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The Development of Simplified Technology Roadmapping for Use by Japanese Chemical Companies

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Abstract--The creation of new businesses is crucial for an enterprise's sustainable growth. An improvement in management methods for reinforcing R&D capabilities is an urgent concern for any technology-based enterprise. Among many studies of new management theories and methodologies, technology roadmapping, for consideration of future prospects, has come into the spotlight.

The Japanese Government released a report entitled "Strategic Technology Roadmap" in 2005, and has been attempting to diffuse roadmapping, by reviewing roadmaps annually in collaboration with academia and industry. However, responses by major Japanese chemical companies to our inquiries indicated that they are reluctant to adopt technology roadmapping, although they are interested in the concept. The reasons for this hesitation are: doubts about the results, complicated explanations about the procedures to be employed, and lots of time required to come up with effective plans.

Thus, referring to Rogers' theory of "Diffusion of Innovation", we have proposed a "simplified half-day course" as a customized roadmapping method, by combining the conventional roadmapping method with KJ method, which is already popular among researchers in Japanese companies, as an idea creation method. Some workshops, with around 100 researchers involved, have been conducted in the corporate laboratories of a major Japanese chemical company to confirm the effectiveness of the proposed method. It has been confirmed that the new method is a useful tool for strategic mid-term R&D planning.

I. INTRODUCTION

Technology roadmapping is a useful tool in strategic planning, for consideration of future prospects. However, according to our inquiries Japanese chemical companies have been reluctant to adopt it, although they are interested in the concept. There are several reasons why they are not willing to adopt it. They point out that;

- 1) the results are doubtful,
- 2) explanations of the procedure are complicated and
- 3) lots of time is needed to reach a conclusion.

Furthermore, some people point out that the reluctance is caused by the conservatism inherent in chemical companies and the fact that innovations have been realized in an unplanned manner, such as through serendipity, rather than in an organized manner such as using technology roadmapping. And moreover, having reviewed the answers for the inquiries, the authors thought there is a possibility of "having prejudice against roadmapping without even trying it".

We thought that "letting them try the idea" is essential for dissemination, and we hypothesized that the explanation

about the concept and the procedures to be employed should be "simple and easy" for them, and the workshop should be designed to conclude within "a short time".

II. PROPOSAL OF "SIMPLIFIED HALF-DAY COURSE"

We have directed our attention to "simple and easy" as the necessary conditions to disseminate technology roadmapping into Japanese chemical companies. On the social basis of the character of Japanese chemical companies, we have analyzed the reasons why they have been reluctant to adopt technology roadmapping, by referring to Rogers' theory of "Diffusion of Innovations" [5], [6]. And we have set up a program of "simplified half-day course" customized for Japanese chemical companies, by combining conventional roadmapping method with simplified KJ method, which has already become popular among researchers in Japanese companies [1], [8], [Section IV,E].

A. The concept of simplified half-day course:

The summary of the concept is shown as follows;

- 1) We have been using simplified KJ method expediently, not only as a creative solution tool, but also as a strategy planning tool for mid-term R&D planning.
- 2) Chemical companies usually take 10 -15 years to create a new business successfully from initial research, and the new product should satisfy the market needs at that time. But, KJ method is an idea creation tool based on past and present data.
- 3) Therefore, in order to make mid-term plans strategically, with more future prospects and more market-oriented, we proposed to add a "time axis" towards the future to the simplified KJ method.
- 4) Concretely, the future vision based on consideration of external and internal social changes is drawn up, and the strategic elements necessary to realize the vision are discussed.
- 5) Most important elements are extracted and correlated to each other.

