Innovation Management of Interdisciplinary Teams: Contribution of OTSM-TRIZ Network of Problems approach

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For the fulfillment of complex tasks such as the definition of a new strategic R&D programs or the invention of new products or services, interdisciplinary teams are launched. They are characterized by features like good command of complex problems, efficiency, and capability of performing simultaneous work, creativity and better decision quality, flexibility in a dynamic market environment as well as improvement of participation. However, the quality of results depends strongly on an efficient working environment. Empirical studies on team work currently discuss specific success factors of interdisciplinary work like communication, coordination, balance of contributions, support of each team members, standards for the working process and cohesion.
The performance of a strategic program R&D is defined at least by two basic components: the novelty of the program and its systematic performance. The identification of arising problems and their duly solutions are required. Novelty of a program is defined by the ability to generate new ideas, their conformity to the set goals and selection according to a number of criteria. The systematic performance depends on the availability of strong new ideas; but to a greater extent it depends on the connection between them, to a smaller extent on the formal procedure programs. In the paper we present instruments to support this activity and a case study that was carried out at the European Institute for Energy Research in order to test these instruments.

1. Introduction

The exploitation of the huge potential of interdisciplinary teams particularly to the development of new R&D strategies needs comprehensive tools and methods for the participation and the structuring of competences as well as for the assessment and propagation of new research activities.

The analysis of traditional innovation management approaches, for example, methods for generation of new ideas like Brainstorming, Morphological box or many other so called Creative Problem solving Methods (CPM) and methods for organization and planning like Project Management, Gantt Diagrams, IDEF and SADT show the limits of their use in interdisciplinary teams that work on complex problem situations such as development of a new strategic R&D program. Methods for generating ideas do not have links with instruments for project management. It could be interesting to have a methodology that allows integrating instruments for non typical problem solving with traditional instruments for regular project management. That could be helpful for a systemic analysis of a problem situation and ways to develop and implement a satisfactory solution. This became primary important for

long term interdisciplinary research projects that involve researchers from various domains of knowledge like: Energy, Environment, Social and Economical sciences etc. This can create additional difficulties emerging due to different terminology, as it often happens that the same word has different meanings in different sciences. And finally this kind of team more and more often consists of people who have different native languages. During the projects often appear new non typical problems that require the development and the implementation of non typical solutions, and in turn these solutions need some additional research in order to be implemented and harmonized with the rest of solutions obtained during such kind of project. One more difficulty of long term strategic R&D programming is the job rotation of people - during projects, even leaders of the project can change. That means that in addition to problem solving and project management we also need integration with knowledge management (KM) systems. We need at least the first generation of KM systems (Knowledge Sharing systems) but better use KM systems based on the paradigm of the second generation – Knowledge Proceeding systems.

It could not be considered as a three stages approach: (1) generating ideas of conceptual solutions; (2) developing a project to implement those ideas and (3) Knowledge gathering and sharing system. A Knowledge Proceeding system is required that could be integrated with means of project management and instruments for solving non typical complex interdisciplinary problem situations. This kind of non typical problem situation is more and more often called "wicked" (Conklin 2006) or "tough" (McElroy 2003) problem.

The objective of the present study was the development of a holistic method for the definition of the strategic R&D Program of an interdisciplinary and international working group in the energy sector based on the OTSM-Network of Problems method.

The presented holistic method has been developed by a collaborative working group of experts on OTSM and Classical TRIZ and the Management of R&D activities. It was tested in a precise case: the development of the mid-term R&D program of the interdisciplinary working group on "Energy in urban context" at the European Institute for Energy Research. The stepwise method consisted of three main phases: (1) sharing information by presentations of the operating R&D program, (2) assessment of new ideas by brainstorming ("Which problems occur for the different target groups? Which solution approaches exist?"), structuring of competences as well as (3) assessment and propagation of new research activities by OTSM-Network of Problems. During the process Knowledge relevant to the research program was presented in a formal way according to OTSM-TRIZ rules for knowledge representation. The knowledge was stored and could be maintained during the next steps of the project.

