STUDIES OF STRATEGIES AND MANAGEMENT

INTERNATIONAL EXPERIENCES AND APPROACHING WAYS TO TECHNOLOGY MAPS AND TECHNOLOGY ROADMAPPING IN VIETNAM

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Abstract:

Notions of technology maps and technology road-mapping are used largely in the world with many different approaching ways to them, subject to technological capabilities of every country as well as objectives of application for purpose of State administration and enterprise management. This paper summarizes different notions of technology maps and technology road-mapping which are in use and various types of technology roadmaps which are applied and developed largely in the world. At the same time, the paper provides an analysis of roles and necessity of technology road-mapping for S&T management activities as well as experiences of technology road-mapping and applications by developed countries such as the US, Canada, Japan, South Korea and some others. On basis of international experiences, the study team makes a deep analysis on approaching ways and contexts of development of models of technology roadmaps and road-mapping in the world. The paper also provides links between technology maps, technology road-mapping and technology innovation roadmaps. On basis of that, the study team proposes approaching ways in conformity to actual development context of Vietnam as technology late-comer, indicates clearly technology gaps to leading countries and sets up objectives of technology development to shorten existing technology gaps.

Key words: Science and technology management; Technology capabilities; Technology map; Technology roadmap.

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Introduction

Notions of technology maps and technology road-mapping are used largely in the world with many different approaching ways, subject to technological capabilities of every country as well as objectives of application for purpose of State administration and enterprise management. Methods of technology road-mapping are credible management tools which

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were developed and used largely since late 1990s. Technology roadmaps are used as a planning tool for coordination of implementation of technology innovation within a company or between enterprises in an industrial sector. Majority of countries conduct researches and apply methods of technology roadmapping as one of tools to build technological development strategies of the country, sectors and enterprises. In addition to concretising long-term strategic objectives which cover and pass through numerous industrial sectors, methods of technology roadmapping can be used also to identify key important technologies which are needed for industrial development (nation, sectors and enterprises). Benefits gained from these methods include: helping identify new opportunities, knowledge and ideas of the community; encouraging to make technology investment decisions; developing effectively technological strategies; identifying stand positions of technology in a business cycle; helping State agencies, industrial sectors and enterprises decide investments for technology innovation in effective ways.

1. Practice of technology road-mapping in the world and proposal approaching ways for Vietnam

Since initial appearance during 1980s, technology roadmaps were used purely to supply forecasts of technologies in exact and clear ways. After that, technology roadmaps were used as tools focused to assist decision-making process for plans and strategies for development of new technologies and products. Actually, technology roadmaps are used as tools to plan integrated development of technologies (such as nano technologies, new energy technologies) in nationwide scale. The tasks to build technology roadmaps help select the most reasonable directions and ways for implementation and, through that, to evaluate business opportunities bound with investments for technological development. On this basis, technology roadmaps would assist companies to optimize investment processes for technology innovation, to develop effectively technological strategies, to identify their own technological stand positions in comparison to competitors and to enhance competing capabilities of their products.

When the practice gained good results at level of enterprises, the Governments of many countries conducted technology roadmapping at higher scales including fields, sectors and national one. These roadmaps play important roles for establishment of policies and strategies for S&T development, transfer and import of technologies, key important research programs as well as actual development strategies of fields and sectors.

However, in order to build up an useful and effective technology roadmap, experiences of leading countries show that in fact they need to pass three

different stages: (i) Building technology maps; (ii) Building technology roadmaps; and (iii) Implementing technology innovation roadmaps. Detail descriptions of the stages are provided as follows:

Stage 1: The building of technology maps is to summary database of descriptions, analysis of actual technological status, links between types of technologies and products, identification of priority technologies and development trends.