B. The procedure of simplified half-day course:

The outline of the procedures is shown as follows;

- 1) Decide ①Theme, ②Time-frame and ③Strategic factors. Then, fill these data in the template, as shown in Fig. 1.
- 2) All participants are requested to write external and internal market driven factors (which may affect the theme in future) on Post-It Notes with black pen.
- 3) Affix these Post-Its in the proper positions for ④External

- and ⑤Internal market driven spaces in the template. And explain what you mean with these Post-Its to all participants, for their complete understanding.
- 4) Discuss and determine the future vision. And write it clearly in ⑥Vision space.
 - 5) To realize the vision, fill in the other spaces for ⑦ Products, ⑧Functions, ⑨Technologies, ⑩R&D process and ⑪Resources, in the same manner as shown above.
 - 6) After affixing all Post-Its on the template, connect the Post-Its to each other with black lines to show their

- correlations. Add some comments if necessary.
- 7) Look over the whole map and write red circles on Post-Its for items which are already available, and red crosses on Post-Its for items which have to be acquired in the future.
 - 8) Each participant marks a blue circle on the issue which needs the most important breakthrough.
 - 9) The leader looks over the whole map, and itemizes necessary actions to be taken right away in ⑫Action space. This total procedure should be done in a half day.

③ Strategic factors		① Theme		② Time	
Market driven	④ Ext.				⑥ Vision
	⑤ Int.				
⑦ Products					⑫ Action
⑧ Functions					
⑨ Technologies					
⑩ R&D process					
⑪ Resources					

Fig.1 Template

III. WORKSHOPS AND RESULTS

A. First workshop:

To confirm the effectiveness of the “simplified half-day course”, a practical workshop has been conducted at the corporate laboratories of the author’s company, as follows;

- 1) Members: 60 researchers at corporate laboratories, divided into 13 groups.
- 2) Preparation: Just before the roadmapping, laboratory

directors assigned 13 themes, each one to each group. No preparation beforehand, such as preliminary investigation on the theme, had been done.

- 3) Explanation: We started mapping with only short guidance (30 minutes) on the concept and procedures of the simplified half-day course.
- 4) Results: A 3.5 hour workshop was conducted to draw roadmaps. Some examples of them are shown in Fig. 2.



Fig.2 First roadmaps created at the first workshop (Aug. 29th 2007)

Just after the workshop, a questionnaire survey was conducted, which gave the following results.

- 1) Our simplified half-day course seems to be a useful method for mid-term R&D planning, because the participants pointed out its usefulness in “strategic planning”, “R&D theme discovery”, “promotion of communication”, “new idea creation”, and so on.
- 2) But, it is recommended to repeat the workshop to improve the accuracy and effects of roadmapping.
- 3) Some participants recommended applying SWOT analysis or Portfolio analysis prior to roadmapping, for the determination of the future vision more clearly.
- 4) And others pointed out the necessity to involve other concerned parties, for collaboration and coordination with them.

B. Second workshop:

Two weeks later, a second workshop was conducted.

- 1) Members: 75 researchers of corporate laboratories, divided into 15 groups, including 38 beginners, totally 98(=60+38) researchers were involved.
- 2) Preparation: Just before the workshop, laboratory directors assigned 15 themes, each one to each group.

This time, SWOT analysis was conducted for 2 hours before roadmapping, adopting the suggestion by the participants of the first workshop.

- 3) Explanation: We began mapping with little guidance. The explanations to beginners regarding concept and procedures were provided by the first workshop participants within each group.
- 4) Results: A 3.5 hour workshop was conducted. Each group made their roadmaps separately.

Just after the workshop, a second questionnaire survey was conducted, which gave the following results.

- 1) SWOT analysis does not seem to be sufficient, although it is somewhat helpful for drawing the future vision clearly.
- 2) Repeating the workshop seems to be important in improving the accuracy and effects of roadmapping.

C. Integrated technology roadmaps:

Directors of each corporate laboratory made up integrated roadmaps for each business domain, as shown in Fig. 3 and 4., on the basis of the technology roadmaps made at the second workshop. These integrated technology roadmaps were used to build up the frame-work of the mid-term R&D plan.

