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Industrial Strategies on the Convergence of IT and the Manufacturing Industry

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Contents

Table Contents

Figure Contents

I. Introduction

Particularly positive has been the fact that despite the economic downturn occasioned by the global financial crisis, Korea has nevertheless shown clear signs of a rapid recovery. According to the OECD, Korea's GDP grew by 0.2% in 2009, which was the 3rd highest growth rate amongst OECD members. A great degree of this national competitiveness is due to the robust competitiveness enjoyed by Korea's national infrastructure industries, at the forefront of which is the IT industry. At this juncture, there is no point to pour over the importance of the IT industry, an industry which accounts for the largest share of the Korean economy.[1)]

This study analyzes how the IT industry has been used in other sectors of the manufacturing industry, and how the development of the leading sectors within the manufacturing industry has been greatly aided by the IT industry. The leading sectors within the Korean manufacturing industry include steel, shipbuilding, automobiles, IT, and construction. To this end, this study examines the role played by the IT industry in terms of the advancement of these leading manufacturing sectors, and also delves into the IT policy measures which can be implemented to ensure the IT industry's effective influence on these leading sectors.

As such, this study analyzes how IT industrial policies have

1) Korea's IT industry accounted for 16.0% of GDP in 2008.

influenced not only the IT industry, but also other manufacturing sectors, and how these manufacturing sectors have as a result been developed. This study also analyzes the manner in which the IT industry has been converged with and used in other sectors of the manufacturing industry as part of efforts to heighten the degree of utilization of an IT industry that possesses a great extent of national competitiveness. In this sense, it will contribute to the establishment of a strategy on how to make optimal use of the IT industry both at home and abroad standpoint. In particular, it is expected for this study to offer the developing countries the role model of IT development policy related to IT convergence with other manufacturing industries. Moreover, this study can make it easier for Korea to enter into the countries' markets by carrying out a consulting research on national industry strategies for the industrial advancement of the countries.

This study mainly consists of 4 parts. In Chapter 2, a review of the characteristics of the IT industry with the potential to be used in the manufacturing industry is conducted. In addition, a review of the general state of IT utilization is carried out. The current state of IT use in the shipbuilding, automobile, and construction industries will be analyzed in Chapter 3. In Chapter 4, an analysis is conducted on the decisive factors in the development of the manufacturing industry based on IT utilization. Lastly, in Chapter 5, the study concludes with IT use policy suggestions and strategic measures for further development.

Ⅱ. IT Convergence in the Manufacturing Industry

1. The Development of the Manufacturing Industry

(1) Innovation Strategy of the Manufacturing Industry

The Korean manufacturing industry has developed strategies to strengthen its market competitiveness by facilitating the formation of a large enterprise-oriented oligopolistic structure. Such strategies focus on the shift into a transitional phase through the decisive omission of the fluid stage of the technological innovation life-cycle model. This transitional phase, as can be seen in <Table Ⅱ-1>, can be regarded as the process of establishing production facilities that are based on dominant designs, and of bringing about market integration through the quality convergence. As it moves from this transitional phase to the mature stage(specific stage), the manufacturing industry establishes a mass production system that makes possible the standardization of products. It eventually stabilizes into an oligopolistic structure.

In terms of the motives that made possible Korea's rapid move to this transitional phase, one can point out the heavy focus on the securing of the necessary capital and decision making within the manufacturing sector. This concentration of capital and prompt decision making has functioned as key strengths as far as the

Table Ⅱ-1. Technological Innovation Life Cycle Model

	Fluid phase	Transitional phase	Specific phase
Product	Emergence of various products & competition	Emergence of dominant design	Gradual innovation based on the advent of a standardized product
Process	Skilled worker + universal facility	Move towards a facility oriented process	Unskilled workers + specialized facility
Organization	Entrepreneurial/ horizontal/organic organization	Fixation of the organization	Hierarchical/ mechanical organization
Market	Various products and split markets	Integration of market	Mass commodity products
Competition	Competition between enterprises providing various products	Quality converged	Oligopolistic structure involving large enterprises selling similar products

Source : Song Wi-Jin(2009), requoted by KIAT(2010).

development of capital intensive module products is concerned. At this juncture, the Korean manufacturing industry can be expected to undergo a process of convergence that will see it emerge as a large enterprise-centered scale intensive industry exhibiting a relatively higher degree of competitiveness.

While technological innovation has taken on many forms in the various sectors of the Korean manufacturing industry, there has been a high concentration on the large enterprise-centered scale intensive industrial model. Of course, this can be regarded as the result of the concentration of capital and of prompt decision making

Table Ⅱ-2. Types of Technological Innovation within the Manufacturing Industry

	Supplier Dominated Type		Scale Intensive Type	Information Intensive Type	Science Based Type	Specialized Suppliers
	Resource Intensive Type	Labor Intensive Type				
Representative industrial sectors	Food processing, petrochemical, non-ferrous metal, ceramics	Textile, clothing, leather, footwear, wood, traditional machinery	Steel, glass, shipbuilding, home appliances, automobiles	Information & communication, finance, wholesale and retail, publishing, travel	Electricity, electronics, chemical, medical, bioengineering, aero space, precision machinery	Capital goods such as machine tools, general industrial machinery, and software
Size of enterprise	Large-sized enterprises	Small and medium-sized enterprises	Large-sized enterprises	Large-sized enterprise (venture enterprises)	Large-sized enterprise (venture enterprises)	Small-sized enterprises
User type	Price elastic	Price elastic	Mixed	Mixed	Mixed	Performance elastic
Main goals for technological activity	Costs reduction	Costs reduction	Mixed	Mixed	Mixed	Improvement of product
Main sources for technological accumulation	Supplier's R&D, consultation services, production learning	Self R&D, facility provider	Production engineering, production learning, supplier, design	Software and system engineering, equipment	Self R&D, basic research, production engineering	Product design, user's R&D, parts and materials provider

	Supplier Dominated Type		Scale Intensive Type	Information Intensive Type	Science Based Type	Specialized Suppliers
	Resource Intensive Type	Labor Intensive Type				
Main direction for technological accumulation	Process technology, related equipment (upstream)	Process technology, related equipment (upstream)	Process technology, related equipment (upstream)	Management and design of information processing systems	Technology related product (intensive)	Improvement of quality
Imitation, technology transfer windows	Equipment and related services purchase	Equipment and related services purchase	Equipment purchase, know-how licensing and related training, reverse engineering	Equipment and software purchase, reverse engineering	Reverse engineering, employment of engineer and scientist with R&D experience	Reverse engineering, learning from suppliers
Tools for technology ownership	Non-technological (marketing, trademark rights)		Secret process, design and management know-how	Copyright, design and management know-how	R&D know-how, patent, design and management know-how	Design know-how, patent, knowledge related to users' needs

Source : Song Wi-jin(2009), requoted by KIAT(2010).

Note : Reverse engineering refers to the process of designing new products through the design and changes made in accordance with the desired uses and based on data(3D shape, drawing, and interpretation) acquired by reproducing existing products. Reverse engineering makes the benchmarking of competitors' products possible, with the results applicable to one own products.

on the part of management. However, it is necessary to analyze how technological innovation is created and used from another aspect. In Korea, large enterprises active in scale-intensive industrial sectors such as steel, glass, shipbuilding, home appliances, and automobiles, have adopted a development path that has seen them learn about secret processes, design, and management know-how through the purchase of equipment, licensing, and training. By facilitating the imitation and application of products, the use of the reverse engineering method during the process of learning this know-how played a particularly important role in accelerating industrial development.

(2) Support Policies for the Development of the Manufacturing Industry

The driving force that would emerge to foster the development of the Korean manufacturing industry first came to light during the process of overcoming the financial crisis of 1998. Viewed from the standpoint of policy, the economic structure improvements through the restructuring of the economy in order to overcome the financial crisis did in fact greatly contribute to strengthening the competitiveness of the Korean manufacturing industry. As part of its corporate restructuring efforts, the government established and implemented five core tasks(1998) in conjunction with 30 corporate groups. These five tasks were: the improvement of transparence in corporate management, mitigation of abusive intra-group transactions and cross-debt guarantees, improvement of the financial structure, selection of core business items, and the strengthening of the responsibility of controlling shareholders and management. In

addition, the Corporate Restructuring Promotion Act (2001) was enacted and implemented as part of efforts to streamline the management of viable firms. These measures made it possible for the Korean manufacturing industry to be competitive in the sectors such as steel, shipbuilding, and automobiles. This happened during the period spanning from 1998 to 2007, or prior to the emergence of the global financial crisis.

After overcoming the financial crisis of 1998, Korea set out to strengthen the competitiveness of its main manufacturing sectors through such means as the establishment and implementation of an industrial development strategy. In doing this, the strategy of selection and concentration was adopted. This move was closely related to the decision to initiate ten next-generation growth engine projects(2003). The active strategic industry policies were put in place by the Ministries of Science and Technology, Commerce, Industry and Energy, and Information and Communication.

In this regard, while the Ministry of Science and Technology concentrated on developing bio-new drugs and organics, the Ministry of Commerce, Industry and Energy focused on developing displays, next-generation semiconductors, next-generation batteries, future vehicles, and intelligent robots. Meanwhile, the Ministry of Information and Communication focused its efforts on developing digital TV and broadcasting, next-generation mobile communication, intelligent home networks, digital contents and SW solutions. In addition, as part of efforts to improve the trade imbalance with Japan and secure original technology, the government implemented the Strategy for the Development of Parts and Materials Industry(2005); a move that greatly contributed to strengthening the capability for technological development and to the localization of

technologies.

In addition, various measures were also implemented to promote joint development between the main actors within the economy and to ease the bipolarization phenomenon. The strategy for the development of the service industry(2007) and the mutual cooperation policy targeting large and small-scale enterprises (2005) have been evaluated as having played a key role in mitigating the imbalance and bipolarization at the industrial, enterprise size, and regional levels.

2. The Effects of IT Convergence in the Manufacturing Industry

(1) Improvement of Productivity

The effects of using IT from the standpoint of the manufacturing industry include the improvement of productivity due to the substitution of production factors, quality improvement, and the advent of economies of scope(technology and product development).

The primary reason why IT use is crucial to the manufacturing industry is that the establishment of an advanced communication infrastructure can facilitate the informatization of enterprise managemen. Moreover, the overall productivity of the manufacturing industry can also be improved based on the automation of the production process, etc. By inducing the innovation of the manufacturing process, IT convergence can decisively contribute to

the improvement of functions, quality, and design.

(2) Inducement of Product Innovation

The second reason for the importance of IT use is that the direct transplant of IT technology to the product makes possible the implementation of the product innovation. This can be regarded as the embedment of IT in products, a process which is well underway in the automobile, shipbuilding and construction sectors. For example, in the case of the automobile sector, mention can be made of the trend towards the advent of automotive electronics and intelligent vehicles. The process refers to the enabling of the electronization of the heretofore mechanical operation of vehicles through convergence with IT. The convergence of the mechanical engineering and electronic engineering technology at the forefront of technological development has led to the acceleration of the electronization of parts and intelligence of vehicles. The ratio of electronic components found in vehicle is expected to increase from 20% in 2005 to 40% by 2015. This will result in creating a global market worth some 200 billion dollars(McKinsey, 2007).

Vehicle intelligence will move beyond the dependence on the information collected by drivers in the cars of today. This means that following the partial convergence of IT with vehicles, in-vehicle information can be gleaned from sensors and ECU. Based on the exchange of information between the vehicle-embedded information systems and the external environment, it will become possible in the future for vehicles to make judgments and move for themselves.

(3) Development of New Markets

Once the usage of IT technology has been improved, new markets can be developed within the existing manufacturing sectors. In the case of the automobile industry, in-vehicle CE(consumer electronics) was identified as one of the most important characteristics of vehicles during the 2008 CES(Consumer Electronics Show) held in the United States. Meanwhile, in the case of the shipbuilding industry, IT accounts for 35% of the components of high-tech cruise ships. The use of smart clothing, or what is known as a wearable PC, is also on the rise.

The importance of IT use is evidenced by the fact that it becomes impossible for manufacturing sectors to even promote expansion into new industries without an IT foundation. The emergence of new industries such as robotics and u-health care is also impossible without an IT foundation. As previously mentioned, the expansion of IT technology can lead not only to the creation of new industries, but also to the destruction of existing ones. For instance, in the case of u-health care, it is essential that a failsafe advanced communication infrastructure be established and that the medical examinations and practices be carried out based on this communication network system. Accordingly, it is necessary to establish precise mechatronics control systems with integrated sensors and control functions.

In addition, an unlimited number of industries can be generated based on the use of IT-based convergence technologies. IT-based converged technologies can be regarded as representative examples of such industries. This refers to technological fields which are able to create new products/services through convergence between

heterogeneous technologies. The technology convergence can improve the quality of existing products through synergistic combination in rapidly developing new technological fields based on IT technology accompanied by BT and NT. IT convergence is being generated at the point of overlap between the fruits of the technological revolution in computers and communications(IT) during the 1980s~1990s and the S-curve junction linking together the results of two of the CT/ET or NT revolutions. The results of such convergence have included intelligent robots, nano semiconductors, bio chips, optical sensors, and audio/image display technology.