Stage 2: On basis of built technology maps, technology roadmaps will be built to define plans for development of technologies, from low level to higher one, to achieve determined targets, of both middle term and long term, for levels of the national scale, sectors, fields and enterprises. This stage requires participation of many leading experts in various technology fields, leading managers of enterprises and market analysis experts to build up technology roadmaps for some key important fields and sectors. For example, China mobilized 1,500 experts for technology roadmapping of 9 fields. Japan mobilized 835 experts from universities and research institutes, industrial sectors and Government agencies for technology roadmapping of 4 key fieldsincluding infomation-communication, life sciences, energy environment and manufacturing.

Stage 3: On basis of built technology roadmaps, a detail plan is set up to include objectives, contents, order and options of use of human resources for implementation of activities of technological innovation to target higher labor productivity, product quality, production of new products and services in well defined periods of time.
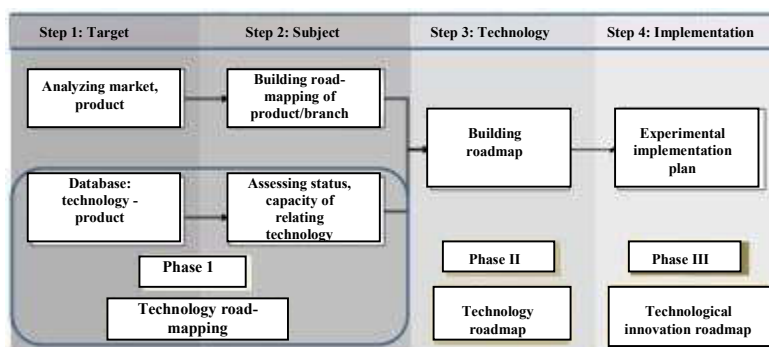
Source: Fraunhofer Institute for Systems and Innovation Research -ISI

Figure 1. Stages in building technology roadmaps in the world's practice

Among these three stages, Stage 1 is said to be the most important one but many countries do not deal with it in full and detail manner. Practice shows

that the outcomes of successful building of technology maps play important deciding roles for quality and effectiveness of use for building of technology roadmaps and technological innovation roadmaps. Technology roadmaps provide right information for various aspects of top concerns including quantity and types of technologies required for a field, sector or product, actual status and capabilities of every technology, links between technologies and products, technology holders, technologies to appear in next future and etc. Because of these multiple benefits, many countries have focused efforts for technology road-mapping to turn them to tools to build strategies for technological research and development. The latter has to be linked closely to directions of national programs for socio-economic development.

However, the countries actually conducting activities to build technology roadmaps need to spend more time and resources for surveys, completion and upgrading of databases on actual technology situation. Experiences from some countries show they need to mobilize strong teams of leading experts to build up technology maps and technology roadmaps for a long duration of time. The typical case is Germany which spent more than 10 years from initial fixation of objectives till full completion of database system. Also, South Korea mobilized more than 800 experts for duration of about 15 years to build a system of technology maps for 10 key production fields.

Strategies of industrial development of a nation need to be built on basis of competitive visions to other nations to secure high competitive quality of its export products. Technology roadmaps should be built on basis of long visions for key important sectors and become tools to set up technological plans and backgrounds for development of industrial fields in future and realization of defined strategic objectives. Technology roadmaps can give contributions to build detail strategies for every time mark stones, technological levels to be achieved and necessary resources required for realization of every established target. Technology roadmaps also define compositions, contents and conditions for systems of strategic products, arrangement of technological targets, selection of best options of technologies to be used for every field, suitable justification of required processes and time duration to achieve every technological target.

Technology roadmaps and technological innovation roadmaps have to be based on basis of integrated knowledge on markets, products and understanding of actual technological status. In case of developed countries, the process of analysis and synthesis of information on technological markets and actual technological status are fundamental steps which were

developed in advance and then integrated during numerous workshops for road-mapping on basis of full and ready volumes of data.