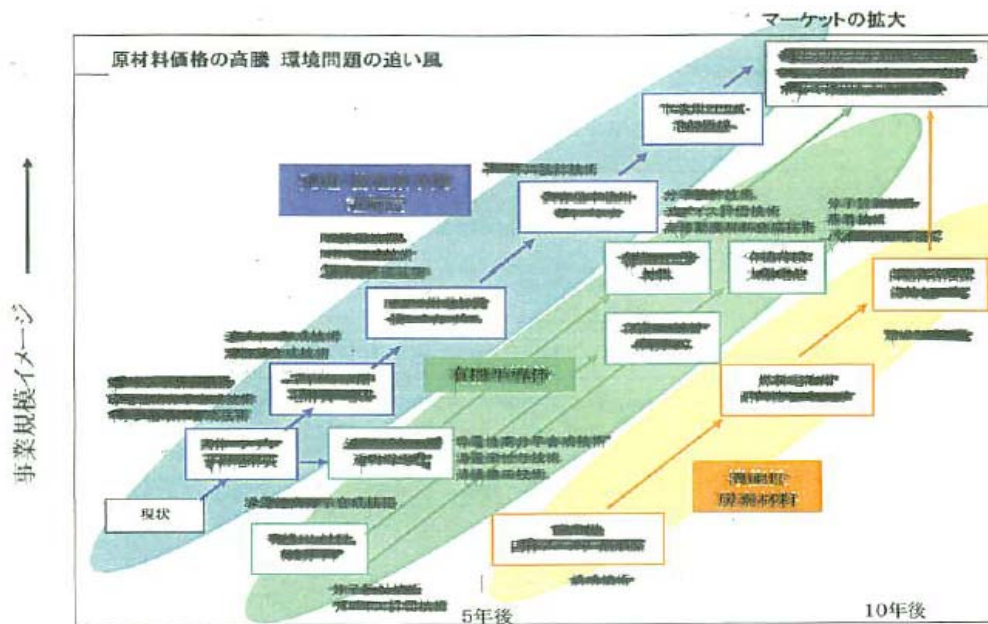


Fig. 3 Integrated technology roadmap for various material businesses [The horizontal axis is the time over ten years and the vertical axis is the economical scale of the business (arbitrary unit). The details are shaded for confidentiality reason.]

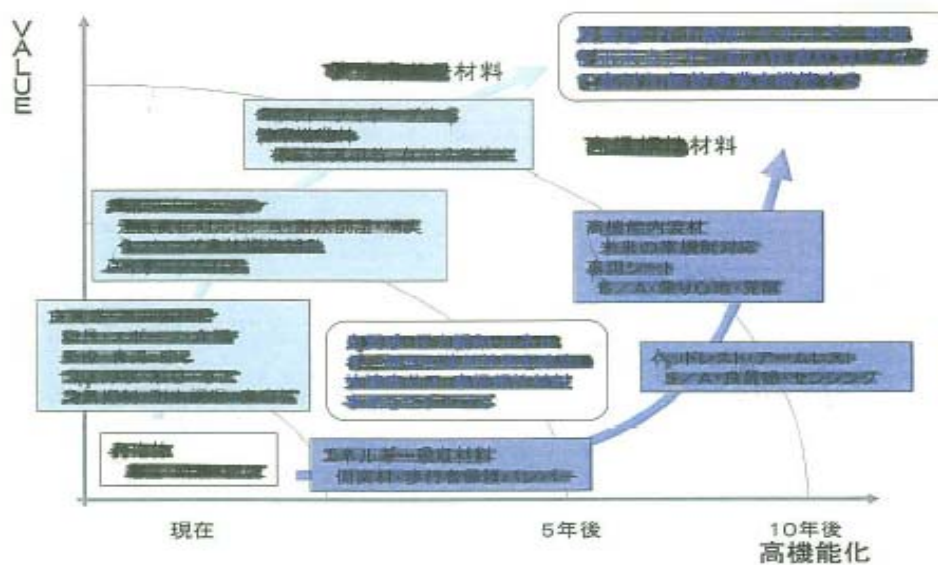


Fig. 4 Integrated technology roadmap of materials of a certain area [The horizontal axis is the time over ten years and the vertical axis is the value created by each material group (arbitrary unit). The details are shaded for confidentiality reason.]

