SEC BOOKS

ETSS
Embedded Technology Skill Standards

New Edition

Embedded Technology Skill Standards

ETSS Overview

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Introduction

Embedded software is installed on various electric and electronic equipment that surrounds us today including industrial instruments, automobiles, mobile phones and home electrical appliances, and plays a critical role in the functions of these equipment. Embedded software is key technology that supports the information society with capability to compete in international markets.

The Embedded Technology Skill Standards ("ETSS") is designed to be guidelines on "human resource development" and the "effective use of human resources" in order to reinforce embedded software development capabilities.

This Overview is an introductory guide to understand what Embedded Technology Skill Standards (ETSS) are.

Part 1 describes the circumstances surrounding embedded-related technologies.

Part 2 explains the overview and framework of the Embedded Technology Skill Standards on each of the three specifications: skills, career, and education and training.

Part 3 provides the examples of embedded technology skill standards utilization images and information on education program design guide.

Additionally, Version 1.2 of the Skills Specification, Career Specification, and Education and Training Specification are provided in the Appendices.

We sincerely hope this Overview to promote better understanding of the Embedded Technology Skill Standards.

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Part 1

Industrial Structure Changes Brought About by Embedded Technology, and Supply Chain

Part 1 explains the background of how the Embedded Technology Skill Standards were formulated and related issues, as well as describes the matters relating to the Embedded Technology Skill Standards.

1.1 Embedded Components in Products

Many industrial products around us make use of components designed using embedded technology. Even components that appear to be hardware components are achieved with embedded systems within the components. Figure 1.1 shows an example of a printer.

The polygon mirror and laser oscillator shown in this figure are components that employ an embedded system. Such components are supplied by component manufacturers called suppliers. Set manufacturers assemble printers with various components procured from suppliers.

The set manufacturers determine what would be the specifications of the products to be moved into the market and also provide the suppliers with the specifications of the components required for the product to be newly introduced. The suppliers design, develop and manufacture the requested components and supply them to upstream suppliers or set manufacturers (Figure 1.2). The general flow from specification formulation of products to be introduced to the market up to provision of components, is called supply chain. The aspect of the supply chain as a chain that supplies components, when viewed from a broader perspective that includes the market, can be regarded as a chain that provides technologies and which also includes set manufacturers. In this document, the chain including suppliers up to set manufacturers will be referred to as a technology chain to distinguish it clearly from a supply chain.

Larger scale technology chains also have been rolled out to overseas companies, including offshore companies. Within such technology chains that have global reach, the concept of only a single company strengthening its manufacturing capabilities will not be viable. It is necessary to extend beyond the views of a single company and take a standpoint of strengthening the manufacturing capabilities of the globally expanded technology chain as a whole.

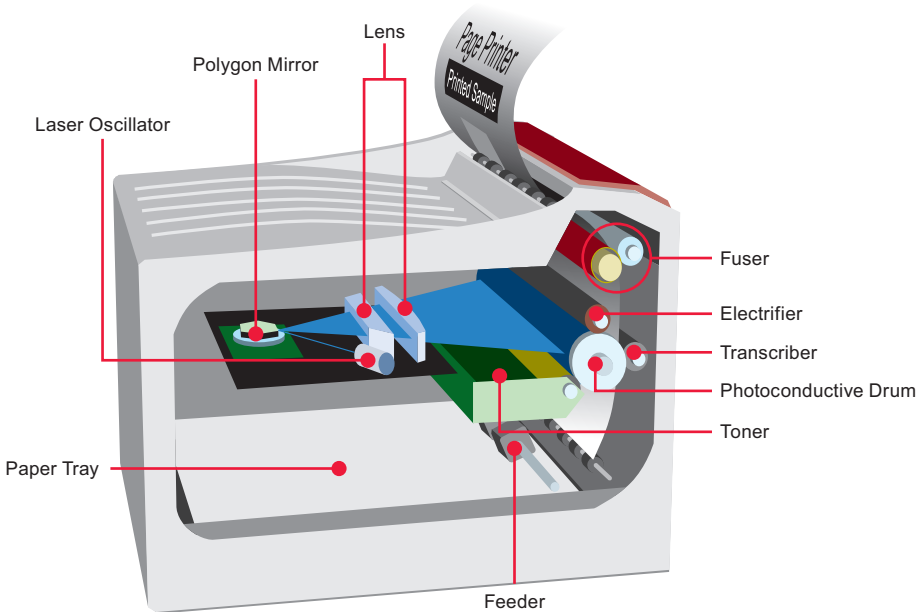


Figure 1.1: A printer also is a collection of components using embedded technology

Although these components appear to be physical components, their functions are achieved through embedded software (components shown in).

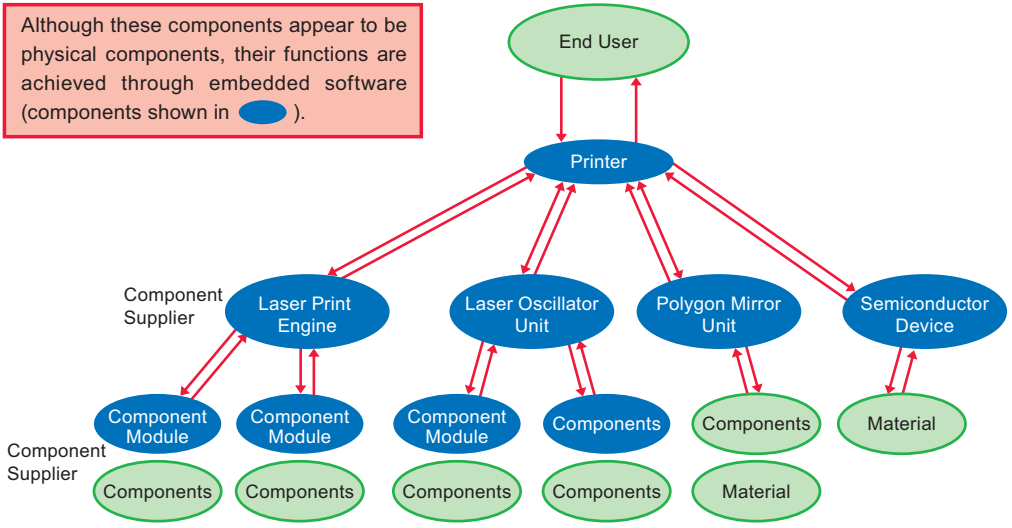


Figure 1.2: Relationship between suppliers and products in the case of a printer

1.2 Changes in the Industrial Structure Brought About by Embedded Technology

Figure 1.3 shows an overview of the structure of a global technology chain. In fact, the industrial structure may have been largely influenced by the advent of embedded technology.

Hardware-Oriented Type Chain

In Figure 1.3, the outer technology chain is the hardware-oriented type chain. This is a technology chain having a core of mass-production designing and manufacturing of hardware components, which are the forte of Japan. The strength of Japan is the capability to provide low-priced products through technologies for improving the yield at the manufacturing stage and producing in mass. However, it is undeniable that this strength has been diminishing with the standardization of hardware components.

Hardware & Software-Oriented Type Chain

The inner chain in Figure 1.3 indicates the hardware & software-oriented type chain. The embedded software constituting the embedded system employed in a component is created by a Research & Development (R&D) chain. From the viewpoint of a hardware-oriented type culture, the mission of this R&D chain does not include creation of products to be introduced to the market. Therefore, the culture of product quality can be considered to be still underdeveloped. However, embedded software is required to be completed in this R&D chain and embedded into components. This implies that the same quality as that required of hardware components will be required of embedded software that is a product of the R&D chain. In addition, because part of component functions will be sent as embedded software into the manufacturing stage, some of

the operations of the mass-production designing chain and manufacturing chain will be reduced, leading to a structural problem of decline in the added value of both the chains as compared to the existing hardware-oriented type chain. This structural change could be considered as a revolution in the technology chain.

Software-Oriented Type Chain

In some products, functions can also be improved with software without making changes to the hardware. In such cases, embedded software is directly provided to the product in the market, skipping the mass-production designing chain up to and including the product manufacturing chain. Within such software-oriented type chain, the value of mass-production designing and product manufacturing chains will disappear. Instead of treating this situation negatively, it must not be forgotten that the combination of all technology chains, including the software-oriented type chain, will lead to value creation.

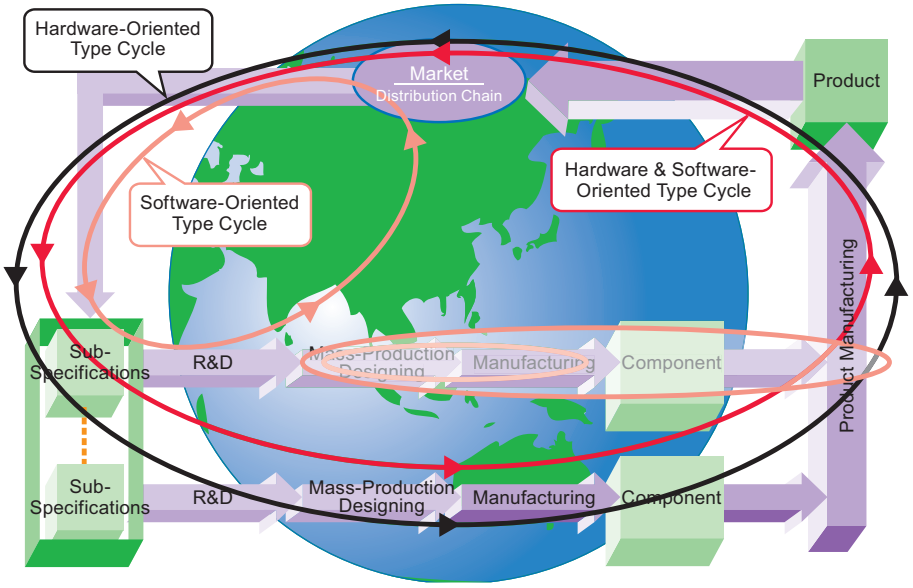


Figure 1.3: Supply chain innovation and human resource strategy based on embedded technology

1.3 Skill Chain

As mentioned earlier, embedded software has brought about structural changes which are in a way revolutionary to the technology chain used to manufacture products. Particularly in the R&D chain wherein the culture of securing quality has yet to develop, it has been a great issue how to satisfy the same quality requirements as those in the manufacturing stage for embedded software to be developed. The following two solutions can be proposed for this issue:

(1) Visualization and strengthening of skills (capability) for engineers who develop embedded software
(2) Development of technologies that improve the quality of embedded software

In the embedded software group of the IPA Software Engineering Center, (1) is developed as an embedded skills domain and (2) as an engineering domain.

The Embedded Technology Skill Standards (ETSS) are a solution to (1). At the same time, ETSS also gives a guideline to be able to plot strategies to cope with changes in the industrial structure. An important aspect of manufacturing, including embedded software, is to treat skills that fully utilize the technologies as one set. Technology alone cannot help with manufacturing. Manufacturing can be achieved only if there are enough skills to fully utilize the technologies. In other words, as shown in Figure 1.4, the technology chain is supported by the skill chain to constitute a technology chain. In addition, improvement and modification of technologies constituting the technology chain, or development of new technologies also depends on the skills of human resources.

ETSS is a tool for visualizing the relationship between such a technology chain and skill chain to enable skill management.

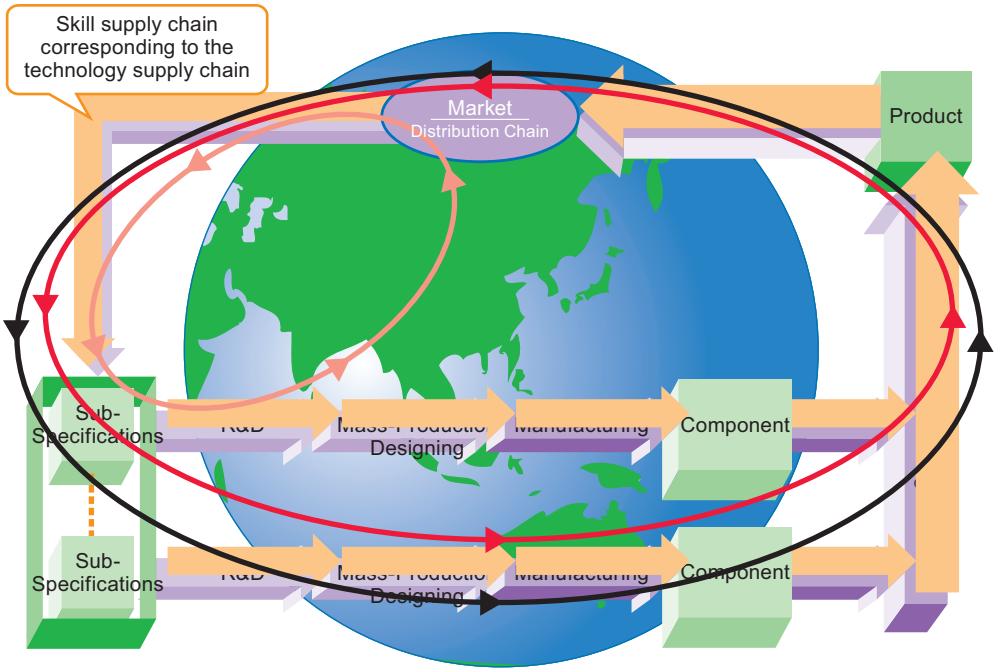


Figure 1.4: Skill supply chain superimposed on the technology supply chain

Technology and Skill

We often use words like “that person (company) has technological capabilities” to describe a competent engineer or front-line company. More often than not we use the phrase “technological capabilities” without paying attention to whether this phrase means “technology” in the form of knowledge or “skill” in the form of development capabilities.

This Embedded Technology Skill Standards (ETSS) defines a framework based on the clear distinction between “technology” and “skill.”

Let’s quickly discuss the reason for the clear distinction between “technology” and “skill” and the difference between these.

In this ETSS, “technology” refers to “the flow of processes (procedures) for designing, developing, and manufacturing an object (product) to be developed, and the tools used to achieve the processes, or the product itself produced through the processes.” “Technology,” which can be rephrased as “knowledge,” has a characteristic of being able to be communicated to many people at once through documentation, including manuals and instructions.

On the other hand, “skill” refers to “the expected level of how much capability an individual has to actually put a “technology” to use. No matter how superior a technology (such as development methods and tools) an organization introduces, if the organization does not have people with the capabilities (skills) to actually utilize it, it is difficult to achieve expected results.

Having said that, it is not quite right to put too much emphasis on “skill” alone. This is because an understanding of the technology to be used, and in some cases, suggestions for improvement of the technology may be required as prerequisites for “skilled” personnel. One should think in the way that any “skill” based on solely experiences without the background of “technology” cannot be applied to the development of a new product, or changes in technology trends.

In order to clearly distinguish between “technology” and “skill,” and develop a product, we can analyze the development potentials, strengths, and weaknesses of the organization or an individual by evaluating the processes and tools (technology) being used, and also the level of capabilities (skill) to make their best use.

Furthermore, after determining what skill is missing in what technology based on the analysis results as mentioned above, it is desired to carry out human resource development in view of the learning characteristics that clarify whether a case is to be communicated as “technology” or whether training is to be provided on it as a “skill.”

About ETSS

Extracting Skill Items

"How do we go about extraction of skill diagnosis items?" is one of the main questions asked by people examining the introduction of ETSS.

In ETSS, technological classification is provided up to the second hierarchy for each of the categories of "technological elements," "development technology" and "management technology" in the skills specification. Based on this, before implementing skill diagnosis, the skills specification must be customized according to the users' requirements by deepening the hierarchy (subdivision, embodiment) and expanding the classification (extension of the target domain).

If an attempt is made to extract skill diagnosis items, there will be many instances of doubts and worries including "Up to what level must subdivision be done?" or "Is there any deficiency or excess in the extracted skills?" To avoid such situations, it is essential to clearly specify at least the purpose of "Why ETSS is to be introduced?" or the utilization scene of "How to leverage ETSS?"

For example, let us assume a usage scene of "Periodical skill diagnosis of department engineers" for the purpose of "Developing development engineers for xx product in the yy department."

The skill items to be extracted with this assumption must be extracted by focusing on the technologies (such as the components of the xx product, development techniques, and management tools for xx product) used to develop the "xx product." First of all, the directly required technologies must be aimed at and extracted. Because the purpose "to develop" is also included, the fundamental technology for utilization of the required technologies must be examined.

Also because the department is limited to the "yy department," technologies not used by the applicable departments may be excluded even if these technologies are required for developing the "xx product."

In this way, by setting the purpose and usage scene of ETSS, the skills that need to be extracted can be restricted to an extent. Naturally, if the assumption is changed in the above example, the range of extraction of skill items and the depth of the hierarchy must also be changed. If the restriction of "xx product" is removed, all products handled by the "yy department" will become the target of extraction.

In addition, best results seem to be obtained not by attempting to establish a complete skills specification with only one-time skill extraction, but by starting extraction of items from a limited range first, repeating the evaluations and improvements for the usage purpose, and extending the range in small steps, to finally raise the perfection level gradually.

Relationship between Common Career Skills Framework (CCSF) and ETSS

The Common Career Skills Framework (CCSF) is a common framework for development and evaluation that organizes the human resource models of high-level IT professionals and the capabilities they must have as required by our country in the future from the viewpoint of the roles (contribution) to be played by these human resources. CCSF is a reference model for each skill standard including Skill Standards for IT Professionals (ITSS), Users' Information Systems Skill Standards (UISS), and Embedded Technology Skill Standards (ETSS). The Information Technology Engineers Examination to be conducted from April 2009 has been designed as a system that, in principle, conforms to CCSF.

Career and Level

CCSF defines three human resource types that are further classified into six human resource models (Table).

Each job category defined in the ETSS career specification is assigned to corresponding human resource model.

Table: Human resource types and models in the Common Career Skills Framework (Excerpt)

Human Resource Type	Human Resource Model	Role of the Model (Outline)
Basic Strategies	Strategist	Leads enhancement of business values using IT.
Solutions	System Architect	Designs the optimum system aligned with the business strategy.
	Project Manager	Coordinates the set up of a high-reliability system under the given restrictions (quality, cost, delivery, etc.).
	Technical Specialist	Takes charge of implementing on technology domains such as the database and network.
	Service Manager	Maintains the system while securing continuous high reliability.
Creation	Creator	Brings innovation to the society and economy by creating new element technologies.
Others	N/A	Corresponds to education of Skill Standards for IT Professionals.

Career Level

The career level (not skill level) is defined in seven stages from level 1 to level 7 based on the extent of the capabilities required of human resources and the roles (contributions) to be played. This definition is the same as that of the ETSS career level.

Body of Knowledge (BOK)

In CCSF, the knowledge required for career level 1 through 4 is systemized as a common BOK (Body of Knowledge). This BOK is classified into nine large classifications and 23 middle classifications. These classifications cover the technologies for ITSS, UISS and ETSS.

BOK has the same hierarchical structure as ETSS skills specification and covers all technological elements, development technologies and management technologies of the ETSS skills specification. BOK can be used in embedded development and is particularly expected to be used as the basis for skills specification in organizations handling enterprise systems.

Furthermore, because BOK is known as a knowledge system, it is also beneficial for visualization of knowledge acquisition. The knowledge associated with algorithms and computers is organized systematically such that it can be used not only for the preparation of the Information Technology Engineers Examination but also for checking the comprehensiveness of knowledge acquisition.

For further details, see CCSF. CCSF can be downloaded from IPA's website (http://www.ipa.go.jp/ *Available in Japanese only).

"*ShuHaRi* (Obey, Break, and Separate)" – Japanese Traditional Human Resource Development Concept That Forms the Basis of ETSS

This section describes "*Shu* (Obey), *Ha* (Break), and *Ri* (Separate)," one of the basic concepts of ETSS / skills specification.

ShuHaRi (Obey, Break, and Separate) has been considered to be a traditional Japanese human resource development policy in tea ceremony and martial arts. Although the period and person who stated this word is not certain, and the range of its interpretation also varies, it can be briefly interpreted as follows:

Shu (Obey):	The aim is to become able to follow the guidance and behave according to the provided form.
Ha (Break):	The aim is to be able to behave at will with little awareness of following the form, although the provided form is followed to some extent, and furthermore to be able to instruct younger people.
Ri (Separate):	The aim is to transcend what one has mastered and create further essential forms and ideas.

Once a person has been trained in "*Shu*" and has reached its goal, he or she can move to the next step of "*Ha*." Once the goal of "*Ha*" has been achieved, it is possible to proceed to the next step of "*Ri*." The biggest goal in the "*Ri*" step is to create a new system outside the frame of the system understood until now. In other words, the final step "*Ri*" of *ShuHaRi* is not to bring up disciples or "yes person" who follows you. It also does not imply observance of tradition. The purpose of "*Ri*" is to become independent from the current world you are learning from and develop younger people who are able to establish a new world. In this way, only a single word *ShuHaRi* shows the steps and final direction to be taken to aim at human resource development.