2. What are Classical TRIZ and OTSM?

Classical TRIZ (Russian acronym for The Theory of solving Inventive (non typical, creative) Problems) appear in the USSR in the middle of XX century as a result of research done by Genrich Altshuller(Altshuller G.S. Shapiro R.B. 1956), (Altshuller G.S. 1984). Until now we are often faced with the mental stereotype: in order to solve non typical, creative problems we have to generate lot of ideas by trials and errors method or its modern modifications and then analyze them in order to chose satisfactory solutions. However in the course of his research Genrich Altshuller formulated the key problem of a problem solving process in a common scientific way: How can we sufficiently increase probability of obtaining a satisfactory solution without useless trail end errors? This is a goal of many applied science: obtain satisfying results by scientific means and eliminate trials and errors as much as possible.

In order to solve the posed problem three main postulates of a problem solving process were formulated during the evolution of Classical TRIZ (Altshuller G.S 1999), (Khomenko N.; Ashtiany M. 2007): Postulate of Objective laws of technical system evolution; Postulate of Contradiction and Postulate of Specific Situation. In order to create instruments for practical need two fundamental models of Classical TRIZ were developed in the course of its evolution: System Operator in order to describe elements involved into problem situation and Model of a problem solving process. Both of those models are the basis for ARIZ, which is the main instrument of classical TRIZ dedicated to solve non typical technical problems.

Between the 70s and the 80s TRIZ became more and more popular among engineers in USSR. It was used for many technical applications. At the same time more and more TRIZ professionals started to apply TRIZ for non technical problems and for kids education. More and more people who had no engineering background wished to learn TRIZ for their professional and private life needs. As a result author of Classical TRIZ - G. Altshuller - started to work on general theory of problem solving (Russian acronym OTSM) as he named it in the middle of the 80s. It was a serious challenge and took a lot of time to achieve valuable result in 1997. One of the authors of this paper was involved in this research under supervising of Altshuller. In the course of the research were formulated key problems to be solved by creating OTSM (could be pronounced Ti-Es-Em), main postulates of the new theory, fundamental models of Classical TRIZ was improved and enhanced.

At the beginning of the 90s, Invention Machine Software created in Minsk (Belarus) started to disseminate TRIZ around the world. TRIZ became more and more popular in Asia, North America and Europe. World-wide companies now use it in a more or less systemic way: Samsung is a leader of TRIZ implementation, Peugeot-Citroen, Siemens, Boeing, General Electric, Microsoft, Intel etc. use it, too.

3. Scope of OTSM-TRIZ

Initially, the scope of classical TRIZ was restricted by engineering, mostly mechanical problems, because of the large amount of patent and technical solutions that were

analyzed in their historical evolution. Classical TRIZ based problem solving process can be considered as a transition of a technical system from one level to the next level of its evolution. In order to make this transition efficiently and in the right direction it is necessary to discover contradictions underlining the problem situation and to eliminate them using resources available in the context of a certain specific problem situation. In addition to classical TRIZ, OTSM consider the problem solving process as a transformation of a specific problem description into satisfactory conceptual solutions description and provide special instruments for this based on the notion of partial solutions which could be viewed as small details of a big picture of the solution. In order to obtain appropriate partial solutions and to integrate them into an image of satisfactory solutions, a set of special instruments and models was developed. Classical TRIZ and OTSM provide problem solver with special techniques to overcome mental inertia and to be prepared to accept unusual creative ideas.

It is necessary to stress it out that neither TRIZ nor OTSM could replace professional knowledge in certain domain. Their instruments just help to a solver rearrange existing knowledge, to overcome mental inertia and to discover what kind of knowledge are missing but important to be obtained to solve the problem efficiently. That is why on of the trend of OTSM evolution is developing instruments to cooperate and to obtain mutual understanding between professionals of various domains.

The more instruments of Classical TRIZ were used the more the scope of their efficient application was growing. Engineers of chemical and electronic industries started to use it and obtain highly efficient solutions as well as researchers in technical and biological domains. This emerge OTSM in order to simplify implementation of Classical TRIZ for solving non engineering problems. As a result a new challenge appeared: How Classical TRIZ and OTSM could help to handle complex interdisciplinary problem solving process.

