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Building a Technological Innovation Roadmap from the Viewpoint of CMC Institute of Science and Technology, Vietnam

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ABSTRACT

CMC Institute of Science and Technology (CIST) is a research and development department of CMC Corporation, Vietnam. The development of a technological innovation roadmap (TIR) is of great significance to the existence and development of CIST. In fact, the construction of a TIR has a wide scope, diverse content, and rich approach. This article does not focus on studying the academic TIR but will clarify the TIR of a specific research institute (CIST) based on the approach of building a roadmap for technological innovation introduced by the Stage Agency for Technology Innovation, Vietnam. The paper is a part of the research results of the topic "Construction technology map and technological innovation roadmap in developing and applying IoT in Vietnam", code: ĐM.40.DA/19.

Keywords: Technological innovation roadmap, CMC

1. INTRODUCTION

Concept of enterprise's technological innovation roadmap

Up to now, there are many different Up to now, there are many different approaches to technological roadmap and technological innovation roadmap (TIR). According to the approach of the Stage Agency for Technology Innovation, Vietnam (SATI, 2016), a technological roadmap (TR) is a plan for the development of technology from low level to high level to achieve goals which are aimed for the medium and long term strategy of a country, industry, sector or business. The TIR is a detailed plan of goals, contents, sequences and plans for using resources to carry out technological innovation activities in order to improve the productivity and the quality of products in a defined period of time (Kostoff, R. and Schaller, R, 2001; Bela pataki, Zsuzsanna szalkai, 2010; Kenneth B. Kahn, 2013).

TR and TIR are two consecutive stages in a similar process of unifying from macro to micro for the technology development. The relationship between the TR and the TIR is shown in Figure 1. In the case of synchronously deployed from the stage of defining common goals to detailed implementation plans, the TR and the TIR are considered to be an uniform roadmap (Barker, D. and Smith, D, 1995; Ta Viet Dung, Nguyen Duc Hoang, 2016; Nguyen Hoang Hai, 2015).

The development of a roadmap for technological innovation plays an important role in the development of enterprises, helping businesses in technologically planning for new product development and limiting possible barriers in the development process. It can reduce business risks, enhance

the ability to respond to change, shorten the taken time to introduce new products to the market, thus increasing the company's competitive position in the market (Martin Rinne, 2004; Cindy Johanna Ibarra González et al, 2008). Thereby, it can support for the decision-making process in strategic innovation planning to find opportunities, generates ideas and finds out priority technology innovation solutions in the short, medium and long term strategies of the enterprise.

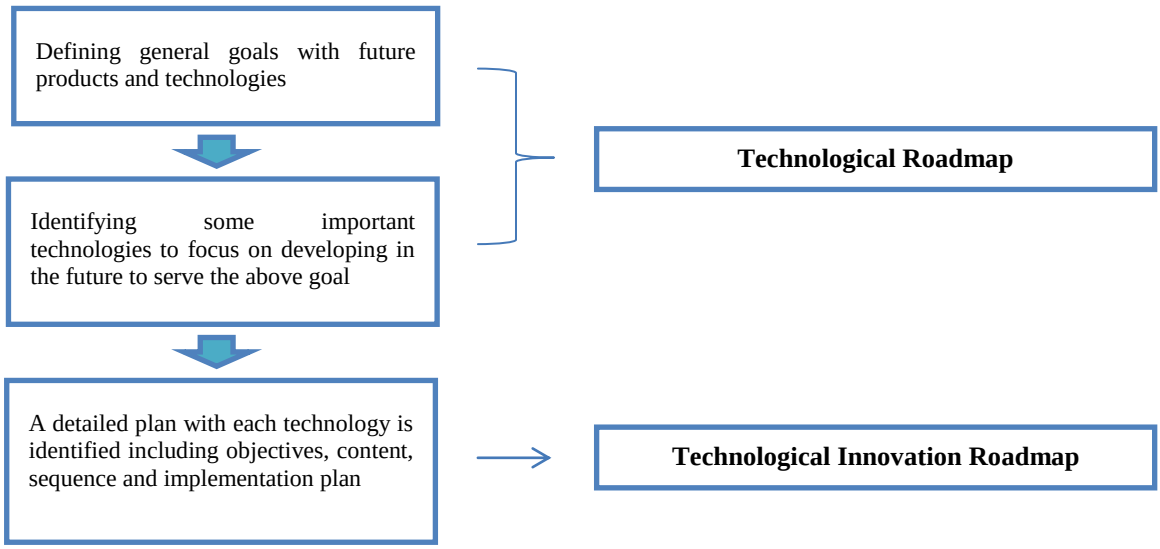

Figure 1. Relationship between technological roadmap and technological innovation roadmap
Source: Stage Agency for Technology Innovation, Vietnam (2016)