In order to be able to "behave according to the provided form" in *ShuHaRi*, it is not

only necessary to acquire proficiency in the form but also learn objectivity and heart positioning, as well as various elements such as breathing techniques and health management methods. For example, when two swordsmen fight to the finish, the technique, form or style of the winner is not always superior to the other. Success or failure is the result of various combined elements such as techniques of both parties, technique level, strategy, physical condition, mental condition and luck. There is not a simple reason that the winner's "technique" or "form" was superior, nor is this an ambiguous story wherein the reason of success is cited as accumulated experiences or superior "style." It is required not only to simply learn the form and hone one's technique but also climb the steps of *ShuHaRi* as a human by acquiring various elements such as manners, health management method and heart positioning.

In the meantime, what are the required conditions to achieve the goal of "*Ri*" wherein there are no direct instructors? These conditions include the capability to objectively observe the target, learn from any person or matter regardless of their strength, age, or seniority and have a flexible mind to be able to deny, affirm or correct various elements which have already been acquired.

Let us find out the policy of *ShuHaRi* in the world of martial arts. For example Mr. Kamiizumi-isenokami who learned *Kageryu* created *Shin-kageryu* and Mr. Yagyu-sekishusai who learned *Shin-kageryu* created *Yagyuryu*. Many styles were born in this manner. Seventy styles were said to have participated in the old martial arts tournament held in 1957 ("New 100 Best Japanese Swordsmen," Kiyoshi Watatani, Akita Shoten, 1990).

Since we dug into maniac contents, let us delve into the game of *Go* a little. Once the game of *Go* is fought to the finish, it is common for both participating parties to analyze the good and bad moves of each other to be able to create a better game than the game that got over. As a result, new policies and set sequences are created. The same will be applied to the world of technologies by not only aiming at the technologies but also widening the view to develop the skills of personnel using these technologies, and looking for the essential qualities such as ideal skills and ideal engineers. The same concept of *ShuHaRi* will also be applied here.

Part 2

ETSS

Part 2 describes an outline of ETSS as a whole, as well as explains skills specification, career specification, and education and training specification which constitute ETSS.

2.1 The ETSS Concept

ETSS Overview

ETSS is designed to promote the development and utilization of human resources for strengthening embedded software development capabilities. ETSS consists of the following three elements.

- "Skills Specification" as a framework for systematically organizing embedded software development skills
- "Career Specification" for defining the job category names and job capacities concerning embedded software development
- "Education and Training Specification" for achieving human resource development related to embedded software development

In the career specification, the skills defined in the skills specification are used to describe what kind of skills are required to pursue the roles in the job categories or specialty fields concerning embedded software development.

In the education and training specification, we use the skills organized in the skills specification to specifically indicate the target educational scope and level for how contents studied in the education programs correspond to what skills.

As mentioned above, the career specification and education and training specification are related with each skill organized by the skills specification.

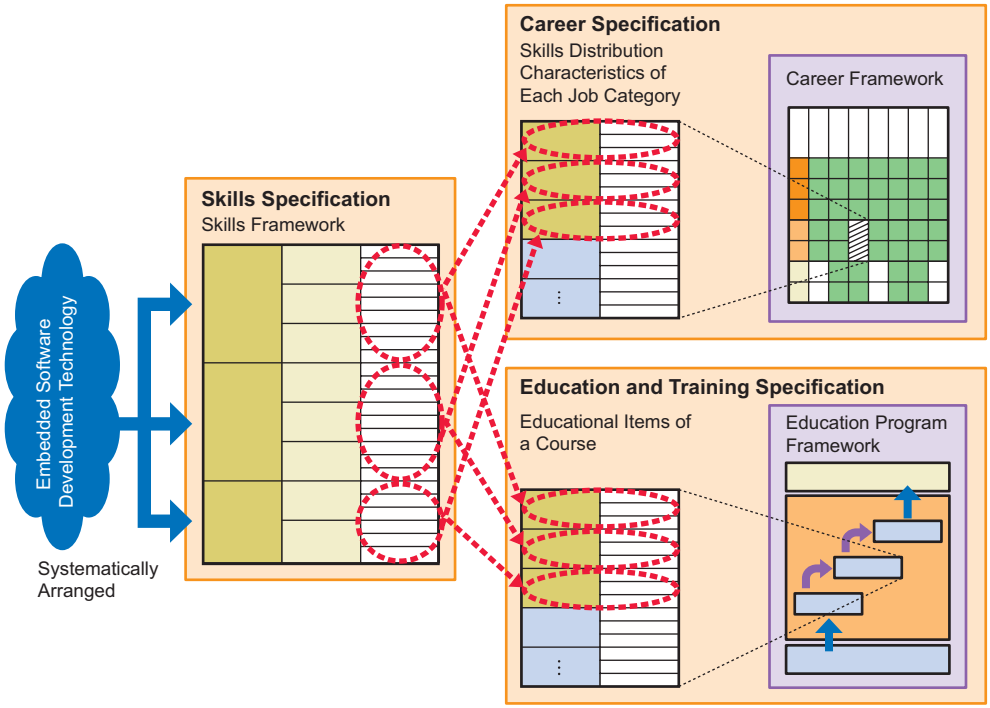


Figure 2.1: Concept of Embedded Technology Skill Standards (ETSS)

2.2 Skills Specification

Skills Specification Framework

The skills specification framework is structured as shown in Figure 2.2 and organizes the skills required for embedded software development based on the following three perspectives.

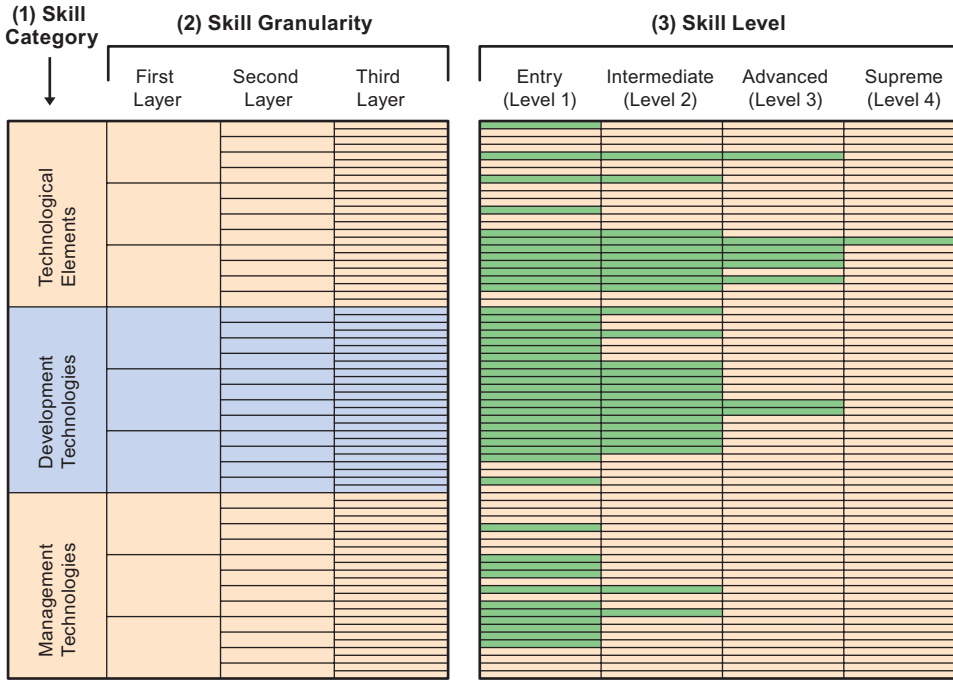


Figure 2.2: Skills framework

(1) Skill category: Indicates categorized skills.

(2) Skill granularity: Indicates depth of skill categories.

(3) Skill level: Indicates skill level.

The Three Categories of the Skills Specification

The skills specification consists of "technological elements," "development technologies" and "management technologies."

The relationship between these skill categories is "by using 'technological elements' as constituents when developing embedded system products, conduct development 'using development technologies' and manage development projects 'by making full use of management technologies'." An image of the relationship is shown in Figure 2.3.

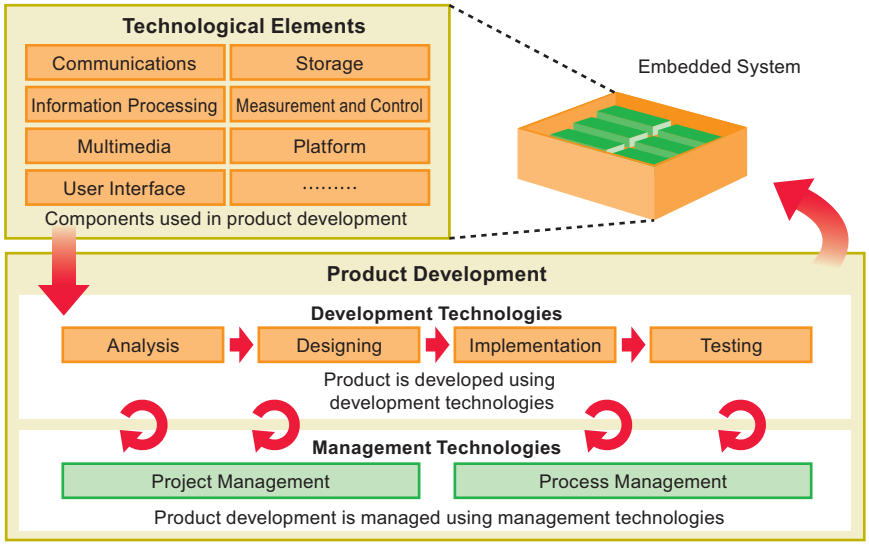


Figure 2.3: Image of relationship between skill categories

Technological Element Skill Category

The technological element skill category defines elements that achieve their functionality once embedded in a system. This category systematically organizes various technological elements including as algorithms, logic, components and standards. Realization of the functionality of these elements can be based on either hardware or software.

The first layer of technological element skill category is defined as follows.

(1) Communications: Element related to communications
(2) Information Processing: Element primarily related to hardware independent data processing
(3) Multimedia: Element related to voice, still image, and moving image processing
(4) User Interface: Element related to control of devices used by people
(5) Storage: Element related to storage system control and processing
(6) Measurement and Control: Element related to external device related to measurement and control
(7) Platform: Element related to the infrastructure for application realization

Image of the correlation between the first layer items ((1) through (7)) in the technological element skill category and the second layer in the items is shown in Figure 2.4.

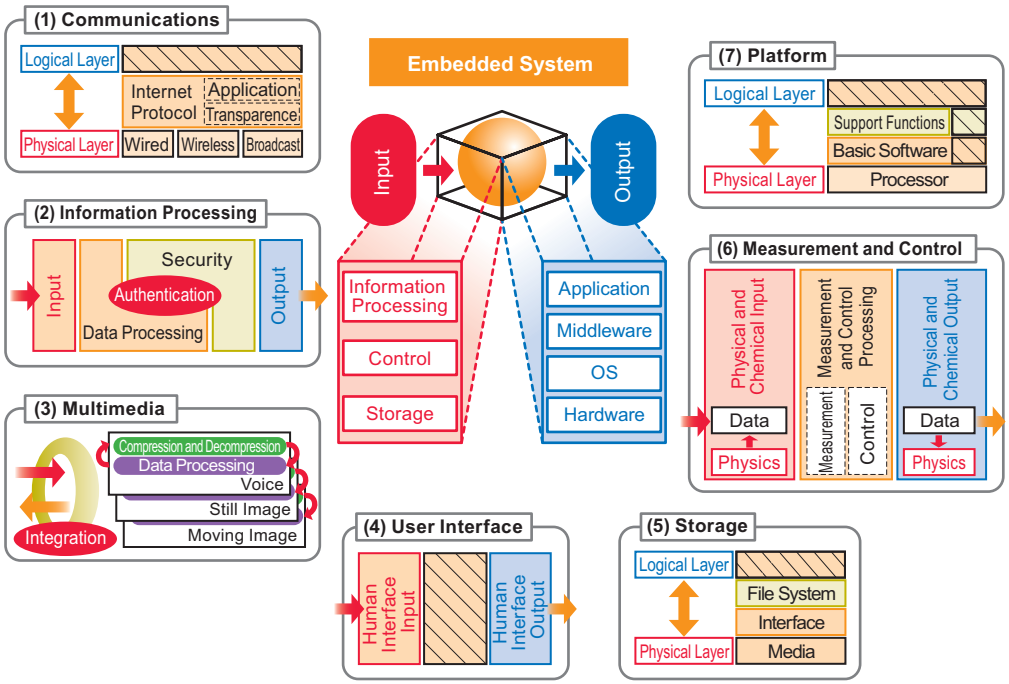


Figure 2.4: Outline and correlation of the technological element skill category

An excerpt from the technological element skill category of the skills specification and an example of the roll-out of skill items are shown in Figure 2.5.

First Layer		Second Layer		Description
1	Communications	1	Wired	Wired communication technologies, such as WAN, LAN, etc.
		2	Wireless	Wireless communications technologies, such as telecommunications and general business wireless technology
		3	Broadcast	Broadcasting technologies, such as digital broadcasting and analog broadcasting
		4	Internet	Internet technologies, such as transparent data transfer and applications
2	Information Processing	1	Information Input	Information input, such as data input and voice input
		2	Security	Security technologies, such as encryption and copyright protection
		3	Data Processing	Data processing technologies, such as compression and databases
		4	Information Output	Information output technologies, such as markup language and document viewers
3	Multimedia	1	Voice	Voice processing technologies, such as data processing, voice compression and voice decompression
		2	Still Image	Still image processing technologies, such as data processing, compression and decompression

Roll-Out

First Layer		Second Layer		Third Layer		Skill Items	Skill Level	
							Can Produce	Can Utilize
⋮	⋮	⋮	⋮	⋮	⋮	⋮		
1	Communications	4	Internet	1	Transparent Data Transfer	1	PPP		
						2	IP		
						3	ICMP		
						4	ARP		
						5	TCP		
						6	UDP		
				2	Application Processing	1	HTTP		
						2	SMTP		
						3	Telnet		
						4	FTP		
						5	SIP		
						6	DNS		
						7	POP		
						8	DHCP		
						9	SNMP		
						⋮	⋮		

Skill Assessment Criteria (Examples)
- **Skills that can produce**
  FTP can be performed using the required specifications, conditions, features, case examples, information, etc.
- **Skills that can utilize**
  Functions using FTP can be achieved by using required specifications, conditions, features, case examples, information, etc.

Figure 2.5: Example of the roll-out of skill items (technological element skill category)

Development Technology Skill Category

The development technology skill category organizes technologies and skills used in embedded system development. For example, the category consists of programming technologies, debugging technologies and testing technologies. This category organizes a series of development skills starting from the analysis of requirements associated with embedded system development to design, implementation and testing.

The first layer of the development technology skill category defines 10 items as follows.

- System requirements analysis
- Software requirements analysis
- Detailed software design
- Software integration
- System integration
- System architecture design
- Software architecture design
- Software coding and testing
- Software qualification test
- System qualification test

The skill items of the first layer shown above use development processes specified in ISO/IEC12207 (JIS X 0160) (Software Life Cycle Process). The second layer assigns relevant tasks (management technologies excluded) from the skills specification defined for technical engineers (embedded system) and software development engineers of the Information Technology Engineers Examination. Defining the development skills per individual task enables visualization of development technology skills associated with embedded software development.

An excerpt from the development technology skill category of the skills specification and an example of the roll-out of skill items are shown in Figure 2.6.

First Layer		Second Layer		Description
1	System Requirements Analysis	1	Requirements Acquisition and Adjustment	Interviewing methods, marketing methods, etc.
		2	System Analysis and Requirements Definition	Modeling methods, analysis methods, requirements definition, etc.
		3	Review of System Analysis and Requirements Definition	Review methods, inspection methods, etc.
2	System Architecture Design	1	Hardware and Software Function and Performance Assignment Decision	Performance estimation, FMEA, FTA, software estimation methods, intellectual property rights, etc.
		2	Implementability Verification and Design Review	Review methods, inspection methods, etc.
3	Software Requirements Analysis	1	Software Requirements Analysis Definition	Modeling methods, analysis methods, requirements definition, etc.
		2	Software Requirements Evaluation and Review	Review methods, inspection methods, etc.

Roll-Out

First Layer		Second Layer		Skill Items		Skill Level
1	System Requirements Analysis	1	Requirements Acquisition and Adjustment	1	Business Judgment	
				2	Interview Methods	
				3	Consulting Methods	
				4	Market Research	
				5	Positioning	
				6	Presentation	
				7	Requirements Definition Document	
				8	Concept Sheet	
				⋮	⋮	
		2	System Analysis and Requirements Definition	1	Modeling Methods	
				2	Analysis Methods	
				3	Requirements Definition	
				⋮	⋮	
		⋮	⋮	⋮	⋮	

Skill Assessment Criteria (Examples)
By using modeling methods, not just customer requirements but also system requirements can be analyzed.

Figure 2.6: Example of the roll-out of skill items (development technology skill category)

Management Technology Skill Category

The management technology skill category organizes management technologies and skills used to proceed embedded system development smoothly. This category organizes the "project management" knowledge items already defined as job categories within the Skill Standards for IT Professionals and the support processes defined in JIS X0160.

This category also organizes skills associated with management tasks of embedded software development from development project planning to configuration management and change management. The following two items are defined in the first layer of the management technology skill category.

- Project management
- Development process management

The management technology skill category is targeted at management associated with embedded software development projects.

However, it is not applicable to the management of organizations (line management) that do not contain elements specific to embedded software.

An excerpt from the management technology skill category of the skills specification and an example of the roll-out of skill items are shown in Figure 2.7.

First Layer		Second Layer		Description
1	Project Management	1	Integration Management	WBS, EVM, conference management methodologies, review methods, etc.
		2	Scope Management	WBS, change management, etc.
		3	Time Management	PERT, Gantt chart, estimation methods, etc.
		4	Cost Management	ROI, ROE, estimation methods, EVM, etc.
		5	Quality Management	Audit, failure analysis, statistical methods, trend analysis, etc.
		6	Organization Management	Team building, OBS, etc.
		7	Communication Management	Information distribution methods and others
		8	Risk Management	Risk analysis, decision tree analysis, risk rating, etc.
		9	Procurement Management	Planning, procurement destination selection, contracts, performance management, etc.
		1	Development Process Definitions	System development process definitions, review planning, etc.

Roll-Out

First Layer		Second Layer		Third Layer		Skill Items
⋮	⋮	⋮	⋮	⋮	⋮	⋮
1	Project Management	3	Time Management	1	Activity Definition	1 WBS
						2 Organization Knowledge
						3 Deliverables Review
						4 Project Plan Document
						⋮
				2	Schedule Creation	1 PDM Method
						2 ADM Method
						3 Activity List, Project Network Diagrams and Templates
						4 Analogous Estimating Methods
						⋮
				3	Schedule Control	⋮
						⋮

Skill Assessment Criteria (Examples)
Schedules can be created using the ADM (Arrow Diagramming Method).

Figure 2.7: Example of the roll-out of skill items (management technology skill category)

Skill Granularity

Skills are arranged (detailed, embodied) in layers within each skill category.

As a standard, the skill categories contain 1 to 4 layers. The “technology name” appears in the lowest layer as the specific skill. This technology name shall be considered as a skill item. When

categorizing skills, if a specific technology name to be considered as a skill item does not appear, the skill category is further divided into five or more layers, if necessary.

Technology name indicates the technological item name widely accepted as a representation of the skill. This includes, for example, the standardized methods, methods commercialized in the market, and methods publicized through documents.

The skills specification provides only the systematic framework of skills, and does not present and disclose specific technology names. This is because, as a standard, the skills specification may restrict the progress and expansion of technology by limiting the scope to specific technologies.

Adding Skill Items and Categories

Skill categories and skill items can be added as necessary. This is because the framework is such that if necessary, the user can add skill categories and skill items thus enabling the creation of the skills specification that fits actual situations. Industrial groups and companies of the application domain can add skill items specific to their domain making it possible to apply characteristic highly practical skills specification.

Keeping the added specific skill items private and undisclosed to the public makes it possible to secure competitiveness and conceal proprietary technologies.

On the contrary, by disclosing the skill items to the public, one can expect to secure human resources and promote improvement in skills by specifying the skills required for the corresponding application domain and companies.

Defining Skill Levels

With the skills specification, levels are defined for each skill item in order to enable visualization of the results of skill measurement.

Skill levels are represented in 3 + 1 levels, including the entry level, intermediate level, and

advanced level, and in addition, the supreme level.

Skill levels

• Level 4	Supreme	Capable of developing new technologies
• Level 3	Advanced	Capable of analyzing and improving tasks
• Level 2	Intermediate	Capable of performing tasks on one's own
• Level 1	Entry	Capable of performing tasks with support

If the tasks that must be handled in each skill level are arranged in the form of input (items that can be expected as prerequisites of a task), processing (tasks to be implemented), and output (items expected as results), the arrangement shown in Figure 2.8 can be perceived.