Ⅲ. Case Study on IT Convergence in the Manufacturing Industry

1. Automobile Industry

(1) The Use of IT within the Automobile Industry

The 2000s have seen rapid progress be made in terms of automotive electronics. One of the main developments has been the convergence of traditional machinery technology and IT as part of efforts to improve safety and convenience. Toyota has since 2000 invested over 1 trillion yen a year in the development of automotive electronics technology. Honda has sought to establish a hierarchical linear model for automotive electronics parts. Furthermore, as part of efforts to achieve light-weight vehicles, increased convergence with BT has become visible in such fields as automotive fibers, plastics, and alternative fuels. Under these circumstances, the ratio of the role played by IT within the automobile industry has rapidly increased. The ratio of automotive electronics found in vehicles, which was less than 25% in the early 2000s, is expected to reach the 40~45% level by 2015.

The current trends in terms of automotive IT convergence are expected to develop into a focus on the following 4 Cs.

○ **Convenient automotive driving service**

- Provide a convenient interface system based on bio-physical information to minimize the safety load for automotive drivers.
- In addition, the growing consumer demands for the integration of multiple functions in their vehicles have led to the rapid spread of onboard entertainment systems. The integration would allow them to pursue such ends as relaxation, entertainment, and the conduct of business affairs,

○ **Comfortable safety driving support**

- Provide integrated safety services based on awareness of the driver's situation by collecting, converging, and processing the driving space sensor information.
- The application of active and passive safety technologies has paved the way for the development of light-weight and high-strength vehicle bodies made using new materials and intelligent automotive technologies. In fact, these safety technologies have been occasioned by the strengthening of various safety regulations

○ **Convergence & Connectivity**

- Linkages with telematics and various other industries

○ **Clean eco-driving service**

- Provide a control system which can lower fuel expenses and

Table Ⅲ-1. Changes in the DNA of the Automobile Industry

	Traditional mechanism	Current mechanism
Drive system	Mechanical drive system	Electrical drive system
Power	Internal-combustion engine power	Electric motor power
Energy	Fossil energy	Electric and hydrogen energy
Control	Mechanical control	Electronic control
Driving	Independent driving system	Intelligence and cross linkages

Source : MIT(2010).

monitor the exhaust of pollutant substances.

- The convergence of the machinery and electronics industries has accelerated as a result of the change in the technology paradigm. Efforts to lower fuel expenses make the technology paradigm change from the internal-combustion engine to electrical vehicles.

Ultimately, customers' desires are growing for enjoying information technologies and processing huge amounts of information for the interior and exterior of vehicles. Such needs are expected to result in increasing the necessity for future vehicles in the ubiquitous era to be equipped with highly advanced IT technologies. Furthermore, this trend is happening in conjunction with a change that has seen services replace manufacturing as the vehicle industry's main source of profit. As such, a new era marked by an expanded market has been initiated. Within the market, the automobile and IT enterprises must cooperate with each other on

the development of various devices, as well as highly advanced H/W and S/W technologies,

(2) Sources of IT Technology

There has been a convergence of IT technologies introduced in the automobile industry in such fields as safety, convenience, fuel efficiency, and networking. However, the source of these various IT convergence technologies incorporated into vehicles can be divided into semiconductors, embedded S/W, Telematics, and HMI(human-machine interface).

First, the convergence of technologies include such as intelligent control systems, vehicle network SoC(system-on-a-chip) technology, radar and image signal IC designed to improve convenience in vehicle driving, vision sensors, PIR(Passive InfraRed) sensors, power devices for fuel efficiency, and control modules. They were made possible by the development of automotive semiconductor technology. Here, automotive semiconductors refer to semiconductors specifically manufactured for vehicles, and which can endure much more extreme external conditions, i.e. temperature, vibrations, and shocks. To this end, semiconductors are expected to occupy an even bigger space within the automotive parts sector in the future. Currently, approximately 1,000 of the 20,000 parts associated with the automotive industry are related to semiconductor technology. As such, the automotive and semiconductor industries have established an inseparable relationship.

Vehicle control RTOS(real-time operating systems), vehicle multimedia OS, automotive S/W platform and development support

tools, and automotive S/W reliability verification tools can all be regarded as the offspring of embedded S/W technology. In this regard, vehicle control S/W and platforms such as the damping device and power-steering systems were originally developed from embedded S/W, and thereafter made their way into the automotive field.

In addition, telematics technology represents the original technology which made possible such feats as the establishment of in-vehicle network systems, as well as vehicle-to-vehicle communication based safety driving systems. Furthermore, wireless communications(telematics) technology has evolved into automotive IT convergence technology such as cooperative vehicle access systems, automatic parking and autonomous driving systems, environment-friendly exhaust gas monitoring, and route guidance (navigation) systems.

The origins of technologies such as HUD(head up display)-based guidance systems and Night Vision-based safety driving support devices can be traced back to HMI technology. In this regard, smart handle, eye tracking system, as well as voice chat and voice command systems can be listed as good examples of the convergence of multiple HMI interface technologies.

HF-based next generation display systems such as the HUD (head up display) and IR(infrared) touch screen first applied by BMW can be regarded as complex yet convenient driving devices. These could not have been crafted without developing advanced display-related technology.

Table Ⅲ-2. Sources of Automotive-IT Convergence Technology

Source	Applications	Main technology and products
Automotive semicond-uctors	• Semiconductors specifically manufactured for vehicles. These can endure much more severe external conditions, i.e. temperature, vibrations, and shocks, than those found in the environment in which industrial semiconductors are employed • Automotive semiconductors must be able to endure at temperatures of -40℃ ~105℃ and have a life expectancy of more than 10 years • Require advanced designing and processing capabilities as well as stable sources of investment	• Intelligent control system, vehicle network SoC (system-on-a-chip) technology • Radar and image signal IC, vision sensor, PIR(Passive InfraRed) sensor, power devices for fuel efficiency, and control module
Embedded SW	• Vehicle control S/W and platforms such as damping devices and power-steering systems loaded onto the vehicle's internal systems • Vehicle control S/W platform and development environment • As these are directly connected to the safety of passengers, there is a need for the S/W that is developed to be highly reliable. It is also necessary to improve technological capacity and to educate the relevant human resources.	• RTOS(real-time operating system) for vehicle control • Vehicle multimedia OS-automotive S/W platforms and development support tools • Automotive S/W reliability verification tool
Vehicle Network (Telematics)	• Linkages between in-vehicle and mobile devices, as well as in-vehicle communications technology • Information sharing network systems with V2V and traffic facilities such as Hi-Pass • Autonomous safety/convenience/ environment-friendly system technology	• In-vehicle network systems • Vehicle-to-vehicle communication based safety driving systems • Cooperative vehicle access systems

Source	Applications	Main technology and products
Vehicle Network (Telematics)		• Automatic parking and autonomous driving systems • Environment-friendly exhaust gas monitoring
HMI (human - machine interface)	• HF-based next generation display systems such as HUD(head up display) and IR(infrared) touch screen • Multi-HMI convergence interface technology such as smart handles, eye tracking systems, voice chat/voice command systems and Haptic systems • Safety load-based adaptive interface devices	• HUD(head up display)-based guidance systems • Night Vision-based safety driving support devices • Convergence of Haptic-Visual-Audible HMI systems such as smart handles and eye tracking systems

Source : Ministry of Knowledge Economy(2008).

(3) Linkage with IT Related Policy

The development of wireless mobile communication technology provided an opportunity for all industries to use telematics as a means to bring about the convergence of bi-directional communication services. This also provided the opportunity for the automobile industry to develop the platform technology. The technology is needed to establish automotive networks such as the connection between in-vehicle systems and mobile devices, in-vehicle communication networks, and the systems for exchanging information with other vehicles and traffic facilities(Hi-Pass).

Furthermore, the domestic development of the computer industry

helped to create a form of platform technology. This made possible the computerization of the domestic automobile industry's manufacturing process, and the production of automotive parts rooted in highly-advanced electronic control systems. The development of the semiconductor industry and the advancement of semiconductor technology have facilitated the development of the automotive semiconductors that constitute core parts within the automotive electronics system. These automotive semiconductors have also contributed to helping Korea not only consolidate its standing, but also secure a technological advantage.[2)]

The addition of automotive electronics developed using Korea's world-class IT and related infrastructure to the existing mechanical systems has heightened the competitiveness of the automobile industry. Furthermore, the active forging of strategic alliances with IT companies has provided opportunities for new value added to be created. In conjunction with its strategic partner the Microsoft Corporation, the Hyundai Motor Company, has developed a speech recognition based audio system, automotive information system, and intelligent navigation system. Meanwhile, Samsung Electronics and its strategic partner BMW have developed a technology for communicating with UCC phones in a hands free manner, that is, using the Blue Tooth function without any additional connection devices.

The development of IT and related convergence has made it

2) The highly advanced technology that goes into these automotive semiconductors makes it possible for the latter to endure temperatures ranging anywhere from -40℃~105℃, and to have a life expectancy that exceeds ten years.

possible to strengthen the competitiveness of the automobile industry. As part of its objective of creating five IT-converged new industries by 2012, the government has identified five major industrial fields in which IT convergence is to be implemented from 2008 onwards. In this regard, the list includes the automobile industry. The possibility of creating intelligent vehicles created by the convergence of IT and the automobile industry is expected to result in great improvements being made in automotive safety, convenience, and networking.

(4) Policy Implications

Although the production technology employed in the automobile industry has begun to show signs of global competitiveness, Korea still lags behind when it comes to the development of basic/original technologies and core parts. In this regard, it is necessary to further enhance innovation in already strong aspects such as production and product development and parts. It is also necessary to carry out more thorough basic studies on such topics as convenient devices, safety, and environmental technology, and develop original technologies. In addition, there is also a need to carry out international standardization as a means to secure the fundamental technology needed to develop next generation vehicles that are based on new IT technology, and to actively implement strategic alliances with companies from advanced countries.

Furthermore, it is also necessary to establish a strategy of selection and concentration. The high technical barriers put in place by advanced companies, as well as the huge amounts of R&D costs required, can make he field of automotive electronic parts tough one.

Accordingly, it becomes necessary to establish a government-led, long-term, development plan, and to concentrate investment.

In addition, it is crucial that convergence related laws and institutions be enacted and adopted. First, it is noticeable that as the existing legal system centering on the development of technologies is limited in terms of its capacity to promote convergence technology. In accordance, it becomes necessary to establish the governing laws that reflect the characteristics of convergence technology. The development of the convergence industry can be facilitated through the re-tooling of related regulations such as those concerning standard industrial classifications, evaluation criteria, and various permit and approval regulations. As these intelligent vehicles will be driven under a new safety environment, there is a need to improve the segments of the existing safety laws that do not mesh with this new safety environment. In order to promote intelligent vehicles, it is required to implement policy mechanisms with taxation, financing, incentives, and financial support for technological development.

Lastly, the establishment of a successful automobile-IT business model has emerged as an urgent task. The establishment of a successful business model represents an essential step towards bringing about the convergence of automobiles and IT. While telematics services and in-vehicle information systems were released during the 1980s and commercialized in the 1990s, their relative lack of profitability resulted in limiting their spread amongst the general public. As such, the establishment of a successful, commercially profitable, automobile-IT convergence technology business model is of the essence.

2. Shipbuilding Industry

(1) Trends in Terms of IT Use

The introduction of IT technologies in the shipbuilding industry has been focused on guaranteeing the efficiency of production and safety during the shipbuilding process. According to organizations specialized in the analysis of shipbuilding such as Clarkson, the ratio

Table Ⅲ-3. SWOT Analysis of Shipbuilding-IT Convergence

Strengths	Weaknesses
• Abundance of experience in various kinds of shipbuilding • Possession of flexible design technology (makes it possible to immediately reflect market demands in design) • R&D, abundant shipbuilding facilities • Possession of IT technology clout in fields such as wireless networks, RFID, and networking	• Lack of high value added core shipbuilding solutions • Lack of technological clout with regards to such ends as the visualization of ship design technology, advancement of ship production technology, and the advent of intelligence in transportation systems • Lack of synergistic effects such as the joint development of technology for IT use caused by the existence of barriers between the shipyard companies
Opportunities	**Threats**
• Pursue energy reduction, protection of global marine environment, high degree of safety and reliability • Increase the necessity for IT use as part of efforts to improve productivity	• Strategic collaboration between Japan and China (Japan's technological clout and China's labor force) • Instability of global shipbuilding market in the future (concerns that productivity may decrease as a result of oversupply)

of the cost of IT converged equipment to overall shipbuilding costs will increase from the current level of 6% to 15%.