In case of Vietnam, we do not have today a national scale system of data on technologies. Database on technologies remain segmented, not classified to systems, and not processed by experts experienced in the related fields. The learning of experiences from advancing countries faces also difficulties because other countries are not ready to share their methods, procedures of implementation and resulted database of built technology maps due to information confidentiality requirements. Therefore, the approaching ways proposed for Vietnam are to conduct itself fully the above noted three stages: technology maps, technology roadmaps and technological innovation roadmaps.

On basis of this analysis, the definitions can be made for technology map, technology roadmap and technological innovation roadmap in actual context of Vietnam as follows:

1.1. Technology map

Technology maps are sets of documents to describe and to analyze actual technological relations between types of technologies and products, and trends of technological development.

Technology maps have to cover full information necessary for realization of three basic contents, namely: (i) Actual technological status; (ii) Relations between technologies and products; and (iii) Trends of technological development in Vietnam and in the world, through various forms: summary reports, schemes, administrative and specific maps and etc.
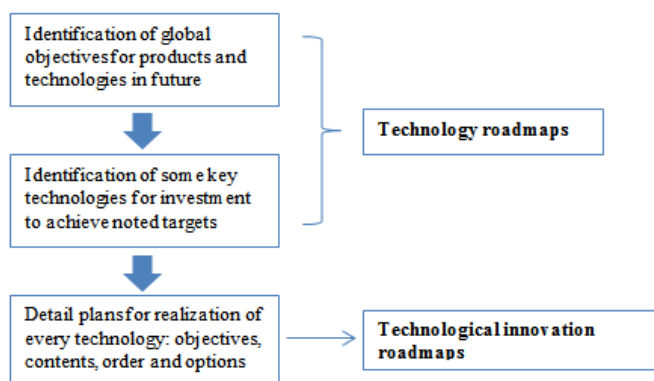
1.2. Technology roadmaps

Technology roadmaps are plans for technological development from low level to higher one to achieve established objectives, in both middle term and long terms visions, for national scale, fields, sectors and enterprises.

1.3. Technological innovation roadmaps

Technological innovation roadmaps are detail plans for objectives, contents, order and options of use of resources for implementation of activities for technological innovation to target higher labor productivity and product quality for a well defined period of time.

Technology roadmaps and technological innovation roadmaps are two consecutive stages in a unified process from macro level to micro level for

technological development. The relations between technology roadmaps and technological innovation roadmaps are shown in the following figure.

Source: State Agency for Technology Innovation, MOST.

Figure 2. Relations between technology roadmaps and technological innovation roadmaps

2. Approaching ways for building technology maps, technology roadmaps and technological innovation roadmaps at levels of fields and sectors

2.1. Structure of technology maps

The above presented definitions permit to indicate the structure and composition of technology maps according to the three main contents as follows:

Actual technological status: Technology maps would provide information on: (i) Quantity and category aspects actually used in fields and sectors under consideration and technologies actually used in Vietnam; (ii) Distribution of these technologies among sectors of local enterprises and administrative structure based distribution of them; (iii) Comparison of existing technologies of Vietnam to the ones of the world (quantitatively reflected through standards, indexes and technical specifications of concerned technologies or qualitative assessment by experts; (iv) Owners and/or holders of these technologies; and (v) Technological production levels of Vietnam enterprises and distribution of technological production technological among enterprises.