The formats of these roadmaps are not particularly special. But the contents of the correlated technology clusters met the CTO's expectations.

And finally, each laboratory director obtained the approval from the Top Management to implement the related plan.

D. Final questionnaire:

A final questionnaire survey was conducted to check the effectiveness of the simplified half-day course as a strategic planning tool.

- 1) Respondents: 32 research team leaders of the corporate laboratories.
- 2) Results: 30% of the team leaders replied that they would be willing to use "simplified half-day course" on the next occasion, while 70% replied "not decided yet" (which means that they will follow instructions from the management). No one made negative comments.
- 3) Reason: We can expect better results step by step, by repeating this simplified half-day course together with improvements in "communication", "human interaction", "mutual understanding", "visualizing future vision", "coordination with other concerned parties" and so on.
- 4) Assignments: "Involving appropriate members and concerned parties", "improving skill and knowledge by

repeating roadmapping exercises" and "deep discussion for creating knowledge" and so on were pointed out as assignments.

- 5) Conclusion: We conclude that the simplified half-day course can be used as a strategic planning tool. Leadership of the CTO is an important factor for further dissemination. Repeating the course at each occasion will improve our skill and experience, and will help us complete the assignments mentioned above.

IV. DISCUSSIONS

We reached the conclusion that the "simplified half-day course" can be used as a strategic planning tool, and 30% of the team leaders would be willing to use it on the next occasion. This figure is already over the "Take-Off" region (10 to 25%) of the S-shaped diffusion curve of Rogers' theory, as shown in Fig. 5. But, in order to heighten the degree of diffusion, it is still necessary to repeat the technology roadmapping exercise at every opportunity. Through these continuous efforts, it might be proved that the real reason of negative attitude in the past would be "having prejudice against roadmapping without even trying it".

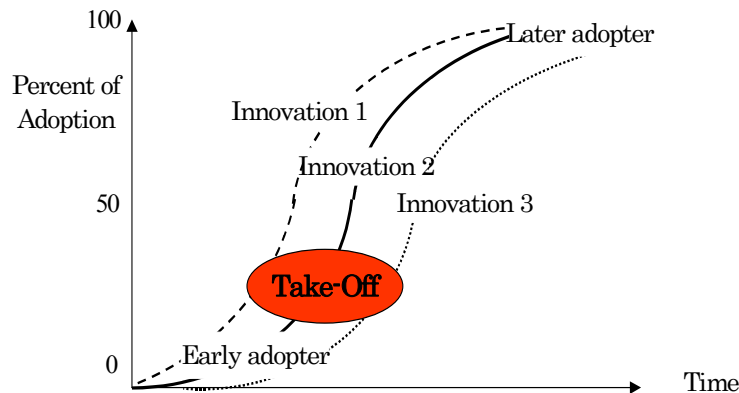


Fig. 5 S-shaped diffusion curve

We can point out the following factors as reasons why our workshop could be successfully conducted in our organization.

A. CTO's decision:

This kind of workshop involving many researchers needs an authority's decision.

In spite of much risk of turning out to be in failure, our CTO took a risk to instruct to do the workshop of technology roadmapping. Why was that so?

In our company, mid-term R&D plans for 3 years have been fixed every other year.

From the review, it was seen that the previous mid-term R&D plans were only a list of different independent technologies. The CTO and his assistants determined promising business domains this time by repeating discussions about market and technology trends over the coming 10 years. The CTO has been interested in letting

researchers plan mid-term R&D strategy using their own original ideas, in a "bottom-up style".

We knew this by chance, and disclosed to the CTO the fact that the author has been studying a simplified half-day course of roadmapping at JAIST (Japan Advanced Institute of Science and Technology). This fortunately became the trigger of workshops in our company. Without the authority's decision, the workshop couldn't be conducted.

B. Trial workshop with author's family:

Prior to the workshop mentioned above, in order to prove the feasibility of our proposal, one of the authors conducted preliminary roadmapping with the author's family; a wife and two children, who are all inexperienced at roadmapping.