A SWOT(Strengths, Weaknesses, Opportunities, and Threats) analysis conducted in the field of Korean shipbuilding. As shown in <Table Ⅲ-3>, the industrial environment has changed so that such ends as energy reduction, protection of the marine environment, and the achievement of a high degree of safety and reliability have become the main pursuits. Accordingly, it is necessary to heighten IT technology use in areas such as the visualization of shipbuilding design technology, advancement of shipbuilding production technology, and the advent of intelligence in transportation system.

(2) Stage Approach to IT Use Strategy

Up until the 1980s, the development of the technologies fundamentally used in the shipbuilding industry revolved around the component technologies needed to improve the shipbuilding process and vessel performance. However, from the early 1990s onwards, the main technologies developed were those such as automated navigation shipbuilding technology, low pollution shipbuilding technology, and the technology to improve shipbuilding productivity. These technologies helped to give form to concepts such as those of high speed vessels, propulsion systems, and the ship structural technology needed to heighten safety and reduce the workforce.

Since the decline in freight space took place after 1998, the shipbuilding industry experienced the development of energy reduction technology, the protection of the global marine environment, the achievement of a high degree of safety and reliability, the application of high quality IT technology, and the

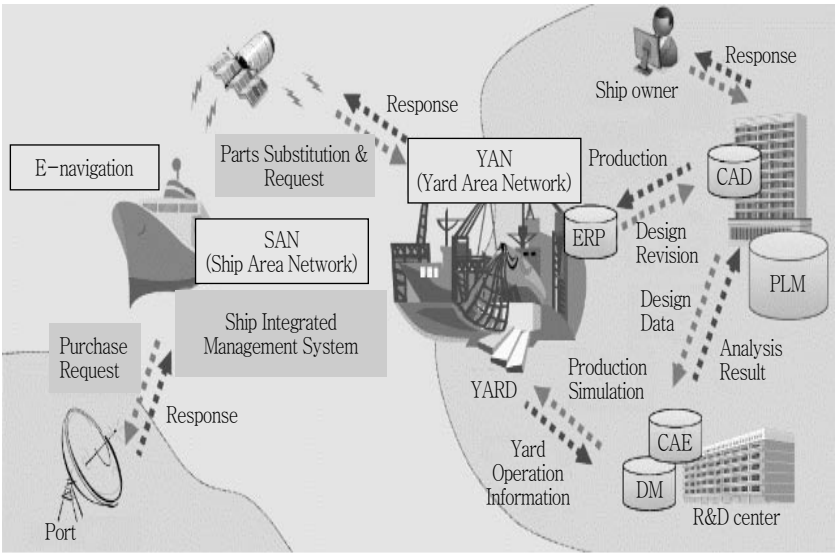
Table Ⅲ-4. Stag-based Approach to the Role of IT Use in the Development of the Shipbuilding Industry

	Stage 1 (Automation)	Stage 2 (Improvement of productivity)	Stage 3 (High value added)	Stage 4 (Digital ship)
	1980s~1995	1990~1997	1998~2007	After 2008
Main technological focal point	Component technologies needed to construct ships and to improve the performance of ships	High speed ship, propulsion systems, ship structural technology, automated navigation shipbuilding technology, low pollution shipbuilding technology, technology to improve shipbuilding productivity, etc	Energy reduction technology, application of high quality IT technology, improvement of shipbuilding productivity	Evolve into service technology capable of supporting safe transportation
Industrial environment	Concentrate on improving shipbuilding productivity	High speed, safety, and workforce reduction	• Pursue high value-added as a result of the reduction of freight space • Protection of marine environment, achievement of a high degree of safety and reliability	• Digital ships • Remote maintenance of ships and development of autonomous transportation systems
IT use	CAD design and augmented reality, ship design technology	Technology to improve the productivity at shipyards	Apply IT technology to ship design, construction of ships, and installation of electronic control systems inside of ships	Integrated management of shipbuilding process, Integrated management of transportation, integrated management of navigation information, IT convergence with ship equipment, shipbuilding PLM, etc

advent of technologies to improve productivity. In addition, as a result of rising labor wages, the shipbuilding industry was forced to pursue cost reduction measures. Such measures included the improvement of design tools, design methods, production processes, and production technology. The industry has in particular been able to heighten the value added of vessels by employing IT technologies in the ship design and shipbuilding processes.

The decrease in marine freight occasioned by the global economic slowdown that began in 2007 was also directly connected to the recession in marine transportation. However, R&D in areas such as the visualization of shipbuilding design technology, advancement of production technology, and the introduction of intelligence to

Figure Ⅲ-1. Concept of Shipbuilding-IT Convergence



Source : Presidential Committee on New Growth Engines(2008b).

transportation systems has greatly contributed to the further development of the shipbuilding industry. The IT convergence employed in the shipbuilding industry has included the integrated management of the shipbuilding process(YAN, Yard Area Network), integrated management of transportation(SAN, Ship Area Network), integrated management of navigation information(e-navigation), IT convergence with ship equipment, and shipbuilding PLM.

Shipbuilding-IT convergence began with the development of ship design technologies such as CAD design and visualization of augmented reality(AR). The technologies needed to improve the productivity at shipyards had been developed. Then, the focus switched to the creation of digital ships which could monitor the state of equipment and systems based on the connection of all the equipment and devices aboard the ship.

These intelligent digital ships are expected to further develop to the point where they essentially become remote maintenance and autonomous transportation systems. As such, shipbuilding-IT convergence began with the improvement of productivity in shipbuilding, and has since evolved into the development of the service technologies needed to support the safe transportation of ships.

A joint research conducted by ETRI and a large-sized ship yard company in Korea since 2008 has investigated the development of a platform technology that can improve productivity and lead to the production of digital ships. In addition, much research has been done on the development of technologies. This can help bring about e-navigation designed to ensure the safety of ships, and those which can support safe and economic ship transportation.

One of these researches has focused on the development of the

technology related to the actualization of smart ships. Based on the convergence of IT technology with SAN-based digital ships, smart ships are vessels that make economic transportation, safe navigation, crew management, and global maintenance possible. The actualization of smart ships will make it possible to manage the various transportation equipment employed on a ship under a common platform. Because of their ability to monitor the state of equipment and the environment surrounding ships, smart ships will also help to prevent crashes between ships and to determine the most economic marine routes.

The most important factor in terms of the infrastructure components required to actualize these technologies is the development of maritime mobile communications designed to assist ship-land communications. Satellite-based communications have become generalized on long-distance voyages. However, integrated communication solutions must be designed in order to make more effective use of communication equipment. Furthermore, there is a need to develop methods of using terrestrial communications in berth areas.

Once the establishment of ship-land communication infrastructure has been completed, it will become necessary to develop various services to assist ships. To this end, a protocol and framework for exchanging data between ships and land will have to first be developed.

Shipbuilding-IT convergence technology will usher in an era. In the era, it will become possible within 10 years to benefit from the safest and most economic transportation systems, and to enjoy various additional services aboard ships.

All the plans, implementation methods, and management

information related to production activities at shipyards, from the contracting to the design, construction, and delivery, will be integrated into a computer network. Furthermore, the securing of the flow of information will ensure that efforts to improve productivity will continue apace. The CIMS(computer integrated manufacturing system) implemented by Japan from the late 1980s onwards was to be completed in the late 1990s. Now, it appears that the concept of CALS(continuous acquisition and life-cycle support) will be applied to the shipbuilding field. CALS refers to a system which makes it possible to organize the information about a product during its entire life cycle.

Above all, there is an urgent need to further develop the technologies in the shipbuilding industry. The preservation of the price competitiveness of main vessels such as tankers, bulk carriers, and containers in the current global shipbuilding market will require improvements in productivity, the reduction of transportation costs, and the establishment of a maritime disaster prevention system. These can be brought about based on the improvement of the production process. To this end, it is necessary to introduce the automatic navigation technology, energy reduction technology, and accident avoidance technology.

(3) Linkage with IT Policy

1) Basic IT Technology Utilization

During the first stage, automation(1980s~1995), ship design technologies such as CAD and the visualization of augmented reality were mainly used. Meanwhile, during the second stage, that of the

improvement of productivity(1990~1997), technologies designed to improve the productivity of ships at the shipbuilding yard were introduced.

These series of IT industrial policies resulted in the full-scale advancement of IT convergence, and ushered in a new perception of the IT industry as an engine that could help propel the other industries forwards. A more aggressive IT use strategy was implemented in conjunction with the facilitation of direct convergence between shipbuilding and IT. However, the use of basic IT technologies was not as important as it had been at the previous level. Thus, the shipbuilding industry can be said to have gone from the market entrance stage to that of market development. The presence of such circumstances greatly enhanced the shipbuilding industry's ability to focus on the accumulation of its own independent technological capacity. The development of computational systems was utilized in conjunction with the design and production of ships and the advent of specialized systems to facilitate shipbuilding process automation in the late 1980s. This can be regarded as examples of the full-scale use of IT technologies to ensure the shipbuilding industry's technological capacity.

The IT policies implemented during the 1980s and 1990s can be regarded as having played a key role in facilitating the use of IT technologies in the shipbuilding industry. Under the Measures for the Development of the Electronics Industry(1987~1996), the Korean government concentrated on the establishment of administrative communication networks and the development of semiconductors, PCs, and TDX. Meanwhile, the main focus under the Basic Plan for the Facilitation of Informatization(1996~2000) was on the establishment of the information and communication(CDMA)

infrastructure and the spread of high-speed communication networks(ADSL and ISDN). These policies contributed to improving the productivity of the shipbuilding industry via improvements in ship designing, which in turn was the result of the increased use of computers; the heightening of the use of SW in accord with the progression of informatization, the establishment of communication networks, and the enhancement of the supply of electronic communications equipment.

2) Shipbuilding-IT Convergence Strategy

The third stage in the development of the Korean shipbuilding industry(1998~2007), was focused on the application of IT technologies to such processes as ship design, shipbuilding, and the implementation of onboard electronic control systems. The fourth stage, the stage of digital ships(since 2008), has been focused on applying IT technologies to the integrated management of the shipbuilding process, integrated management of ship transportation systems, integrated management of ship navigation information, IT convergence of ship equipment, and shipbuilding PLM. As such, the main trend in terms of IT technology has gone from the application of basic IT technologies to IT convergence. It relates to the integrated management of the entire shipbuilding process and ship navigation systems. In the past, basic IT technologies were used in conjunction with automation processes such as the introduction of CAD technology in ship design and of computation into the shipbuilding process. However, the development of the shipbuilding industry and growing sophistication of IT technology have resulted in convergence between the IT and shipbuilding industries being on

the rise. As such, the emphasis has been on the development of direct IT convergence technology that can be used within the shipbuilding industry.

The major policies which have been implemented in the 2000s, including Cyber Korea21, have revolved around the integration of various development strategies. In this regard, the Broadband IT Korea 2007(2003~2007) can be regarded as the policy that established the implicit strategic direction known as the spread of IT technologies to other industries. Cyber Korea 21(1999~2002) involved the implementation of measures such as the development and advancement of high speed communication networks, e-government, e-commerce, and the integration of networks between small and large enterprises. For its part, the policy known as e-Korea Vision 2006(2002~2006) was characterized by a focus on the establishment of next generation internet base(IPv6, WLAN), home networking and wired/wireless integration, and mobile e-government. Here, we can see the trend towards the development of a network-centered IT industry.

Therefore, the policies established after the Broadband IT Korea 2007 have had a direct influence on the shipbuilding industry. The Broadband IT Korea 2007 policy was concentrated on the development of BcN, IT Soc(next generation semiconductors), mobile communications, imbedded SW, digital contents, intelligent robots, next generation PCs, digital TV/broadcasting, RFID/USN, telematics, and wired/wireless home networks. Meanwhile, the core strategies developed under the u-Korea(2006~2007) policy involved the implementation of RFID/USN, BT+NT, imbedded SW, wireless internet(WiFi), Wibro, HSDPA, digital TV/broadcasting, home networks, telematics, intelligent robots, u-computing, digital

contents, and IT convergence. The development and advancement of wired/wireless networking, product recognition, product awareness, ubiquitous communication environment, SW technology, and robot technology have greatly contributed to improving the productivity and safety of the shipbuilding industry.

The New IT Strategy launched in 2008 has involved the implementation of measures designed to facilitate direct IT convergence with other industries such as SW/computing, electronic information devices, information and communication media, next generation communication networks, robots, knowledge service USN, and bio medical appliances. The facilitation of direct convergence is expected to speed up the development of the digital ships which the shipbuilding industry seeks to create. Here, the strategy of establishing a cooperative system linking together IT research institutes, the shipbuilding industry, and the academic sector is expected to emerge as an important policy variable. This cooperative system will lead to the implementation of joint research on the development of the platform technology. This is expected to contribute to the improvement of productivity and advent of digital ships and e-navigation enabling technology.

(4) Policy Implications

In the case of communication-related fields such as ship mobile/satellite communication technology and RFID/USN, investment should be focused on special tag technology, interference avoidance and removal technology, and high speed tag attachment technology.