Relations between technologies and products: technology maps can reflect technical and technological requirements needed for production of various
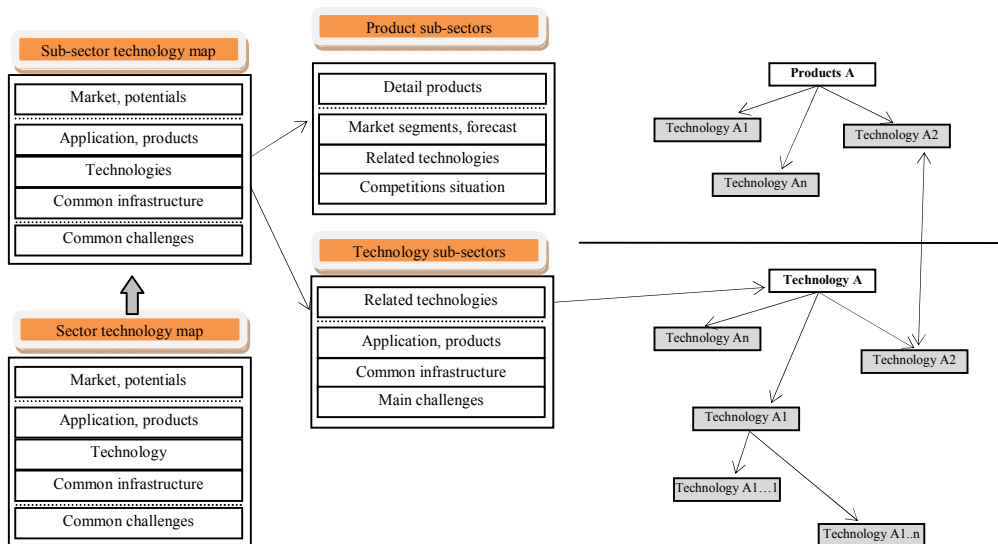
categories of products. The relations between technologies and categories of products are reflected through evaluation of market segments of products with various technical specifications (classified on requirements of high, middle and low levels of technologies). Then, technology maps help to determine those technologies Vietnam uses actually to produce various categories of products for concerned market segments, particular attentions being turned to the categories of technologies used for development of products with higher specifications for high ranked market segments. In addition, for the national system of technology maps, the relations between technologies and products are reflected also through categories of inter-sectorial products such as car manufacturing, ship building and etc. In terms of inter-sectorial products, technology maps permit to extract data to give answers to questions such as "Which level of development and which types of technologies are required for car manufacturing industry?" or "Which technologies are shared for common application in a single sector or multiple sectors (such as IT and technologies for measuring techniques, tests, experiments and etc.)?"

Identification of technological development trends in Vietnam and in the world: technology maps help make evaluation of directions of research and development of actual technologies of Vietnam and priority directions for development of new technologies in the world. It is a group of aspects of which we need to have right and exact identifications to make right support policies for determination of directions and promotion of technological development activities for leapfrogging as well as encouraging development of newly emerging technologies for catching-up the world's trends.

On basis of the above presented structure, the State Agency for Technology Innovation conducted studies and proposed the basic concepts reflected in the following contents of technology maps for levels of sectors and sub-sectors (Fig.3).

In case of technology maps for different levels, the main contents include: information on markets and market potentials, application and products, existing technologies, infrastructure and global challenges.

Information of markets and market potentials are reflected through statistic data, reports and forecast for markets, and, then, the identification of potentials for Vietnam industrial sectors should be based on available analysis and forecast for markets.

Sub-sector technology map

| Market, potentials |
| Application, products |
| Technologies |
| Common infrastructure |
| Common challenges |

Sector technology map

| Market, potentials |
| Application, products |
| Technology |
| Common infrastructure |
| Common challenges |

Product sub-sectors

| Detail products |
| Market segments, forecast |
| Related technologies |
| Competitions situation |

Technology sub-sectors

| Related technologies |
| Application, products |
| Common infrastructure |
| Main challenges |

Products A — Technology A1, Technology A2, Technology An

Technology A — Technology An, Technology A2, Technology A1, Technology A1…1, Technology A1..n

*Source: State Agency for Technology Innovation, MOST*

Figure 3. Structure and relations in technology maps for different levels

Information on application and products are to describe fields of main applications of the technologies under consideration (for example, the medical, biological and environmental fields of nano technologies). Information of technologies is the one of sub-groups of the technologies under consideration (for example, sup-groups of designing, simulating and laser techniques of nano technologies). Common infrastructure includes equipment and technologies globally used for all related products and technologies (for example, equipment for measuring techniques, tests, experiments and etc.). Information of common challenges is to deal also with difficulties and barriers in development process of the fields under consideration. It may cover information on markets, competitors, policies or limits of existing technologies.