2. METHODS OF BUILDING THE ENTERPRISE'S TECHNOLOGICAL INNOVATION ROADMAP

Firstly, the scenario development method: Building a "scenario" which is used in many different industries/sectors and also exploited to develop a roadmap for technological innovation. This method is used to make future scenarios based on certain assumptions, thereby identifying key factors that influence and govern the development; scenarios can be constructed based on an extrapolation of potential trends, or contrasts (Nguyen Van Thu, 2004). The reliability of the scenario depends on the past and present data and the quantification of hypothetical conditions. In the development of a technological innovation roadmap, the scenario-building method allows to predict the future perspectives and assumptions of technological innovation activities in an interaction between factors of different perspectives including economics, politics, technology and integration trends.

Secondly, the problem tree method: This method shows us the relationship between phenomena and their causes. The application of the problem tree method allows to know the causes of the phenomenon and thereby have a method to solve the problem. In building a roadmap for technological innovation, this method allows us to know deep and core causes affecting technological innovation activities and thereby find ways/methods to solve and promote them. technological innovation activities (Kostoff, R. and Schaller, R, 2001; Nguyen Van Thu, 2004). This method has certain limitations such as not showing long-term interactive visions and not quantifying difficulties and barriers that may occur in the future in technological innovation activities.

Thirdly, the expert method: This method is conducted to seek consensus of experts by asking opinions about judgments and evaluations on some future issues by using questionnaires. The questionnaire was sent to a group of selected experts (Nguyen Van Thu, 2004; Nguyen Huu Xuyen, 2016).

The results of the first round are sent to the experts in the second round, which allows the experts to consider and revise opinions given in the first round; In the third round, the consensus of experts is taken. In special cases of the third round, if there is not a high consensus among the experts in the selected group, it is possible to invite additional experts having a deep understanding of the issue for further evaluations to achieve consensus. A prerequisite condition to use this method is that a large enough number of experts having advanced knowledge of issues related to technological innovation is required. The questions/questionnaires need to be designed and tested carefully to help experts understanding issues of technological innovation. Thus, this method requires a lot of time and efforts to be implemented.

Fourthly, the method of technology foresight: Technology foresight can be understood as the science that studies the future of technology development in the context of changing environmental conditions to identify technologies that have a great impact, priority technologies to bring about the greatest possible economic, social, and scientific and technological benefits. Many scholars believe that technology foresight is just a new form of technology forecasting. However, the reality shows that these are two activities with fundamental differences. The technology forecast is an activity that can be independent of policy making and decision making, while technology foresight is always associated with the policy and decision making (Cindy Johanna Ibarra González et al, 2008; Kenneth B. Kahn, 2013). That is to declare, technology foresight answers the question of what technologies expected to be achieved in the future, while technology forecasting answers the question of which technologies will appear at what time in the future. In developing a roadmap for technological innovation, this method allows to identify key technologies at the national level to guide future investments in the technological innovation. This serves as a basis for national technology policy making for technologies which are necessary, appropriate and play an important role in mainly affecting the endogenous technology capacity, the national position, the industry capacity and new competitive products in the future.

Fifthly, SWOT analysis method: SWOT is an abbreviation of the words Strengths, Weaknesses, Opportunities, Threats. SWOT gives an overview of comparative advantages, development goals, as well as making future judgments based on past and present results. To know the strengths and weaknesses in building a roadmap for technological innovation, it is necessary to analyze factors of the internal environment such as: financial capacity, organizational structure, technology, research and development activities (Barker, D. and Smith, D, 1995; Ta Viet Dung, Nguyen Đuc Hoang, 2016). To figure out opportunities and challenges in building a roadmap for technological innovation, we need to conduct an analysis of factors in the external environment such as economic, political, legal, socio-culture, nature. For building an innovation roadmap at the industry/organizational level, Attentions should be paid to customers, suppliers, competitors, and substitute products. SWOT is often used for the strategic analysis of a country, industry, or business. On basis of strengths, weaknesses, opportunities, and threats, a SWOT matrix is formed. The components of the SWOT matrix suggest us strategic solutions to take advantage of opportunities, prevent threats, and limit weaknesses in seizing opportunities from outside in building develop a roadmap for technological innovation.