In terms of systems, there is a need to develop remote

maintenance/management systems and ship equipment electronic SW. Meanwhile, as far as sensors are concerned, investment should be concentrated on the development of maritime high-tech network sensors.

It is noticeable that the recent trend within the shipbuilding industry is towards the development of shipbuilding and navigation systems, as well as global remote ship maintenance/management systems. Accordingly, it essential that support for the development of the SW technologies is needed so as to bring about the optimization of shipbuilding and navigation systems.

In addition, there is a need to establish industrial standards in conjunction with the IT convergence technology specific to the shipbuilding industry, and to support efforts to ensure that these industrial standards are internationally recognized. Such a move represents an essential step in terms of the strengthening of the competitiveness of the shipbuilding industry. Moreover, a further strengthening of the competitiveness of IT technology standards is expected to be brought about through the extension of the fields in which such IT technology is employed.

It is also essential that proper support be provided for the development of the infrastructure for the exchanges of resources between the industries. In addition, there is a need to establish an education and training sphere. Through this, the specialized knowledge pertaining to the interactive technology involved in the IT and shipbuilding industries can be exchanged and further developed. Finally, there is also a need to establish organized windows for the exchange of technological information so as to facilitate the smooth access to technological information.

3. Construction Industry

(1) Trends in IT Use

The Korean construction industry is somewhat behind in terms of the fields which make possible the creation of high value-added, such as engineering, environment-friendly energy reduction materials, and intelligence. Meanwhile, the production and construction capacity of Korean construction companies was estimated at 83% that of the advanced countries. On the other hand, the planning, designing, and overall construction process capacity of Korean construction companies was found to be respectively 59%, 63%, and 67% that of the advanced countries.[3)]

The low technological competitiveness of Korean construction companies can be explained by the continuation of the application of the design and managerial style of the 1970s~1980s without any new technological developments or facility investment.[4)]

In addition, the domestic construction industry achieved rapid growth until the late 1990s, with the main focal points of this expansion being production and construction. However, growth has slowed in the 2000s. In this regard, the transformation of the domestic construction industry into a new growth engine for the

3) Choi In-seok et al, "Evaluation of the technological competitiveness of construction products sold overseas", October 2006.

4) This fact is true with the exception of major construction companies such as GS E&C, Daewoo Engineering & Construction Co. LTD, Hyundai Engineering & Construction, Lotte Engineering & Construction, Samsung C&T Corporation, and SK Engineering & Construction Co. LTD.

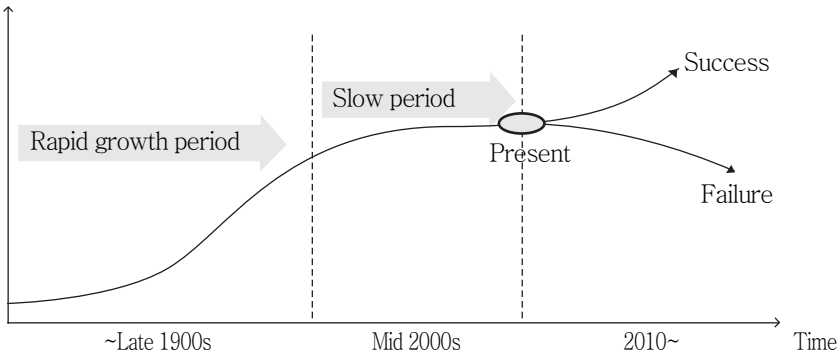
national economy will require the development of cutting-edge construction engineering technologies created through a convergence with IT technology.

The ability to improve the productivity of a Korean construction industry that currently suffers from low competitiveness, and to heighten profitability, will require more than the simple use of IT technology; what is in fact needed is the convergence of the construction industry with IT technology.

It is noticeable that the rapid increase in the demand for construction-IT convergence comes from the growing desire to enhance the quality of life through such means as the development of environment-friendly goods, energy reduction, and the advent of u-Cities. This is expected to result in the Korean construction-IT convergence industry emerging as a new national growth engine.

Korea's IT capacity in fields such as next generation mobile

Figure Ⅲ-2. Need for Construction-IT Convergence



Source : Goo Ji-hee, "Prospect for Construction-IT Convergence", 2007.

communications, telematics, and home networks has been estimated to be in excess of 90% that of the world's best in terms of technological standards. Meanwhile, its technological prowess in the fields of next generation PCs, intelligent robots, and IT SoC is 80%

Table Ⅲ-5. SWOT Analysis of Korean Construction - IT Convergence

Strengths	Weaknesses
• Securing of competitiveness in the fields of construction and engineering • Possession of world-class information technology and infrastructure • Development of competencies needed to improve the productivity of construction, environment-friendly construction, and value-added based on the use of IT technology • Accumulation of construction - IT convergence knowhow through the establishment of a U-City test bed	• Lack of high-tech construction design technology • Lack of global standard production systems • Regional bias in overseas markets such as the Middle East • Lack of the technological innovation infrastructure created through the linkage of construction and IT • Backward R&D system for construction technology
Opportunities	**Threats**
• Increased opportunities to enter the markets in Asia and the Middle East • Increased demand for construction occasioned by the enhanced desire for quality of life elements such as environment-friendly surroundings, energy matters, and pleasant spaces. • Rapid increase in demand for construction-IT convergence projects such as u-Cities	• Trend towards complex, large-scale, and technology-intensive construction projects • Comparative disadvantage vis-a-vis the advanced countries in terms of technological prowess, and vis-a-vis China and Southeast Asia in terms of price competitiveness • Competition for brand value, worsening of competitiveness within the global market

Source : Division of Construction-IT Convergence, TFT, April 2008.

that of the world's best. As such, the world-level status of Korean information technology & infrastructure is expected to provide conditions that are advantageous for construction-IT convergence.

However, as far as Korean construction-IT convergence is concerned, efforts will have to be made to overcome the factors such as the stagnation of cutting-edge design technology, lack of global standard production systems, regional bias of overseas markets. These factors, with the absence of technological and price competitiveness, have meant that Korea does not enjoy a comparative advantage vis-á -vis the advanced countries and China.

(2) Stage Approach to the IT Use Strategy

Construction-IT convergence is defined as the heightening of the value-added of the construction industry from a labor-intensive industry to a technology-intensive one through the selective convergence of the traditional construction industry and IT technology.

The convergence of the construction industry with IT has been implemented in three stages: namely, the informatization of the construction industry that began from the mid 1990s onwards, the advent of home and building automation systems during the early 2000, and the advancement of construction-IT convergence during the late 2000s.

Construction-IT convergence was designed to establish u-Cities. U-Cities are innovative cities where convergence, integration, and intelligence are combined based on the use of ubiquitous computing and information communication technologies. As such, the Korean construction industry has experienced a move from the

Table Ⅲ-6. IT Use during each Stage of the Development of the Construction Industry

	Stage 1 (informatization)	Stage 2 (home and building automation systems)	Stage 3 (advancement of construction-IT convergence)
	1990~1999	2000~2007	2008~
Core technology	Informatization of construction industry, integration of business process, establishment of collaboration system	Cutting-edge information &communications, integration of systems within each sector, such as building and office automation	Energy reduction, environment-friendly, and intelligent construction infrastructure
Industrial environment	Enhancement of the efficiency of the construction industry through informatization	Improvement of home and office environment, heightening of the value of building	Establishment of intelligent buildings, advancement of construction process and infrastructure, pursuit of energy reduction / environment-friendly construction
IT use	ERP, PMIS, PLM, BIMS, RFID etc	Home networks, IBS, IPv6, telematics, GIS, ITS, USN, BcN, RFID, e-government, etc	RFID/USN based real time location awareness technology. Introduction of robot automation in construction equipment, 4D CAD/BIM/GIS, construction and new materials technology, etc

informatization of construction companies to the advancement of high value-added, intelligent, and human-oriented construction IT convergence.

The first stage of IT use was aimed at achieving the informatization and enhanced efficiency of the construction industry through such means as the introduction of RFID(radio frequency identification), ERP(enterprise resource planning), and PMIS (project management information systems).

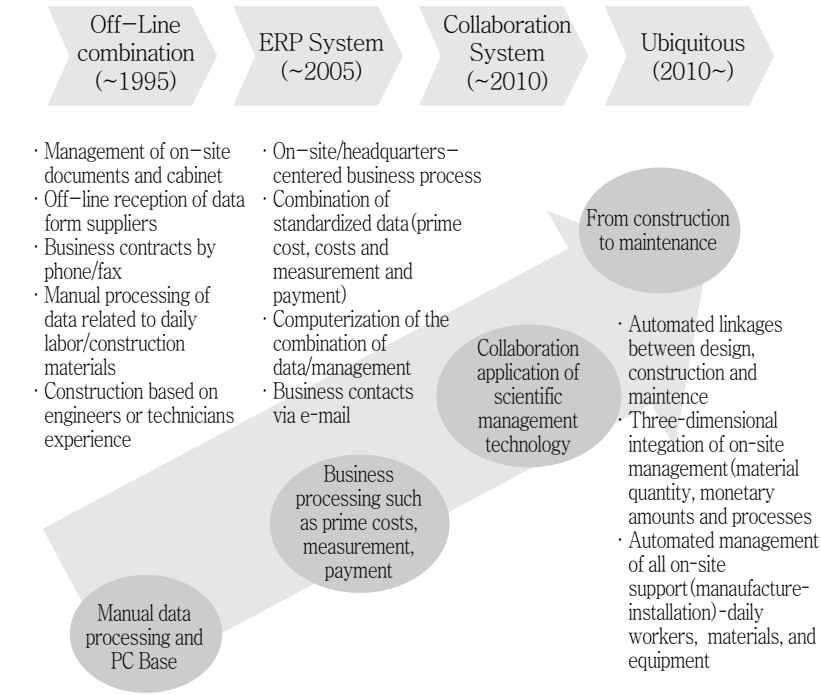
The informatization of the construction industry can be divided into informatization at the enterprise, industrial, and project management levels. The informatization of the construction industry began at the enterprise level. And, it evolved to the integration of processes related to business activities at the time of the establishment of the informatization of internal management and business processes.

Thereafter, movement was made towards informatization at the industrial level. At the level, the functions of on-site management and business processes were linked and integrated towards the activation of interrelationships and e-business between the various participants in the construction industry.

Informatization at the project management level included three elements: First, the establishment of organic relationships between the participants, second, the production and management of the overall life cycle, and third, the informatization of the on-site processes of construction enterprises.

The informatization stage of the construction industry was focused on the management of physical distribution. The management is based on the application of RFID technology, as well as the enhancement of the efficiency of the construction industry

Figure Ⅲ-3. Informatization Stage of the Construction Industry



through the linkage of USN and ERP. The IT technologies employed at this level include the RFID, ERP, PMIS, PLM and BIMS.

The second stage of construction-IT convergence revolved around the establishment of home and building automation systems. This stage moved beyond the simple use of building spaces and towards the integration of systems such as cutting-edge information & communications, building automation, and office automation.

At this stage, while the occupants of a building were able to enjoy a much improved home and office environment, the owner/landlord benefitted from a significant heightening of the value of the building.

This also marked the early stage of moving from u-Home to u-Town, with the ultimate goal being that of creating a u-City.

u-City has a comprehensive construction concept which encompasses home networks and intelligent building systems(IBS). All the functions and services provided by a city, such as administrative affairs, transportation, environment-related matters, security, urban life, business activities, and disaster relief, are harmoniously organized in accordance with the concept of ubiquity.

The IT technologies used during the second stage included home networks, IBS, IPv6, remote measurement systems, remote treatment, and remote education. However, it also included USN, BcN, GIS, telematics, ITS, e-government, and the environment and disaster management systems needed for the construction of u-Cities.

The third stage, that of the advancement of construction-IT convergence, refers to a stage of integration that is approached from the standpoint of convergence rather than the use of IT technologies. In addition, this stage necessitates the presence of an intelligent construction infrastructure capable of dealing with environmental pollutants at the national and enterprise level. This stage is resolving the issue of reducing the use of energy within buildings, and facilitating the establishment of u-Cities.

Therefore, the third stage is divided into three parts: namely, the development of smart construction services focused on intelligence and energy reduction; the advent of environment-green construction; and the establishment of u-construction that can be linked to u-Cities.

The IT technologies used during the third stage include Green IT; intelligent building safety management systems to prevent the

advent of disasters; 4D CAD, GIS, and BIS to reduce the construction period; construction process management IT capable of diminishing production costs; and automated materials management systems that are based on u-GIS.

Other technologies include highly-functional construction parts and new materials development technologies. The technologies are related to the automation of construction robot collaboration designed to improve productivity and conduct precise construction; intelligent construction equipment technology; flexible emotional lighting; and information walls.

(3) Linkage with IT Policy

IT technology has traditionally been used in the construction industry as a tool with which to heighten the overall efficiency associated with various work processes. However, recent efforts have been focused on the advent of a high value-added IT convergence industry capable of improving productivity and increasing profitability within a construction industry.