2.2. Structure of technology roadmaps and technological innovation roadmaps

As described in Fig. 2 on relations between technology roadmaps and technological innovation roadmaps, in case of integrated implementation from the stage of definition of global objectives down to plans of detail implementation, these two roadmaps are considered as joint in an integrated process (usually called as technology-technological innovation roadmaps). Therefore, the State Agency for Technology Innovation proposes methodology and structure for building technology roadmaps and

technological innovation roadmaps which are similar to the ones of other countries as shown in the following figure.
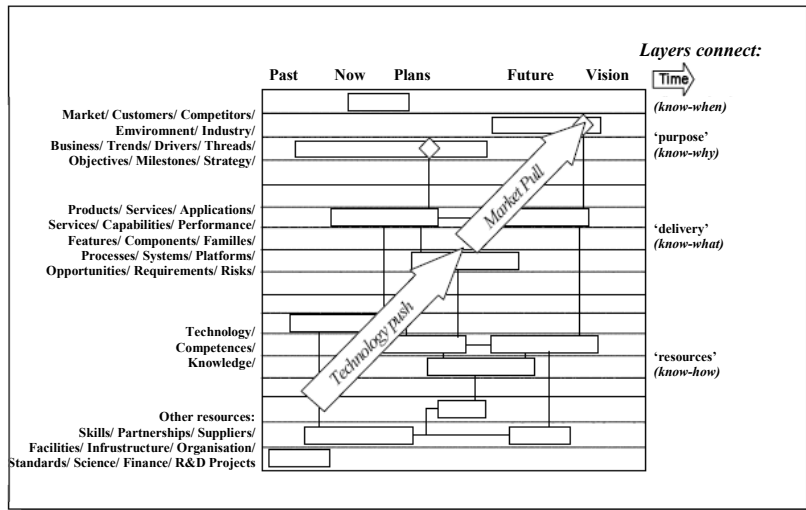
Source: Robert Phaal, Centre for Technology Management, University of Cambridge,

Figure 4. Basic structure of technology roadmaps

2.3. Roles and scope of application of technology maps, technology-technological innovation roadmaps in Vietnam.

In the actual context of Vietnam the works to evaluate the actual status and technological capabilities in fields and sectors are found necessary where it is required to identify clearly basic technologies, core technologies, emerging technologies and technological gaps to other countries which include:

- Identification of key technologies related to develop national classified products and to enhancement of competing capabilities;

- Identification of technological gaps to the world's level;

- Building of development strategies and actual action plans to be implemented in future on basis of analysis of technological capabilities, technological gaps and required resources;

- Promotion of public-private partnership (PPP) in investment activities for research, development and innovation of technologies in Vietnam.

Then, technology maps and technology-technological innovation roadmaps would help make:

- Identification of central and key points as well as order of development demands which lead to build action programs and implementation plans;

- Identification of important technologies and supporting technologies to produce priority groups of products in future;

- Identification of overlapped works in R&D activities;

- Supports for long term research activities to meet demands of industrial sectors;

- Supports for the Government to get involved better into R&D contracts with actual industrial fields through better determination of research programs and implementation plans.

Vietnam should use principles and ways which were applied by the group technological runner-ups such as South Korea, China, Singapore, Australia and others for purpose to identify technological gaps to leading nations and to implement works to build up technology roadmaps and technological innovation roadmaps to shorten the gaps. The idea comes from the similarity in a series of aspects between Vietnam and some countries from this group, namely:

- Contexts of development and capabilities (similar to the ones of South Korea during 1980s with GDP rate of USD1,900 per capita);

- Application from the national level down to the level of fields, sectors and enterprises;

- Objective of industrialization (lowest costs for highest efficiency, substitution of import commodities and intensive growth of export commodities).