After explanation of the procedure for 15 minutes, we just entered the "simplified half-day course" with the theme of "washing machine of 20 years beyond". The result is shown in Fig. 6.



Fig.6 Trial roadmap with family (July 22nd 2007)

During the discussion on the external market driven factors, market analysis data, such as “water price jumps double” and “stricter regulation of waste water”, were given.

After the discussion, we reached the idea of “water-free washing machine” as a vision for the future, 20 years from now.

In order to realize this vision, we continued the discussions on “Product”, “Function”, “Technology” and so on, one by one. During this process, we created ideas like “washing by vibration”, “decomposition by microbes” and “washing with ozone or steam”, which were almost impossible for the author’s family to imagine in their usual

daily life.

Coincidentally, 3 weeks after our roadmapping, we encountered the article on R&D for a new washing machine by SANYO Electric Co., Ltd., in one of the Japanese industrial newspapers, with the headline of “Improvements for saving water”.

The article says that Sanyo’s goal is a high level “water saving function”. The keys to this are;

- 1) decomposing dirt by sterilization and deodorization with ozone, without using water.
- 2) reusing rinse water by purifying it with ozone, and so on.

三洋電の洗濯乾燥機 節水性能に磨き

高い節水性能を支えるのは「オゾン」による2種の技術だ。一つ目は「エアウォッシュ」水を使わずにオゾンで除菌・消毒し、汚れを分解する。衣類だけでなく、革、靴まで洗える。洗濯機に取り付けられたオゾン発生ユニットで空気中の酸素からオゾンをつくる。発生したオゾンを加熱して反応性を高める。これにより10分で済むオゾン洗濯が可能だ。

二つ目の技術が「フックリ」だ。オゾンで洗った水を浄化して再利用するほか、貯水タンクに取り込んだ風呂水を浄化し洗濯水に利用する。水を使わない洗濯と使い捨てない洗濯の両方で節水効果を大幅に高めた。

もったいない

消費者の節水意識は高まっている。三洋電の調査によると「風呂水を捨てるのはもったいない」と感じているのは全体の約93%。なな別の調査では、風呂水を洗濯水に再利用しない人は30%である。「風呂水は汚い」というイメージが理由だ。

「風呂水を除菌、消毒で再利用しない人は9%にまで減る。」

三洋は創業から6年後の1953年、滋賀県の瀬田のほとりですべて洗濯機の生産を始めた。半世紀以上をわたり「水を大切にしたい」という思いが強い。

（土肥部長）地元の人々が製品づくりに携わってきた。受け継がれた伝統と技術の誇りが、一般消費者向け製品開発のオゾンによる洗濯の実用化に結びついた。

道半ば

土肥部長が自覚するのは「水道水ゼロ」の理想の姿にはまだ「道半ば」だ。蒸気とオゾンを組み合わせた技術の実用化などにも挑み、さらなる節水を追い求める。

三洋電機は現在、経営再建中。機械としての経営「シンクガナ」一環で「エナジー先進メカ」を進めようとする方向を明確にするには、投入する商品で実証していくしかない。土肥部長はその役割を「自負している」と話す。

「リダーたちの勘やない信念が復活への軌跡を確かなものにするはずだ。」

（大阪・大友記者）

Fig. 7: News Article about Sanyo (Nikkan-Kogyo Newspaper, Aug.15th 2007)

“Challenge to accomplish technology breakthrough by utilizing ozone-gas and vapor!” and “Our ideal goal is water zero”.

Namely, we experienced that even after only 3 hours of roadmapping by non-experts, we could reach an idea similar to professional researchers’, although the depth of the idea is quite different, of course.

Family trial and News article gave us more confidence in conducting roadmapping at our laboratories. We introduced the family trial and the news article to our corporate researchers to attract their interest. Actually, many of them inclined favorably to hear our explanation about the function of roadmapping. We believe that this fortuity tickled researcher’s pride to challenge roadmapping.