In addition, to build a technological innovation roadmap, we also consider a number of other methods such as: consultation, global value chain, national innovation system (Nguyen Huu Xuyen, 2018), industry innovation system, multi-criteria analysis methodology.

3. Roadmap for technological innovation of CIST

3.1. Introduction to CIST

CMC Institute of Science and Technology, Vietnam (CIST) was established in 2014, CIST is a modern private research unit, with a team of talented young researchers from many domestic and foreign institutes and organizations. CIST's mission is to research and apply the latest technologies in the fields of BigData, AI, Blockchain, IoT, Cyber-Security to support customers who are Vietnamese enterprises to improve their competitiveness in the context of Industry 4.0 with many new opportunities and challenges

CIST is organized in a matrix operation model with a high flexibility and market orientation. With modern laboratory infrastructure, high-performance data center and server system, innovation center and professional training system, CIST has formed an innovative ecosystem that comprehensively supports applied researches.

Main functions of CIST: Participate in research according to the strategy of CMC technology corporation; Building long-term R&D capacity; Technology transfer to member companies of CMC group; Cooperation with research institutes, universities at homeland and abroad.

Resources of CIST are included: Innovative investment fund up to 2 million USD for start-ups both inside and outside CMC Corporation; Creative Center; Modern laboratories; Data Center standard Tier 3; at the same time, CIST cooperates with more than 10 universities and research laboratories, 40 researchers (divided into 4 groups).

CIST plays an important role in the development of CMC Corporation and has a high dependence on the development strategy of CMC Corporation. CIST focuses on research activities on technology and highly applicable products, and at the same time participates in supporting the planning and consulting on technology strategies for CMC Corporation. In the immediate future, CIST focuses on applied research activities ordered by CMC Corporation, while developing markets, supporting the technology transfer, and expanding the investment. Therefore, a close connection is needed to ensure that the research product is suitable for the market and commercialized successfully.

The main research directions of CIST:

Big Data/AI (banks, customers, insurance, government,...); Security (BlockChain, ...); IoT (Smart Devices, Smart Cities, ...); Social Data (Social Network listening).

In order to well implement research orientations, CIST has a close cooperation with CMC Corporation, as well as with a number of R&D organizations, universities and other partners. For CMC Corporation, CIST is the unit to create new solutions and products with high and different technology content; On the contrary, CMC Corporation and its member units are the output and application of the Institute's products, the one who orders and consumes the Institute's products. As for R&D organizations, universities and other partners, CIST is an outlet for research students, a partner for research cooperation and scientific expertise exchange; on the contrary, research institutes and universities are where CIST can find talented professionals and students working for its, can combine training and professional research in the main research directions of the CIST.

3.2. Building a technological roadmap and technological innovation of CIST

3.2.1. Determining requirements and scope of developing technological roadmap

Limited time, content of building technological roadmap

Firstly, limit the time range. Building a technological roadmap of CIST to 2025, orientation to 2030.

Secondly, limit the content. Focusing on CMC's priority technologies and products on basis of CMC Corporation's development strategy to 2025, orientation to 2030. Thereby, conduct analysis of product characteristics, characteristics of technology that CIST researches and deploys towards target customers and consistent with the qualifications, capacity, resources and mobilized resources of the CIST by 2025. According to CIST, the target customers of CIST are as follows:

- **Medium and large enterprises:** There is a strong need for digital transformation to expand business on the Internet platform and increase user experience to help businesses improve their competitiveness in the context of rapidly changing technology.
- **Government sector (including public administration, urban areas, traffic, environment,...):** The need for technology application and digital transformation is a cross-cutting policy of the Party and State, many large-scale technological problems to improve national competitiveness and people's satisfaction.
- **Banking - Finance:** the most powerful argument transfer demand, large scale, very high quality requirements, especially user security. Data analytics is one of the technologies of top interest in banks.
- **Telecommunications:** always leading in digital transformation, often, especially technologies related to data analytics, IoT, Bigdata, AI,...