The transformation of the construction industry into a high value-added IT convergence industry is made possible by the IT technology and infrastructure developed under the auspices of national IT policies. In other words, whenever an advanced IT technology is selected and developed in a strategic manner as part of national IT policies, the construction industry can then redevelop and use the IT technology in a high value-added manner.

The informatization of the construction industry was made possible by the previous establishment of the social basis needed to introduce informatization systems. This social basis included such

elements as the distribution of computers, development of semiconductors, and the establishment of communications infrastructure and ADSL. It was brought about as a result of the implementation of policies such as the Establishment of a National Basic Information System and Measures for the Development of the Electronics Industry,

The subsequent advent of IT policies such as the Basic Plan for the Promotion of Informatization and Cyber Korea 21 had the effect of expanding informatization from the enterprise to the industrial and industrial management levels. The effect could be attained in more part by the further development of communications networks,

National IT policies also had a tremendous influence in terms of bringing home and building automation to the construction industry. The advancement of ADSL called for in the Cyber Korea 21 policy paved the way for the establishment of network connections between home appliances as well as office equipment. What's more, it also provided the basis for the full-scale actualization of home networks and building automation. Meanwhile, the e-Korea Vision strategy facilitated the widespread development of home and building automation related technologies such as IPv6, WLAN, home networks, and integrated wired/wireless technology.

For its part, the Broadband IT Korea policy was designed to bring about the development of next generation IT technologies. This could facilitate the advancement of home and building automation, such as next generation PCs, digital TV/broadcasting RFID/USN, and telematics. This policy can be regarded as having made possible the technologies needed to actualize the u-Cities of the future and the basic infrastructure.

Construction-IT convergence related technology has also

developed in a manner that has reflected the direction taken in terms of national IT policies. In fact, the development of IT technologies has been replicated in the construction-IT convergence industry. This was linked to the trend towards intelligence and environment-friendliness contained in the New IT Strategy, as well as the growing convergence between IT technology and all industries,

The New IT Strategy implemented from 2008 onwards has revolved around the implementation of IT convergence in conjunction with five major industrial fields. The industrial fields include construction, automobiles, and shipbuilding, with the end goal being the creation of five new converged industries by 2012. In keeping with this objective, the construction industry has selected green construction technology, u-construction technology, and smart construction technology as promising construction-IT related technologies.

As such, there has been a close relationship between IT use and the convergence technology developed for the Korean construction industry and national IT policies. However, as far as informatization and home and building automation are concerned, the relationship between IT policy and the construction industry was one of supply (IT policy) and demand(construction industry).

As a result, IT use in the construction industry became little more than a tool used by constructors with a limited understanding of IT technology to usher in a spike in the price of buildings. In other words, IT technology failed to be positively introduced at the enterprise and industrial levels.

However, in a clear departure from the past, a joint partnership has now been established between IT policy and the construction industry where construction-IT convergence is concerned. This

Table Ⅲ-7. Connectivity between Construction-IT Convergence Technology and IT Policy, and the Use of IT Technology

	1980~1994	1995~2004			2004~2007		After 2008
Stage	Establishment of information-communications industry and the basis thereof	Development of information and communications industry and advancement of communication networks			Advancement of information and communications industry		Search for New IT through convergence
Plan	Measures to Develop of the Electronics Industry	Basic Plan for the Promotion of Informatization	Cyber Korea 21	e-Korea Vision 2006	Broadband IT Korea 2007	u-Korea	New IT Strategy
Period	1987~1996	1996~2000	1999~2002	2002~2006	2003~2007	2006~2007	2008~
IT Technology	Establishment of administrative information networks, semiconductors, PC, and TDX	Establishment of information and communications infrastructure (CDMA, ADSL, and ISDN)	Advancement of ADSL, e-government, and e-commerce, Establishment of integrated networks between small and large enterprises (CALS)	Establishment of next generation internet base (IPv6, WLAN), home networking, wired/wireless integration, and mobile e-government	BcN, IT Soc(next generation semiconductors), mobile communications, embedded SW, digital contents, intelligent robots, next generation PC, digital TV/broadcasting, RFID/USN, telematics, wired/wireless home network	RFID/USN,BT+NT, Embedded SW, wireless internet (WiFi), WiBro, HSDPA, digital TV/broadcasting, home networks, telematics, Intelligent robots, u-computing, digital contents, IT convergence	Industrial technology convergence, SW·omputing, electronic information devices, Information and communication media, next generation networks, robots, knowledge services USN, bio medical equipment

	1980~1994	1995~2004		2004~2007	After 2008
Construction-IT convergence technology	Informatization	Informatization at the enterprise level(ERP)	Informatization at the industrial level (PIMS,CALS)	Informatization at the industrial management level(PLM, BIM), Materials/logistics management and efficiency through linkages with RFID,USN, and ERP	
	Home and building automation stage		Home networks, remote measurement, remote medical treatment, remote education, IPv6	IBS, GIS, ITS, telematics, USN, BcN	WiBro, HSDPA
	IT convergence advancement stage			Embedded SW, u-sensor, intelligent robot, LBS	RFID/USN based location awareness technology, energy reduction/ environment-friendly construction, new materials technology, 4D CAD/BIM/GIS technology, Barrier-free building interior and exterior, wireless transmission protocol, BEMS, etc.

increased collaboration between the IT and construction industries was made possible by the formation of the perception. The perception was on the need to create new markets through IT-convergence with other industries and the need to transform into a high value added industry through convergence with the IT industry.

(4) Policy Implications

There remain some problems which must be resolved before concrete construction-IT convergence can be achieved.

The problems are the failure to apply IT technology at the appropriate time occasioned by the technological development gap that exists between the IT and construction industries; the lack of support measures designed to facilitate the application of IT technology; and the low percentage of constructors willing to introduce IT convergence. Furthermore, constructors' hesitance to invest in IT convergence has also served as an obstacle to the activation of construction-IT convergence.

It is essential that selection and concentration be brought about where construction-IT convergence is concerned. To this end, it becomes necessary to select detailed areas of cooperation and develop profitable convergence service models.

It is also essential that construction-IT convergence related laws and institutions be improved. In this regard, there is an urgent need to offer incentives to constructors who introduce IT technology, and also to establish provisions that make the introduction of IT technology obligatory.

There have been, up until this point, a lack of areas in which the construction and IT industries can achieve a win-win situation. To this end, it has become necessary for the government to establish a policy which can facilitate the active introduction of IT in a construction industry that continues to have a weak understanding of IT. There is also a need to bring about the creation of new markets and commercialization through the establishment of a construction-IT convergence R&D plan. In addition, it is essential that the overall

plan for the development of construction-IT convergence technology effectively involve not only the development but also the application of such technologies. Such a denouement can be achieved by connecting this plan with the government-led u-City pilot project.

It is also necessary to facilitate the establishment and participation of an international standardization organization related to construction-IT convergence technology. Finally, there is a need to introduce market-oriented(*De facto*) and technology-led standards (*De jure*) that could not only facilitate the initiation of related technologies, but also the preemptive capture of markets.

Ⅳ. Analysis of IT Convergence Mechanism in the Industrial Development

1. Supply and Demand for IT Technology

(1) Supply of IT Technology

Recently, the IT industry has been focused on developing customer-oriented technologies. While the competition within the IT industry in the past was concentrated on assuring platform technology, the current competition is focused on improving market competitiveness by providing various kinds of additional functions. The increase in customer demands for sensible items has had the effect of making the provision of individualized contents related to sensibility a key to success in the market.

The onset of the network convergence era has heightened the quest for total solutions combining contents and digital devices. Under such circumstances, the provision of individualized contents in set products has been identified as the main factor behind the success of the set industry. To this end, it becomes necessary to develop smart set products and to embed network systems in set products. There is also an urgent need to improve the regulation system and to establish the open technology development system needed to support such products.

In addition, the emphasizing of the importance of additional functions in the competition for platform technology within the

overall IT industry is expected to result in the importance of such additional functions. The functions are being enhanced in terms of the competition for the production of electronic goods. The growing social concerns about high oil prices, as well as environmental and safety issues, has heightened the need for functional supplemental policies capable of actively responding to these social concerns. As such, the current situation is one in which interests in securing the stability of materials, energy reduction, biometrics, security, and materials technology have been heightened.

<Table Ⅳ-1> shows the possibility of using IT technology in the various manufacturing sectors from a functional standpoint.

First, as far as sensors are concerned, it is important to develop both passive sensors with an awareness of the chips equipped inside objects and of active sensors capable of detecting external changes such as sounds and movements and of conveying the related information. The development of both sensors is expected to result in the evolution of logistics management, resources management, environmental management and automation within the manufacturing industry.

As far as processors are concerned, it is important to enhance ability to analyze and judge the data obtained from sensors. Such enhancement is expected to facilitate the advent of greater precision in terms of logistic, resource, and environmental management, as well as the onset of real-time processing within the manufacturing sector.

In the communications sphere, it is important to move towards near field communication and integrated networks capable of aiding interactions and the delivery of various contents between connected objects anywhere and at any time. Such move is expected to

Table Ⅳ-1. The Potential for IT Use in the Manufacturing Industry-IT Functions

	Developmental direction	Technological direction within the IT industry	IT use in other manufacturing sectors
Sensors	Develop into passive sensors capable of detecting the chips embedded in an object and active sensors capable of detecting external changes such as sound and movement and to convey the detected information	Use of RFID for object recognition, active badge system, bio sensors for recognition of human motion and security, chemical sensors, tactile sensors	Logistics management, resources management, environment management, and automation
Processors	Analyze the data obtained from sensors	Evolution of the computing OS into one that is less burdensome in terms of processing as information can be frequently used through networks, and one in which real time processing is possible	Design based on the real time processing, and precision of logistics/resources/ environmental management
Communi-cations	Near-field communication and integrated network which can interact with all connected objects anytime and anywhere, and which can assist in the conveying of various contents	Advancement of the functions of near-field wireless communication devices such as Bluetooth, UWB, ZigBee; Ad-hoc network technology; and mobile/internet technology	Strengthening of industrial convergence caused by the expansion of cooperation between economic actors and the interactions between markets

	Developmental direction	Technological direction within the IT industry	IT use in other manufacturing sectors
Interface	Intelligent human-oriented interface	Development of input technology such as voice, letter, and gesture recognition; development of display devices which can be embedded anywhere, including mirrors, walls, and textiles	Increase of the value added of a product through the embedding of intelligence in consumer goods
Security	Security technology capable of guaranteeing the safety of the information provided under a network environment, and the technology needed to overcome the contradictory relations that exist between various privacies.	Development of cryptographic technology for confidentiality purposes, ID authentication technology, and information leak confirmation technology; expansion of authentication technology using chips and sensors such as those related to bio-information and behavioral patterns	Expansion of consumer goods through the increasing of individually optimized products

strengthen industrial convergence in the manufacturing sector. This denouement can be explained by the resulting increased cooperation between the main economic actors and the expansion of interactions between markets.

In terms of interfaces, the development of human-friendly

intelligent interfaces is expected to increase the scale of value-added products through the advent of intelligent consumer goods in the manufacturing sector.

In the security sphere, it is noticeable that the development of security technology can guarantee information under a networking environment. And, it is also noticeable that such technology can move beyond the trade-off between information utility and privacy. From the facts, it is expected to expand the consumer goods market by increasing individually-optimized products.

<Table Ⅳ-2> constitutes an analysis of the influence of potential IT use in the manufacturing industry based on the direction undertaken in terms of technological development.

Technological development within the IT industry is expected to head in three directions: intelligent computing, ubiquitous networking, and the embedment of IT technology.

The development of IT technology from the standpoint of intelligent computing will facilitate the creation of intelligent products and services. This is expected to increase activities designed to heighten the utility of IT technology within the various production-related processes of the manufacturing industry.

As far as ubiquitous networking is concerned, the expansion of the U-network environment has translated into the establishment of a ubiquitous production and supply environment. This can make possible the use of the necessary services and technologies anywhere and at any time within the manufacturing sector.

The embedment of IT technology within the IT industry will help create high value-added products by facilitating the development of various types of convergence. In fact, technologies are equipped in various industrial sectors such as the medical, automobile,

Table Ⅳ-2. IT Development Trends and its Impact on Convergence in the Manufacturing Industry

Development Trends	Results	Target sectors	Convergence in other manufacturing sectors
Intelligent Computing	Intelligent products/ services	• Humanoid robots • Smart vehicles • home networking devices • Wearable PCs	• Adding of intelligence to products and services heightens IT use in the manufacturing industry's production process
Ubiquitous networking	Establishment of a u-network environment	• RFID/USN • S/W • BcN • Sensors	• Establishment of a ubiquitous production - supply environment makes it possible to use services and technologies anywhere and at any time
Embedment of IT technology	Expanded IT industry	• Medical • Automobile • Mechanical equipment • Logistics • Aerospace • Construction • Agriculture • Energy	• IT technology is embedded in other technologies and industries, leading to converged types of industries and the creation of high value-added

machinery equipment, logistics, aerospace, construction, agriculture, and energy fields.