C. Rogers’ theory:

Referring to Rogers’ theory of “Diffusion of Innovations”, we have developed a “simplified half-day course” of

roadmapping, by combining conventional roadmapping method with KJ method.

As factors which affect “diffusion of innovations”, Rogers gave the following five characteristics.

- 1) Relative advantage: the degree to which an innovation is perceived as better than the idea it supersedes
- 2) Compatibility: consistency with existing values, past experiences, and needs of potential adopters
- 3) Simplicity: simplicity in understanding and practice
- 4) Trialability: possibility of small-scale experiment
- 5) Observability: visibility of result to others

The conventional roadmapping methods are not enough to satisfy these conditions.

Therefore, we tried to obtain “compatibility” by combining conventional roadmapping method with simplified KJ method, which had already become popular among researchers in Japanese companies. And roadmapping method has “relative advantage” compared with KJ method, for a

long term planning, because roadmapping is provided with more future prospects and more market-oriented. The family trial prior to the workshop at laboratories played an important role in confirming “trialability” and “observability”.

D. Comparisons with conventional roadmapping methods:

In order to confirm the characteristics of our simplified half-day course, compared with conventional roadmapping, Table 1 was prepared.

TABLE 1 COMPARISONS WITH CONVENTIONAL ROADMAPING METHODS

Items	Our simplified half-day course	Phaal [2],[3],[4] Fast-Start approach	Tschirky [7],[9] Innovation architecture
Time needed	half-day	several half-days	many days
Understanding	easy	rather difficult	difficult
Practice	easy	easy	difficult
Compatibility	best	-	-
Simplicity	easiest, simplest	-	-

Our method can be understood as the best one from the viewpoints of “relative advantage”, “compatibility” and “simplicity” of innovation’s characteristics. In addition, our method does not require any special knowledge and preparation of the participants beforehand.

E. KJ method:

KJ method was invented and developed by Jiro Kawakita, a Japanese anthropologist.

We believe KJ method is applicable for finding problems, grasping situation, searching essence, setting issues and so on in various fields such as research and planning. In fact, many organizations in Japan today use it in various ways, and it is recognized as one of the most effective idea creation methods. Author’s company has also introduced and customized this method as a “Simplified KJ method” since about 30 years ago. The outline of our method is shown as follows;

- 1) Label Making: Each participant writes data relevant to the problem, on the labels. It is desirable to make 50-100 labels in total.
- 2) Label Grouping: One participant reads his or her label and explains to the others what the label is trying to say. If the others think that some of their labels seem to belong together, put them together to make a group of labels. The next participant reads to explain his or her label to make a new group. Continue this process in turn until all labels come out in front of participants. Then, make title of each group and write it on a new label. The title should clearly describe the essence of all labels in the group. As the next step, make the bigger groups by using the new labels of the titles. Then, make bigger titles for them, in the same manner as in the first grouping. Repeat this process until

the number of the final groups becomes less than ten.

- 3) Chart Making: Arrange the final groups in the most appropriate pattern. And, transfer this arrangement on to a large sheet of paper, and proceed to arrange all sub-groups and labels in the same manner. After this arrangement, paste all labels and draw a chart in handwriting. Show the relationships between groups and labels.
- 4) Written Explanation: Grasp the entire structure of the problem from the chart and discuss the essence implicating the problem. Then, write the essence of the problem at the top of the chart. Through this process, we often develop new ideas about the problem. In this way, chart making and written explanation enable us to understand the issues more thoroughly. Usually, we complete this total process in a half day, with about five participants.

For the original concept and more details, please refer to J. Kawakita [1] or R. Scupin [8].

F. The overview of our action research:

We tried to show the overview of our action research in Fig. 8. At JAIST, the development of “simplified half-day course” was proposed by hybrid combination of conventional roadmapping and simplified KJ method through Rogers’ theory. Then, at our company, the verification of the hypothesis was carried out at the workshop following the decision by CTO.

We observed and confirmed that the trial with family played a role of “initiator” to inspire the participants to take part in the workshop smoothly.

