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# Study on a Roadmapping Process Model as a Way to Support Technology Creation in University Setting

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## ABSTRACT

With the development of Management of Technology (MOT) in industry, many methods of MOT have been proposed for technology creation. In this research we want to propose some methods which have been used successfully in industry to deal with some problems for supporting researchers to create technology in university setting. With the development of internet, researchers can easily obtain a great quantity of data and information, but sorting through that data and information to get ideas of technology creation, is not a trivial problem. After introduces differences between technology creation in industry and university, we get a conclusion that the process of technology creation in industry and university is very similar. Therefore, in this research we will propose a process method for supporting technology creation in university setting with cooperation among government, industry and university. Roadmapping method as a process method for technology forecasting, planning and marketing strategy making is used wildly for supporting technology developers to create technology. Therefore, in this study we address a problem that if roadmapping method can also deal with some problems of technology creation in university, how it can support researchers to create technology. Based on a framework with integration methods by roadmapping process proposed for supporting researchers to create technology, a case study concerning integrated forecasting of a transportation fuel cell roadmap is carried out for how to support fuel cell researchers to create fuel cell technology by roadmapping process. At last, a framework of a roadmapping system for supporting researchers to create technology in university is proposed based on the process of case study with a systemic thinking way.

**Keywords:** Technology creation, systemic thinking, roadmapping process, technology forecasting

## 1. INTRODUCTION

Roadmapping is a disciplined process for identifying the activities and schedules necessary to manage technical (and other) risks and uncertainties associated with solving complex problems. *Robert Galvin, CEO of Motorola, 1998*. Roadmapping is used as a planning process that gives decision-makers a means to identify, evaluate and select among strategic alternatives for achieving technological objectives in industry[1]. In this case, technology roadmapping is a technology creating process for supporting researchers doing scientific research in a university setting. A roadmap is an extended look at the future of a chosen field of inquiry composed from the collective knowledge and imagination of the brightest drivers of change in that field . *Bennett R. Idaho National Engineering and Environmental Laboratory (INEEL)*. The roadmap document resulting from the technology roadmapping process is the first step toward technological innovation [1]. In industry, a technology roadmap document presents consensus on a number of topics: a vision of the industry at a set time in the future; what new types of products (or services) will be required; the enabling technologies to create those products; the feasibility of creating the needed technologies; the technological alternatives for achieving the needed technologies; and how to address these technology needs through R&D [2]. The roadmap document addresses the role of an industry's suppliers in creating the desired future, human resources needs, governmental and non-governmental barriers, and other topics [1]. In this context, companies must use effective tools to plan their future. Roadmapping is a way to identify future product or service needs, map them onto technology alternatives,

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and develop plans to ensure the required technologies will be available when needed [1]. The principal functions of technology roadmaps have been for representation, communication, planning, coordination, and technology forecasting and selection [3]. For researchers in university timely, advantageous, and original research is what they want to do. How technology will be created, what are the advantageous of technology and products, what are the societal influences on technology creation [4]. As a result what we find in this research is the process of technology creation in industry and university is very similar, based on the process of technology creation in industry, we propose a process model for supporting researchers to do technology creation in university.

## 2. TECHNOLOGY CREATION IN UNIVERSITY

How researchers can utilize the vast amount of available data and information to make decisions regarding their future research to create technology is an extremely important problem in university setting .

### 2.1 Why Support to Researchers

For almost technology creation topics, a cooperative effort among industry, research institutes and government is a very effective way. In this cooperation, the most important part is between industry and research institutes [5]. In this paper, we present a concept for cooperative research for technology creation among industry, institutes and government [6]:

- Industry: industries that introduce products
- Institutes: universities that make technology or method of technology creation as research topics.
- Government: government organizations that make the policy for technology and marketing development .

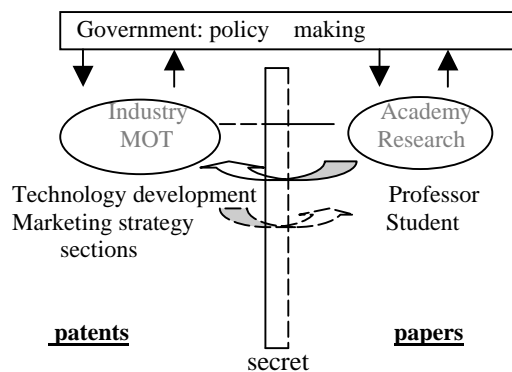


Fig.1 Cooperation between industry and academy

As Fig. 1 shows, there is an obstacle to realize cooperation between industry and institutes. In industry, there is support from the technology development and marketing sections to obtain patents [7]. In universities there are no such organizations to support researchers in their scientific research. On the other hand, as shown in Fig. 2, government uses reports from industry to get data to make policies to support technology creation, while industry gets data from universities to create marketing strategies and develop technology [8], but where will the researchers in university who want to do technology creation get their data? Therefore, in this paper, we want to propose a model supporting researchers to do technology creation in university.