<Table Ⅳ-3> considers the potential for IT use in the manufacturing industry from the standpoint of digital convergence.

First, the emergence of wired/wireless De/Recoupling and broadcasting/communication convergence as part of efforts to

Table Ⅳ-3. The Potential for IT Use in the Manufacturing Industry –digital Convergence

Convergence area	Target object	Process	Convergence within the IT industry	Convergence in the manufacturing industry
Networks	Communication/ Internet/ broadcasting	De/Re-coupling, broadcasting/communication convergence between wired and wireless systems in order to bring about the effective distribution of services and contents	• Move from vertical integration within industries to horizontal integration within identical fields • Independent structure linking together All IP, services and networks	Industrial reorganization through the activation of the establishment of seamless networks
Contents	Multimedia/ voice/ services	• Convergence of various contents such as voice, sound, image media etc. • Multiuse of digital contents	• Integration of communication portals and broadcasting platforms • Integration of services like SOIP	Expansion of home/business platform-integrated networking services
Devices	Computers/ information & communication devices/ electronic home appliances	Digitalization of terminal devices due to the development of digital technology; development of technology capable of integrating devices	• Digitalization • Functional integration • Device connection	Expansion of integrated type devices

ensure the effective distribution of services and contents greatly increases the likelihood for the reorganization of related manufacture industry. This effect can be achieved through the activation of the establishment of goal-oriented seamless networks.

Second, it is necessary to understand the importance of convergence of various contents such as voice, sound and image media and popularization of multiple uses for digital contents. This is expected to result in the expansion of home/business platform integrated networking services within the manufacturing sector.

Third, as far as devices are concerned, it is necessary to understand the importance of digitalization of terminal equipment via the development of digital technology and the advent of technology making integration between devices. This is expected to further the spread of integrated devices boasting a wide range of functions.

(2) Demand for IT Technology in the Manufacturing Industry

<Table Ⅳ-4> introduces the necessity for convergence and the future direction of convergence from the standpoint of the development of traditional manufacturing industries.

The evolution of automobiles into 'mobile living spaces' featuring heightened safety and convenience is expected to foster the development of convergence based on the concept of safe and convenient automobiles.

The development within the shipbuilding industry of shipbuilding and optimized navigation systems based on the use of SW technology renders essential the securing of shipbuilding, navigation, and global remote ship management and maintenance systems. It is

Table Ⅳ-4. The Development of the Traditional Manufacturing Industry and its Convergence Strategy

Manufacturing sector	Direction of evolution	Problem-solving tasks	Convergence strategy
Automobile	Evolve into a "mobile life space" in which safety and convenience are heightened	Development of high value added vehicles such as environment-friendly vehicle and improvement of fuel consumption, assurance of original technologies such as core parts and vehicle embedded SW etc	Safe and convenient automobiles
Shipbuilding	Shipbuilding based on use of SW technology, optimization of navigation systems	Localization of production of shipbuilding and navigation systems, securing of global remote management/ maintenance systems	Navigation manageme nt services
Construction	Energy reduction, environment-friendly, Intelligence	Securing of construction design, energy reduction, environment-friendly, and intelligent construction technologies	Intelligent green construction
Textiles	Functionality, convenience, and high quality of life environments such as well-being and LOHAS	Responses to the ubiquitous digital lifestyle such as wearable computers and smart daily necessities	IT-Wear based u-services
Home appliances	Evolution into next generation digital home appliances which reflect diversified and enhanced consumer needs	Securing of the competitiveness of core parts, original technology and international standardization	Future sensible, real-sense, well-being based convergenc e home appliances

Manufacturing sector	Direction of evolution	Problem-solving tasks	Convergence strategy
Defense	Social safety monitoring, homeland security, manned/unmanned technological convergence	Future electronic environment network-oriented management and automation technology	Digital military system
Aerospace	High precision digitalization	Establishment of production facilities, radars, controlled flight, navigation management systems	Safe and convenient aerospace navigation systems
Medical	Establishment of future medical system which encompasses everything from new Bio converged chips to optimized medical service areas	Responses to changing paradigms such as the advent of an aging society, reduction of medical costs, early diagnosis and prevention of diseases	u-health care
Education	u-education converged with IT	Create markets through the development of learning systems that are in accordance with the demands for u-learning	Real-sense convergence learning systems

Source : New Economic Growth Engine Planning Team(2008b).

also necessary to establish a convergence strategy for services related to the management of ship transportation.

The evolution of home appliances into next generation digital home appliances reflect diversified and refined consumer needs renders. This means that it necessary to establish a development

Table Ⅳ-5. IT Technology Demands within Individual IT-Converged Traditional Industries

Industry	Developmental stage	Demanded IT technology	
Automobiles	① Individual sensor - based adaptive IT vehicles ② multiplex sensors/ communication based adaptive IT vehicles ③ Environment - friendly autonomous IT vehicles ④ situation awareness based autonomous IT vehicles	Core parts	• Vehicle SoC technology • High precision sensors and converged sensor technology
		S/W and systems	• HF/HMI technology • Standard platform technology • Vehicle communication technology • Infrastructure-linked technology
		Auto parking· Autonomous driving systems	• Auto parking systems • Autonomous driving systems
		Convenience and environment - friendly systems	• Convenience systems • Environment-friendly systems
Shipbuilding	① Marine mobile satellite communications ② real - time navigation monitoring ③ Ship communication networks ④ Intelligent remote management/ maintenance systems	Cutting-edge navigation solutions	• Ship equipment electronic SW • Intelligent navigation systems
		Globalization of ship management/ maintenance	• Marine mobile satellite communication technology • Marine high-tech network sensors • Remote management/ maintenance systems

Industry	Developmental stage	Demanded IT technology	
Construction	① Intelligent construction ② Smart city construction ③ Smart homeland construction ④ Human-oriented sensible home environment	Energy reduction/ Green construction technology	• Safe green technology • Construction materials lifecycle management technology • energy reduction/environment-friendly construction new materials technology • Energy awareness-based building energy management technology
		u-construction infrastructure	• Automation of construction projects and robotic technology • 4D GIS-based environment-friendly visual construction technology • Intelligent u-construction wireless network technology
		Intelligent construction services technology	• IT-converged human-oriented sensible home environment technology • Environment-friendly intelligent residence/building service technology • Integrated management of environment-friendly cities and u-construction infrastructure technology
Textiles	① Digital-based mobile electronic agent systems ② Electronic textile-based wearable electronic assistance systems	Platform technology	• Accessory type computers (watches, wallets, belts etc) • Clothing type computers, bio shirts • SoT(System on Textile) computers • Intelligent/Autonomous everyday product platform technology
		SoT technology	• Thin-film packaging technology and optical fiber technology • Conductive fiber weaving technology • Large area conductive fibers production, electronic interface technology

Industry	Developmental stage	Demanded IT technology	
Textiles	③ SoT(System-on-Textile) computers ④ SoT based u-health u-life service platforms	Electric power technology	• Wearable power technology
		Wearable networks	• WBAN(Wireless Body Area Network) technology • Human body communication protocol and harmless-to-body communication interface technology • Intelligent agent middleware technology
		Smart I/O	• Eyeglass display and wireless interface technology • SoT based area display technology • Textile based wearable multifunctional sensor technology • Texture and Kinesthetic sense based haptic(tactile) interface technology
Home appliances	① user-aware/ converged home appliance ② user-aware/ real-sense home appliances ③ user-aware /sensibility home appliances ④ human-oriented/ sensible integrated home appliance services	Sensible home appliances	• Development of original technology for sensible home appliances • Development of commercialization technology for sensible home appliances
		Real-sense home appliances	• Real-sense augmented reality technology • Real-sense device technology • Real-sense home appliance services and commercialization technology
		Well-being home appliances	• Development of original technology for well-being converged home appliances • Human body-friendly platform development and commercialization technology

Source : New Economic Growth Engine Planning Team(2008b).

strategy for future convergence home appliances that is based on the concepts of sensibility, real sense, and well-being.

<Table Ⅳ-5> exhibits the IT technologies needed at various stages of the development of IT convergence in traditional industries.

2. The Balancing Mechanism for IT Technologies

The following table introduces, from a functional standpoint, the detailed technologies currently being demanded by other industries and provided by the IT industry. It also describes the preconditions needed to achieve a balance between supply and demand.

As can be seen in the above table, viewing the supply-demand of IT technologies allows us to see that the final goods sector is concentrated on such ends as convenience, intelligence, safety, energy reduction, and the human body-oriented utilization. Meanwhile, the intermediate goods sector is concentrated on such ends as environment-friendly, interface-based, and high functionality.[5] In addition to such commodity-oriented utilization of IT technology, the manufacturing industry can assure the utilization of IT technology through the improvement of systems or process innovation. This can be attained via such means as enhanced cost and production efficiency, functional integration, human interface (convenience and portability), satisfaction of customer needs, and the advent of economies of scope.

5) Refer to p. 106 in KIET(2007).

Table Ⅳ-6. Preconditions for the Achievement of a Balance in Terms of the Supply-demand of IT Technology

Technology	Supply-Demand	Preconditions for the achievement of a balance in terms of supply-demand	Functional utility
Networking	• Need to establish collaboration on basic infrastructure such as control/network/ communications, wireless networks, and RFID/USN networks in the automobile, construction, shipbuilding, and textile industries	• Networking which reflects the establishment of purpose-oriented networks within the industry • Establishment of a ubiquitous environment which can facilitate the advent of production and supply anywhere and at anytime	• Convenience (access), Flexibility (ubiquitous)
Commun-ications	• Near Field Communications such as Bluetooth, UWB, and ZigBee; mobile communications, satellite communications etc.	• Development of open technology based on communication media which makes possible internal and external communication regarding industrial products	• Convenience (connectivity), Flexibility (Openness)
Platform	• Platform commercialization technology for individual industries such as automobiles, textiles, and home appliances	• Supply and demand of intelligent, automotive, and human body-oriented platform technologies and evolution into integrated types of such technologies	• Convenience (automation), intelligence, flexibility (human body oriented)
Interface	• Input technology such as those related to voice, characters, and motion detection; displays which can exist anywhere, such as in the human body, mirrors, walls, and textiles	• Diversification and interface collaboration on types of displays such as those related to human body communications, wireless, and real sense	• Intelligence (strengthening detection), flexibility (various interface), high-functionality (human body-oriented)

Technology	Supply-Demand	Preconditions for the achievement of a balance in terms of supply-demand	Functional utility
Systems	• Establishment of industrial systems such as those related to convenience, maintenance/ management, and life cycle management in the fields of automobiles, shipbuilding, and construction	• Evolution into computing OS which faces fewer burdens in terms of processing and under which real-time processing is possible as a result of the frequent use of information through networks • Sophistication of designing/logistics/ resources/environment management through real−time processing	• Convenience (always-on), Intelligence (real-time processing), Safety (Refinement of management), Energy reduction, environment-friendly
Intelligence	• Intelligent navigation, human-oriented sensibility home environment, sensibility home appliances, humanoid robots, smart automobiles, and wearable PCs etc.	• Concretization of development of such areas as sensibility/ recognition /automation/ robot/smart areas occasioned by the advancement of industrial intelligence in the fields of shipbuilding, construction, textiles, and home appliances	• Convenience (automation), Intelligence (recognition, smartness), Flexibility (human body-oriented), high-functionality
Environment−friendly	• Environment-friendly system, new materials for energy reduction/ environment-friendly construction, environment−friendly cities and u-construction infrastructure integrated management, well-being convergence home appliances etc.	• Development of environment-friendly technologies in the fields of automobiles, construction and home appliances such as those related to environment-friendly systems/ materials/services/ infrastructure management/energy efficiency	• Convenience (integrated management), Safety (integrated management), Energy reduction, environment-friendly

Technology	Supply-Demand	Preconditions for the achievement of a balance in terms of supply-demand	Functional utility
Sensors	• High-precision sensors and convergence sensors, maritime high-tech network sensors, textile based wearable multi-functional sensors, real sense devices, real sense home appliance services, and commercialization technologies • Evolution of sensor technologies such as those related to RFID and active badge systems for object recognition, biosensors for human motion and security recognition, chemical sensors, tactile sensors	• Advancement of logistics/resources/ environment management and automation • Evolution of functional sensors such as those related to convergence/ networks/multi-functions/real sense in the fields of automobiles, shipbuilding, textiles, and home appliances	• Convenience (management), Intelligence (automation), Safety (security awareness), Flexibility (human body-oriented), high functionality (highly-precise)

A balance between the supply-demand of IT technology can be achieved from two different standpoints. First, the balancing of the supply-demand of IT technology can be carried out from the standpoint of the creation of new markets. Viewed from the standpoint of IT convergence, this approach can be regarded as being rooted in the phenomenon of bilateral or tripartite combinations. And, through convergence a new idea(contents) and

technologies from other fields are integrated to a new or existing technology.[6] Moreover, through this technological convergence, it becomes possible to create a new market based on the development of new products and services, introduce new production/logistics/ and marketing methods, and to gain access to new markets.

