instead a traditional trial and error procedure would have been employed. The second one is linked with the "non-compromised" way of treating the problem. Both the fact to formulate an ideal goal and to refuse the simplicity of a compromise to solve it has also been felt as an important improvement compared to their traditional design process. The importance of the value of the result is strongly felt since both of the initial parameters have been improved. In terms of inventiveness of a solution, it is also a significant improvement that, in its turn, touches the strategy of the company and its willingness to offer breakthrough solutions in their market. We can also state that regarding the management of innovation of Thalès, this approach helped the company to switch from a random way, where ideas confront to each other without finding solutions, to a logically constructed process. Both major contradictions pose the problem to be solved using a clear formulation understandable by anyone within the company.

As another element of conclusion regarding the case, we may also state that for the team responsible of new design challenge within a company, to choose solutions also signify to be able to argue and defend them (support them) in front of the client. Beyond the case study itself, the rigorous way to acquire the results is of great important for the team. Moreover, if a parameter is subjected to evolution, this method would now allow restructuring the network and focusing on another appropriate contradiction to be solved in its turn.

5.2 On the expected improvements in design with this driving mode

The impact of such formalization in terms management modes of contradiction's network provide significant advantages in the stages of formulation of strategical problems of the firm. This impact can allow not only assisting strategical decisions concerning R&D activities, but also allows, by its abilities to be managed, for the company to learn about his own problems and to forecast in accordance with technological systems evolutions.

5.3 Perspectives of research regarding this subject

The strategical assistance of the company, at any level, by a representation of its problems oriented "network of contradiction" also provides interesting perspectives for knowledge computerization [17]. This nature of knowledge representation "contradiction oriented" (therefore problems) shall favor, by the creation of computer tools, not only the robustness of problem solving activities but also internal training of teams [18] and the constitution of means to represent the problems of the company's product evolution [19]. Ongoing research works [14] shows that partial representation of a particular technological field of the company ease the robust spreading of inventive processes and thus contribute an important way to increase design practices efficiency's of project teams.

6 AKNOWLEDGMENTS

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7 REFERENCES

[1] Epstein, H. T. ,2001, An outline of the role of brain in human cognitive development. Brain and Cognition, 45, 44-51..

[2] Allen, T. J., Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information Within the R&D Organization (Cambridge, MA:MIT Press, 1979).

[3] Altshuller G.S., 1986, "To Find an Idea: Introduction into the Theory of Inventive Problem Solving", Nauka, Novosibirsk (in Russian).

[4] Khomenko, N., Kucharavy, D., 2002, "OTSM-TRIZ problem solving process: Solutions and their classification", Proceedings of TRIZ Future Conference, Nov 6-8, Strasbourg, France.

[5] Stata, R. "Organizational Learning - The key to Management Innovation." Sloan Management Review: Volume 30, Number 3, spring 1989, p. 64.

[6] Darren Filson, 2001. "The Nature and Effects of Technological Change over the Industry Life Cycle," Review of Economic Dynamics, Academic Press for the Society for Economic Dynamics, vol. 4(2), pages 460-494, July.

[7] May, R. (1975). The Courage to Create. New York. Norton & Co.

[8] Waldrop, M.M. (1992). Complexity: The Emerging Science at the Edge of Order and Chaos. New York. Simon & Schuster.

[9] Turner, I., 1998, "Strategy, Complexity and Uncertainty", in Pool, January-February issue.

[10] Frizelle, G., Gregory, M. J., "Complexity and the Impact of Introduction new Products", International Conference on Complexity and Complex Systems in Industry, University of Warwick, UK, 19-20 September, 2000.

[11] Christis, J., "Functional analysis and causal explanation: living apart together?" *6th World Congress of Sociology, July 7-13, Brisbane, Australia*.

[12] Rolland, C. ,1994, "Modeling the evolution of artifacts", Proceeding of the 1st IEEE International Conference on Requirements Engineering, Colorado Springs, Colorado, 1994.

[13] Schwartz, A. , "Using Brainstorming to Identify Creative Solutions," *Supervisory Management*, Vol. 36, No. 10 (October, 1991), p. 4.

[14] Eltzer, T., forthcoming in 2005, "Contribution à l'intégration des approches de conception standard et inventive. Application à l'injection des thermoplastiques", PhD Thesis, Université Louis Pasteur, France.

[15] Dubois, S., 2004, "Contribution à la formulation des problèmes en conception de systèmes techniques. Étude basée sur la TRIZ", PhD Thesis, Université Louis Pasteur, France.

[16] Leaman, O., 1999, "Key Concepts in Eastern Philosophy", Routledge, 352 pages, ISBN 0415173639.

[17] A. Borgida, 1988, Modeling class hierarchies with contradictions, Proceedings of the 1988 ACM SIGMOD international conference on Management of data, Chicago, Illinois, Pages: 434 – 443, ISBN:0-89791-268-3

[18] Senge, P. M. The Fifth Discipline: The Art and Practice of The Learning Organization. New York: Doubleday, 1990. 414 pages.

[19] Sujan M., Rizzo A., Pasquini A., Contradictions and critical issues during system evolution, Proceedings of the 2002 ACM symposium on Applied computing, Madrid, Spain, ISBN:1-58113-445-2.