As a respond to this challenge starting from the middle of the 90s the Problem Flow Networks (PFN) approach started to appear which is based on the theoretical background of Classical TRIZ and OTSM (Khomenko N.; De Guio R. Kaikov I. Lelait L. 2007). In the context of OTSM PFN approach problem situation is viewed initially as a network of problems that should be created according certain rules. If those rules are respected then we can easily find bottle necks and vicious circles of the problem situations. The next stage is formulating the set of contradictions underlining those bottlenecks and vicious circles. Those contradictions must be integrated into the network of contradictions to be resolved in order to overcome the initial problem situation. Next steps of the PFN approach are described in: (Khomenko N.; De Guio R. 2007). PFN approach can be considered as a background to create instruments for managing innovation in the long term, in international, cross disciplinary research team. In this paper we present first steps that were done on this way. Bellow we will focus just on the OTSM Network of Problems and how it was used in our case. More detail information and illustration could be found in: (Khomenko N.; De Guio R. 2007).

3. What is an OTSM Network of Problems?

OTSM Network of Problems was chosen for our case because of its role in the complete OTSM based problem solving process which is clarification of fuzzy initial situations in order to choose the right problems to be solved in order to overcome a problem situation. This instrument is helpful in order to arrange a system of goals to be achieved during problem solving and to disclose some place in the problem situation that need special attention and knowledge.

The Network of Problems is a semantic network that is presented by an oriented graph. Nodes of the graph are problems, solutions and subject to be researched. Edges (arrows) of the graph start from the super node to be solved (if it is a problem), implemented (if it is a partial solution) or researched (if it is a subject to be researched). The edges arrive to sub nodes that could be sub problems, sub subjects or sub partial solutions.

The nodes that do not have an input arrow are treated as goals to be achieved. And sub-nodes of those goals considered as needs to be done achieving the goal. Certain sub nodes have lot of incoming arrows; they are considered as bottleneck and need special treatment. There are some other topologies of the sub graphs that need special treatments and there is a special rule to make interpretation of the topology of the entire Network of problems or its sub-graphs. If the network of problems was done correctly and according to all of those rules, then it appears as well formalized description of the initial fuzzy problem situation. This description could be viewed as a map of the problem situation in order to develop strategy of movement trough the situation and achieve. Same like a general before battle observe map of the battlefield to create strategy and tactics of the battle.

Then, other instruments of Classical TRIZ and OTSM can be used for gathering appropriate information and treating the problems. These instruments both help to increase the level of formalization of the knowledge representation and to the knowledge proceeding in order to be able to solve problems or to identify correct goals or to represent the entire network whenever necessary during the research or problem is solving process. Usually these changes influence the strategy and tactics of the research or problem solving.

This network can also be helpful during discussion on building up a priority system for the topics, decreasing subjective and personal factors. This leads to more objective decisions and provides visual support for the discussion.

4. Framework of Application of OTSM Network of Problems for the Development of an Interdisciplinary Strategic R&D Program in the Energy Sector

In this study, a new R&D program for the group “Energy in urban context” of the European Institute for Energy Research has been developed with the participation of an

interdisciplinary team with 12 members in several plenary working sessions. The interdisciplinary team was consisted of architects, urban planners, engineers, economists and sociologists.

At first, the whole group worked together during a one-day workshop. Afterwards, the work was carried out in temporary working groups according to the directions chosen by the coordinator of the works (the head of the R&D group) in a time frame of four weeks. The construction of a network of problems was carried out according to the recommendations of the technique developed by the experts in OTSM and was made clear for every participant of the group. As result, the OTSM network of problems was presented to the team members. The purpose of the discussion was to put forward new perspective projects within the formation of strategic program R&D. The final formation of a new strategic program on the basis of the formulated proposals was carried out by the head of the group. In order to simplify the process of the network development, the software Microsoft Visio 2003 was used by the team.

5. Proceeding for the use of OTSM Network of Problems for the Development of the Strategic R&D Program

Usually, the initial stage of the problem network developing is a short education for all members of the group. It takes at least one or two days. We had a strong time pressure in our case and it was difficult to find at least one day that all members could be available for the training. Then we decided to skip initial education and replace initial stages of the network development by brainstorming sessions. Unfortunately, this did not save our time but produced some difficulties during the sessions.