Limits on the choice of methods and sources of information for the development of technological roadmaps

Firstly, CIST's technological roadmap is implemented based on:

- Guidance document "Building a technological roadmap for enterprises" of the Stage Agency for Technology Innovation, Vietnam
- **Market analysis method according to the approach of marketing, done through three basic steps:** Identify market segments; collect market information, customer tastes; identify market development trends.
- **Method of competitor analysis:** This method is used to determine the competitive situation.
- This analysis includes both domestic and foreign competitors. For the development of the technological roadmap of CMC Corporation, the analysis of competitors is also to determine the level and capacity of competitors such as types and prices of products in the market, as well as identify development trends, competitors' goals through the analysis of research activities, product and technology development.
- **Technological life cycle method.** This is the method used to analyze the technology currently used for the product line. On that basis, it is possible to predict the limitations of technology, anticipate changes to avoid investing in outdated technologies. The technological life cycle is divided into four stages with different levels of competition (formation, growth, maturity, and decline).
- **In addition, some other methods are also used such as:** SWOT (Analysis of Strengths, Weaknesses, Opportunities and Threats). From there, form a SWOT matrix to give strategic suggestions); product class structure analysis method; method of analyzing priority list (products, technology); quality function implementation method (QFD – this is the method used to ensure customer needs through design and manufacturing); BMO analysis method to select preferred technology; AHP hierarchical analysis method; technological gap analysis method; Delphi survey method (This is a commonly applied method to identify important factors that need to be prioritized in terms of products, technologies, and strategic goals,

thereby synthesizing the views of experts and customers in forecasting the future about products, technologies and applicable strategies)

Secondly, the information collected to serve the development of CIST's technological roadmap:

- **Using secondary data:** using published survey and survey data of domestic and foreign firms and organizations related to science and technology, technological innovation roadmap, IoT.
- **Using primary data:** collecting opinions from scientists, experts, enterprises, state management agencies in the fields of science and technology, IoT, information and communication technology.

3.2.2. Identifying and selecting priority products

To identify and select priority products, CIST established a research group to organize seminars, combined with opinions of experts, state management agencies, and active businesses. in the field of IoT.

Participants are identified through analysis of factors affected by the results of the roadmap and who have knowledge and experience related to the structure of the items. These members include CIST engineers with the participation of Robotics/IoT team, Big data team, AI team; along with the participation of CEOs, market development departments of CMC Corporation (they are responsible for defining competitive strategies in the market. These members are divided into groups: secretariat, roadmap team and specialist groups).

The secretariat team is responsible for developing the schedule management framework based on the plan, making the schedule management files, taking notes in order, preparing the logistics during the development of the route. This group includes 03 engineers who are studying at CIST in the Robotics/IoT group.

The roadmap team consists of 9 people who are responsible for coordinating professional activities, coordinating the activities of working groups in each specific content. The leader of the construction team is a person with extensive knowledge and experience in the business field and understanding of the relevant technologies. The establishment of a roadmap group includes the Director of CIST Institute, obotics/ IoT team leaders, Big data team leader, AI team leader, and invites experts from CMC Corporation with understanding of business planning, Technology market product development plan.

A team of 5 people is responsible for clarifying and answering issues related to professional content such as technologies: Image Processing, BigData, Natural Language Processing, Blockchain.

On the basis of the panel discussion, collecting expert opinions, combined with analysis of secondary data from firms and corporations, CIST has come up with the following (Table 1):

- **Competitors in security surveillance products (buildings, urban areas):** Viettel; Beet Innovators; Hikvision; Dahua.
- **Competitors in traffic monitoring:** Silver Sea; Cadpro
- **Competitors in terms of analyzing social network data competitors:** Reputa (Viettel); VN Social (VNPT); Social network listening system (Vietnam Academy of Science and Technology).
- **Competitors on CIST chatbot products:** Viettel – Cyber bot; Fpt Chatbot; Lac Viet.