Second, the balancing of the supply-demand of IT technology can be brought about through the development of new products and services, as well as through the improvement of existing products and services. This is more strongly associated with the trend towards the gradual development of the existing manufacturing industry. The gradual development is based on the improvement of existing technologies and processing methods rather than any epochal technology development. As mentioned above, the utilization of IT technology in the manufacturing industry can lead to innovation through such means as the improvement of systems. The improvement is related to cost and production efficiency, multi-functionality, human interface(convenience and portability) and the advent of economies of scope.

The establishment of these preconditions required for the achievement of a balance between the supply-demand of IT technology must be backed by the technological capacity of the IT industry; moreover, the flexible acceptance of IT technology in the manufacturing sector should be guaranteed. This means that the manufacturing sector should possess the basic competencies needed to conduct proper market analyses, bring about the adaptation of technology to market needs, and enjoy marketing flexibility, as well as the competence to develop new products.

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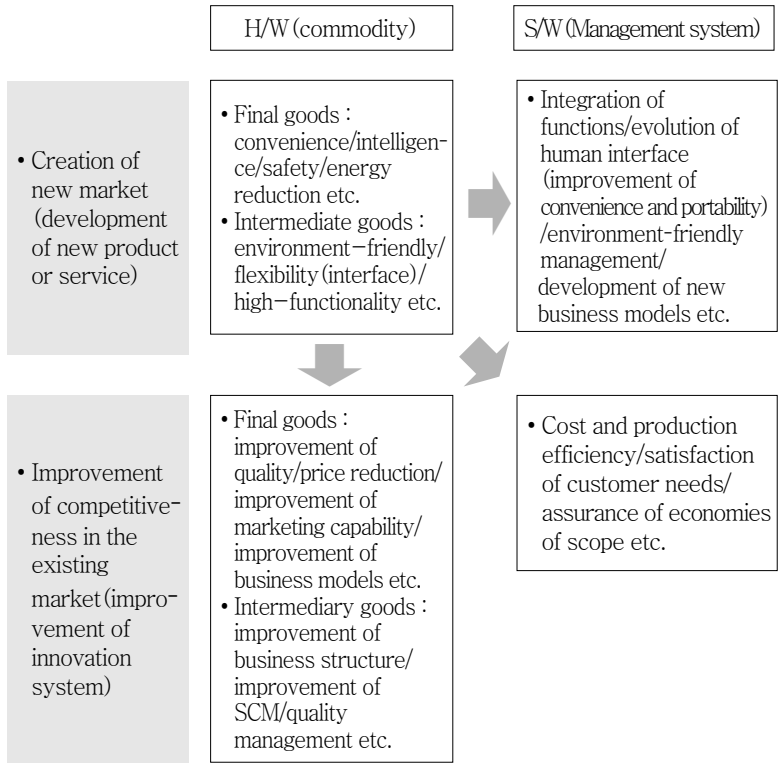
6) Refer to p. 101 in KIET(2007).

Figure Ⅳ-1. Balancing Mechanism for IT Technology



<Figure Ⅳ-1> depicts the balancing mechanism for IT technology. As previously mentioned, the balancing mechanism can, depending on the degree of convergence, be divided into that used for new and existing markets. Moreover, an additional balancing mechanism for the supply-demand of IT technology can be created by dividing the subjects of technological demand into those related to commodities and those pertaining to management systems. This makes it possible to see the connection between this mechanism and the improvement of competitiveness within the existing market.

From the standpoint of commodity, the effects are occasioned by the improvement of management systems through the advent of the functional utilities of IT technology such as convenience, intelligence, stability, environment-friendly, flexibility, and high-functionality.

3. Analysis of Decisive Factors in IT Convergence

Analysis in this section is based on the 'evaluation indicators related to the development of a convergence innovation index' introduced by KIET(2007). The index shows that the various factors influence the heightening of IT use within the manufacturing industry. This analysis of course assumes the continued development of the IT industry. The heightening of the degree of utilization of IT technology is predicated on the carrying out of open technological innovation within the manufacturing sector. Open technological innovation, a concept which differs from that associated with closed systems, refers to the methods used by various organizations to acquire technologies from both inside and outside of their structures. This can also be taken to mean that the industrialization of technologies can be carried out via multi lateral paths.[7] As such, the degree of openness found at each stage of the value chain can be considered as a decisive factor in terms of IT use. It is necessary to improve internal capabilities at certain stages of the value chain, including R&D, the development of new products, and the forging of business models. It is also necessary to establish a

7) Refer to p. 99 in KIET(2007).

system through which internal and external technologies and ideas can be introduced.

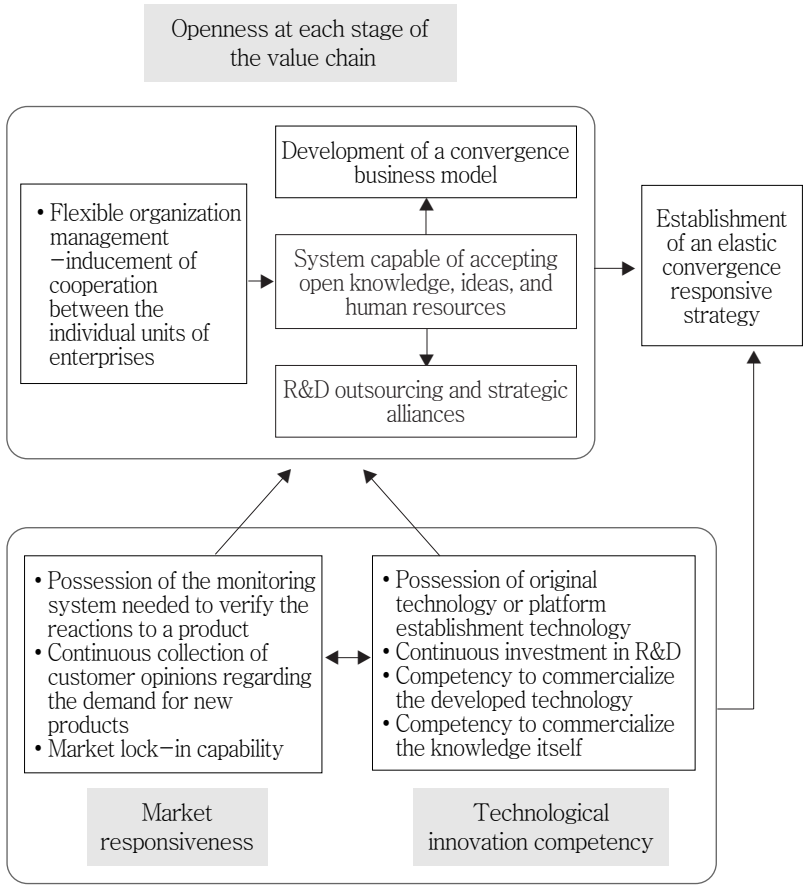
The establishment of such a system requires, above all, cooperation between the individual units of enterprises so as to create smooth exchanges between their heterogeneous functions. The advent of such flexible organizations can lead to the erection of a system which facilitates the open-minded acceptance of knowledge, ideas, and human resources. It also facilitates the establishment of the convergence strategy needed to develop business models and implement technological innovation. This ultimately leads to the formation of an organization culture which facilitates convergence, and to a heightening of responsiveness to convergence in general.

The advent of an innovative system that can facilitate convergence is connected to the activation of outsourcing, which in turn heightens the utilization of external resources. It makes possible the pursuit of effective external uses and technological networking when it comes to developing technologies at the R&D level. This takes the form of R&D outsourcing and strategic alliances. The forming of technological alliances has a tendency to create synergy effects. The effects accelerate the learning ability and to facilitate the production of complicated and high-tech products which a single enterprise would be hard-pressed to produce on its own.

However, even though these convergence innovation activities are in fact implemented, it is difficult to guarantee the efficiency of the convergence innovation process as long as there is a lack of innovative competency. The possession of the necessary technological competency is an important factor that influences the implementation of innovative activities. In fact, the main actors

involved with innovation can possess technological wherewithal in the form of original technology or platform establishment technology. It is also possible to continuously invest in R&D. And, they can possess the competencies needed to commercialize the developed technologies and to commercialize the knowledge itself,

Figure Ⅳ-2. Analysis of Decisive Factors in Terms of IT Convergence



In addition, responsiveness to customer needs within the convergence market can also become another decisive factor in terms of the facilitation of convergence. The ability to respond to demands for convergence in a timely manner can also be another decisive factor in terms of facilitating convergence within the market. In fact, a company can possess a monitoring system that allows it to verify the reactions to a product. The said company continuously can collect the customer opinions regarding the demand for new products. And, they can possess the capability to lock-in to markets,

The following figure showcases the relationships between the decisive factors in terms of IT convergence. Depending on the flexibility of the organization, such open innovative activities can be invigorated at each stage of the value chain. Moreover, the market responsiveness and technological innovation competencies used to support open innovation can contribute to the establishment of a final elastic convergence responsive strategy.

V. IT Convergence Strategies for the Industrial Advancement

1. IT Development Strategy for the Industrial Innovation

(1) Technological Innovation Strategy in the Manufacturing Sector

The successful advent of a new paradigm requires that the innovation of the manufacturing industry be implemented alongside the development of key factor technology. To this end, there is a need to forge a successful business model which can be harmonized with the new industrial paradigm, and establish a technological development road-map.

The achievement of effective technological development based on a technological development road-map requires that a strong focus be placed on the selection and concentration strategy. To this end, it is necessary to derive key technological areas which can lead to the overall development of the industry within each sector. However, there is a certain time lag between the production of new IT technology and its actual use in traditional manufacturing sectors.

As such, it is necessary to facilitate convergence between the IT and manufacturing industry sectors through a gradual approach that is based on a keen consideration of such time lags. In this regard, the most important point is to ensure the provision of information so as

to make it possible for enterprises in the traditional manufacturing industries to use the results of technological development during the IT technological development and commercialization process. Another important point is to facilitate the use of IT-related human resources. In addition, there is a need to establish an IT convergence system which encompasses every process from technological development to commercialization. The IT convergence system can be connected not only at the IT convergence R&D planning stage but also, from the standpoint of new market creation and commercialization, to government-led pilot commercialization projects.

The advent of effective technological development based on a technological development road-map is predicated on the establishment of a resources distribution plan which is focused on a clear selection and concentration strategy. In this regard, it is essential that the government and private sector both play an active role. For example, concerns exist about the heavy burden of R&D costs and technological barriers of advanced countries. In this case, it becomes more effective, in terms of heightening the concentration of investment, to establish a long-term based technological development strategy that involves government leadership.

In addition, the effective implementation of a technological development strategy within the manufacturing sector must involve a joint prosperity strategy. The strategy is rooted in the establishment of a cooperative system and the division of roles amongst the main actors. When it comes to technological development and commercialization, it is necessary to establish a cooperative relationship between manufacturing enterprises and universities/research institutes.

It is also essential that a strategic cooperative system be established. The system is capable of producing synergistic effects through the organic mutual connections. To attain this, it is necessary to establish a clear division of labor structure that is based on an industry-academy R&D cooperation system. In other words, manufacturing enterprises need to plan the specifications of required products and services and the related commercialization technology. On the other side, universities and research institutes need to provide platform and key factor technology such as H/W, S/W, and systems. Industrial sectors can contribute to the advancement of the industrial structure by facilitating cost reduction and the improvement of productivity. For this end, a cooperative system might include joint research and technological collaboration with intermediate materials and parts suppliers.

(2) Core IT Technologies Development Strategy

As can be seen in the following table, the areas of IT technology regarded as being essential to the facilitation of manufacturing-IT convergence include networks, communication, interface, SoC, environment-friendly, and sensors. In this regard, it is necessary to establish an IT technology development strategy that is specifically optimized for the manufacturing industry. <Table Ⅴ-1> shows the technology development strategies for facilitating IT convergence in the manufacturing industry.