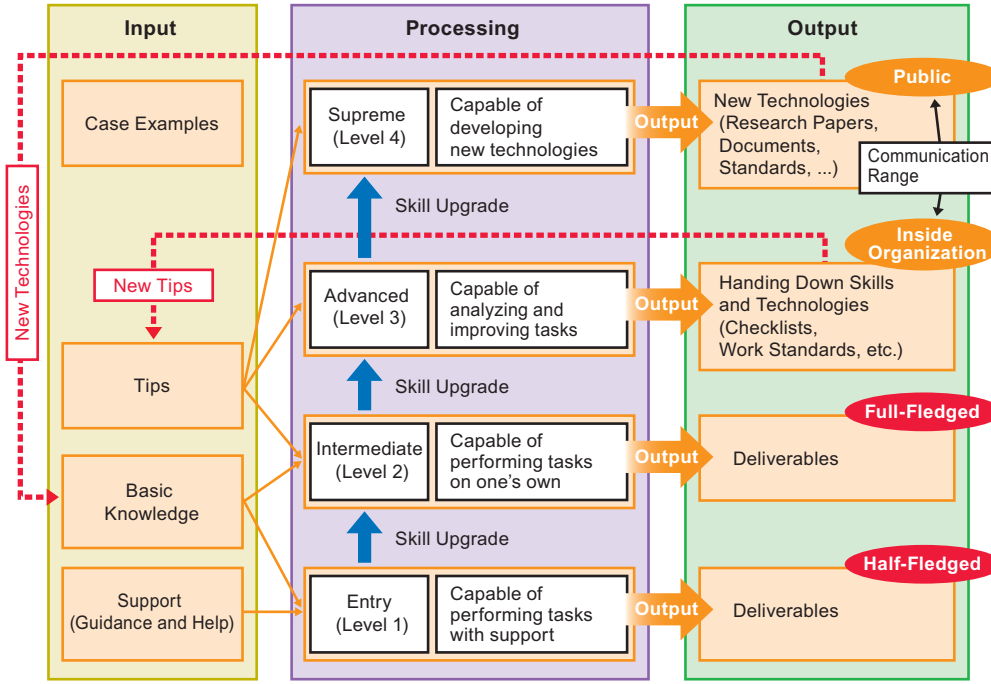


Figure 2.8: Results expected in each skill level (output)

In the technological element skill category, the skill levels are divided into "skills that can produce" and "skills that can utilize." This is based on the fact that the nature and level of the skills to be used differ depending upon whether a person is capable of "producing" a technological element as a function, or whether a person is capable of "utilizing" a technological element to implement a function.

Measuring Skills

The requirements of skill items to be fulfilled are defined as skill assessment requirements. Overall common assessment requirements are provided in the skills specification.

- Assessment requirements of technological elements

  Skills that can produce: "Capable of implementing the xx technology within a given environment."

  → xx: Technological element name

  Skills that can utilize: "Capable of incorporating the xx technological element to implement the required function within a given environment."

  → xx: Technological element name

- Assessment requirements of development technology

  "Capable of yy using zz."

  → zz: Development technology methods name, development tool name

  yy: Development process name

- Assessment requirements of management technology

  "Capable of yy using zz."

  → zz: Management technology methods name, management tool name

  yy: Management process name

Two viewpoints concerning action and knowledge are required in the case of the phrase "capable of yy" used in the assessment requirements.

"Capable of yy" refers to the fact that the task can actually be performed as an action. When performing a task, while "accuracy" and "efficiency" are the basic requirements, skill application capability in the form of appropriate "judgment of the situation" is also required. A prerequisite for performing such actions is the knowledge of the technologies and tools to be used in the task. Knowledge of the object on which the technologies and tools are to be used, as well as awareness of the environment and procedures are also required.

By checking these actions and knowledge, it will become possible to assess whether "capable of –." A few examples of skill measurement methods are presented below (Table 2.1).

The skill measurement methods presented here are mere illustrations. Skill measurement methods are not limited to these methods alone. A skill measurement method must be selected in accordance with the usage purpose of the skills specification because there is a trade-off between the effort and cost and the credibility of the measured values.

Table 2.1: Examples of skill measurement methods

Assessment Method		Outline
Self Reporting		A self report, or a report including the results of an interview with the mentor, such as a superior → Currently, this assessment method is the main trend in many companies
Evidence		The assessment of "capable of -" is conducted using evidence such as work history → Equivalent of ISO9001. Defining evidence for each technological skill is extremely difficult.
Tests	Selective Response	Assessment based on multiple-choice questions
	Description	Assessment based on free description format questions
	Statement	Assessment based on short essay description tests
	AO (Admission Office)	Assessment based on performance and interviews
	Practice	Judgment based on case studies, and execution of evaluator tasks
Trial		Assessment of skills through trials during a fixed probation period

2.3 Career Specification

ETSS Career Specification Overview

In the ETSS career specification, the job categories related to development of embedded systems are categorized into 10 categories including “project manager,” “system architect,” and “software engineer,” and individual areas of specialization is established for each job category.

The career specification aims at realizing an environment that enables appointment of the right person for the right place and development of human resource from the viewpoint of engineering. They are under consideration to be established as indicators to obtain consensus such as “the responsibility of embedded software development lies with the embedded software engineer” and “the responsibility of managing the development of embedded software lies with the embedded software project manager.”

It is expected that based on the indicators presented in the career specification, concerns such as “what should be learned and experienced and how as human resource development” and “what strategies and tactics should be employed to leverage human resources” are addressed through approaches and actions from an engineering point of view.

An outline of each job category based on the classification in the career specification is presented below:

Product Manager

A person responsible from an administrative point of view for the overall life cycle of a product from product planning, to development, manufacturing, and maintenance

Project Manager

A person responsible for planning, leading, and supervising a product development project during the course of its setup and execution

Domain Specialist

A specialized technical engineer having high-level and expert knowledge and development experience regarding a specific technology and product field

System Architect

An engineer who designs the system structure and development processes fulfilling the requirements of system usage and development

Software Engineer

An engineer responsible for the development, implementation and testing tasks during each software development process

Bridge SE

An engineer responsible for coordination between project organizations dispersed organizationally and geographically

Development Environment Engineer

An engineer responsible for the design, setup, and operation of the development environment, including the tools and equipment used in the project

Development Process Improvement Specialist

A specialized technical engineer responsible for assessing the development processes and their execution status, and propelling the improvement process

QA Specialist

A specialized technical engineer responsible for propelling the tasks of securing, maintaining, and improving quality in all processes of a project

Test Engineer

An engineer responsible for executing various test operations, including test designing and test execution

Responsibility of Job Categories

Each job category participating in embedded system development must play a certain role and take up certain responsibilities.

The scope of responsibilities of the job categories and examples are presented in the ETSS career specification, and the roles to be executed by each job category are clarified. The skills and knowledge required for each job category are what will be expected when assuming these responsibilities (Table 2.2).

Table 2.2: Responsibilities required of each job category

Job Category Name	Responsibility	
	Scope of Responsibilities	Examples of Responsibilities
Product Manager	Product development business	Revenue and contribution
Project Manager	Project	Quality, cost, and delivery
Domain Specialist	Roll-out of technologies	Efficiency of product development
System Architect	System structure and implementation method	Development efficiency and quality
Software Engineer	Deliverables of software development	Quality, productivity, and delivery
Bridge SE	Joint operations with external organizations	Quality, cost, and delivery
Development Environment Engineer	Quality of the development environment	Usability and work efficiency
Development Process Improvement Specialist	Improvement of development processes of the organization	Process improvement effect
QA Specialist	Process quality Product quality	Quality problems after shipment
Test Engineer	System validation and verification	Quality, test efficiency, and test delivery

Figure 2.9 shows the arrangement of the above-mentioned responsibilities to be executed by each job category from the viewpoint of the organization and project system.

Within an organization, the required skills and knowledge can be associated based on the target range of the responsibilities to be fulfilled during the course of work for each job category (embedded system or embedded software), and also based on the position (positioning).

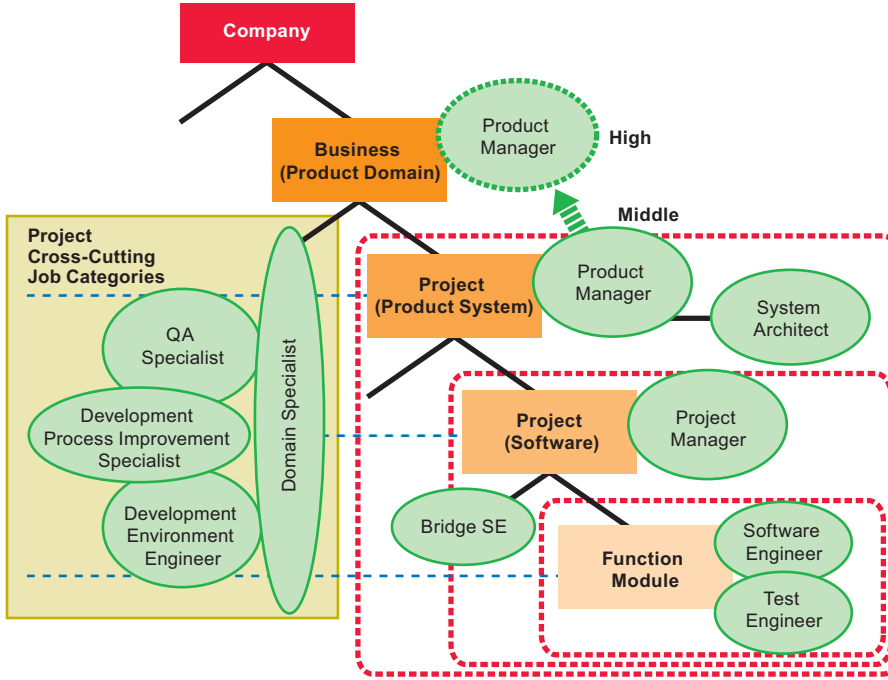


Figure 2.9: Image showing the relationship between an organization and job categories

Defining Career Levels

In the career specification, career levels are presented in seven stages in each job category and specialty field based on the degree of economical efficiency and responsibility required of a professional.

As the career level gets higher, the degree of economical efficiency and responsibility towards the society also increases (Figure 2.10).

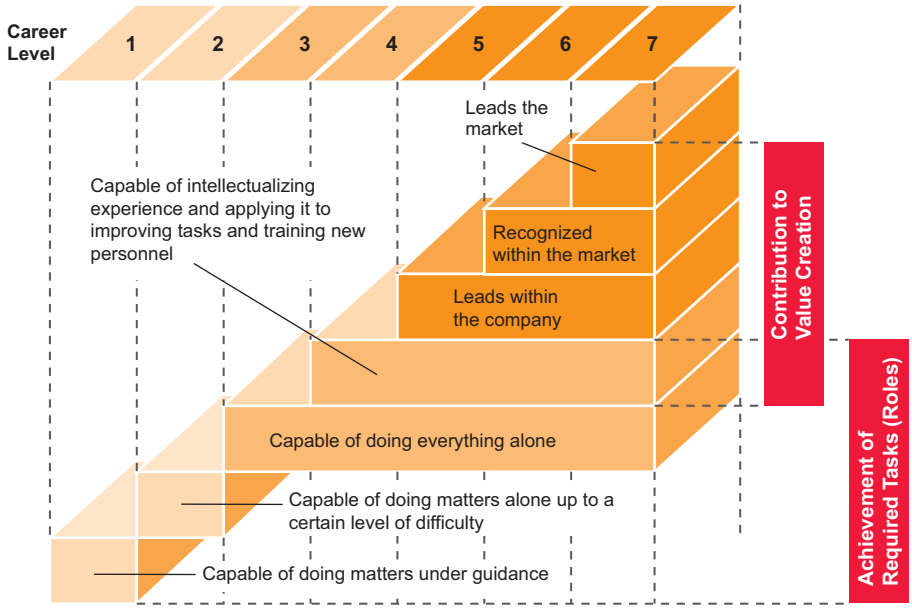


Figure 2.10: Relationship between the career level and economical efficiency and responsibility towards the society

Figure 2.11 shows the lateral arrangement of the levels of job categories and specialty fields.

In Figure 2.11, each colored section indicates that a career level exists in that particular job category or specialty field. In some job categories and specialty fields, professionals are not required to exhibit economical efficiency and responsibility in the lower levels.

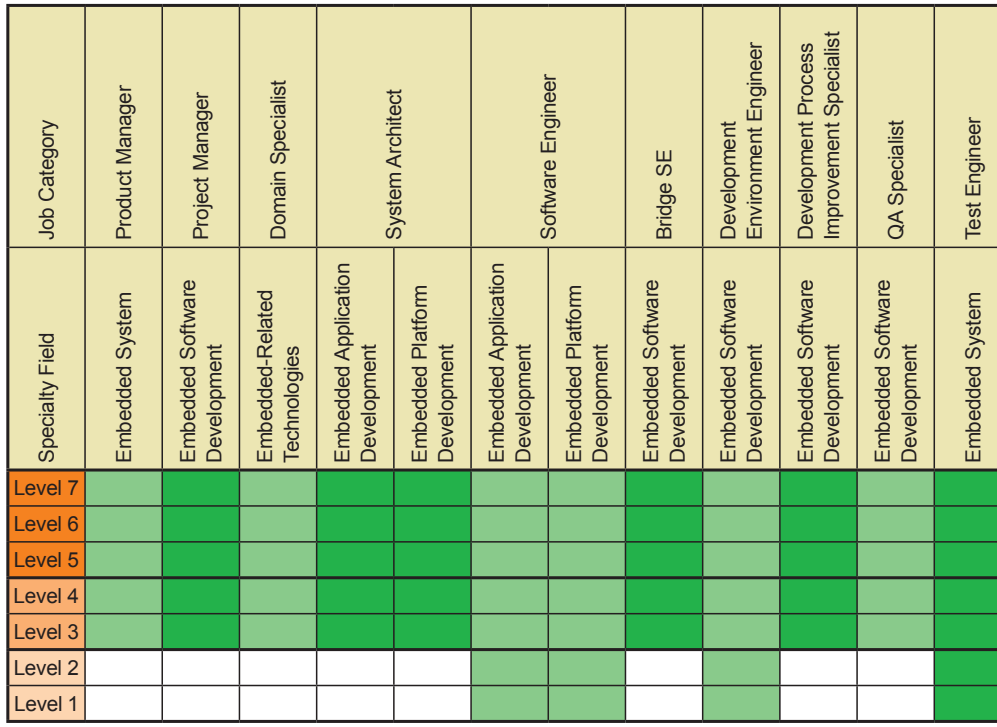


Figure 2.11: Career framework

Concept of the Career Path

This section describes the concept of the career path used to upgrade or change a career in a job category or specialty field defined in the career specification. In this Overview documentation, cases in which a level is upgraded within the same job category or specialty field are referred to as career upgrade, while a change of a job category or specialty field is called a career change.

Although the levels of the job categories and specialty fields that can participate in embedded software development are limited depending upon the skills and experience of the person, it is possible to plot various career designs starting from a level and aiming towards the direction in which to proceed.

When a career is upgraded or changed, various conditions need to be fulfilled, such as the

related skills set up in the level of the job category after change. In other words, once these conditions have been cleared, it is possible to change or upgrade the career from the current level of a job category to the target level of a job category (Figure 2.12).

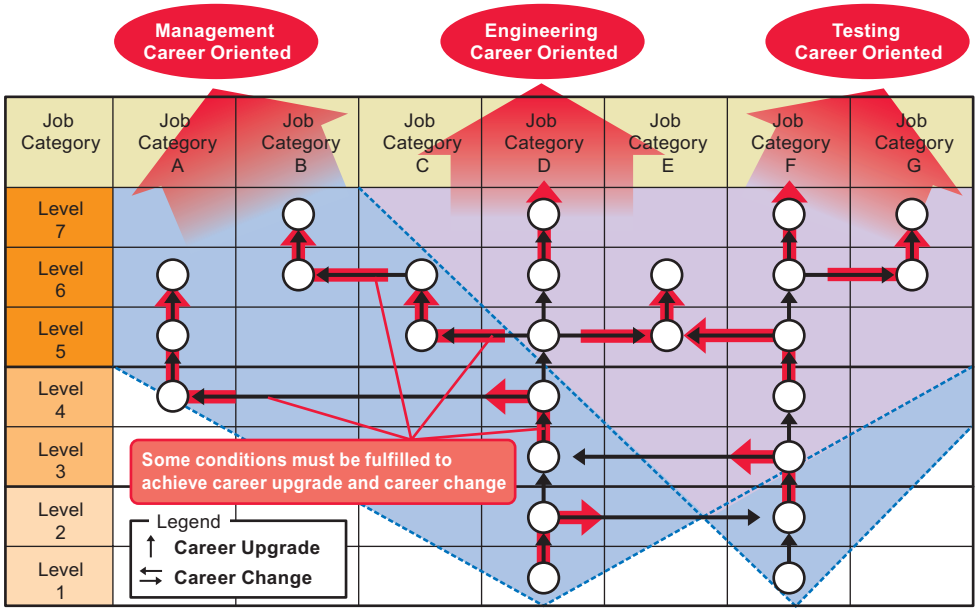


Figure 2.12: Relationship between career upgrade and career change

Starting with the current job category and level as the base, various career paths can be envisaged as the route to attaining the target job category and level. For example, it is possible to plot a career path through which wide technology and experience can be accumulated by experiencing various job categories through career changes, or become thoroughly expert in a specialty through repeated and consistent career upgrade in the specialty fields of a specific job category.

The target to be achieved through a career path is not necessarily the highest level 7 of each job category. The targets to be achieved are determined by the circumstances of the society and/or company the person belongs to, and also by the sense of values toward an individual's career (Figure 2.13).

Furthermore, the importance of a job category may change with changes in the society or progress made in a technology, and new job categories and specialty fields may be added. The target to be achieved should be flexibly adjusted in accordance with such changes in the circumstances.

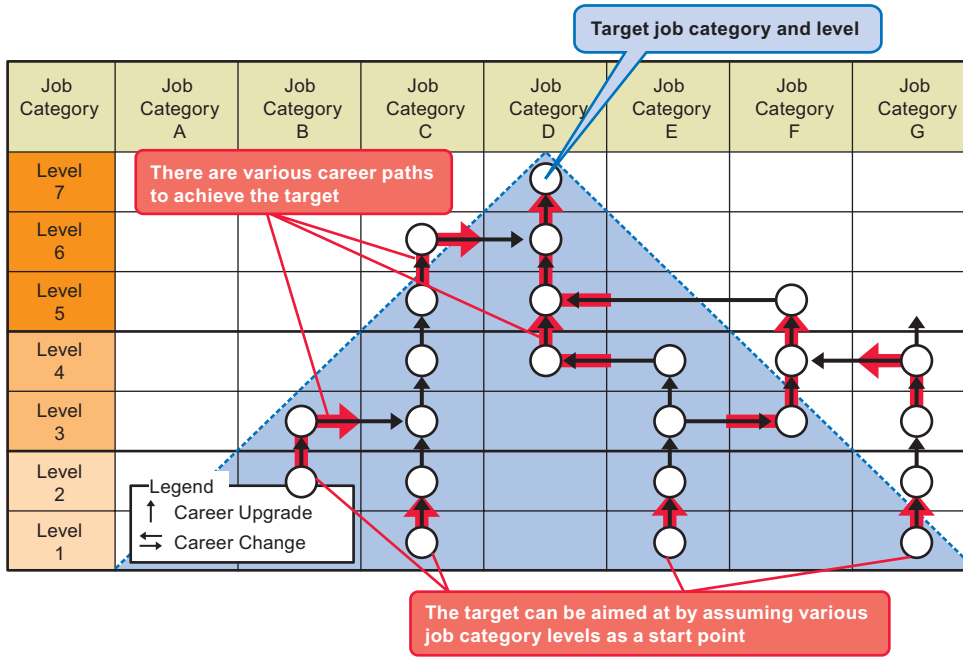


Figure 2.13: Aiming at the target with various levels of the job categories as the starting point

About Skills Other Than Technology

The career levels of ETSS indicate the extent of contribution to value creation as a business and professional. This contribution cannot be achieved merely with technological skills, but one also needs social skills and business skills.

Figure 2.14 is an iceberg model showing the elements required to achieve results in business.

To achieve results in business, activities that make use of skills and knowledge are required.

In the ETSS skills specification, such skills are defined as technological skills. To put these skills and technology to use, fundamental elements such as social skills and business skills will be required.

Figure 2.14: Iceberg model: Elements required to achieve business results

As a result, the ETSS career specification defines social skills and business skills as the skills and knowledge required to achieve business results and fulfill one's responsibilities (Table 2.3).

Table 2.3: List of business and social skills

Skill Category	First Layer		Description
Social Skills	1	Communication	To speak, listen, write, etc.
	2	Negotiation	Questions, investigations, statements, etc.
	3	Leadership	Capability development, time management, motivation, etc.
	4	Problem-Solving	Observation, ideas, problem finding, analysis, logical reasoning, etc.
Business Skills	1	Management	Analysis, strategy, assessment, etc.
	2	Accounting	Financial analysis, accounting, etc.
	3	Marketing	Analysis, market investigation, strategies, etc.
	4	HCM*	Personnel strategies, personnel management, capability development, etc.