Table 1: Competitors with CIST

Products/fields that compete with CIST	Competitor's name	The level of competition
Security monitoring products (buildings, urban areas):	Viettel; Beet Innovators; Hikvision; Dahua.	Very high
Traffic monitoring:	Silver Sea; Cadpro.	Very high
Social network data analysis	Reputa (Viettel); VN Social (VNPT); Social listening.	High
Products chatbot CIST	Viettel – Cyber bot; Fpt Chatbot; Lac Viet.	High

Source: CIST

Compared to competitors in terms of products in each field that CIST is researching and deploying, CIST has launched priority products to develop until 2025, specific products include CIST's priority development products including: Building security monitoring solutions; Urban security monitoring solution; Smart Parking Solution; Traffic monitoring solution; Social network data analysis system; Chatbot products; Electronic signature products; Product traceability.

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According to experts in the roadmap development team, combined with secondary data, CIST has conducted analysis of market size, growth, competitiveness, product life cycle at present and predicted in the future. From there, assess the attractiveness and potential of the target market of CIST's future product groups. The assessment of market attractiveness with CIST's existing products is determined through parameters such as the average annual growth rate of the product, the relative growth of the market size and the expansion rate of the product in the market. Analytical methods that can be applied in this activity: Synthesizing a list of priority products according to CIST experts and the roadmap development team using Brain Storming method, method statistics and analysis of market data and forecasting methods.

Thus, the priority product groups of CIST are attractive and have market potential (CIST's product market share currently accounts for about 8-10%). However, the level of edge of the priority product groups is assessed at a high level.

- Competition in security monitoring products (buildings, urban areas) and traffic monitoring are evaluated at a very high level. Because, in this field, developed countries also have many complete solutions, the market size is growing rapidly, attracting investors, researchers and businesses.
- Competition in social network data analysis and CIST chatbot products is highly appreciated. By investing in data analysis, AI is a trend when more and more data about users and businesses online.

3.2.3. Defining the goal of the priority product roadmap

On the basis of market analysis, competitors and priority product groups of CIST Institute. However, in reality, product development is not only driven by market or technology, but rather a combination of many factors, including economic, social, environmental, political and legal factors. These factors may influence CIST Institute to varying degrees in expanding or limiting CIST's activities in the market. Therefore, before determining the target of the roadmap of priority product groups, CIST has researched and identified influencing factors from macro policies, environment, business institutions, new trends and other factors, future events. Along with that, CIST also conducts an assessment of the suitability, current and potential capacity of the Institute, a comprehensive assessment of the rationality of the strategy and an assessment of CIST's intrinsic ability to meet the requirements for priority product lines. Therefore, the roadmap development team, in conjunction with the CIST Institute, has determined the goals of the priority product roadmap as follows (Table 2).

Table 2: Targets of priority products roadmap

Product	Product details	Targeted customer	Goals to 2023	Goals to 2025
Security monitoring products (buildings, urban areas):	Building: - Face and behavior recognition - Controlling access, weapons, break-in, timekeeping Urban: - Detecting crowds, riots - Searching people, track criminals in the city - Security alert, weapon, break-in	Enterprises, Banking Blocks, Retail Blocks, Office Buildings, Big city	Commercialization of total building security solutions. Pilot urban security solutions. Objective: to test the solution in practice, to find the test implementation unit, to optimize the solution	Commercialization of urban security solutions for big cities
Traffic monitoring:	Number plate recognition, traffic flow monitoring Identifying violations, save evidence of cold penalties Controlling traffic lights	Big city, government	Pilotting urban transport solutions. Target: Deeply perfecting core technologies, developing control center solutions and supporting mobile applications	Commercialization of urban transport solutions. Objective: Commercialize the solution for large cities, integrated with national traffic data axis on vehicles and owners
Social network data analysis	Information monitoring support system Company information system Social network user analysis system	Police, state organizations and local management Banks, state auditors, enterprises with SME customers Retail and service businesses	Completing the data collection system on a variety of sources. Completing data processing algorithm functions such as natural language processing, image video processing for analysis purposes	20 companies use the system
Products chatbot CIST	Providing a platform to help building chatbots through an interface, powered by a leading natural language processing core combined with a knowledge base system	Large and medium enterprises, government organizations	The chatbot platform includes natural language processing as the core	Virtual assistant with knowledge logic platform

Source: Roadmap team, combined with CIST

CIST's priority product groups may be replaced by some other products currently on the market (domestic and foreign) by competitor solutions for indoor/building security, transportation and other solutions for Retail, Smart City. CIST is interested in these priority product groups because these are the main objects of the process of developing the technology roadmap. It is very important to synthesize important product characteristics on the basis of CIST's level, internal capacity and market demand. This activity allows to synthesize and select the most suitable priority product group to allocate resources for research and development activities.