First, to activate the manufacturing-based SoC industry, it is important to move away from an assembly type that is based on simple modulation. It is also important to produce goods which reflect the industrial characteristics required by demanders. As such,

Table V-1. IT Technological Areas Needed to Facilitate Manufacturing-IT Convergence

Technology area	Industry	Required IT technologies	Technological development strategy
Networking	Automobile	• Infra-link control technology	• Reflect industrial requirements such as control/network/ communication in the fields of automobiles, construction, shipbuilding and textiles • in the case of RFID/ USN, there is a need for concentrated investment in special tag technology, interference avoidance and removal technology, and high speed tag attachment technology
	Construction	• Intelligent u-construction wireless network technology	
	Textiles	• WBAN(Wireless Body Area Network) technology	
Communication	Automobile	• Vehicle communication technology • HF/HMI technology(vehicle)	
	Shipbuilding	• Maritime mobile/satellite communication technology	
	Textiles	• Wearable, battery technology	
Platform	Automobile	• Standard platform technology	• Development and commercialization of industrial platform technology such as automobile, textile, and home appliance • Concentrate on developing various types of displays and the related interface
	Textiles	• Intelligent/Autonomous daily product platform technology	
	Home appliances	• human body-oriented platform development and commercialization technology	
Interface	Textiles	• Human body communication protocol and armless-to-body interface technology • Eyeglass display and wireless interface technology	

Technology area	Industry	Required IT technologies	Technological development strategy
		• SoT based area display technology • Texture and Kinesthetic sense based haptic (tactile) interface technology • Accessory-type computers (watches, wallets, and belts etc) • Wearable computers, bio shirts • Large area conductive fiber production and electronic interface technology	
Systems	Automobile	• Convenience systems • Auto parking systems • Autonomous driving systems	• Need to develop industrial systems such as those related to convenience, maintenance, and lifecycle management in the fields of automobiles, shipbuilding, and construction
	Shipbuilding	• Remote maintenance/ management systems • Ship equipment electronic SW	
	Construction	• Construction materials lifecycle management technology	
Automation	Construction	• Construction automation and robotization technology	• Automation is an essential technology needed not only in construction but also in various industrial sectors
SoC	Automobile	• Vehicle SoC technology	• Need to develop technology that is keeping with industrial characteristics, and to move away from assembly types based on simple modulation
	Textiles	• SoT (System on Textile) computers • SoT technology (thin layer fiber packaging technology and optical fiber technology/ conductive fiber weaving technology)	

Technology area	Industry	Required IT technologies	Technological development strategy
Intelligence	Shipbuilding	• Intelligent navigation systems	• Need to establish a technological development strategy that is focused on the definition of industrial intelligence in such fields as shipbuilding, construction, textile and home appliances, and on the provision of information/sensibility/ middle ware that is in keeping with industrial intelligence
	Construction	• IT-converged human-oriented sensibility home environment technology	
	Textiles	• Intelligent agent middleware technology	
	Home appliances	• Sensibility home appliance original technology and commercialization technology	
Environment-friendly	Automobile	• Environment-friendly systems	• Need to develop technologies related to environment-friendly systems/materials/ services/infrastructure management/energy efficiency in the automobile, construction and home appliance sectors
	Construction	• Safe Green construction technology • Energy reduction/ environment-friendly construction new materials technology • Environment-friendly intelligent home/building service technology • Environment-friendly city and u-construction infra integrated management technology • Energy recognition based building energy management technology • 4D GIS based environment-friendly virtual construction technology	

Technology area	Industry	Required IT technologies	Technological development strategy
	Home appliances	• Well-being convergence home appliance original technology	
Sensors	Automobile	• High precision sensor and converged sensor technology	• Urgent need to establish a sensor development strategy which reflects industrial demands with regards to such aspects as convergence/ networks/multi-function/real sense in the automobile, shipbuilding, textile, and home appliance sectors.
	Shipbuilding	• Maritime high-tech network sensor	
	Textiles	• textile based wearable multifunctional sensor technology	
	Home appliances	• Real-sense augmented reality technology • Real-sense device technology • Real-sense home appliance service and commercialization technology	

there is a need to first analyze the attributes of the products which can be employed within the industry. And then we should analyze the contents to be developed within the SoC industry and the industrial demand therefore. In addition, it is essential to pursue reverse engineering-based production which can be used to satisfy potential demand. It is also necessary to develop SoC in a manner that reflects the overall design of the development process. In other words, once the marketability of the production method have been ascertained, it becomes necessary to establish cooperative measures with companies manufacturing finished products.

The effective application of wireless networking in the manufacturing industry is predicated on the development of RFID/ USN core technology. To this end, it becomes necessary to strengthen R&D in the three major related fields, namely next generation RFID, USN factor technology, and convergence technology. And, it is also necessary to facilitate the development of technologies which can mitigate on-site difficulties through such means as the improvement of the recognition rate.

The main concerned technological areas include special commodity-specific tag technology, interference avoidance and cancellation technology, and high-speed tag attachment technology. In addition, the transformation of RFID/ USN into a leading demand sector will require that the social efficiency and transparency of items such as government commodities(procurement and defense), logistics infrastructure(ports and logistics hub), distribution(liquor, jewellery and beef), and finished products logistics(pharmaceuticals and clothing) be improved. It is also required that the creation of industrial demand be promoted at the initial stage. To this end, it is essential that corporate competitiveness be strengthened by facilitating the development of RFID-based parts logistics. In addition, their diffusion between large and small & medium-sized enterprises, and that a new work efficiency model should be established. The importance of next generation semiconductors within the manufacturing industry cannot be overstated. The development of next generation semiconductor technology should be divided into three areas: first, the next generation integrated memory which makes it possible to bring about industrial convergence; second, the system semiconductors which can create large-scale markets; and third, industrial convergence promoting

system semiconductors. The government's plans to develop next generation semiconductor technology includes the goal of raising the technological levels of these three areas from 70% in 2008 to 90% by 2013.

The development of next generation display industrialization technology is regarded as a key interface area in the manufacturing industry. The technology development rests on the ability to ensure the industrial competitiveness of next generation displays such as OLED and flexible displays, as well as the strengthening of the competitiveness of downstream industries. It is particularly important to secure large area OLED core technology, processing/materials & elements oriented flexible/ transparent display technology, and IPR. The government plans to support participation in overseas exhibitions by establishing a display industry support center. Current plans are to implement the commercialization of five flexible display products in 2013.

Lastly, the strengthening of the competitiveness of the semiconductor and display industries is heavily predicated on the localization of the production equipment. To achieve this objective, high value-added equipment should be localized through the development of commercialization technology for semiconductor and display equipment; moreover, the commercialization technology needed to promote new processing equipment must be established. The effective implementation of such a strategy requires that industrial competitiveness be strengthened by improving the system integration capability. This can be achieved through the enforcement of organic cooperation between equipment and parts companies.

2. IT-led Green Innovation on the Manufacturing Industry

To facilitate green manufacturing based on IT use, it is necessary to first facilitate the development of a green IDC(Internet data center) model and bring about new commercialization. More specifically, there is a need to establish a green IDC model capable of minimizing electricity consumption and losses. In fact, these side effects have increased as a result of the rapid spike in the distribution of information. It is also important to facilitate the advent of a new business model and commercialization for export purposes. The development and standardization of a green IDC model must be brought about. This can help to enhance IDC battery systems, integrate IT system resources, develop highly efficient servers and storage, and improve efficiency based on the use of cloud computing technology. In addition, it is essential that a testing facility be established in order to remodel the existing IDC into a power reduction-type center, and that environment-friendly and new & renewable IDC also be developed.

Second, it is necessary to establish a green IT technology test bed. More to the point, there is a need to establish a test bed that is designed to facilitate the development of a green technology-converged green home model. The model can be applied to such products as solar cells, battery systems, high efficiency home networks and home appliances. To this end, it is essential that an industry-government-academic sector council be established to facilitate the commercialization of developed technologies. This can be realized through such green IT test beds, the distribution of the

IT technology-converged Green Home model and the commercialization of exports.

Third, there is a need to ensure the diffusion of industrial EMS (Energy Management System). To do this, it is necessary to implement EMS pilot projects in the electronics industry as part of efforts to establish a real-time energy and resources consumption monitoring system. In the case of the electronics industry, energy consumption has been concentrated in fields such as clean room (42%), air conditioning(24%) and purity.

Fourth, it is urgent to manage waste resources within industrial complexes based on the use of u-IT technology. In this regard, waste information should, using GPS and RFID technology, be shared between enterprises in a real-time manner. In addition, support should be provided for the autonomous exchanging and recycling of byproducts. To attain this, it is urgent that the information related to byproducts be shared. And, it is also urgent that an autonomous exchange system based on a collaboration structure between the enterprises within an industrial complex be established(Presidential Committee on Green Growth, 2009).

3. Industrial Development Strategy for Promoting IT Convergence

The industrial development strategy used to facilitate manufacturing-IT convergence should be implemented based on the following detailed areas:

(1) Support for the Development and Commercialization of Business Models

The facilitation of manufacturing-IT convergence requires the urgent development of business models for IT-traditional industries convergence. It also requires the establishment of standard test bed platforms, and the implementation of business model pilot projects in conjunction with local governments. The first step in advancing the structure of traditional industries is to establish a successful business model.

In terms of selection and concentration in the manufacturing-IT convergence field, it becomes necessary to develop particular IT cooperation fields and profitable convergence service models. This can be facilitated by selecting areas to focus on during specific stages of the product and service life-cycle. In addition, the ability to commercialize the business model is predicated on the implementation of pilot projects which are linked to existing industries' regional innovation resources.

The adoption of such an approach can help facilitate the reduction of risks in terms of the commercialization of the business model, as well as the smooth formation of new markets. It also necessary to prepare support measures such as the installation of exhibition halls for IT-converged products designed to facilitate marketing.

(2) Improvement of Laws and Institutions

The facilitation of the commercialization of IT convergence is predicated on the improvement of related laws and legal institutions. Such a step is needed to move beyond the limitations faced by

existing manufacturing industries. The emergence of new concepts of products and services renders it essential to introduce new regulations and to reorganize existing permission and licensing-related regulations.

In addition, there is a need to introduce advanced institutions in the areas of information security, safety. And, there is also a need to secure IT-convergence related industries. These facts make it incumbent that measures to streamline the legal system be put into place. Furthermore, the industrial classification of IT-converged products and services renders it necessary to improve regulations such as those related to quality evaluation standards. This is because the problem will emerge amidst the new industrial environment.

It is also vital that the commercialization and industrialization of IT convergence be facilitated through the establishment of measures to improve laws and legal institutions. For example, it can greatly contribute to facilitating the commercialization of RFID to improve institutions such as the mandatory attachment of RFID on containers in ports(internal regulations on the management of ports, Ministry of Land, Transport and Maritime Affairs). Another example is the mandatory introduction of RFID in conjunction with the management of in excess of 10,000 government procurement items(Enforcement Regulations of the Commodity Management Act, Presidential Committee on Green Growth(2009)). In the case of automobiles, the announcement of the Long-term Vehicle Fuel Efficiency Regulation Plan has led to the activation of the environment-friendly automobile industry. The plan is designed to improve current 'Average Fuel Economy Standards' and reduce vehicle fuel consumption and greenhouse gases

In addition, it is necessary to improve the IT convergence-related

legal system as it pertains to government support. IT convergence can be facilitated through the inclusion of incentives related to the introduction of IT technology. And, IT convergence also can be facilitated through the insertion of clauses pertaining to the mandatory introduction of such IT technology. Furthermore, it is essential that support measures that can ease the spread of IT converged products during the early stages be prepared. What's more, we should consider the high distribution costs associated with IT converged products during such early stages. The fact heightens the importance of the provision at the government level of taxation, financial, and institutional incentive during the early stage of the industrialization process.

(3) Standard Development and International Standardization

The activation of IT convergence and strengthening of the competitiveness of IT convergence requires the provision of support for the development of strategic standards. Such efforts should be made to bring about the international standardization needed to strengthen cooperation with international standardization organizations.

In this regard, there is an urgent need to establish a domestic standard system. Such a system would help to take the initiative in terms of international standards by facilitating active participation in the international standardization process. It would also lower prime costs through the increase of demand and advent of mass production. For example, in the case of the automobile industry, international standardization is required in order to secure the

platform technology that is needed to develop new IT technology-based next generation automobiles.

Meanwhile, in the case of the construction industry, there is a need to bring about the establishment and participation of an international standardization organization related to construction-IT convergence technology. It is also necessary to seize the initiative and preemptively occupy markets in terms of related technologies based on the introduction of market-oriented(De facto) standard and technology-led(De jure) standards.

(4) Education of IT Convergence Human Resources

It is necessary to activate human resources exchanges between traditional and IT industries by implementing an IT convergence workforce education program. In this regard, the education of human resources specialized in industrial convergence is essential. The policy will play a leading role in the creation of IT-converged new industries through the combination of IT and traditional manufacturing industries,

To attain this, it is necessary to establish an education system that is geared towards an enterprise demand-centered convergence technology workforce. It is also important to designate IT-convergence research centers(ITRC) at universities that will be responsible for educating highly-skilled R&D manpower. ITRC will be also responsible for producing human resources specializing in IT platform technologies such as RFID/USN, next generation semiconductors, and next generation displays.

The facilitation of organic convergence between traditional and IT industries necessitates that a clear mutual perception be developed

within both industries. The key to this endeavor ultimately lies in the production of convergence specialists. However, a more urgent task is that of establishing support policies designed to build human networks responsible for strengthening exchanges amongst specialists in the existing manufacturing and IT industries. This can help induce various forms of collaboration until the final stage of commercialization. This effect can be attained by fostering the sharing of development strategies as well as actual technological development throughout the entire value chain.

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