Bellow we shortly describe the stages that were carried out. All of them were moderated either by the OTSM-TRIZ experts (during three main workshops) or leaders of the groups (during meetings in subgroups.)

Stage 1. Brainstorming (whole group)

Starting point of the work was a brainstorming on typical problems and solutions on the topic of Energy in urban context taking into account the point of view from public authorities, energy companies and energy consumers.

Brainstorming was organized as workshop for all team members. During the brainstorming, a set of various problems, subjects for research and potential solution concepts were proposed.

After brainstorming a working group analyzed the proposals and grouped them into several sets that were used during developing the network of problems.

Stage 2. Establishment of a network of problems and solutions (small group)

As soon as preliminary analysis of the sets was done, a working group of three group members developed the initial network of problems and solutions in cooperation with OTSM experts.

As soon as the initial network of problem was done, a second workshop was organized for all members of the research group. During the workshop, the researchers learned some basics on how the network could be read and analyzed. Then they analyzed the initial network of problems and some discussion took place on what should be done next. This was important to make sure that a corporative decision was taken by all team members to start the next stage of analysis.

During these discussions of the entire network and problem situations some correction was done, some new sub-nodes appeared and the system of goals was clarified. We must notice that an entire network of problems helps to observe a big picture of the problematic relevant to the research activity and that it consists of a very large amount of problems that are behind the bounds of competence. Then, taking into account the competences and experience available in the group, three sub networks were chosen for further development in small groups of professionals according to their scientific interests.

Stage 3. Assignment of current projects (few small groups)

During a third workshop all three working groups presented their sub-networks and this improved mutual understanding of the problems relevant to the research program and vision where the group has to go. This prepared the members of the group to understand and accept the assignments that were done afterwards by the group leader. The assignments appear as a result of final formation of a new strategic program that was written by the leader of the research team.

6. Result achieved during the case study and Recommendations.

The case based application of the method allows the deduction of first results and recommendations.

Reactions to this approach vary a lot. Some team members say that they like this way of planning their research work. They explain that previously, when they were working in other research centers, often manager just asked them to list research they were going to conduct and after that gave the plan of the research to the team. It was difficult to understand why some subjects were accepted and others just refused. There was also miscommunication on criteria of selection and what was considered as a most important subjects and goals for research. OTSM experts often got these feedbacks after implementation OTSM network of problems and PFN approach for team work. People usually say that this increases mutual understanding, decreases conflicts and as a result efficiency of a team work grows when they apply this method.

Some other participants mention that the process of the network construction creates a good platform for more deeply discussion on a lot of relevant topics, for achieving mutual understanding, decreasing stress between team members and helpful to overcoming misunderstandings that often happen in interdisciplinary teams.

This experience in the described case study and some previously done for different other purposes allows us to recommend the OTSM PFN approach or its components for various kind of negotiations on different topics when all sides are looking for Win-Win solutions of their problems.

The second positive issue that was mentioned by participants is the creation of a Visual Map – Network of problems. It that is helpful for representing the knowledge of individuals and making it available to all team members. We call this effect of a "big picture" which is very important for team management and especially for interdisciplinary international research teams. This effect positively influenced discussions on the topics presented in the network. This became possible because the knowledge was presented in a better formalized and readable way in the context of the specific case.

The effect of a "big picture" - an overview of the complexity of the activities and competences has been shared by all team members, an overview of various perceptions of existing problems due to various disciplines was given, and awareness on this given problem was raised. Group members considered this as a positive result and would like to keep the process going further.

Working on the network of problems helped some participants to understand general prioritization of the team and to develop prioritization for their own part of the research. The group had new members, so it was a very good opportunity to know better the other members and their preoccupations.

It means that the OTSM based Network of Problems could be recommended for the situation when it is difficult to achieve mutually shared and accepted systems of priorities for the team work.

Another important achievement that was delivered by the method was the identification of new important topics that were not recognized before and their transformation into new project proposals.