3.2.4. Identifying and selecting priority technologies

Current technologies of CIST include: Image processing; BigData; Natural language processing; Blockchain. The goal of this step is for CIST to identify and select the preferred technology to meet the requirements and specifications of the priority products according to the goals of the product roadmap and the requirements of customers and markets. The main group responsible for this activity are the research and development engineers of CIST. CIST technologies can be replaced by existing technologies in the market (domestic and foreign) provided by competitors in image processing, BigData, natural language processing and Blockchain technology. Therefore, the position of customers is very high and there are many options for CIST technologies.

To identify and select priority technologies, CIST conducts analysis of component technologies related to the production and development of selected priority products. Deployment of analysis of component technologies is broken down and fully analyzed to technical standards through expert opinion and consistent with each step in the respective market and product development roadmap. After selecting the preferred technology to serve product development with accompanying technical characteristics, preferred technologies should be analyzed with the

utmost detail. The absorption assessment for technology is also implemented at the most detailed level. The priority technologies of CIST Institute are as follows (Table 3):

Table 3: Priority technologies of CIST

Technology	Component Technology	Explaining component technology	Current status
Image processing technology	Face recognition technology Technology to recognize age, gender, emotions Iris recognition technology Behavioral and body recognition technology Technology to recognize people and objects Smoke and fire detection technology Character recognition technology	- Face recognition technology: Face detection, analysis of facial features to determine identity - Technology to recognize age, gender, emotions: Analyze facial features to determine gender, predict age, and emotions Iris recognition technology: Analyze iris biometric features for identity verification Body and behavior recognition technology: Analyzes body shape and behavior to warn of abnormal behavior Human and object recognition technology: Classification of people and objects, counting people, detecting weapons, classifying vehicles, monitoring traffic flow Smoke and fire detection technology: Detecting smoke and fire, early warning of the risk of fire Character recognition technology: Application for text character recognition, identification documents, traffic number plate recognition	Has mastered all component technologies. It is necessary to research optimal accuracy in different environmental conditions, optimize processing speed on different types of hardware
Big Data Technology	Data collection technology Big data storage and management technology Big data analytics technology	- Data collection technology: Synthesize data of enterprises / organizations from many different sources into a single centralized storage address. The data is collected in real time or periodically. - Big data management and storage technology: Organizing and storing data, ensuring data's update and integrity - Big data analytics technology: Synthetic analysis of data on big data systems using Spark parallel processing technology, which accelerates data mining	Have mastered the technology and successfully tested it on Lab
Natural language processing technology	Language model Natural language generation system Sound processing	A language model is a model that helps identify and represent keywords in context, helping to perform natural language processing problems with high results. Natural language generation system is a problem to help generate text from keywords Audio processing is geared towards text-to-speech and vice versa. Noise processing and speech classification	Fully mastered language modeling, updated according to the world Natural language generation and audio processing system under research
Blockchain Technology	Blockchain network model Smart Contract Consensus Mechanism	The blockchain network model is a model of the operating components of a blockchain network in which mainly peer-to-peer machines that host the distributed blockchain. SmartContract are smart contracts defined to handle the business of each problem to interact with data on the blockchain. Consensus mechanisms are algorithms built to ensure the consistency of data and actions on the blockchain	Mastered the ability to create smart contracts and build a network model that combines several consensus mechanisms on several blockchain platforms for business problems

Source: Roadmap team, combined with CIST

For each type of technology, there will be component technologies and similar technologies with different technology levels to meet the current and potential needs of the product groups selected by CIST above. By analyzing to find technology development opportunities to meet the requirements of the technology development roadmap is very important for CIST. Through the analysis of the technologies in use, CIST can identify emerging technologies in the market that can replace that technology, means technologies that have the potential to deliver better operability and increased appeal to priority product groups.

3.2.5. Defining technological roadmap

The technologies selected to be included in the roadmap are important

technologies in the development strategy of CMC Corporation, therefore CIST has conducted an assessment according to criteria such as: technical relevance to the business and strategic importance of the selected technology; feasibility in finding and developing these technologies, such as in-house research and development, mergers and acquisitions, outsourcing or limited investment.