* HCM: Human Capital Management

Apart from “social skills” and “business skills,” there are some other requirements, such as engineer ethics and compliance that are required for developers to understand and follow.

Skills Distribution Characteristics

Because of the difference in the responsibilities to be fulfilled and roles to be played in each job category and its career levels, the necessary skills and knowledge, and required skill levels are also different.

Figure 2.15 is an image depicting an example of the ratio of elements such as “technology,” “management,” and “strategy” required in each job category. For example, in the case of a “software engineer,” emphasis is laid on the “technology” element for developing a product. For a “project manager,” emphasis is put on the “management” element, and a certain level of importance is also given to business “strategy.” With regard to “technology,” only items necessary to perform the “project” within one’s range of responsibilities are required.

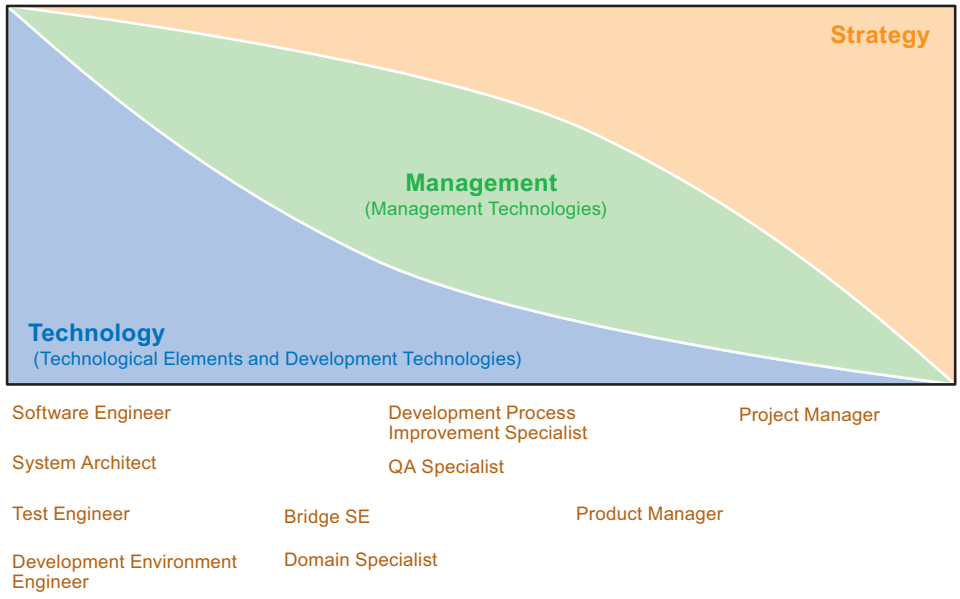


Figure 2.15: Image showing the ratio of Technology, Management, and Strategy

In the ETSS career specification, the skills and knowledge required to fulfill such responsibilities in each job category are mentioned in documents “Skills Domain” and “Skills Distribution Characteristics” in the standards.

The ETSS career specification defines the skills distribution characteristics for each job category and level (level 1 to 7). The skills distribution characteristics in the career specification present the distribution characteristics of the skill levels necessary to fulfill responsibilities in each level of an job category for the three technological skills (“technological elements,” “development technologies,” and “management technologies”) defined in the ETSS skills specification, and each non-technological skill (“social skills” and “business skills”) defined in the career specification.

The skills distribution characteristics of each job category defined in the career specification are explained hereafter (Figure 2.16).

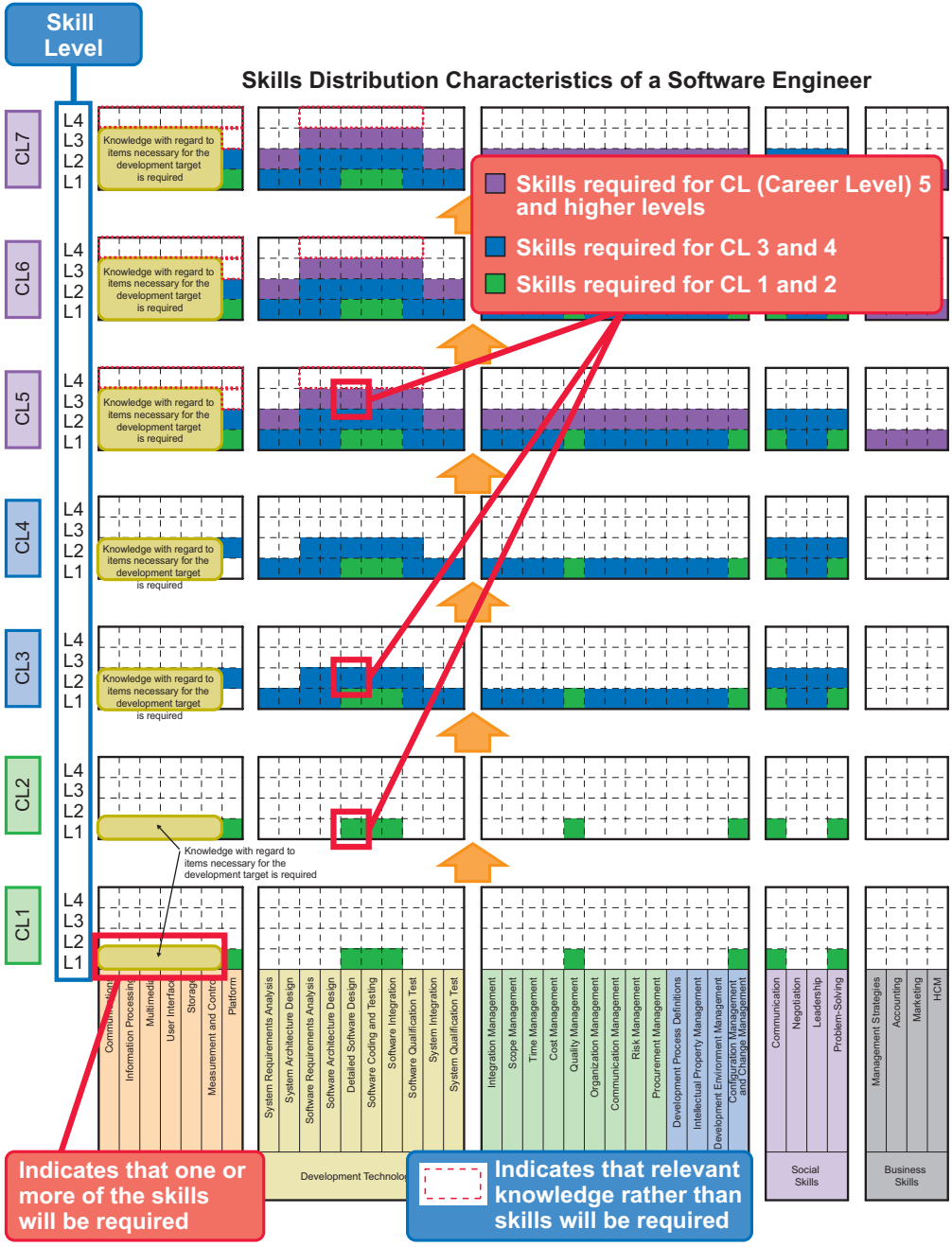


Figure 2.16: Skills distribution characteristics of each job category

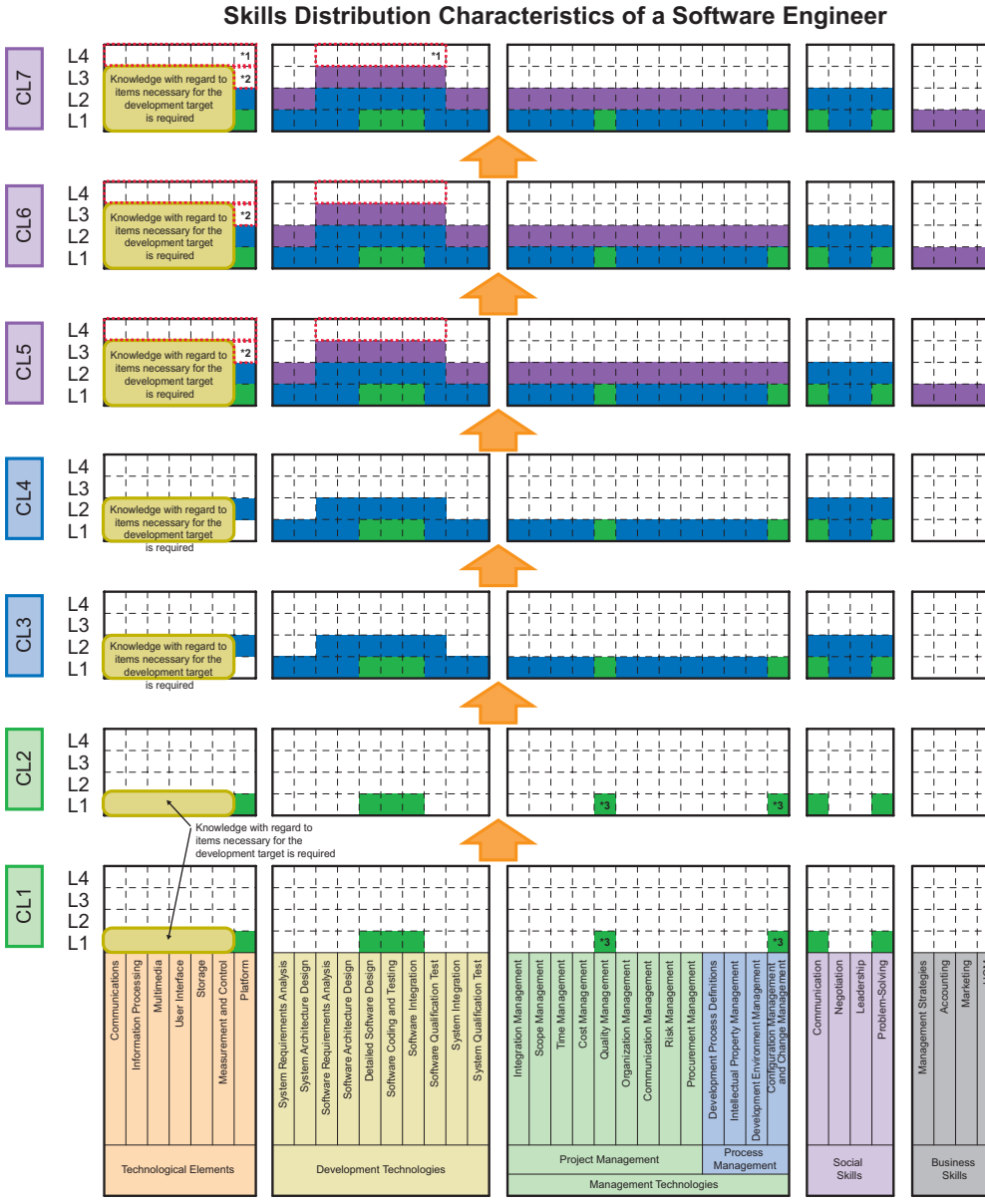
Skills Distribution Characteristics of a Software Engineer (Figure 2.17)

A software engineer is an engineer who can design, implement, and test software of a sub-system based on the system requirements and system architecture defined and designed in the higher development process in embedded system development.

According to the ETSS career specification, there are two specialty fields in the job category of software engineer, namely "embedded platform" that requires skills to be able to develop the technological element "platform" technology, and "embedded application" that requires skills to be able to procure and implement these.

The main responsibility of a software engineer concerns "software development deliverables." To be able to fulfill this responsibility, as the career level increases, the necessary skill levels become higher and target range broader focusing on the items concerning implementation of the development technology in software.

Regarding management technology, skills to be able to perform support management tasks, such as collection and reporting of the management information of the sub-system being handled, under the guidance of the project manager and higher-level engineer, will be necessary.



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.
*2: Skills that are required when the specialty field is “Embedded platform.”
*3: As for the management, skills for being managed are required.

* This information is created for the purpose of human resource development, and not for career level assessment

Figure 2.17: Skills distribution characteristics of a software engineer

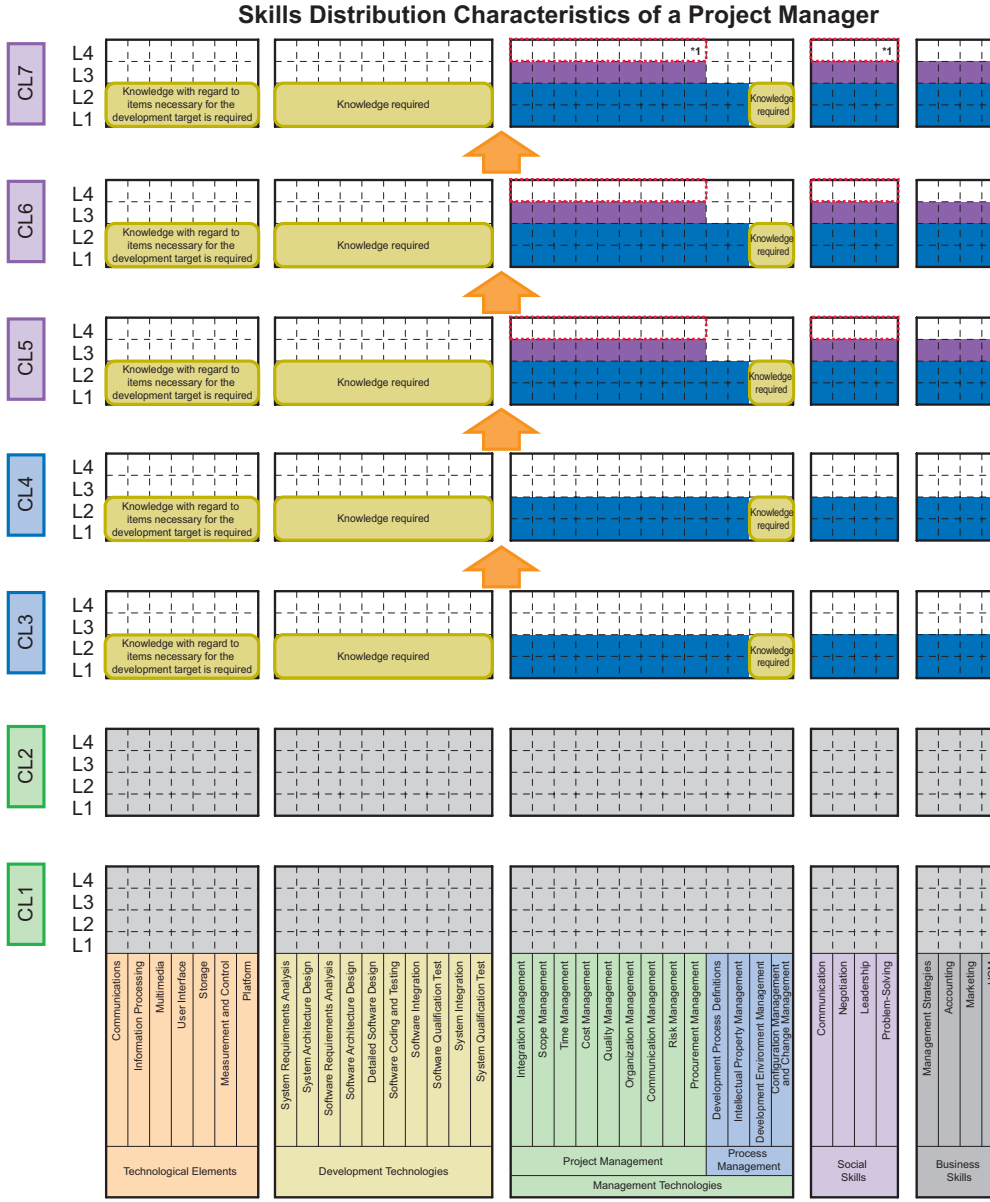
Skills Distribution Characteristics of a Project Manager (Figure 2.18)

A project manager is responsible for planning, leading, and supervising a project during the course of the setup and execution of a product development project.

The range of responsibilities of a project manager as defined in the career specification is the "project." To be able to fulfill this responsibility, the skills distribution characteristics of a project manager focuses on the technology required to appropriately control the project by focusing on the management technologies. Furthermore, the "leadership" for promoting the project, "negotiations" for coordinating with stakeholders, and business skills for value creation of the product and profit generation will also be necessary.

Because a project manager is not directly involved in the development of software, the required technological elements are not skills but knowledge of the target product.

Similarly in terms of development technology too, instead of technological skills required for the actual development of software, the general knowledge required to make a judgment and take decisions in order to accomplish the development project will be required.



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.

* This information is created for the purpose of human resource development, and not for career level assessment

Figure 2.18: Skills distribution characteristics of a project manager

Skills Distribution Characteristics of a Test Engineer (Figure 2.19)

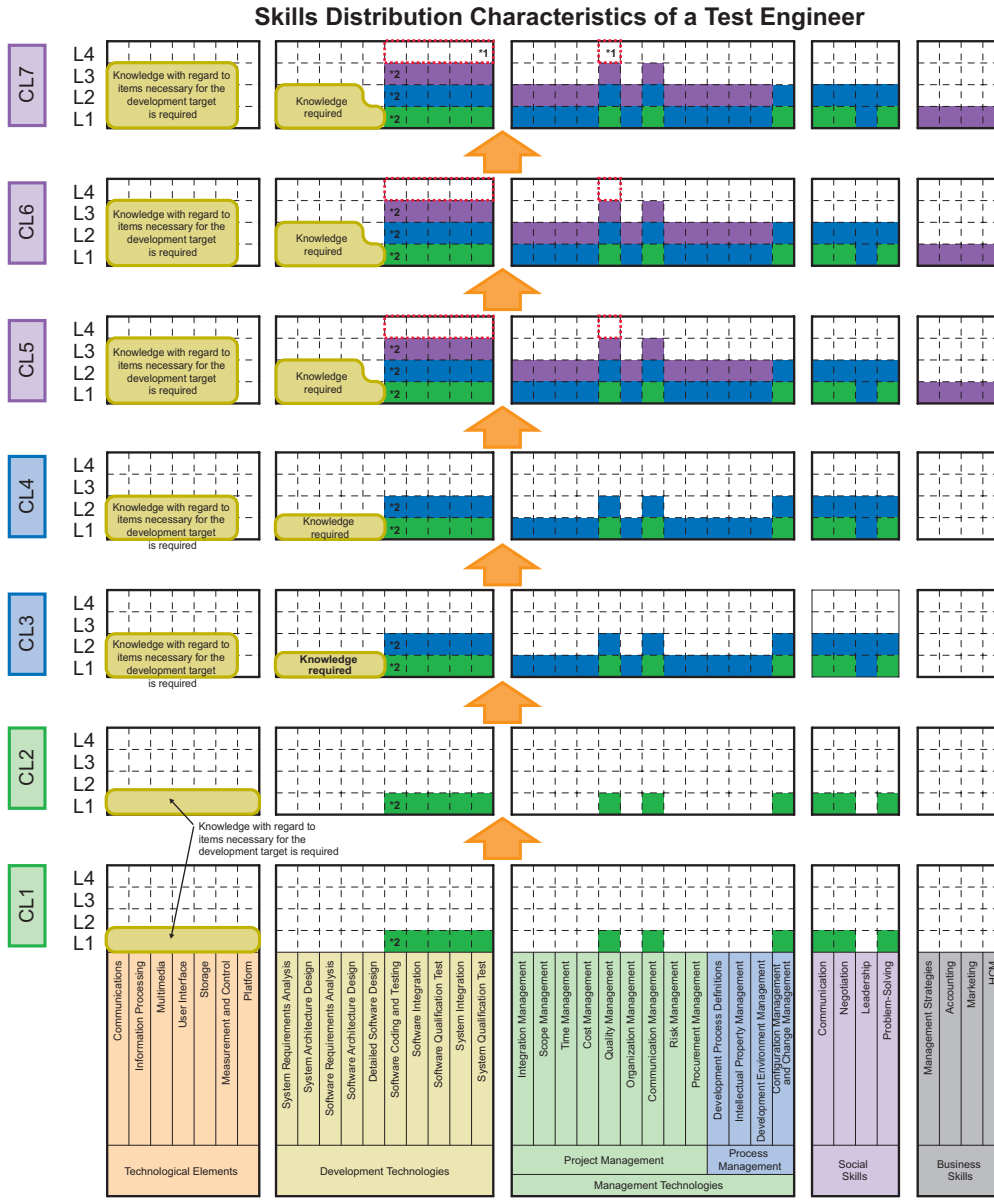
A test engineer is an engineer responsible for performing tasks such as test designing and test execution.

According to the ETSS career specification, the scope of responsibilities of a test engineer in a product development project includes “system validation and verification.”

To fulfill this responsibility, a test engineer must not only have technological skills for testing, but must also possess skills to understand specifications in order to implement test designs and validity of tests. Furthermore, management technologies such as quality management and configuration management will also be necessary to control product quality.