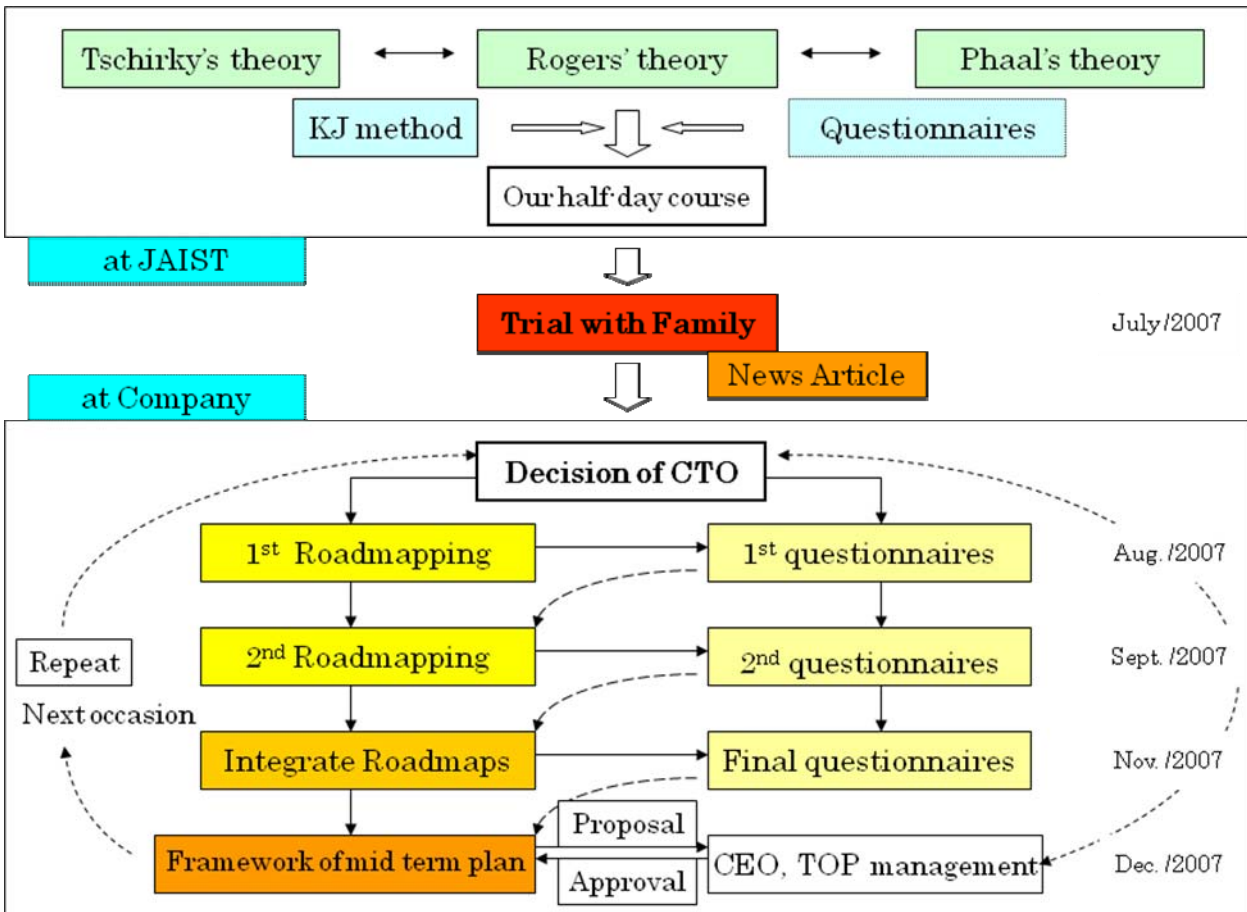


Fig. 8 Overall diagram of action research

V. CONCLUSIONS

“Simplified half-day course” can be used effectively as a strategic planning tool. 30% of team leaders have indicated their willingness to use it on the next occasion.