On the basis of priority product groups and priority technologies, the linkage between products, technologies and objectives of CIST's technology roadmap is as follows (Table 4). CIST's target determination to 2023 and to 2025 is determined based on the following factors: financial readiness of CIST; the importance of technology and products for the development of the Institute; identification of costs, risks and complexity of each technology, product; analysis of each technology. Especially based on the development strategy of the parent company - CMC Corporation.

Table 4: Relationship between products, technology and goals of CIST's technological roadmap

Technology	Product	Goals to 2023	Goals to 2025
Image processing technology	Security monitoring solutions for buildings and urban areas Traffic monitoring solution	Research to optimize accuracy in different environmental conditions, optimize processing speed on different types of hardware	Perfecting technology at the commercial level
BigData Technology	Business data analysis system for enterprises	Tools to aggregate, store and manage business data from popular data sources of businesses in Vietnam Tools to mine in-depth analytics like forecasts, segments, recommendations on business data	An open database on the market in Vietnam, supporting market analysis for businesses. Tools to support data analysis: NL2SQL
Natural language processing technology	Chatbot – virtual assistant	Building chatbot platform, researching audio processing platform	Combined as a micro service to build a virtual assistant, aimed at serving everyday tasks. Logicalization of knowledge
Blockchain Technology	Education management blockchain	Building blockchain solutions in education to support educational management problems	Expanding the ecosystem of solutions for education

Source: Roadmap team, combined with CIST

3.2.6. Defining technological innovation goals

The goal of technological innovation is decisive in the selection of options to implement in the CIST's technological innovation roadmap. On the basis of analysis and judgment of the roadmap development team, combined with expert assessment, CIST has supplemented and emphasized a number of important bases for determining the goal of innovation in the technology roadmap such as:

- **Strengths of CIST (S):** Modern infrastructure (DC system and data connection); have young and talented human resources; have the opportunity to approach customer problems; have strong investment resources; has a network of experts from many institutes, universities and technological enterprises.
- **Weaknesses of CIST (W):** Research force is spread across many technologies; Experience in commercializing products is still limited.
- **Main opportunities of CIST (O):** Opportunities from the trend of digital transformation and application of new technologies; the opportunity to update new technology trends and knowledge is increasingly favorable.
- **CIST's main challenge (T):** Fierce competition for good talent among technology corporations; Technology trends change too fast, product life cycle, technology is getting shorter and shorter.

After analyzing and clarifying strengths, weaknesses, opportunities and threats, CIST has set targets corresponding to priority technologies to create product

groups targeting the identified market segments. Some key goals in the technological innovation roadmap to 2025 are as follows (Table 5):

Table 5: Objectives of CIST's Technological Innovation Roadmap

Targets	2023	2025	Market (domestic / foreign)
Leading in blockchain application	Towards leading blockchain solutions for schools	Expanding into a blockchain education ecosystem for smart schools that support digital transformation	Towards domestic schools and education departments to handle problems in education management
Leading in NLP application in natural language processing	Leading in applying NLP to build a chatbot-virtual assistant solution	Towards activities of text generation, text synthesis and logical response from text information	Leading in chatbot solutions – virtual assistants in the country, aiming to provide natural language processing solutions for countries such as Japan, Korea, APAC market
Leading in image processing applications	Leading in image processing applications in small-scale security monitoring solutions (houses, buildings)	Leading in image processing applications in security monitoring solutions, large-scale traffic monitoring (city, country)	Towards large-scale applications (urban, national) domestic and foreign markets
Leading in enterprise data analytics applications	Aggregate business data from multiple sources, perform descriptive and in-depth analysis on enterprise databases	Language processing application technologies in support of data analysis	SMEs in Vietnam

Source: Roadmap team, combined with CIST

3.2.7. Identifying options to achieve the goal

Determining a plan to achieve the goal depends heavily on current resources and resources that can be mobilized from outside. To determine the options for implementing the goal, CIST has clearly identified factors such as the person in charge, development time, development method, and investment source. The options for implementing the item are shown in the following table (Table 6):