Understanding of the quality properties required of products developed will also be needed to implement appropriate tests. As such, knowledge of the technological elements of the products developed will also be necessary.

It is also important and necessary for a test engineer to possess social skills such as “communication” and “leadership” for smooth execution of these tasks.



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.
*2: Coding is not applicable. Only for testing (such as static analysis)

* This information is created for the purpose of human resource development, and not for career level assessment

Figure 2.19: Skills distribution characteristics of a test engineer

Supplementary Explanation of Job Categories

Within the actual development workplace of embedded software, the roles and responsibilities of some of the job categories defined in the ETSS career specification are not distinguished clearly. However, in the field of embedded system development where scale and complexity continue to grow, these roles and responsibilities are expected to become important in the future. A supplementary explanation is presented below on some such categories.

"Bridge SE" – Bridging Development Sites

In the ETSS career specification, a bridge SE is an engineer responsible for coordinating between project organizations that are organizationally and geographically dispersed.

Bridge SEs include coordinator type bridge SEs and engineer type bridge SEs.

Coordinator type bridge SEs are resources who visit both of the entrustee and entruster organization and perform various pre-arrangements. A coordinator type bridge SE is required to have managerial skills and communication skills to assume the responsibilities that need to be fulfilled.

Engineer type bridge SEs are engineers who are stationed at the centric site of the development project, and collect application-related know-how of the development target product field as well as resolve gaps in the development techniques and rules. Therefore, coordination and communication skills related to the technical contents will be required to fulfill these responsibilities.

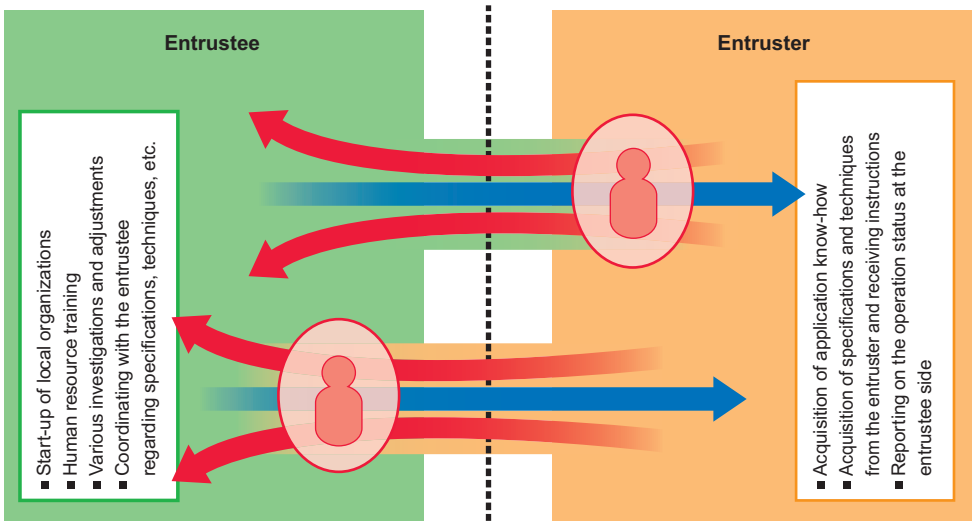


Figure 2.20: Image showing responsibilities of a bridge SE towards entrustee and entruster organizations

"Domain Specialist" - Specialist of the Embedded System Technology

According to the ETSS career specification, a domain specialist is a specialized technical engineer having high-level and expert knowledge and development experience regarding a specific technology and product field. For domain specialists, there are two application areas, namely "specialist in technological elements" and "specialist in product domain."

A "specialist in technological elements" is an expert in a specific technological element such as those referred to as "specialist in graphics" and "specialist in OS." The role of a "specialist in technological elements" is to expand the technology to various embedded systems.

A "specialist in product domain" is an expert with deep knowledge and skills concerning the product developed and who is referred to as, for example, "specialist in printers" and "specialist in electronic branch exchanges." The role of a specialist in product domain also includes application of existing development tips towards multiple product development projects.

During the course of product development, the domain specialist cooperates with members belonging to the project, such as the project manager and software engineer to perform tasks.

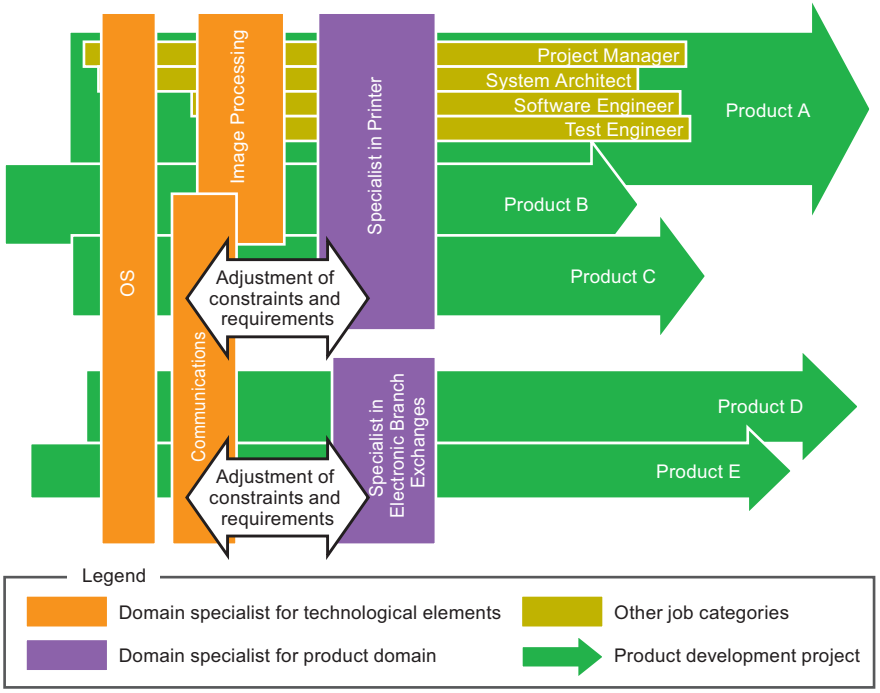


Figure 2.21: Relationship between domain specialist and other job categories

Defining Job Categories Using the Career Specification

Issues Concerning Job Categories

Until now, "programmer," "SE," and "manager" were the often used names for the job categories in the field of embedded software development. Even in the response to the question "What is the job category name you currently use?" asked in a questionnaire survey conducted by IPA on embedded system developers, the earlier-mentioned three job category names occupied the top-most positions, thus supporting this fact (Figure 2.22).

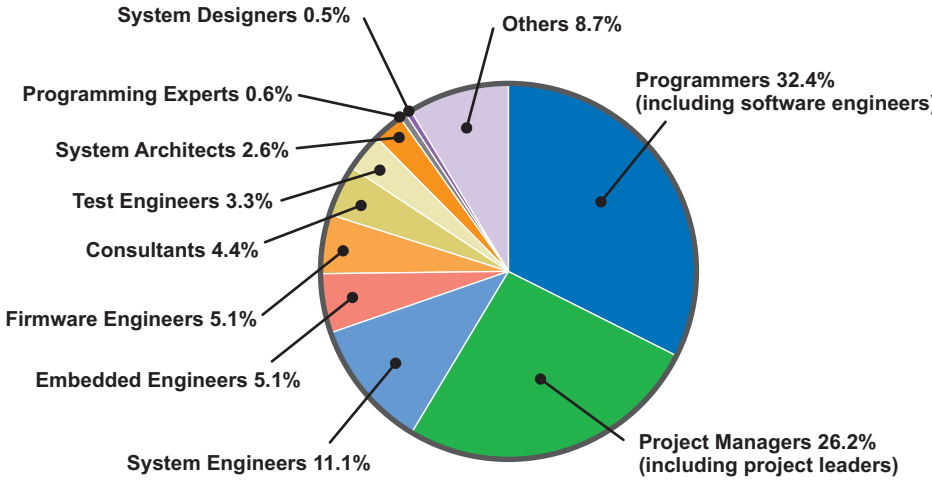


Figure 2.22: What do embedded developers call their job categories (ETSS questionnaire survey IPA/SEC)

In the current embedded system development workplace, resources capable of performing the series of development processes from designing to testing are in demand rather than simple developers who only have programming skills. Although while calling themselves "programmers," in reality, we occasionally come across developers who perform tasks from designing to testing, and even management. The current situation is that a wide range of duties is executed beyond the roles of the conventional job category names.

Utilizing the ETSS Career Specification

In response to such situation with regard to job category definitions, ten job categories that can be used across the industry were defined in the ETSS career specification for the field of embedded system development.

These job categories are conceived in a way that they can be correlated to the job categories of "project manager," "SE," and "programmer" commonly used in the current field of embedded system development. Furthermore, job categories for which the importance of their roles is expected to increase in the field of embedded system development are also defined (Figure 2.23).

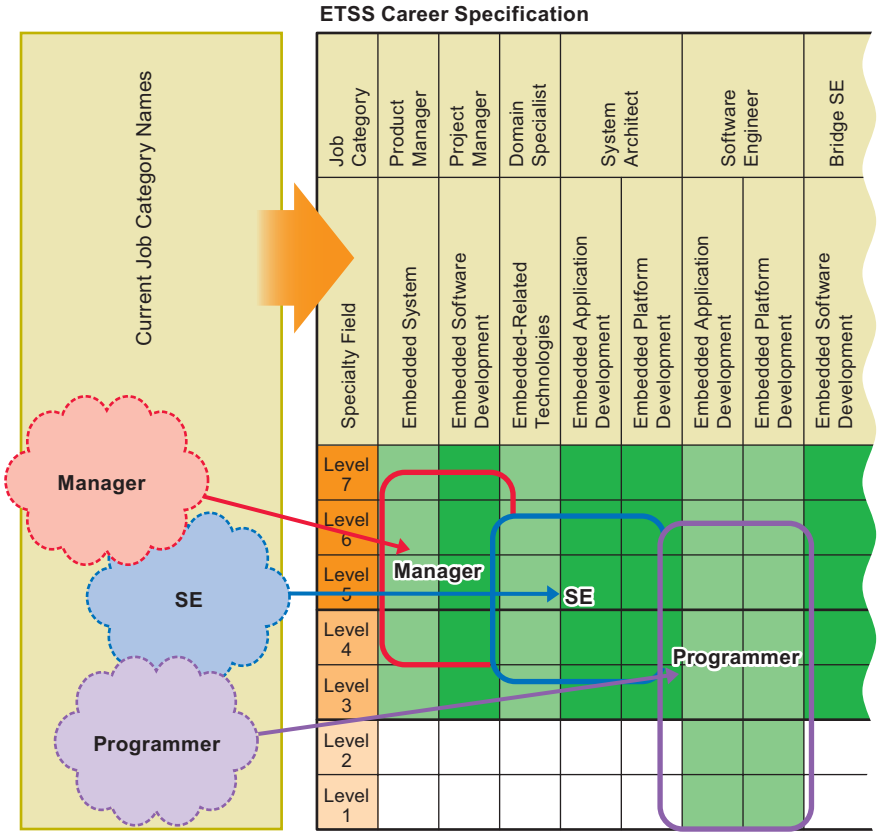


Figure 2.23: The ETSS career specification was formulated giving consideration to the current arrangement of job categories

However, when an attempt is made to introduce the ETSS career specification, there are existing job posts and job category names within the organization, which may give rise to issues such as "the definition of the ETSS career specification diverges from these," "the awareness of the ETSS career specification is not so high," and "a definition of job categories with a higher level of expertise than the ETSS career specification needs to provided."

It is anticipated that because only a short period of time has elapsed since the publication of the ETSS career specification, it is in a transition period with respect to popularization, and therefore, such issues may arise.

One method of adopting the ETSS career specification is to change all definitions of the

job posts and job categories within the organization to those of the ETSS career specification. However, presently, there are many issues as mentioned above, and a forced introduction of the ETSS career specification may lead to confusion and distrust. And consequently, that may result in deviation from the indicators of the original purpose of "utilization of human resources" and "human resource development."

Another method of adoption could be to use the currently used job post and job category names in parallel with those of the ETSS career specification. In order to do that, responsibilities and roles of each of the job categories currently used in the organization, such as "system engineer," "modeler," "programming expert," and "assistant programmer" shall be matched with the contents defined in the ETSS career specification. As a result, the relative positioning of the job categories within the ETSS career specification could be understood. When speaking in terms of Figure 2.24, it can be said that "a programming expert corresponds to level 5 through level 6 of a software engineer in the ETSS career specification."

Furthermore, definitions such as "expert," "senior," "chief," and "assistant" may be used to define job titles in an organization. The level of these definitions can also be determined relatively to the ETSS career level.

In this way, by using the ETSS career specification as a relative index for the position and level relative to the standards used in each organization, speculated consensus of standards of job categories and job titles defined across multiple organizations can be achieved.

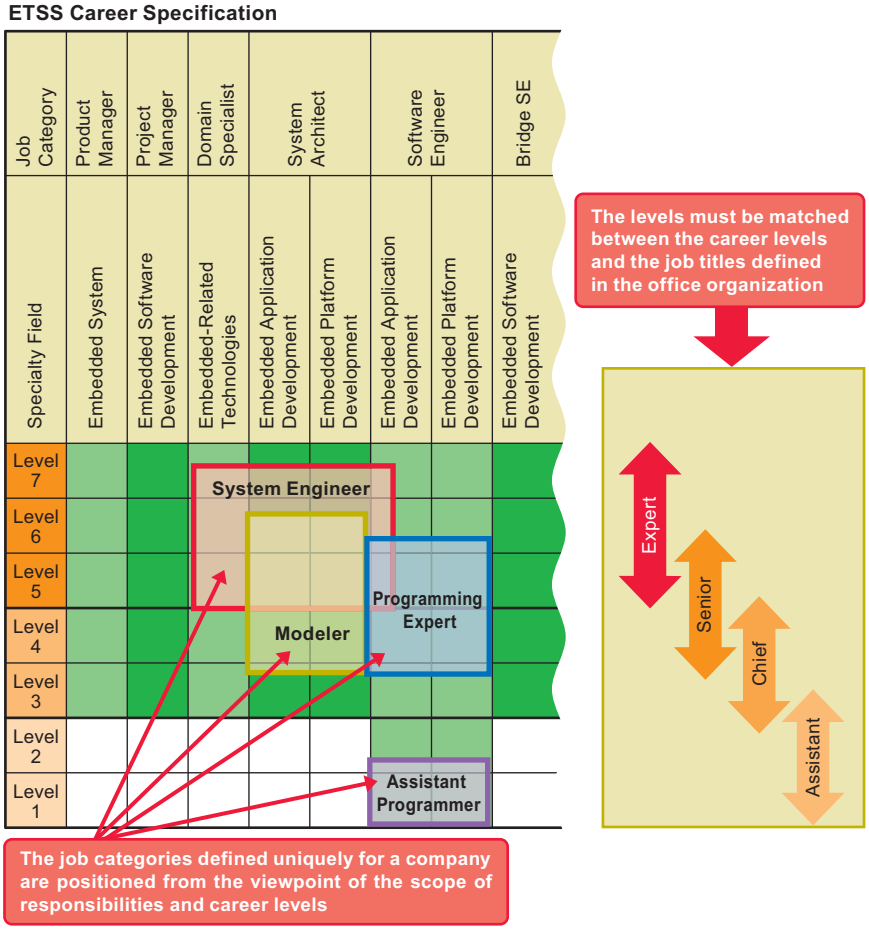


Figure 2.24: Using the ETSS career specification as a yardstick

2.4 Education and Training Specification

What Is Education and Training Specification?

The ETSS education and training specification defines the structure and mechanism for education and training in the field of embedded software development.

There are innumerable technologies in the field of embedded system development, and depending upon the field of the development target product, the technological field to be addressed is also different. Because until now there was no standard framework of technologies and skills that could be used across the industry, instructions on the range of technologies and the levels to be addressed during education could not be communicated properly.

Because standard indicators have been lacking, developers in the field of embedded system development were faced with an inconvenient situation when it came to looking for and selecting education programs suitable to their purpose such as skill upgrade or career upgrade.

Also, such a situation was one of the causes that hindered the development of education that would meet the needs of the field of embedded system development.

The education and training specification defines the “education program framework” and “education program for people inexperienced in embedded system development” that define the structure and terminology for the education program.

Education Program Framework

The education program framework defines the structure and terminology for the education program that constitutes the specific means of human resource development in the field of embedded system development.

Education programs would normally have a clear purpose as to that what kind of human resource (educational targets) are to be trained to become what kind of human resource (educational objectives). The education programs can be viewed as a step to achieving this purpose.

In the education program framework of the education and training specification, to further clarify the human resources who are to be set as the "educational targets" and "educational objectives," the ETSS career specification and skills specification are put to use. Furthermore, the education items of the education program are also clarified using these frameworks.

The education and training specification aims not only to clarify the education program by using the frameworks of each specification of ETSS, but also to implement an education program that links with the ETSS skills specification and career specification.

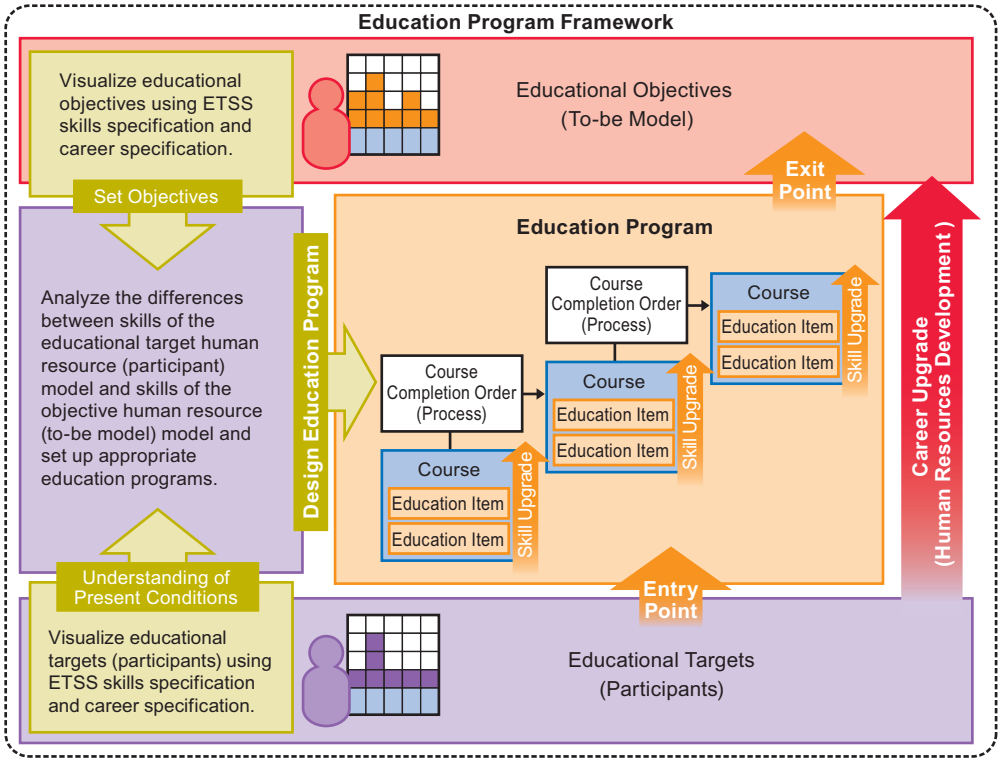


Figure 2.25: Education program framework

Major terms defined in the education program framework are explained below:

Educational Targets

Educational targets refer to the human resource models of the participants who will subject to the education program.

The educational targets are set up quantitatively using the ETSS skills specification and career specification.

Educational Objectives

Educational objectives refer to the human resource models that will be the resulting goal of the education program.

As with educational targets, educational objectives are set up quantitatively using the ETSS skills specification and career specification.

Education Program

An education program is a combination of courses arranged in an appropriate order of learning which are required to develop educational target human resources (participants) into the ideal human resource model (to-be model).

Analyze and extract the gap between the educational targets and educational objectives, and then put together and implement the courses required to acquire the knowledge and skills that are lacking.

Course

A course is a combination of education items required to acquire the knowledge and skills concerning a specific technological field.

Education Item

An education item is a technological item that must be acquired through education and

training. In the education and training specification of ETSS, an education item is expressed in a form conforming the skill classification defined in the skills specification and career specification.

Education Program Linked with the Career Specification

The ETSS career specification present the distribution characteristics for the skills required to fulfill the responsibilities assigned to the job categories in the field of embedded system development. In other words, if an education program participant is able to acquire the knowledge and skills regarding the technologies presented in the skills distribution characteristics, he/she can be expected to fulfill the responsibilities corresponding to the career level of that job category.

By applying the skills distribution characteristics presented for each job category to the educational objectives and educational targets of the education program, an education program suitable for career upgrade and career change can be set up.

An education program linked with the career specification is set up by the following procedure:

(1) Establish the skills distribution characteristics to be possessed by the educational target and educational objective human resource model based on the skills distribution characteristics defined in the ETSS career specification for each job category.