3. Approaching ways for building of technology maps and technology roadmaps at the national level

3.1. Approaching ways for building of the system of national technology maps

The system of national technology maps is built up on basis of technology maps and technology roadmaps for the scale of fields and sectors.

For purpose to build technology maps, the most basic and regular works are to make surveys and evaluations to gather information on actual status and technological capabilities. On basis of collected raw materials, teams of experts would check and review data and then use different computing tools to make necessary results to be included into technology maps. Technology maps of various levels would make know the actual technological status of Vietnam and its gaps to the world's level. It is information necessary for building of technology roadmaps of corresponding levels.

The classification of levels of technology maps and technology roadmaps is presented in Fig. 5.
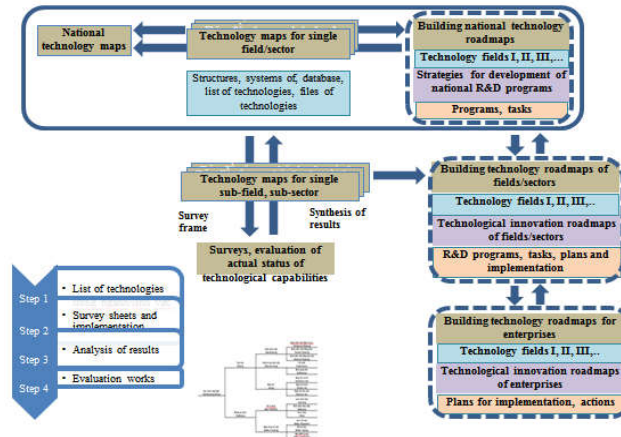
Source: State Agency for Technology Innovation, MOST

Figure 5. Levels of technology maps and technology roadmaps

Upon establishment of the system of national technology maps, the relations in the chain technologies - products - application - fields and sectors should be checked and get unified in the system of national technology maps. The relations are reflected in the Fig. 6.
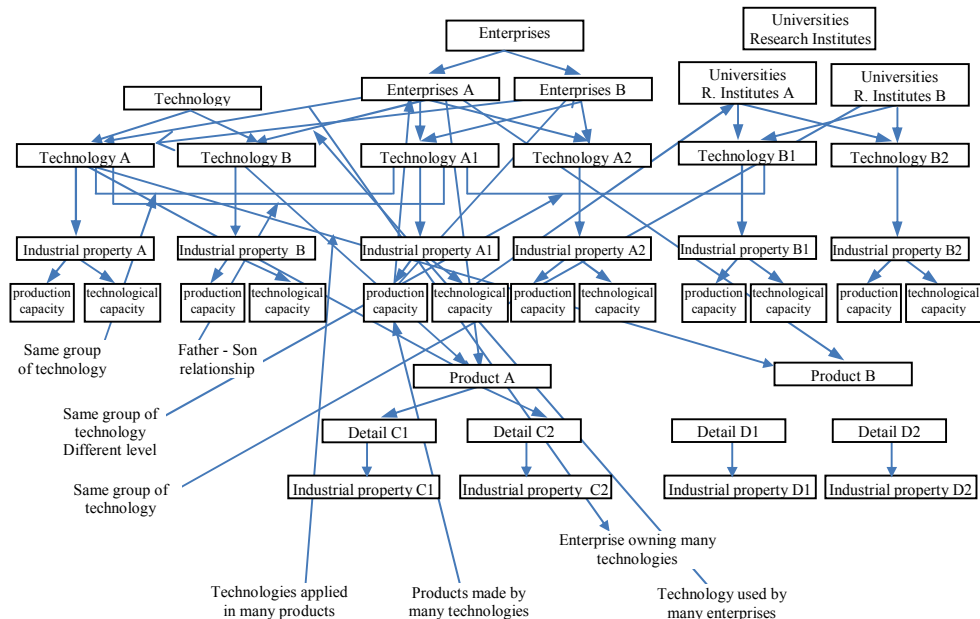
Source: State Agency for Technology Innovation, MOST