Table 6: Options for achieving CIST's technological innovation roadmap

Targets	Plans	Person in charge	Department in charge	Power
Leading in blockchain application	Combined: - Self-studying core technology nghệ Renting cloud storage services	Head of Lab Blockchain/Security	Lab Blockchain/ Security	Researcher Blockchain/Security Lab
Leading in NLP application in natural language processing	Combined: - Self-studying core technology nghệ Renting cloud storage services	Head of Lab AI	Lab AI	Researcher Lab AI
Leading in image processing applications	Combined: - Self-studying core technology nghệ - Buying hardware platforms Hiring infrastructure deployment services, cloud storage services	Head of Lab IoT/Smart-Devices	Lab IoT/Smart-Devices	Researcher Lab IoT/Smart-Devices
Leading in enterprise data analytics applications	Combined: - Self-studying core technology nghệ - Renting cloud storage services	Head of Lab Social Data and Lab Big Data	Lab Social Data and Lab Big Data	Researcher Lab Social Data and Lab Big Data

Source: Roadmap team, combined with CIST

The selection of options to achieve the goals of CIST's technological innovation roadmap is made on the basis of calculating and balancing existing and mobilizing resources, and support from CMC Corporation and comments and assessments by experts on technology development trends, market trends, factors related to competitors, customers, suppliers, and factors affecting CIST's product and technological market development by 2025.

4. CONCLUSIONS AND RECOMMENDATIONS

Thus, in order to implement CIST's technological innovation roadmap, it is necessary to define a plan for monitoring and updating data. In fact, in order to

monitor the implementation options to realize the goals of the technological innovation roadmap, CIST has reviewed, checked, monitored and tracked the implementation results. To ensure the feasibility of the developed technological innovation roadmap, CIST will review and evaluate on the basis of each important content such as: Are the assumptions made such as product lines, target customers appropriate? Is the source of information used in the technological innovation roadmap accurate? Is the given technology reasonable? Is the resource mobilization plan feasible?

Defining the plan for monitoring and updating the data should focus on the key to success. To achieve the goal, CIST will conduct anticipating potential risk factors and have a treatment plan and refer to the support of internal and external departments of CIST. Some questions that CIST always ask and answer as current priority technologies can create the desired product, can it meet the target market? What are the costs incurred in the process of implementing the options of the roadmap and solutions? What are the obstacles and difficulties in terms of information, data sources, human and financial resources in each stage of the technological innovation roadmap? Always making assumptions and finding answers will help CIST accurately determine monitoring and data update plans that are appropriate to CIST's conditions and circumstances.

In addition, at each stage of the roadmap, CIST will conduct an assessment to ensure that the technology innovation roadmap is properly implemented, and at the same time point out the limitations and existing in the implementation process so that appropriate adjustments can be made at the right time to meet the set objectives. Especially challenging goals such as: Leading in blockchain application; Leading in NLP application in natural language processing; Leader in facial and behavioral recognition applications; The leader in enterprise data analytics applications.

In addition to supporting CIST in implementing the roadmap, the Government of Vietnam also needs:

Firstly, continue to create a favorable legal corridor for enterprises to conduct research, development and technology innovation activities; supporting applied research institutes in enterprises through incentives in using the enterprise's science and technology development funds in the spirit of effective implementation of legal regulations on enterprises, investment, business is regulated in the Law on Enterprises (2020), Law on Investment (2020), Law on Investment in the Form of Public-Private Partnership (2020).

Second, support businesses to proactively adapt and catch up with the Fourth Industrial Revolution through promoting IoT applications in production, improving the operational efficiency of innovation in order to effectively support and develop the startup and innovation ecosystem based on the IoT application platform.

Thirdly, financial support for research institutes in the research enterprise, manufacture and test research results in the direction of concentrating resources for the development and application of priority technologies to actively participate in the Fourth Industrial Revolution, especially IoT technology; priority is given to research institutes in enterprises participating in the implementation of a number of national key research programs on the Fourth Industrial Revolution, including IoT application and development.

Fourthly, to develop and promulgate a system of national standards and technical regulations on products and services according to international practices in service of participating in the Fourth Industrial Revolution; promoting research institutes to participate in activities on ensuring standards and regulations in line with reality in the development of new products and services.

Fifthly, building a legal corridor to ensure network information security,

especially information security of telecommunications infrastructure, IoT devices, personal information protection, deploying network information security monitoring centers; at the same time, issuing policies on open data, data sharing, development of national data integration, connection and sharing platforms to promote data commercialization, especially big data.

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