(2) Analyze the differences in the skills distribution characteristics established for the educational targets and educational objectives, and quantitatively extract the technological and skill elements that are lacking.

(3) Based on the results of the analysis, appropriately put together the courses required to fill the gap for the technologies and skills that are found to be lacking by either developing new courses or using existing ones.

(4) Execute and operate the courses that have been put together, in an efficient and

practical order of learning (process).

Figure 2.26 shows an image depicting the approach of setting up an education program for the purpose of career upgrade, using the skills distribution characteristics defined in the career specification.

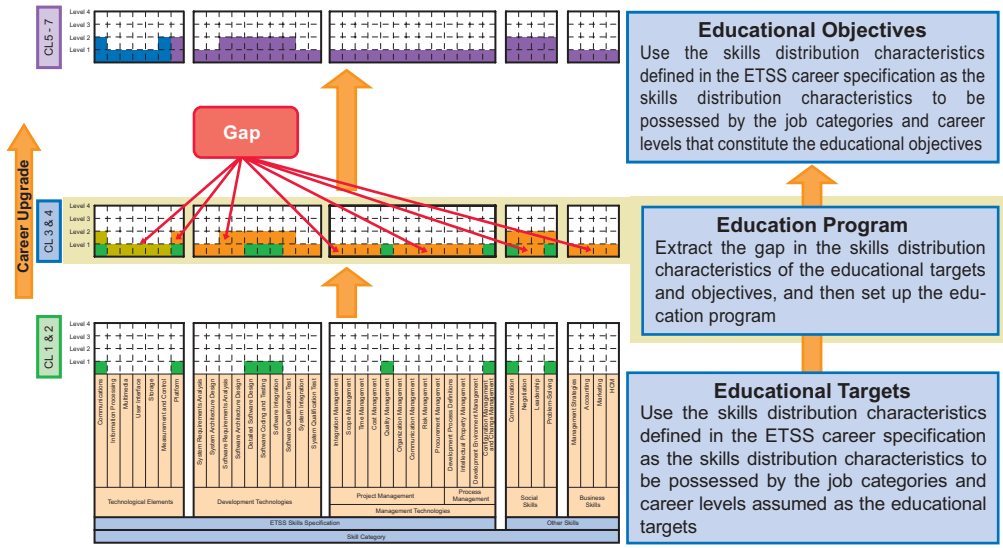


Figure 2.26: Linking the education program with the career specification

The education contents of an education program may differ in accordance with the settings of the "educational targets (participants)" and "educational objectives" (Figure 2.27). If an education program requires one to again complete the learning process of already acquired skills and knowledge, it will be a waste of time and cost. On the other hand, if the number of courses corresponding to the required skills and knowledge are insufficient, it will be difficult to achieve the educational objectives of the program.

It is important to set up an education program consisting of appropriate courses that are neither in excess nor are insufficient by understanding the skills distribution characteristics of the "educational targets (participants)" and correctly analyzing its gap from the "educational objectives."

Furthermore, depending on the technologies and skills in question, training and self-study through actual practices, such as in on-the-job training (OJT), can result in high level of

acquisition. Select an appropriate form of providing education considering the characteristics of the technologies and skills to be acquired.

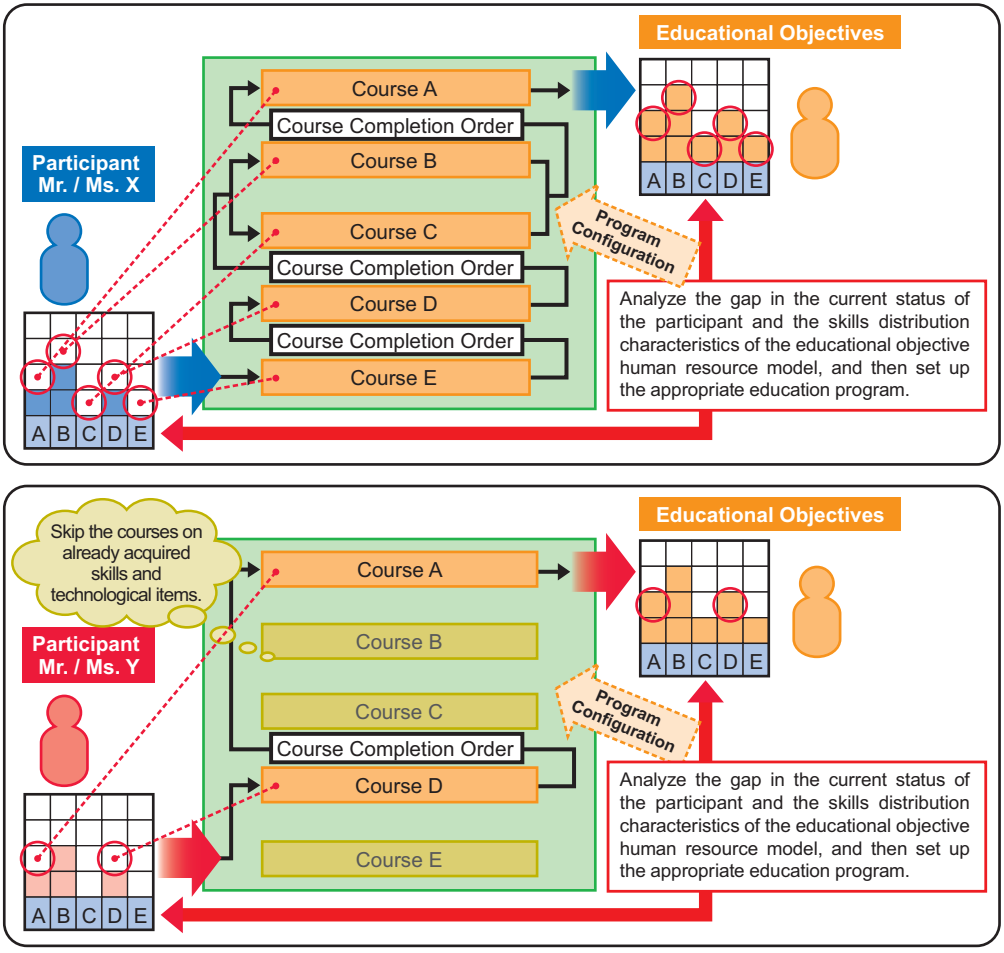


Figure 2.27: The contents may vary if the “targets” and “objectives” of education are different

About Courses

According to the education and training specification of ETSS, the item classification and acquisition level of the skills and technologies established for the educational targets and

educational objectives of the courses of an education program are defined using the skills framework of the ETSS skills specification and career specification.

Similarly, the education items comprising the courses also are represented in accordance with the framework of the skills specification.

To achieve increased education results and efficiency, a course is generally implemented by combining together multiple education items. For example, instead of just educating a course in which the education items of the same field have been put together so as to improve the skill application capabilities to similar technologies (Figure 2.28), and educating the programming grammar through training on programming, the effect (result) of education is improved by combining together the education items on peripheral technologies, such as the tools and platform used (Figure 2.29).

"Intermediate Internet Technology" Course

Skill Category	Education Item	Education Target Level →	Education Objective Level
Technological Element	TCP/IP	Entry (level 1)	Intermediate (level 2)
Technological Element	SIP	Entry (level 1)	Intermediate (level 2)
Technological Element	HTTP	Entry (level 1)	Intermediate (level 2)
Technological Element	FTP	Entry (level 1)	Intermediate (level 2)
⋮	⋮		

Figure 2.28: Image of a course comprising education items of similar technological fields

"Intermediate Internet Technology" Course

Skill Category	Education Item	Education Target Level →	Education Objective Level
Technological Element	System Call	Inexperienced	Entry (level 1)
Development Technology	Structured Design	Inexperienced	Entry (level 1)
Development Technology	C Language	Entry (level 1)	Intermediate (level 2)
Development Technology	Debugging Methods	Entry (level 1)	Intermediate (level 2)
⋮	⋮		

Figure 2.29: Image of a course comprising peripheral technologies related to the technical education items constituting the core

Figure 2.30 is an excerpt of the description of the education items related to the course "embedded system technology" of an education program for the inexperienced to which the framework of the skills specification has been applied.

Course name: Embedded System Technology

Skill Category			Education Target Level	Education Objective Level	Related Technological Items
Category	First Layer	Second Layer			
Technological Elements	Measurement and Control	Physical and Chemical Input	Inexperienced	Entry	External Input Device
					Sensor
		Physical and Chemical Output	Inexperienced	Entry	External Output Device
					Actuator
	Platform	Processor	Inexperienced	Entry	MPU Peripheral Technology
					Basic I/O Technology
		Basic Software	Inexperienced	Entry	Real-Time Processing
					Real-Time Kernel
					System Call
					Interrupt Processing
					Device Driver
					Middleware
					Multi-Task Processing
					Memory Management
					Exception Handling
Development Technologies	System Requirements Analysis	Review of System Analysis and Requirements Definition	Inexperienced	Entry	High Reliability Design
					Design for Safety
					Requirements Analysis Methods
	System Architecture Design	Implementability Verification and Design Review	Inexperienced	Entry	System Architecture Design Technology
	Software Requirements Analysis	Software Requirements Definition	Inexperienced	Entry	Function Analysis Methods
					Requirements Analysis Methods
	Software Architecture Design	Software Structure Design	Inexperienced	Entry	Structured Design
					Architecture Specifications
		Software Structure Design Review	—	—	
	Detailed Software Design	Detailed Software Design	Inexperienced	Entry	Module Design Technology
					Structured Design
					Specification Change
					Design Quality

Figure 2.30: Image showing the linkage between the skills specification and course (education items)

Education Levels of a Course

The education and training specification of ETSS defines the education levels corresponding to the skill levels of the ETSS skills specification to represent the standard indicators of the acquisition levels of educational targets and educational objectives of courses comprising the education program. When attending a course, the confirmation of the education levels serves as the material for determining whether or not the education levels are the desired levels.

The education levels of a course represent the levels established as the educational objectives of the course. For example, in the case of a course with education level "intermediate," the level will be defined as one that aims at skill level 2 (intermediate) for the technology of education items.

Table 2.4 shows the definition of the education levels of a course.

Table 2.4: Education levels of a course

Education Level of Course	Skill Level as Educational Objective	Definition of Skill Level as Educational Objective
Supreme	Level 4 (Supreme)	Aims at the acquisition of knowledge and skills to be capable of developing new technologies
Advanced	Level 3 (Advanced)	Aims at the acquisition of knowledge and skills to be capable of analyzing and improving tasks
Intermediate	Level 2 (Intermediate)	Aims at the acquisition of knowledge and skills to be capable of performing tasks on one's own
Entry	Level 1 (Entry)	Aims at the acquisition of knowledge and skills to be capable of performing tasks with support

Education Program for the Inexperienced

In the field of embedded software development, human resources who can comply with the requirements and issues of complex specifications, large-scale development, short-period development, and high quality are chronically deficient.

To make up for this deficiency in the quality and quantity of human resources, active participation in the forms of "job applicants from educational institutions such as universities" and "career changers from other fields" is desired. However, until now there was a lack of systematic education programs for training inexperienced human resources in the field of embedded system development.

To comply with the features of embedded software development and the requirements of "larger scale," "further complexity," and "shorter development periods," the provision of an education program for people inexperienced in embedded system development considering factors such as the characteristics of software engineering and embedded system development, is expected to lead to resolution of the shortage of human resources in the field of embedded software development.

Outline of the Education Program for the Inexperienced

The education and training specification of ETSS present an "education program for people inexperienced in embedded system development (hereinafter called the education program for the inexperienced)" for inexperienced people.

The purpose of providing the education program for the inexperienced is to reduce the gap in technologies and skills when a human resource shifts to the embedded field, and to encourage upgrade in the level of new entrants into the embedded field, thereby resolving the shortage in human resource.

The aim of the education program for the inexperienced is to develop human resources by assuming people inexperienced in the embedded field as educational targets (participants), and the state where one is capable of becoming engaged in embedded software development tasks as

the educational objectives. In this education program for the inexperienced, the "technological elements," "development technologies," and "management technologies" defined in the ETSS skills specification, and the "social skills" defined in the career specification are considered as the education items.

This education program is created with the assumption of being used in institutions for advanced education such as universities, or as part of training given by companies to the newly hired as well as training given to support the change in career from a different field to the field of embedded software development.

Table 2.5: Outline of courses of the education program for the inexperienced

Subject Name	Outline	Education Item
Embedded System Technology	Acquire the basic embedded technology required of an embedded software engineer.	History of the embedded system, characteristics of the embedded system, current situation of the embedded system, I/O control, start-up programs, memory management, interrupt processing, hardware monitoring, exclusive control, trade-off design, hardware architecture, MPU peripheral technology, Basic I/O, external peripheral equipment, implementation technology, high-reliability design, design for safety, system LSI, Outline and history of embedded software, characteristics of embedded software, real-time kernel, device driver and middleware, multi-task programming, execution environment, development environment, embedded software development technology….etc.
Embedded Programming Exercise	Acquire programming technology centered around the C language required of an embedded software engineer.	Memory arrangement, stack size, start-up program, interrupt processing, I/O access, coding methods, optimization, development support tools (integrated development environment, compiler, debugger….), assembly language, requirements definition, software design, program implementation, testing and debugging, etc.
Embedded System Development Project Type Exercise	Positioning this as a roundup for the education program for people inexperienced in embedded system development, through a project type exercise, experience and acquire the technology and knowledge necessary for engaging in embedded software development.	* To acquire practical knowledge and technology through actual use of knowledge items related to "embedded system technology" and "embedded programming exercise" from the "ET Introductory course" that are prerequisites of this training course, as well as the knowledge items of the training courses "IT Fundamentals 1" and "IT Fundamentals 2" from the education road map of Skill Standards for IT Professionals that are prerequisites of the above-mentioned knowledge items, through project type exercises.

Project Type Exercises

The project type exercises are prepared as a roundup of the education program for the inexperienced. Because numerous embedded software development tasks are carried out by a project structure, the importance of joint efforts and distribution of roles in the project is understood, and the skills concerning project management and social skills (such as communication, leadership, and negotiation) are acquired within the pseudo project.

By following the contents completed up to a certain point during the education program for the inexperienced in the form of an actual project, the series of processes of software development life cycle, from requirements definition up to testing, can be experienced in reality, thereby improving proficiency.

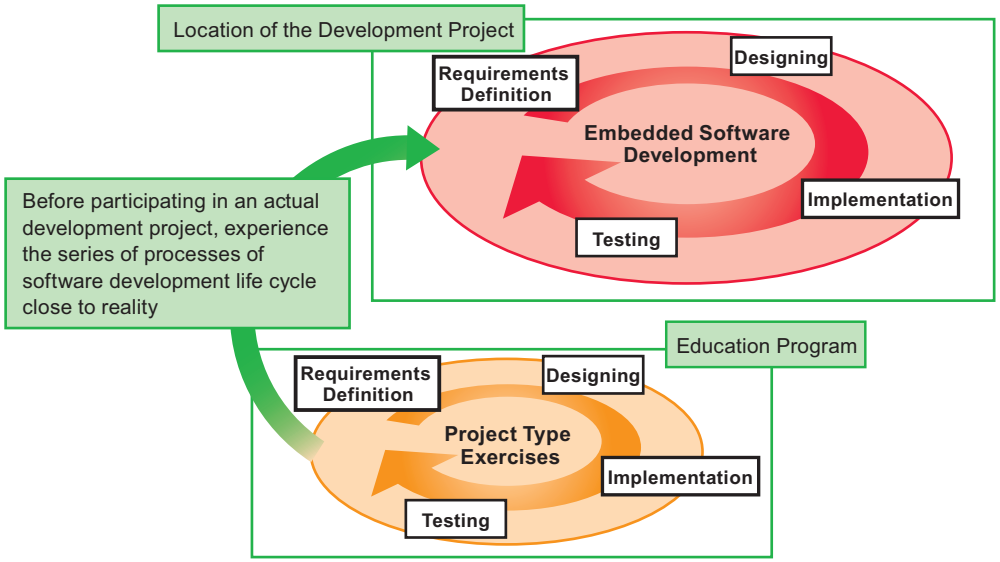


Figure 2.31: Project type exercises

Considering Reliability against Existing Programs

The education program for the inexperienced comprises courses that are split up in a way that they are easily compatible with the skill levels of the participants as well as the existing programs, and are aimed at the acquisition of technologies and knowledge specific to the

embedded system. As for the basic technologies and knowledge common with other fields, the burden of designing and developing new programs can be expected to be reduced by making use of existing programs, such as the training course conforming to the inexperienced level from the training road map of Skill Standards for IT Professionals

Part 3

Utilization of the Embedded Technology Skill Standards (ETSS)

Part 3 provides suggestions for utilizing the Embedded Technology Skill Standards, as well as illustrates and explains skill measurement for mobile phone development and DVD recorder development.

3.1 Embedded Technology Skill Standards (ETSS) Utilization Image

Image of Utilization by Managers and Project Leaders

Optimizing Project Formation

The optimum development project organizational framework can be formed using the distribution of skill levels required for the development target product, and the distribution of skill levels of engineers to be assigned to the project. Furthermore, optimization can also be promoted by forming a team framework at the appropriate timing in line with skills distribution required for each development process (Figure 3.1).

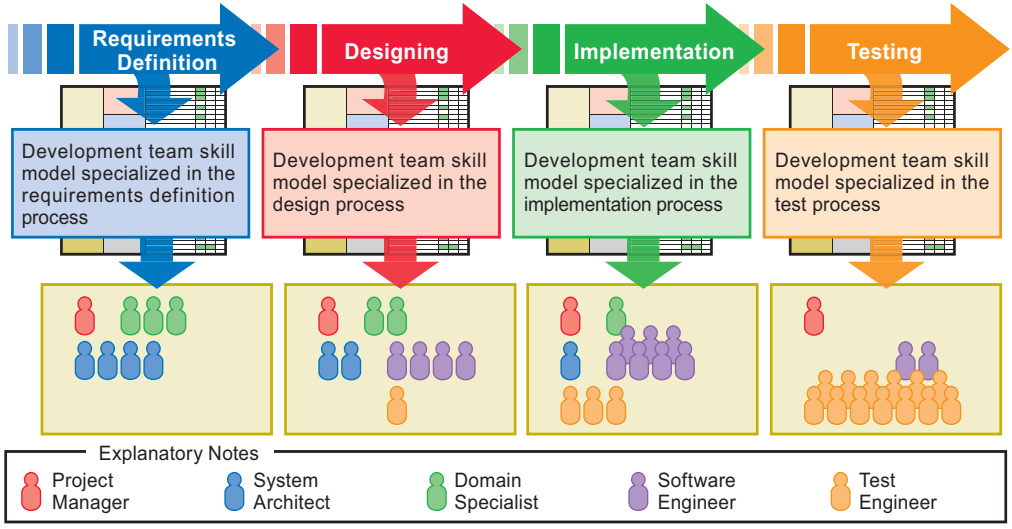


Figure 3.1: Optimizing project formation

Analyzing and Managing Development Risks Related to Skills

By comparing the distribution of skill levels required for the development target product to the skills distribution of the development team, the risks of a development project due to shortage of skills can be analyzed. The quantitative visualization of skill shortage will serve as an index for formulating an accurate risk hedge plan, such as creating a list of skills that necessitate additional staff.

Image of Utilization by Executives

Planning and Assessment of Human Resource Strategies

The strengths and weaknesses of a company regarding embedded software development can be visualized by measuring the skills of human resources within the company, and combining them as an organization. By comparing the trends of the industry and technologies with the skill measurement results of the company, strategies for human resources to compensate for such weaknesses can be established quantitatively. Furthermore, the formulated strategies for human resources can be used as a specific index when hiring and developing human resources (Figure 3.2).

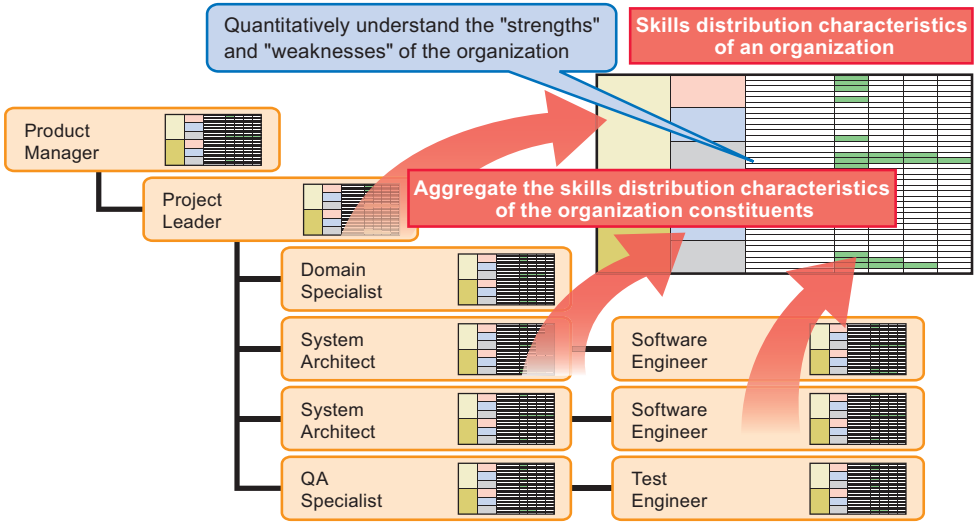


Figure 3.2: Visualizing the skills of an organization

Developing and Procuring an Education Program

Companies providing education services can develop highly effective education programs focused on the "career levels of job categories" and the "levels of skills specification" sought by customers.