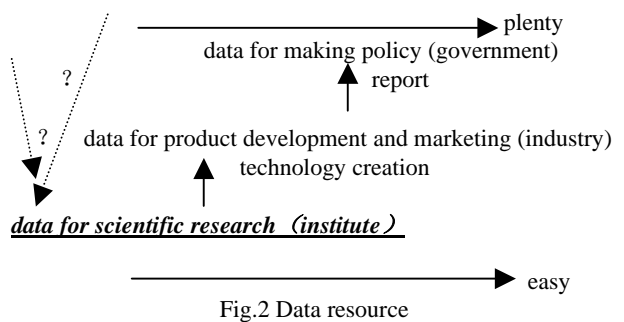


Fig.2 Data resource

### 2.2 How to Support Researchers to Do Technology Creation?

As Fig. 3 shows, the process of technology creation in industry and university is very similar, so if we can find a process method of technology creation in industry, maybe it can also deal with some technology creation problems in university. With the development of MOT in industry, roadmapping is proposed as a process way to do forecasting and planning to support technology creation. Therefore, in this research, we will use roadmapping process to propose a roadmapping process model to support technology creation in university. In industry, they use roadmapping method as a way to do technology development with four approaches [8]:

- To present a concept of the needs of technology and market
- To forecast the trend of technology
- To provide the data not only for technology, but also include the society influences
- To support decision makers to do technology development and three steps [8]:
  - step1 Centralizing: decide technology development topics
  - step2 Dispersing: share and discussion
  - step3 Centralizing: feedback and conclusion

For researchers in university they have no chance to discuss on technology creation topics with other

researchers who are in the same research field and get necessary data and information from industry and government. Therefore we will propose a roadmapping process model for supporting researchers

	Industry	University
Purpose	New product benefit { new technique	new theory knowledge-{ new technique
Process	Needs ↓ Development customer ↓ evaluation	Needs ↓ Research plan Experiment/data Result
Object	Definite/objective technique	Ambiguous/subjective knowledge
Result	Benefit wealth/fame	Original ideal/theory Wisdom/capability

Fig.3 Comparison between technology creation process in industry and university

in university to get necessary data and information for technology creation with cooperation among industry and government. Fig. 4 shows the framework of roadmapping process model:

- Data collection: Collect data from four sides, technology, marketing, economic influence such as costs and benefits, and environmental influences, from the internet and papers, and structure a database.
- First-cut Roadmap: Analyze the data collected, produce a first-cut roadmap for technology forecasting.
- Idea exchange: Show the first-cut roadmap to researchers who are in the same research field, collect their opinions about the roadmap and ideas for forecasting items, and find out further information what they need, then re-roadmap.
- Cooperation: Collect information from industry and government about the the products, marketing and societal influences of technology witch researchers want to develop, get the scenarios for how to develop and evaluate technology which researchers want to create.
- Research topics or methods of technology creation: Integrate the roadmap and scenarios get idea for technology creation.

### 2.3 Integrations Method in Roadmapping Process

In this framework, two kinds of integration methods are proposed, physical integration and chemical integration. Physical integration means “architectural integration”,

which links things together while leaving the core design concepts untouched [10]. Chemical integration means “meta-integration”, which

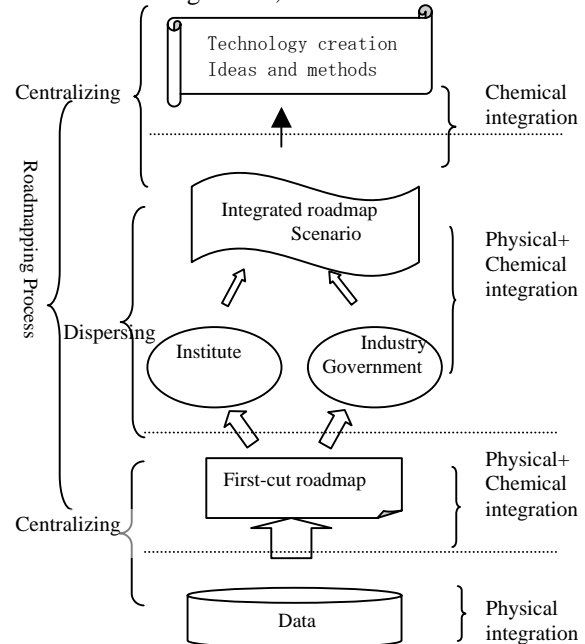


Fig.4 Roadmapping process model framework

has a wider meaning, may touch the core concept, and change the overall characteristics [11]. For example, for enterprise integration, the architecture consists of [12]:

- Technical integration architecture
- Information integration architecture
- Business integration architecture
- Service integration architecture

The dimensions of meta-integration of enterprise are [13]:

- Goal and criteria
- Business process
- Application
- Information
- Hardware and software
- Network and communication
- Management

In this paper, we look at physical and chemical integration in terms of supporting researchers get new ideas of technology creation.

Physical integration: no new ideas, no new technology is created

- Technology : Classify the technology in a specific research field
- Marketing : Put the marketing information together to find marketing requirement

- Societal influences: Collect the societal influences of every kind of technology

The purpose of physical integration is to collect and analyse data, show the trend to researchers. The methods of physical integration include summing up, concluding, and classifying.

Chemical integration: new idea, new technology, new methods of technology creation are created.

- Information
- Application
- Communication
- Cooperation

The purpose of chemical integration is to get some new ideas or method of technology creation by integrating information, application, communication, and cooperation. The methods of chemical integration include inference, abstraction, and creation. Fig. 5 shows how integration methods work in roadmapping process. In this framework, we integrate data and information with two kinds of integration methods to support researchers to create technology.

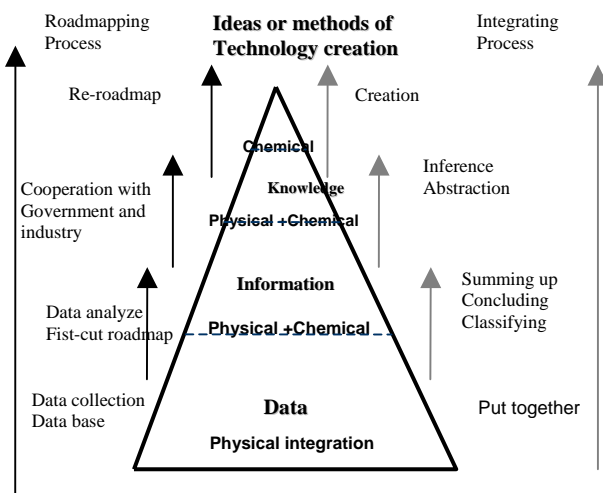


Fig.5 Integration methods in roadmapping process

### 3. CASE STUDY

In this paper, we examine a case study for supporting fuel cell researchers in JAIST with a forecasting roadmap by roadmapping process. The fuel cell can trace its roots back to the 1800s. A Welsh born, Oxford educated barrister named Sir William Robert Grove, who practiced patent law and also studied chemistry or "natural science" as it was then known, realized that if electrolysis, using electricity, could split water into

hydrogen and oxygen then the opposite would also be true. Combining hydrogen and oxygen, with the correct method, would produce electricity. To test his reasoning, Grove built a device that would combine hydrogen and oxygen to produce electricity, the world's first gas battery, later renamed the fuel cell [14]. Because of its characteristics such as long durability, high efficiency and no pollution, the fuel cell has been used in several fields (this paper deals only with the transportation fuel cell). How do fuel cell researchers make their decisions about research ideas and topics of technology creation,? What kinds of information do they need and what information do they want? In order to address a problem how to do the support for researchers to create technology in university by roadmapping process, we carry out the case study. Fig.6 shows the first-cut roadmap of technology forecasting for transportation fuel cell. We collect data from internet and papers of researchers in university, technology developer in industry, and policy maker in government with four items technology, marketing, economy and environment, after data analysis, get the first-cut roadmap. From this roadmap, fuel cell researchers can get data and information about technology in current, present, and future, data and information about evaluation of technology development is also provided. We show the first-cut roadmap to researchers who are in the same research field, interview them getting suggestions that how to improve roadmap and what kinds of data and information else they want. As a result of interview, almost researchers want to know more information about advanced technology research topics and who are doing such research not only in university, but also including technology developers in government and industry. As a future work, we will interview technology developers in industry getting their suggestions of first-cut roadmapping.