The feature of our simplified half-day course is “simple and easy”. Participants can join the workshop without any special preparation, although high accuracy of mapping can not be expected at the initial stage. However, repeating it at various times could improve skills and experience for better roadmapping.

When we analyze the process of our action research, we can explain the keys of success according to Rogers’ theory of “Diffusion of Innovations”. Therefore, we believe that our “Simplified half-day course” is effective in diffusing ideas

into the organization, so that we could succeed in conducting the workshop at a Japanese chemical company. This success could be a big step in MOT from the viewpoint of long-term strategic technology management.

At the end of our action research, we tried to express our future expectation for the uses of roadmapping in Fig. 9. When the technology roadmapping process is conducted functionally and R&D activities go well as a result, researchers become confident in their activities and trusted by top management. They’ll be released from anxiety, complaints and distress. Aiming at a clear goal, a vital workplace filled with confidence and enthusiasm will be built up. This leads researchers to another success in R&D, and creation of new innovative business. Virtuous circle is realized.

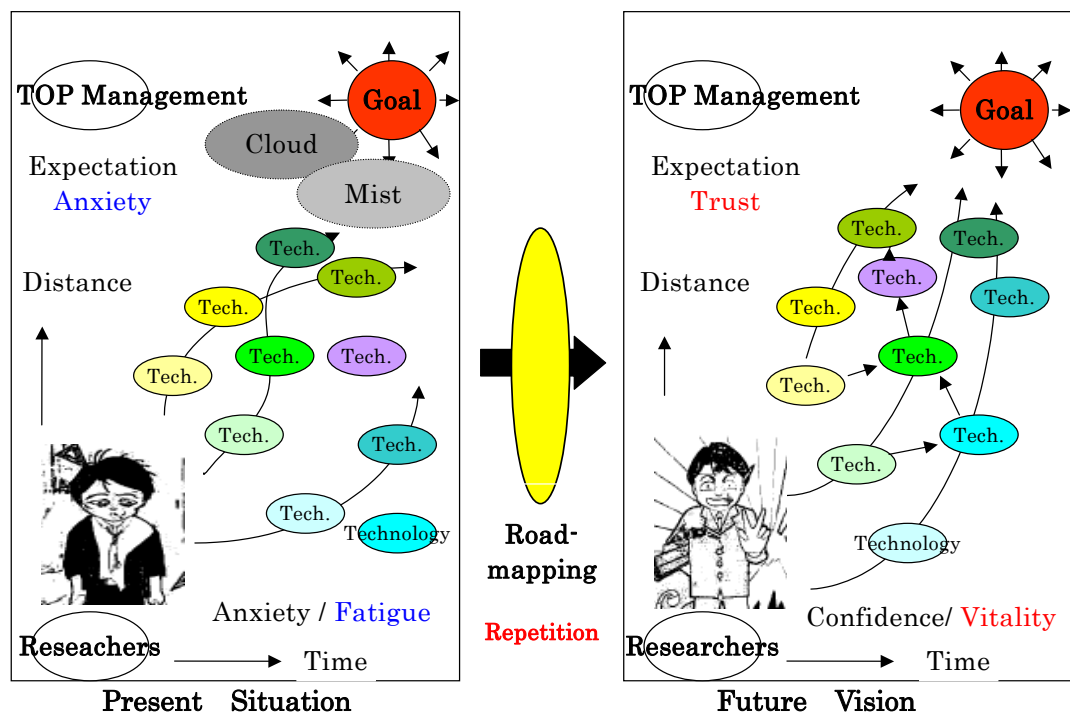


Fig. 9 Present Situation and Future Vision, turning it to virtuous circle

VI. FUTURE RESEARCH

In order to verify our hypothesis more clearly and to disseminate “simplified half-day course” into Japanese chemical companies, we have a plan to take the following actions.

- 1) Repetition of roadmapping at each suitable occasion.
----- May 2008~
- 2) Dissemination of roadmapping to other divisions.
----- Sept. 2008~
- 3) Dissemination to other chemical companies.
----- 2009~
- 4) Confirmation of our dream for building a vital workshop.
----- some years later

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