Companies where human resource development is needed can select an education program according to their purpose. Furthermore, education results can also be used to objectively measure whether the purpose of the education program (such as skill upgrade) has been accomplished. Providing such feedback can be useful in improving the quality of the education program.

Image of Utilization by Individuals

Recognizing the Strengths and Weaknesses as an Engineer

The distribution of skill levels can be visualized by measuring the embedded software development skills of an individual engineer using the skills specification. The strengths and weaknesses of an engineer can be recognized objectively from the distribution of skill levels.

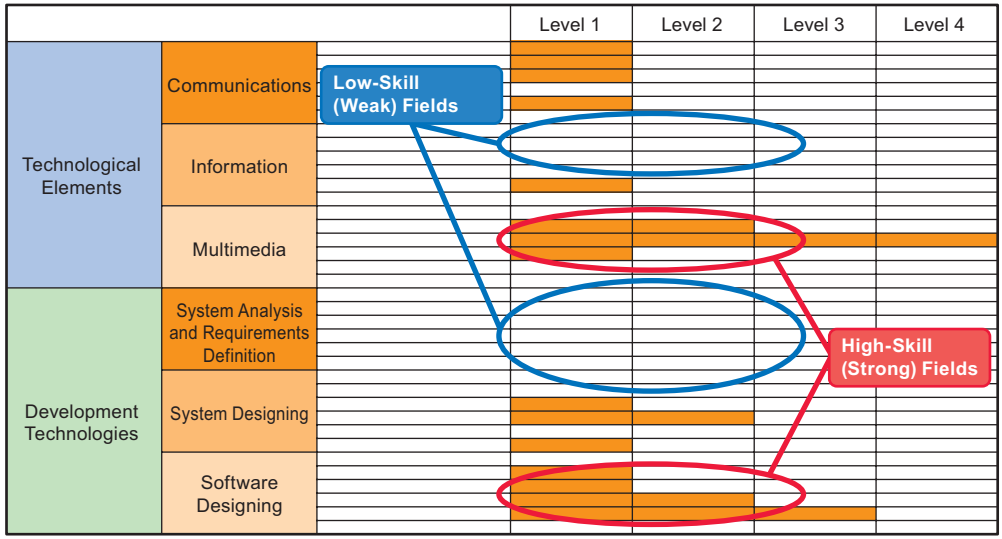


Figure 3.3: Visualizing "strengths" and "weaknesses"

Based on the visualized skills distribution characteristics, plan out the development strategies according to the purpose of the company and individuals as to whether a “broad and shallow” all-rounded skills distribution is desired, or a “narrow and deep” specialized distribution is desired.

Confirming a Specific Career Path

The validity of the career levels can be confirmed by correlating them with the related skills of the career levels of job categories and specialty fields defined in the career specification based on the distribution status of skill levels of an engineer whose skills have been measured. Furthermore, a specific image can be established for the route to be adopted as the career path to reach the target career level of a job category, and for the ways to improve the level.

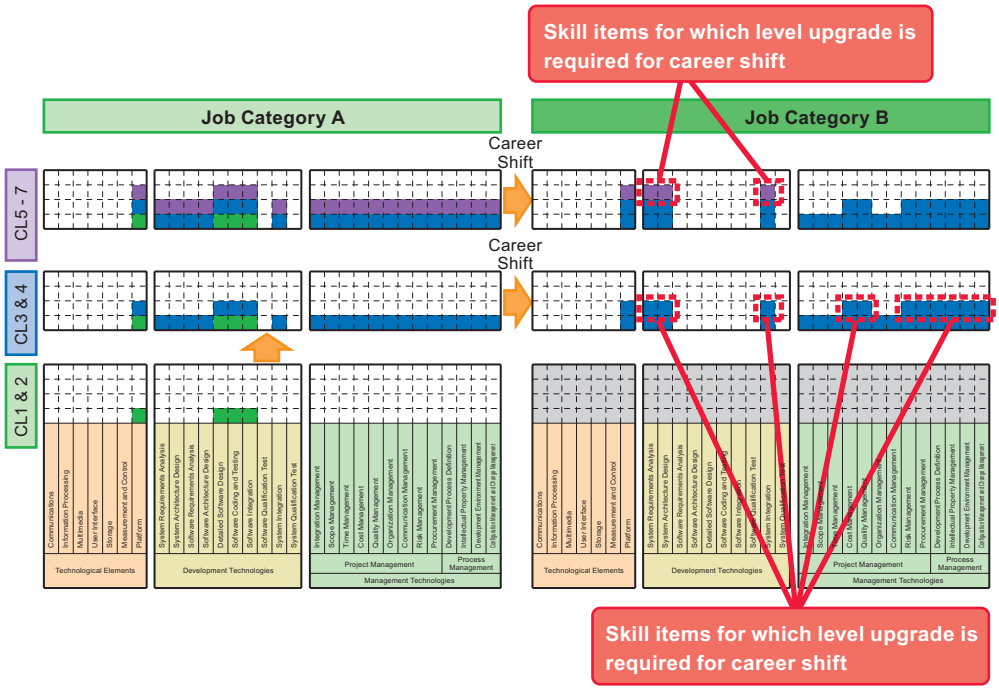


Figure 3.4: Skill items whose level must be improved for a career shift

3.2 Examples of Embedded Technology Skills Specification Analysis

About the Examples of Skills Specification Analysis

Examples of skill item analysis of embedded software development for specific products (a mobile phone and a DVD recorder) are presented here.

These examples provide analyses of the skill items required for embedded software development performed using the ETSS skills specification that have been explained earlier. Analyzing the skill items of a development project using the skills specification would produce deliverables such as those shown in the following two skill analysis examples. Measure the skills of the development organizational framework and engineers for each skill item that has been analyzed and identified.

Here, standard functions of the above-mentioned products are selected, and fictitious product images are analyzed. Because these are just examples of skill analyses, even if a similar product were to be created, the results achieved would be different due to differences in the technologies used and development methods.

Also, more detailed and diverse skill items may be identified during the course of actual product development.

Skill Analysis Example for Mobile Phone Development

A skill analysis result example for mobile phone development is presented below.

Product Outline

This product is a mobile phone with camera functions. The camera can capture still images and moving images, and is capable of storing data as well as allowing simple editing of the

images. Furthermore, this data can be written onto a memory card or sent to another terminal through the e-mail function.

It is also equipped with a Web browser function that allows access to various contents over the Internet. Music contents downloaded from the network can also be played.

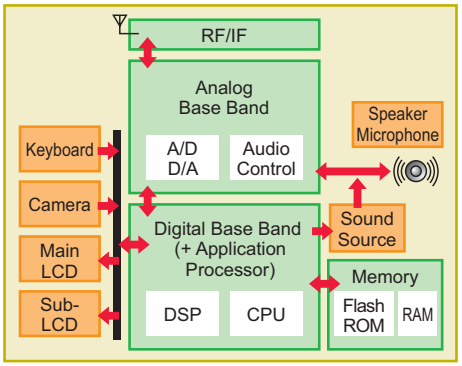


Figure 3.5: Hardware configuration of the mobile phone (outline)

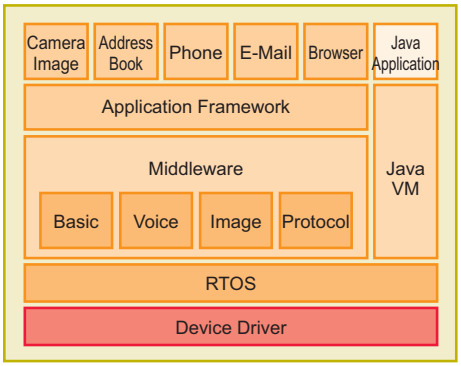


Figure 3.6: Software configuration of the mobile phone (outline)

Skill Analysis Example

(1) Technological Elements

First Layer	Second Layer	Third Layer	Skill Item	Can Utilize	Can Produce
Communications	Wired Communications	PAN	USB		
			RS232C		
	Wireless Communications	Wireless Telecommunications	PDC		
			CDMA		
		Short Range Communications	IR Communication		
	Internet	Transparent Data Transfer	PPP		
			IP		
			TCP		
		Application Processing	HTTP		
Information Processing	Information Input	Type Input	Kana-Kanji Conversion		
			Input Prediction		
		Code Input	Bar Code		
			QR Code		
		Markup Language	Web Browser		
			SVG Browser		

First Layer	Second Layer	Third Layer	Skill Item	Can Utilize	Can Produce
Information Processing	Image Processing	Image Format	JPEG		
			GIF		
			PNG		
		Moving Image Compression and Decompression	MPEG4 H263		
			H264		
		Moving Image Recording and Replaying	MP4		
Multimedia	Voice Processing	Voice Compression and Decompression	ADPCM (G.726)		
			CELP		
			MC		
		Filter Processing	Echo Canceller		
		Audio Device	Amplifier / Speaker		
			Microphone		
	Picture and Voice Integration	Mobile	3GPP SD-Video		
User Interface	Input Device	Button Input	Buttons		
			Keyboard		
		Coordinate Input	Direction Key		
	Output Device	Display Output	LED		
			LCD		
		Voice Output	Sound		
			Sound Source		
Storage	Media	Removable Media	SD Card		
		Memory Storage	NAND / NOR Flash Memory		
Platform	Basic Software	Kernel	Kernel		
	Virtual Machine Interpreter		BREW		
			JAVA		
	Support Functions		Logging		
			Trace		
			Software Update		
	UI		GUI Library		

(2) Development Technologies

First Layer		Second Layer		Skill Item	Assessment Requirement Example	Skills
1	System Equirements Analysis	1	Requirements Acquisition and Adjustment	Interview Methods	Capable of acquiring requirements for the development target system using interview methods	
				Requirements Definition Documents Formulation Rules	Capable of creating the requirements definition documents using the requirements definition documents creation regulations	
				Requirements Definition Documents	Capable of confirming the requirements specifications with the stakeholders using the requirements definition documents	
				⋮	⋮	
		3	Review of System Analysis and Requirements Definition	Review Methods	Capable of conducting a review using inspections	
				Inspection Methods		
				Review Rules	Capable of review management such as calling for and proceeding with meetings based on the review rules of the company	
				⋮	⋮	
2	System Architecture Design	1	Hardware and Software Function and Performance Assignment Decision	FMEA / FTA Methods	Capable of designing reliability and safety using FMEA / FTA methods	
				Estimation Methods	Capable of estimating the scale of the software using estimation methods	
				⋮	⋮	
6	Software Coding and Testing	1	Program Creation and Identification of Program Testing Items	Coding Rules	Capable of programming according to rules using coding rules	
				Assembler Specifications	Capable of programming in the assembly language using the assembler specifications of the installed microcomputer	
				White Box Test	Capable of extracting test items for the white box using boundary value analysis	
				⋮	⋮	
		2	Code Review and Program Test Items Design Review	Static Analysis Tool	Capable of static analysis of the program using software static analysis tools	
				Review Methods	Capable of conducting a review using inspections	
				Inspection Methods		

First Layer		Second Layer		Skill Item	Assessment Requirement Example	Skills
		3	Program Test Implementation	Driver / Stubs	Capable of conducting program tests prior to HW acceptance using the driver / stubs	
				Test Tool	Capable of conducting automatic program tests using a test tool	
				⋮	⋮	
7	Software Integration	1	Software Integration Test Specification Design	Test Design Methods	Capable of designing software integration tests using test design methods	
				Coverage Measurement Methods	Capable of calculating the validity of software integration tests against the software requirements using coverage measurement methods	
				⋮	⋮	
9	System Integration	⋮	⋮	⋮	⋮	
		2	System Integration Test Implementation	ICE	Capable of conducting system integration tests and defect analysis using ICE	
				Oscilloscope	Capable of performing defect analysis of system integration test results using an oscilloscope	
				⋮	⋮	

(3) Management Technologies

First Layer		Second Layer		Skill Item	Assessment Requirement Example	Skills
1	Development Project Management	1	Integration Management	Project Planning Methodology	Capable of formulating a project plan using project planning methodologies	
				WBS (Work Breakdown Structure)	Capable of creating a project plan document using WBS	
				⋮	⋮	
		8	Risk Management	Risk Identification Methods	Capable of identifying risks of incident cases in the existing system using risk identification methods	
				Risk Rating Matrix	Capable of conducting risk analysis using a risk rating matrix	
				Decision Tree	Capable of conducting risk analysis using a decision tree	

First Layer		Second Layer		Skill Item	Assessment Requirement Example	Skills
		9	Procurement Management	Procurement Specifications	Identification of external procurement can be achieved using the procurement specifications of the company	
				Request for Quote Formulation Rules	Capable of requesting a quote for external procurement using the request for quote formulation rules of the company	
				Subcontract Management Rules	Capable of performing subcontract management using the subcontract management rules of the company	
2	Development Process Management	1	Development Process Definition	Development Performance Information	Capable of defining development processes using past development performance information	
				Development Process Standard	Capable of defining development processes using standard concerning development processes	
				Standard Questionnaire	Capable of conducting development processes evaluations using a standard questionnaire	
		2	Intellectual Property Management	Patent Application Rules	Capable of applying for a patent according to the patent application rules of the company	
				Patent Database	Capable of searching for patent information using public patent databases	

Explanation

As shown in the example, many technological elements are used in the development of a mobile phone.

Although the technological elements may differ depending on the communication career and terminal specifications, the second and third layers of skill granularity will have more or less a similar configuration. The differences in the concrete specifications and components of each product will be reflected as differences in the skill items of the lowest layer.

With reference to this skill layer division, break the system down into components, and define

the actually used technology names.

The engineers and development teams will be required to improve their skills for the identified technological elements, which may include “expanding the coverage of the area of skill items,” or “increasing the level of expertise of specific technological elements.” The ways of improving skills need to be planned in consideration of the position and roles required of an engineer, as well as the intended career. If the development processes and management procedures of the development technologies and management technologies are proceduralized, the identification of skill items will be relatively easy by analyzing the skill items asking questions such as “which tasks need to be executed for each phase?” and “what methods and tools are used to perform those tasks?”

Although this overview document presents the skill analysis examples with development technologies and management technologies omitted, if the software development processes are actually covered in full, a large number of skill items will be identified depending on each development process.

Skill Analysis Example for DVD Recorder Development

A skill analysis result example for DVD recorder development is presented below.

Product Outline

This product can play commercially available DVDs, and can also record and play terrestrial and analog satellite television broadcasts on a hard disk and DVD.

It is also equipped with a function for simple editing of the data recorded on the hard disk.

It has a network connection function, and can display electronic program guides and enable reservation of programs using Internet technology. Furthermore, the versions of software and firmware can also be upgraded over the Internet.

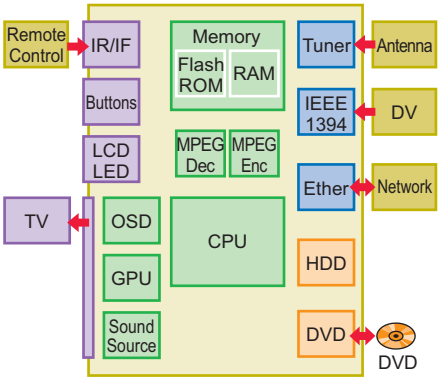


Figure 3.7: Hardware configuration of the DVD recorder (outline)

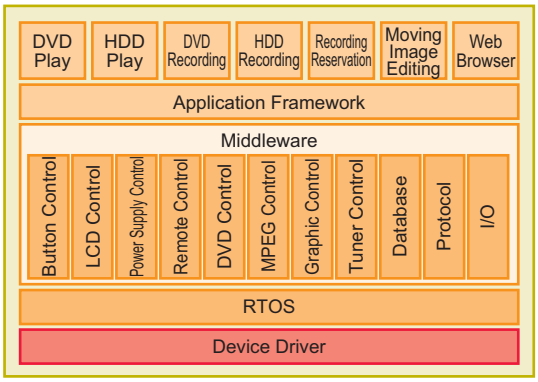


Figure 3.8: Software configuration of the DVD recorder (outline)

Skill Analysis Example

(1) Technological Elements

First Layer	Second Layer	Third Layer	Skill Item	Can Utilize	Can Produce
Communications	Wired Communications	LAN-MAN	CSMA/CD		
		PAN	IEEE1394		
	Wireless Communications	Short Range Communications	IR Communication (Remote Control)		
	Internet	Transparent Data Transfer	TCP		
			UDP		
		Application Processing	HTTP		
			DNS		
			DHCP		
			FTP		
Information Processing	Security	Encrypting	Encrypting Technology		
		Copyright Protection & Management	CSS		
			CPRM		
	Information Input	Data Input	Electronic Program Guide		
			Compressed Code Reservation Input		
		Type Input	Character Code Conversion		
			Kana-Kanji Conversion		
			Postal Code Conversion		

First Layer	Second Layer	Third Layer	Skill Item	Can Utilize	Can Produce
	Information Output	Markup Language	Web Browser		
		Movie Data Viewer	DVD Player		
			Hard Disk Player		
	Data Processing	Database	SQL		
			RDB		
Multimedia	Moving Image	Moving Image Compression and Decompression	MPEG2		
	Voice	Voice Format	PCM		
		Audio Device	Sound Source Control		
			Mute Control		
	Integration	Media	DVD-Video		
			DVD-VR		
User Interface	Human Interface Input	Buttons	Remote Control		
			Buttons		
		Coordinate Input	Joy Stick		
	Human Interface Output	Display	LCD/LED		
			OSD		
			RGB		
		Voice	Sound		
			Alarm Sound		
Storage	Media	Removable Media	CD-ROM, R, RW		
			DVD-ROM, R, RW, RAM		
		Memory System Storage	Flash Memory		
		Large-Scale Storage	Hard Disk		
	Interface	Full-Time Connection Type Interface	ATA, ATAPI		
	File System		ISO9660		
			UDF		
			ext2fs		
Measurement and Control	Control	Driver Control	DVD Drive Control		
		Power Supply Control	Power Supply Control		
Platform	UI		In-House Standard GUI Library		
	Support Functions		Logging		
			Software Update		
			Memory Dump		
	Basic Software		System Booting		
			Kernel		

(2) Development Technologies

The skill analysis example of development technologies is almost the same as that indicated in the section of the mobile phone. However, items such as designing and assessment procedures of the standard specifications and image quality of the DVD are different from those of the mobile phone.

(3) Management Technologies

The skill analysis example of management technologies is almost same as that indicated in the section of the mobile phone.

In the case of management technologies, differences in the products and application domains alone do not result differences in skill items. During product development, differences in the forms of development including "use of human resources from outside the company or from overseas" and "adoption of different development processes" may bring about changes in the configuration of skill items.

Explanation

Except for some areas where methods and tools specific to the application domain have differences, the development technologies and management technologies of DVD recorders are mostly the same with those of mobile phones, and as such, have been omitted.

According to the current analysis, Web browsers, codec related parts of MPEG, GUI libraries, and databases were assumed to be present already or purchased as a package. If these were to be created, the skill items need to be identified will have been more diverse.

Technological elements related to real-time OS control, such as interrupt processing and inter-task communication, have been compiled under "Platform → Basic software → Kernel."

3.3 Education Program Design

What Is the Education Program Design Guide?

To implement human resource development required by an organization or developers, an education program that constitutes the policy of human resource development must be designed appropriately. Therefore, similar to the task of developing software, the task items to be performed for education program design must be performed at the appropriate stage. Reasonable understanding and experiences will be required to perform these items appropriately and efficiently.

Thus, intellectuals concerned with education program development were brought together, and matters such as what kind of procedures exist for the development of a education program with the purpose of training human resources in the field of embedded software development, and specific tasks to be executed and points to be considered in such procedures were put together in the "education program design guide."

Process of Education Program Design (Figure 3.9)

The scope of performance of the process for education program design varies depending on the situation of the company or organization in which the education program is to be implemented, and on how to set the targets of education. Though there may be cases in which all task procedures need to be implemented, it may be possible in some cases to perform the procedures by selecting and performing only the required portion. With an understanding of the contents and purpose of each task process, it is important to judge beforehand whether the task

procedure will be required for the intended education program to be designed.

The procedure for designing an education program comprises the following six processes:

Human Resource Development Planning

Understand and analyze the human resource model(s) required by the organization and the current situation of available human resources, and plan a clear and appropriate human resource development plan.

Education Planning

To implement the human resource development plan, examine the required education program system, and put it together as an education plan.

Also examine the constitution of required courses and course outlines to achieve the educational objectives that are set in each education program.