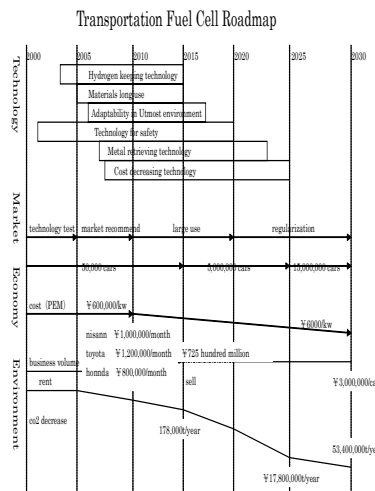


Fig.6 Fist-cut roadmap of transportation fuel cell

#### 4. ROADMAPPING SYSTEM

For researchers in university, they have no chance to discuss technology creation topics with other researchers in other university, and get related data and information from industry and government face to face. Therefore, we will propose a roadmapping system to give them a chance discussion with all researchers in university, industry and government at the internet. Fig. 7 shows plan of a roadmapping system structure and function based on the case study of the thetransportation fuel cell roadmapping process.

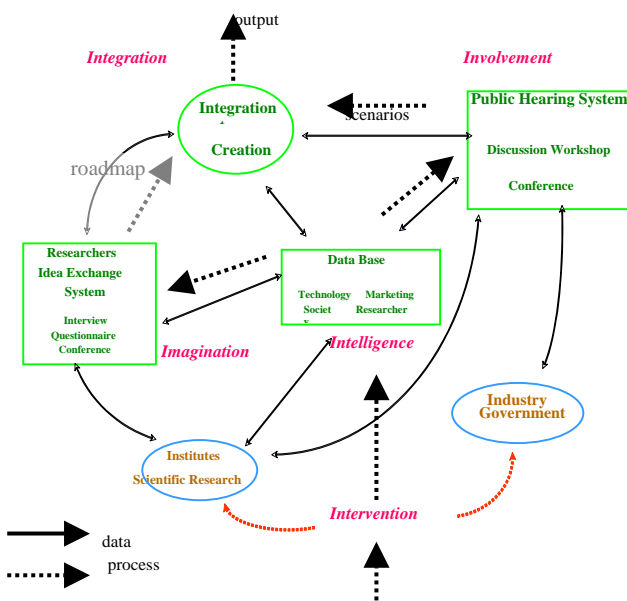


Fig.7 Roadmapping system structure and function

- One database: data of technology, marketing, society influences for making technology forecasting roadmap in a specific research field. Researcher can search with keywords.
- Two sub-systems: provide a chance for researchers discussion with other researchers in other university (researchers idea exchange sub-system), industry and government (public hearing sub-system).
- Three protagonists: researchers in university, technology developers in industry, related policy makers in government. Technology creation will be solved by cooperation among university, industry and government.

#### 5. CONCLUSION AND DISCUSSION

Roadmapping as a method of MOT is used widely in industry, how we can do some supporting for researchers in university to create technology is the problem addressed on this study. We find roadmapping process may be can deal with some problems for technology development because the process of technology creation in industry and university is very similar. For researchers having no chance to discuss problems of technology creation with other researchers face to face, we propose a system to support them discussion at internet. The roadmapping system can be explained with a system thinking way, i-system [15].

- **Intervention:**  
The purposes, issues, problems of the technology creation topics
- **Intelligence:**  
Collect data in different fields such as technology, marketing, economic influence (costs and benefits), and environmental influences (air, water, noise pollutions), and structure a database. After data analysis, produce first-cut roadmap.
- **Imagination:**  
Show the roadmap to researchers to collect their ideas and suggestions about the roadmap and identify their need for further information, re-roadmap.
- **Involvement:**  
For industry and government, collect related product information, research topics and policy in accordance with what researchers want to know, and put all this information into the database, get some scenarios about how to realize technology development or evaluate topics of technology creation.
- **Integration:**  
Integrate all the data collected from industry, institutes, and government supporting researchers get new ideas for technology development.

Before integration, after getting new roadmap and scenarios, come back to intervention, if there are new discovery of technology creation purpose, issues and problems do intelligence-imagination-involvement again until no new discovery is found. Finally, move to the information integration system to integrate the data collected. Through this recurring cycle (Intelligence-Imagination-Involvement-Integration), researchers can comprehend recent and future forecasting information, not only in terms of technology, but also including the researchers ideas along with policy and marketing information. Researchers can get some ideas for technology creation. Yet, as a result of fuel cell researchers interview, what is researchers who want to do technology creation want to know is advanced technology and product information, prompt related policy information and who are doing such

research, producing such product. Therefore we will provide roadmapping process model, make a real roadmapping system for researchers supporting technology creation in university. We hope that this system will prove to be a dynamic and powerful tool for technology creation at university research institutes and will be helpful in expediting cooperation among industry, institutes, and government.

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