Some team members said that the implicit knowledge of individuals was transformed into explicit knowledge of the group. This is very interesting achievement participant shared with us first time. It means discussion during developing the network helped them to discover their implicit knowledge and to share it with the team. It seems this became possible because team members asked each other lots of questions in order to understand various point of views and some of them started to reflect on why they did this like they did many times but not the way someone proposed during sessions on the network development.

This effect leads us one more time to recommend about integration this approach with Knowledge Management (KM) system. It is commonly known that one of the problem of the KM experts is how to extract knowledge out of the expert, especially if the knowledge is in implicit form.

This allows us recommending the use of this PFN Approach in order to gather professional knowledge relevant to a specific case, to store it for further needs and to use it later for knowledge maintaining Knowledge Management systems,

The Network of problems created during sessions of initial planning could be useful not only for strategy planning but also for developing and implementation the research program further. The created platform could be used for continuous discussions until the end of the program and then used for evaluation and reflection by the managers or/and team members for reflection and further improvement efficiency of their work.

But in this case some recommendation should be respected: someone has to do regular updates of the network and manage it permanently in order to keep the network of problems reflecting the actual situation with the project – state of the art.

Other important lessons learnt from this case study:

It is important to well explain the methodology and the expectations at the beginning to the involved group members. Brainstorming was opened very wide in the case of the group "energy in urban context". Consequently, analysis and exploitation was very time-intensive. In order to avoid this, brainstorming has to be better focused or the traditional TRIZ approach has to be preferred.

Working alternately in small groups and in bigger groups is a very good mean to keep group members motivated. Some knowledge can be better focused in small groups. Then, the discussion and analysis should reintegrate the whole group. Finally, the results have to be presented to the group in order to share the satisfaction of the common work, to valorize the results and to implement the new strategy.

Achieved results look very attractive. However, currently no long term impact on this method could be derived. The sessions have happened in the second half of the year 2007 and it was not enough time to discover long term impact. Just one interesting result we could mention here about long term impact. During sessions and soon after sessions many people gave positive responses and they were happy because they discovered something new for them and for their teams. But several months later, when they started to work on the plan that was developed during the sessions they say that achievements were not so important for them. This was completely opposite to their initial responses. OTSM-TRIZ experts know this effect perfectly. At the end of OTSM-TRIZ coaching sessions they are happy and start to file patents and write papers. But after one or several years or even earlier they consider their results as not so important. Even so the patent was filed and a lot of problems were solved on the conceptual level. Two reasons help to understand this phenomenon. At first, people achieve conceptual solutions for the problems they have been working on for several years and this makes them happy. However implementation of the conceptual solution also needs additional work and solutions of less difficult problems. It takes time and needs certain efforts to be applied. As a result, achievements they got in the past are not so important compared to the job they have to do to implement the conceptual solutions achieved during problem solving sessions.

So, one more recommendation should be done to managers of innovation and research. Now there is a very

popular Problem Solving paradigm when OTSM-TRIZ instruments used by managers as a trouble shooting tools. A lot of useful things disappear in memory of people and become unavailable for the next sessions, especially when we have a rotation of team members. The Problem Solving (trouble shooting) paradigm should be replaced by the paradigm of Problem Management. In this case they will have a permanent process of innovation and its systemic implementation according needs of the organization.

Nevertheless, it can be stated that the new OTSM based participative holistic approach contributes to the efficient management of interdisciplinary teams in R&D departments, regarding the cited success factors and requirements of R&D activities.

7. Conclusions.

The proposed approach of using OTSM network of problems was helpful to create a platform for communication on the research strategy for the international interdisciplinary team of scientist.

This instrument was helpful to improve communication, to expose implicit and explicit knowledge of individuals to the all members of the group. As a result mutual understanding of a 'big picture' of the problem situation appeared and prioritization was done clearly and in a transparent way. This helped decreasing the potential conflict situations that often occur when prioritization has to be carried out in certain complex interdisciplinary situations.

The method allows extracting important knowledge represented it in better formalized way and stores it for future needs and maintains the knowledge during the project realization.

It is worthier to dedicate one or two days for initial education on OTSM-TRIZ and its application for research problems, this will save time and increase productivity of workshops and working sessions of the groups. For the same purpose, special educational and references materials for team members should be developed to help them learn and implement the method.

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