Figure 6. Structure of the system national technology maps

The relations to link fields of super data are very complex. In a global view, the relations are reflected in combinations of the following pairs:

1. Enterprises-Products;
2. Universities, Research institutes -Technologies;
3. Enterprises-Technologies;
4. Technologies - Technologies;
5. Technologies - Products;
6. Products-Products;
7. Technologies - Technology files - Research capabilities;
8. Technologies - Technology files – Production capabilities;
9. Enterprises-Production capabilities;
10. Enterprises-Research capabilities;
11. Universities, Research institutes- Production capabilities;
12. Universities, Research institutes-research capabilities;
13. Fields-Sub-fields;
14. Fields-Sectors;
15. Sectors-Sub-fields;
16. Fields-Products;
17. Fields-Technologies;
18. Sub-fields-Products;
19. Sectors-Technologies;
20. Sub-fields-Technologies;

3.2. Approaching ways for building of national technology roadmaps

Upon establishment of the system of national technology maps, national technology roadmaps will be built which indicate global national objectives and strategic objectives listed in 10 year plans. A mixed approaching way is proposed for building of national technology roadmaps including both top-down and bottom-up modes. The bottom up approaching way is based on the system of national technology maps which indicates clearly the actual technological status, technological capabilities, technology - technological innovation roadmaps at field and sector levels. The top-down approaching way is based on directions of socio-economic development of Vietnam and

orientations of implementation of resolutions of the Party and the Government. Some national key products get dealt in 10 year plans, then they can be listed in the next level of technology roadmaps. Key technologies are determined to produce national top key products and to achieve strategic objectives. Key technologies related information are discussed toughly and collected. Targets are to equip every key technology with a rich information table like a technology file. Extended evaluations during 2 or 5 years would show the progress of every key technology and provide chances to adjust policies for research activities, research investments and research priorities. This would permit to get lessons of every stage and to orient to the best measures of innovative policies for every development stage of Vietnam.

The procedures to build national technology roadmaps include 5 steps of mixed approaching ways including:
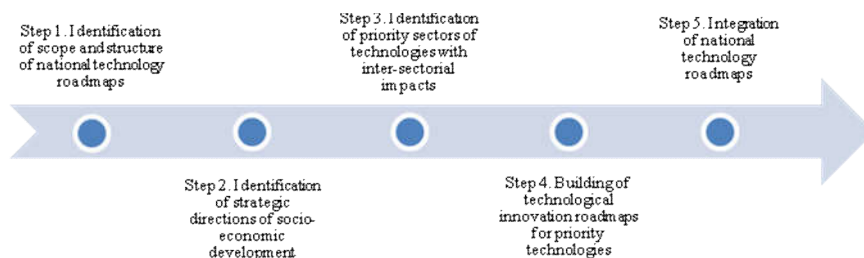
In Steps 1 and 2, socio-economic development directions are synthesized and used as reference marks for clear identification of long term targets of Vietnam which show well national needs and driving forces of development. In addition, technological needs, technological vacuum and technological capabilities get identified from the system of national technology maps. These factors are input data for determination of priority sectors of technologies to be developed in Step 3. On this basis, technological innovation roadmaps of every priority technology are to be developed first (in Step 4) and then get integrated in national technology roadmaps (in Step 5). The time-frame of use of national technology roadmaps should be at least 10-15 years in order to secure adequate technology development process.

Conclusions and proposals

Technology roadmaps for fields and sectors are used as tools to support forecasting of future development trends. By other way, the technology road-mapping is a method to get consensus of enterprises, universities/research institutes and Government organizations in a unified view to market needs in future technologies compulsorily required to meet

these needs. It is a type of mechanisms which permits experts to forecast development trends of technologies in actual fields and sectors. In addition to that, it is also a framework usually used by industrial sectors for planning and coordinating of development strategies. Also, technology roadmaps are useful tools of large corporations for management of plans to develop technologies and products, and, by this way, to concretize business strategies through development of core technologies to secure market competitiveness of products. Regarding SMEs, the building of their own technology roadmaps based on the ones of large corporations or an industrial sector is a key important factor for enterprises to maintain their roles and positions in supply chains to meet demands of large corporations and to enhance their competitiveness in related industrial sectors.

Experiences of many countries show that before building technology roadmaps they conducted always surveys for evaluation of actual status and technological capabilities in concerned industrial sectors as well as R&D capabilities of partner universities and research institutes. Database on the actual status, technology capabilities and technological gaps can be built in advance or at the same time with implementation of works to build technology roadmaps subject to development level of the country. It is a large practice that developed countries have rich databases collected and updated in industrial sectors and management agencies and they need only to synthesize them from numerous sources to get necessary data for building roadmaps. It is also a large practice that the countries are not so generous to share information and they do not make public reports on their technology maps and actual technological status because this information remains controlled under confidentiality regulations and then cannot be made public. Regarding the context of Vietnam, the lack of database including information on actual status, technological gaps and local technological capabilities leads to necessity to build its own system of database and to set up national technology maps.

For some other countries including Japan and South Korea, database collected from works of evaluation of technological status are synthesized and systematized to build technology maps for individual fields and sectors and then get compiled to make national technology maps which are used to build technology roadmaps of levels of national one, fields, sectors and enterprises. These technology maps would provide full information on descriptions, analysis of actual status, applicability of technologies, technological gaps, availability, relations between types of technologies, needs of technological development, identification of technological development trends, priority technologies and etc.

Experiences of South Korea show that the survey and evaluation of actual technological status were conducted first in initial stages to build technology maps for individual fields and sectors. On basis of these databases, the national technology roadmaps get developed and technology roadmaps of fields and sectors get implemented on basis of directions of national technology roadmaps. The South Korea Government also provided enterprises with supports to build up their technology roadmaps on basis of developed technology roadmaps at level of fields and sectors.

Actually, Vietnam has adopted strategies to develop applied technologies to meet needs of production activities and to put enterprises into center positions of activities of technological innovation. In this context, the effectiveness of R&D activities is an important topic to attract management knowledge and skills of government agencies from central level to local one. The application of methodology of building of technology maps, technology-technological innovation roadmaps has high practical sense and big effects in supports for building of strategies and policies for S&T development as well as development policies for fields and sectors. In addition, technology maps and technology and technological innovation roadmaps would help enterprises to evaluate their actual technological status in comparison to competitors, to set up plans for practical and effective technological development and innovation, to save investment costs, to enhance productivity, quality and competitiveness of enterprises. However, in order to build up successfully and effectively technology maps and technology-technological innovation roadmaps, it is necessary to require a mobilization of all resources, long efforts and unified views to the works. In addition, it is necessary to build up and to complete methodologies and common implementation procedures for the system of database.

International experiences show that the identification of actual technological status and capabilities are top essential conditions for building and implementing of technology roadmaps over the world. When implementing works to build technology roadmaps, all countries need to have database on actual status, technological capabilities and technological gaps as backgrounds to build up technology roadmaps at levels of national one, fields and sectors.

In actual context, Vietnam as technological late-comer should apply the models which were applied by the group of technological runner-ups such as South Korea, China, Singapore, Australia and etc., targets being focused on determination of their technological gaps to technologically advanced nations and on efforts to build technology-technological innovation

roadmaps to shorten existing gaps. It is necessary to bear in mind that the actual context of Vietnam is highly similar to the one of South Korea by 1980s.

Vietnam should apply integrated approaching way from national scale down to fields, sectors and enterprises and then organize implementation activities on basis of the above presented order of 5 stages./.

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