Course Designing

Design the courses in order to clearly define the education items to be implemented in each course, and to be able to effectively acquire related skills and knowledge. Clearly identify the specific items to be studied in a course, and the appropriate form of implementation (teaching methods).

Education Material Creation and Procurement

To achieve the educational objectives that are set for a course, create and procure various education materials, such as appropriate texts.

Execution

To achieve the educational objectives that are set for a course, prepare the required environment such as classrooms, as well as education materials and equipment.

Also perform various supporting tasks required for smooth operation on the day the class is held.

Assessment

Collect the execution results of the education program, and then compare and analyze the collected execution results against the initial educational objectives. Following this, identify any problems.

Examine the improvement methods for the identified problems, and provide a feedback on the procedures to be improved.

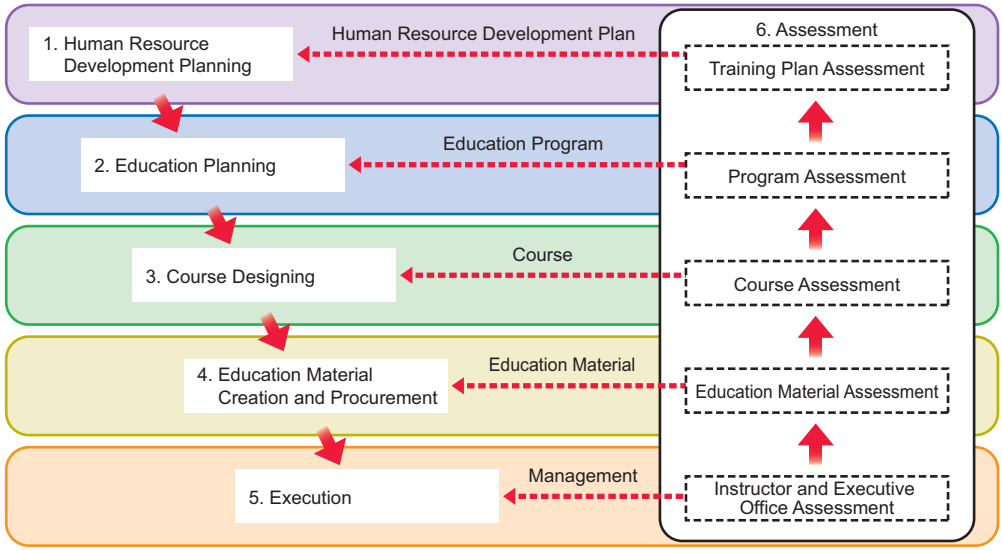


Figure 3.9: Process of the education program guideline

Using the Education Program Design Guide

Persons in charge of human resource development should read the education program design guide. Those who are going to plan and develop an education program of embedded system

development as well as those who have already developed a program and are managing it should find the guide useful.

This guide explains the procedures for designing an education program, and the points to be considered as well as provides case examples.

To perform all of these procedures is not what is important. What is important is to understand the necessity and background of the described procedures, and select and execute the procedures necessary for the education program to be developed. In some cases, items for which no procedures have been described in this guide would certainly and will need to be devised and extended. Select and perform the appropriate design procedures for your education program according to the purpose and conditions to be fulfilled by the education program.

Appendix

1

Skills Specification (Version 1.2)

Appendix 1 is based on Skills Specification Version 1.2. Some expressions and phrases have been revised for publication.

I. Overview

In the “Embedded Technology Skill Standards (hereinafter abbreviated as ETSS),” which aims to strengthen embedded software development capabilities, the framework for the systematic arrangement of embedded software development skills is called “skills specification.”

1. Overview of the Skills Specification

The skills specification identifies and systematizes the skills required for embedded software development, and provides an index (common specification) for effective human resource development and utilization of embedded software developers.

Although various skills are required for embedded software development, the skills specification focuses only on “technologies,” and does not define business and social skills.

2. Necessity of the Skills Specification

Similar to system LSIs, one of the characteristics of embedded software is that it is used across industries.

Embedded software has a characteristic of being developed concurrently with diverse hardware, and being developed under strict constraints, including requirements for high safety, reliability, and realtime performance. In the recent years, embedded software has been increasing in size and complexity along with diversification of products and improvements in hardware performance, and at the same time, it is required to be developed in a short period of time.

Owing to such characteristics and trends, problems caused by the quality of embedded software have occurred in the market, which may affect the Japanese industry that is known for its high-quality product development.

Because embedded software development is used across industries, the technologies being used are innumerable; and thus, a wide range of skills is required for engineers who develop embedded software. Furthermore, progress in technology is fast and products becoming obsolete in increasingly shorter time. As a result, engineers involved in embedded software development are required to have skills for acquiring new product technologies in a timely manner.

By systematically arranging and identifying skills required for embedded software development, human resource development and utilization of human resources can be promoted, and high-quality products can be developed within a relatively short period of time. This will ensure and improve the international competitiveness of the Japanese manufacturing industry.

3. Expected Results of the Skills Specification

The skills specification systematically organizes technological skills for embedded software development. The use of systematically arranged skills helps in implementing effective human resource development and utilization of human resources. They can also be used as tools and information in engineering.

(1) Human Resource Development

By using the skills specification in human resource development, the vision in human resource development could be expressed, and identification of training targets would be possible. Furthermore, the increase in skill level before and after the time of training can be visualized when checking the training status, and motivation with regard to the training can also be expected to be achieved.

(2) Utilization of Human Resources

The skills specification is used to visualize the skills of an individual engineer and organizations (including companies and teams), and the visualized information is extensively used as follows:

Plan: Establishment of management strategies and project plans

Hiring and Procurement: Hiring and procuring human resource according to the above "plan"

Task performance: Accomplishment of tasks by human resources (skills) that have been acquired through the above mentioned "hiring and procurement" according to the above "plan"

Assessment[*1]: Assessment of the task performance status and results, and providing feedback on activities of organizations and individuals

(3) Engineering

Because the skills specification organizes the relationship between the attributes of development projects and the skills, it can be used as an engineering tool for development.

For example, from the viewpoint of skills required in a development project (technological elements, development technologies, and management technologies), it can be used in performing risk management. In a development project, technological attributes (such as quality properties) are assessed and examined, and risk management, including identification of risks, is performed.

*1: Application of this skills specification to the assessment and treatment (pay, benefits, position assignment, etc.) of human resources is off the point from the original intention of "strengthening of company's competitiveness and human resource development through visualization of skills," and it must be specifically noted that in some cases, it might lead to decline in the motivation of engineers, and eventually result in a negative impact.

4. Problems Not Resolved by Skills Specification

The skills specification is an index, and applying it without a purpose and strategy, will not contribute to strengthening the development capabilities of a company. The same holds true for its application to career development and education based on the skills specification.

II. Skills Framework

1. Overview

1.1 Definition of Skills

Skills are often represented as mastery and expertise. In this skills specification, skills indicate the capability to accomplish a task, and expresses being "capable of ….," and just having knowledge is not considered as a skill.

1.2 Structure of the Skills Framework

The skills framework has a structure as shown in Figure F1.1, and is set up with the purpose of organizing embedded software technologies.

◆ Skill categories

The technologies required for embedded software development are classified into three technologies, "technological elements," "development technologies," and "management technologies," and these categories are the starting point for arranging each in a hierarchical order.

◆ Skill levels

Skill levels represent the 4-tier arrangement of the expected values of task performance capabilities for the technologies arranged in a hierarchical order.

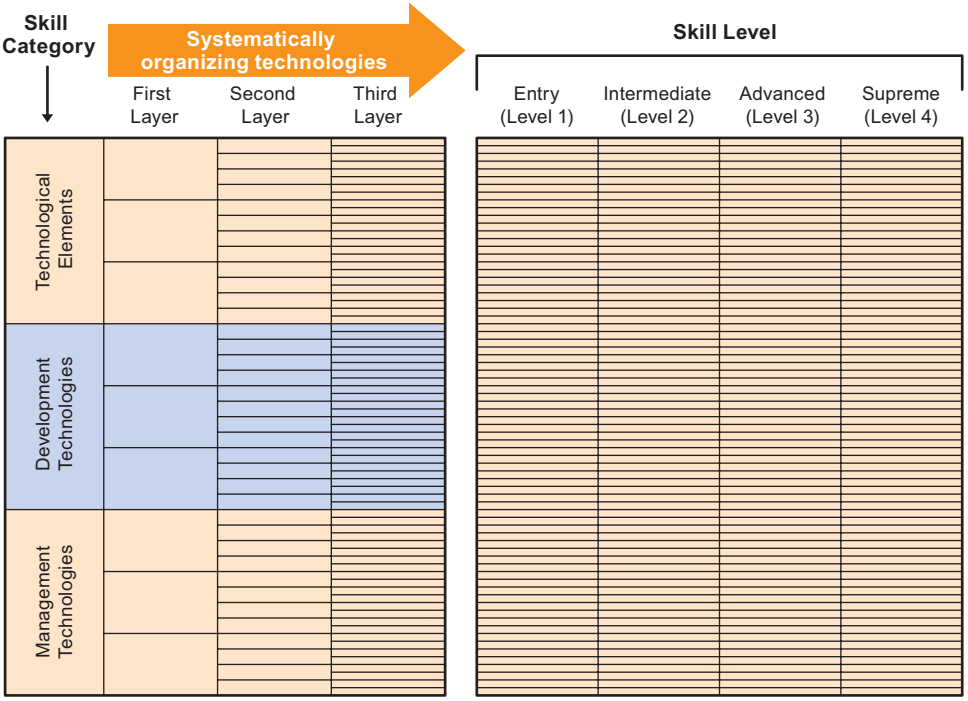


Figure F1.1: Skills framework

2. Description of Skill Categories

The skill categories of the ETSS skills framework serve as the starting point for a systematic classification and arrangement of technologies related to embedded software development.

◆ **Skills are arranged in the skill categories "technological elements," "development technologies," and "management technologies"**

Technological elements: The technological items representing the functions of the system, which are incorporated into the embedded system itself, are classified as "technological elements."

Development technologies: The technological items used at the time of development for

implementing various technological elements in the embedded system are classified as “development technologies.”

Management technologies: The technological items used to progress the embedded system development smoothly and properly are classified as “management technologies.”

◆ **With the skill categories as the starting point, arrange the technologies of embedded software development in a detailed and specific hierarchical arrangement from the first layer to the nth layer.**

Define the skills for the lowest layer so that they could be identified as specific technology names for which assessment of skills is possible.

The skills specification presents the skill categories only up to the second layer and the skill items having lower layers are not defined specifically. These are expected to be put into use according to the definition provided by companies or organizations using them.

3. Description of Skill Levels

3.1 Definition of Skill Levels

The skill levels of the ETSS skills framework have a common definition in each skill category.

In ETSS, the expected values (potential) of task performance capabilities are represented by a four-tier skill level arrangement for each technological item.

Skill levels 1 (entry) to 3 (advanced) of ETSS define the level of task performance capabilities for established technologies, and in addition, supreme - skill level 4 is defined to assess the capabilities to promote technological reforms (innovation).

◆ Level 4: Supreme	Capable of developing new technologies
◆ Level 3: Advanced	Capable of analyzing and improving tasks
◆ Level 2: Intermediate	Capable of performing tasks on one's own
◆ Level 1: Entry	Capable of performing tasks with support

3.2 Assessment of Skill Levels

The skill assessment criteria clearly define the requirements for "having skills (task performance capabilities)." Although there is an approach to provide specific assessment criteria for each skill, the ETSS skills framework provides common assessment criteria.

◆ Technological elements

Can produce: "Capable of implementing the xx technological element within a given environment"

→ xx: Technological element name

Can utilize: "Capable of incorporating the xx technological element to implement the required function within a given environment"

→ xx: Technological element name

Environment indicates the "specifications, conditions, features, case examples, information, etc."

◆ Development technologies

"Capable of yy by using zz"

→ zz: Development technology methods and development tool names, yy: Development process name

◆ Management technologies

"Capable of yy by using zz"

→ zz: Management technology methods and management tool names, yy: Management process name

Two viewpoints concerning operation and knowledge are required in the case of the phrase "capable of yy" used in the assessment criteria.

"Capable of --" means that the task can be performed as an actual action. When performing a task, while "accuracy" and "efficiency" are basic requirements, skill application capability in the form of appropriate "situational judgment" is also required.

Knowledge of the methods and tools to be used in the task is required as a prerequisite for performing the actions. Therefore, knowledge related to objects, environment and procedures for using the methods and tools, is also required. By checking these actions and knowledge, it is possible to assess that one is "capable of -- ."

In skill assessment, the assessment methods, the assessment system, and the evaluator's qualifications such as whether he/she possesses high knowledge, especially of technological items, are important factors. How to assess the level of skills from the execution status of the development tasks needs to be sufficiently examined and explicitly expressed.

III. Skills Specification

1. Skill Categories in Embedded Software Development

The skill categories up to the second layer which are defined as the skills specification are described below.

1.1 Technological Element Skill Category

Table F1-1: Technological elements

First Layer		Second Layer		Description
1	Communications	1	Wired	Wired communication technologies such as WAN and LAN
		2	Wireless	Wireless communication technologies, such as telecommunications and general business wireless technology
		3	Broadcast	Broadcasting technologies, such as digital broadcasting and analog broadcasting
		4	Internet	Internet communication technologies, such as transparent data transfer and applications
2	Information Processing	1	Information Input	Information input technologies, such as data input and voice input
		2	Security	Security technologies, such as encryption and copyright protection
		3	Data Processing	Data processing technologies, such as compression and databases
		4	Information Output	Information output technologies, such as markup language and document viewers
3	Multimedia	1	Voice	Voice processing technologies, such as data processing, compression and decompression
		2	Still Image	Still image processing technologies, such as data processing, compression and decompression
		3	Moving Image	Moving image processing technologies, such as data processing, compression and decompression
		4	Integration	Integrated processing technologies, such as voice and image

First Layer		Second Layer		Description
4	User	1	Human Interface Input	Human interface input device control technologies, such as buttons and coordinate input
		2	Human Interface Output	Human interface output device control technologies, such as visual and voice output
5	Storage	1	Media	Storage media technologies, such as removable storage and memory
		2	Interface	Storage interface technologies, such as removable devices and full-time connections
		3	File System	File system technologies, such as ISO and native OS file systems
6	Measurement and Control	1	Physical and Chemical Input	Physical and chemical input technologies, such as electrical, pressure, and light input technologies
		2	Measurement and Control Processing	Measurement and control technologies, such as coordinate & movement processing, and signal processing
		3	Physical and Chemical Output	Physical and chemical output technologies, such as actuators, light, and heat output technologies
7	Platform	1	Processor	Processor technologies, such as CPUs and GPUs
		2	Basic Software	Basic software technologies, such as kernels and booting
		3	Support Functions	Support function technologies, such as data recording and acquisition

1.2 Development Technology Skill Category

Table F1-2: Development technologies

First Layer		Second Layer		Description
1	System Requirements Analysis	1	Requirements acquisition and adjustment	Interviewing methods, marketing methods, etc.
		2	System analysis and requirements definition	Modeling methods, analysis methods, requirements definition, etc.
		3	Review of system analysis and requirements definition	Review methods, inspection methods, etc.
2	System Architecture Design	1	Hardware and software function and performance assignment decision	System function related and non-function related design, design methods, performance estimation, system scale estimation, hardware and software role assignment, etc.
		2	Implementability verification and design review	Review methods, inspection methods, etc.

First Layer		Second Layer		Description
3	Software Requirements Analysis	1	Software requirements definition	Modeling methods, analysis methods, requirements definition, etc.
		2	Software requirements evaluation and review	Review methods, inspection methods, etc.
4	Software Architecture Design	1	Software structure determination	Performance estimation, reliability design, fault tolerant technologies, software estimation methods, intellectual property rights, reuse, etc.
		2	Software structure design review	Review methods, inspection methods, etc.
5	Detailed Software Design	1	Detailed software design	Design methods, design tools, real-time performance design, etc.
		2	Detailed software design review	Review methods, inspection methods, etc.
6	Software Coding and Testing	1	Program creation and identification of program testing items	Programming methods, programming tools and environments, test design methods, coverage measurement methods, simulations, etc.
		2	Code review and program test item design review	Review and inspection methods, static analysis tools, dynamic analysis tools, etc.
		3	Program test implementation	Drivers and stubs, test tools, regression tests, etc.
7	Software Integration	1	Software integration test specification design	Test design methods, coverage measurement methods, simulations, emulation, hardware environments, etc.
		2	Software integration test implementation	Test tools, ICE, monitors, logic analyzers, oscilloscopes, regression tests, etc.
8	Software Qualification Test	1	Software qualification test preparation and review	Software qualification test implementation
		2	Software qualification test implementation	Test tools, ICE, monitors, logic analyzers, oscilloscopes, regression tests, etc.
9	System Integration	1	Test item selection, test procedure determination and review	Review methods, inspection methods, etc.
		2	System integration test implementation	Test tools, ICE, monitors, logic analyzers, oscilloscopes, regression tests, etc.
10	System Qualification Test	1	System qualification test preparation and review	Review methods, inspection methods, acceptance tests, etc.
		2	System qualification test implementation	Test tools, regression tests, etc.

1.3 Management Technology Skill Category

Table F1-3: Management technologies

First Layer		Second Layer		Description
1	Project Management	1	Integration Management	WBS, EVM, conference management methodologies, review and inspection methods, etc.
		2	Scope Management	WBS, change management, etc.
		3	Time Management	PERT, Gantt charts, estimation methods, etc.
		4	Cost Management	ROI, ROE, estimation methods, EVM, etc.
		5	Quality Management	Inspection, fault analysis statistical methods, trend analysis, etc.
		6	Organization Management	Team building, OBS, etc.
		7	Communication Management	Information distribution methods, etc.
		8	Risk Management	Risk analysis, decision tree analysis, risk levels, etc.
		9	Procurement Management	Planning, procurement source selection, contracts, performance management, etc.
2	Development Process Management	1	Development Process Definitions	System development process definitions , review settings, etc.
		2	Intellectual Property Management	Related regulations, management systems, etc.
		3	Development Environment Management	Development environment planning, design, construction, operation management, etc.
		4	Configuration Management and Change Management	Identification, control, recording, inspection, etc.

2. Range of ETSS Description

The range of technologies defined in ETSS includes those used commonly in embedded software. Specific technologies used in individual companies and application domains are not handled.

For such specific technological skills, it is expected that standardization and handling of those skills are deliberated in organizations or groups of the individual companies or within the relevant application domains. If there is concern that outflow of technological skills may reduce competitiveness, operation must be performed without disclosing the information. On the other hand, technological skills can be made open to public and can be used to acquire human

resources who have skills required by the company, and can also be reflected in ETSS as skill common to embedded software.

3. Time-to-Time Revisions

In accordance with rapid technological changes and progress in embedded software development, it can be assumed that skill items and their values are not constant and continue changing. This skills specification will also be subject to continuous and appropriate content validation as a systematic arrangement of skills, and will be flexibly revised as needed.

Appendix. Rolling Out the Skills Framework to Other Fields

An image is presented below for application of ETSS in activities other than embedded software development, such as hardware development.

1. Characteristics of Embedded Product Development

One of the characteristics of embedded software is that it is developed concurrently in cooperations with engineers engaged in fields other than embedded software. Hardware development including LSI (Large Scale Integration), various data to be incorporated into products (such as maps in car navigation systems and graphics in user interface functions), and software for general-purpose computers that operates in coordination with the products (such as device drivers and application software) are developed concurrently.

Furthermore, it is often seen that hardware development engineers and development engineers of various data and software for general-purpose computers also belong to the same organization.

If we see ETSS only in terms of the technological elements, development technologies, and management technologies skill categories, there is no category that is specific to embedded software. Furthermore, the first layer represents skills that can be applicable to hardware development and LSI development, apart from activities limited to software development in the development technologies. The first layer of development technologies consists of activities concerning the development process of SLCP (Software Life Cycle Process, JIS X 0160), and these can be considered as skills that are not restricted to embedded software and may also be applied to general-purpose software development.

2. Application to Hardware Development

When applying ETSS to hardware development including LSI development and PCB (Printed Circuit Board) development, or mechanics development, hardware development activities executed concurrently with activities existing in development technologies of the first layer, from software requirements analysis to software integration, should be defined additionally in the first layer of the development technologies category.

For example, in the case of LSI development, define the activities concerning behavior and RTL (Resistor Transistor Logic) design and verification of layout and masking, and also define the skills required for these activities. Because activities concerning LSI development are not defined in ETSS, it is desirable that standard activities in the LSI industry be defined as necessary.

In such a case, activities other than those related to software development in development technologies are activities that are related to the system. Because these activities are not dependent on software and hardware, they can be applied at a common level.

Furthermore, it is possible that skills that are not defined in the technological elements also exist in mechanics development. Skills concerning hardware must also be clearly distinguished into “skills that can produce” and “skills that can utilize.” This can be done by additions to the first layer. However, mapping to the existing first layer and second layer needs to be examined sufficiently.

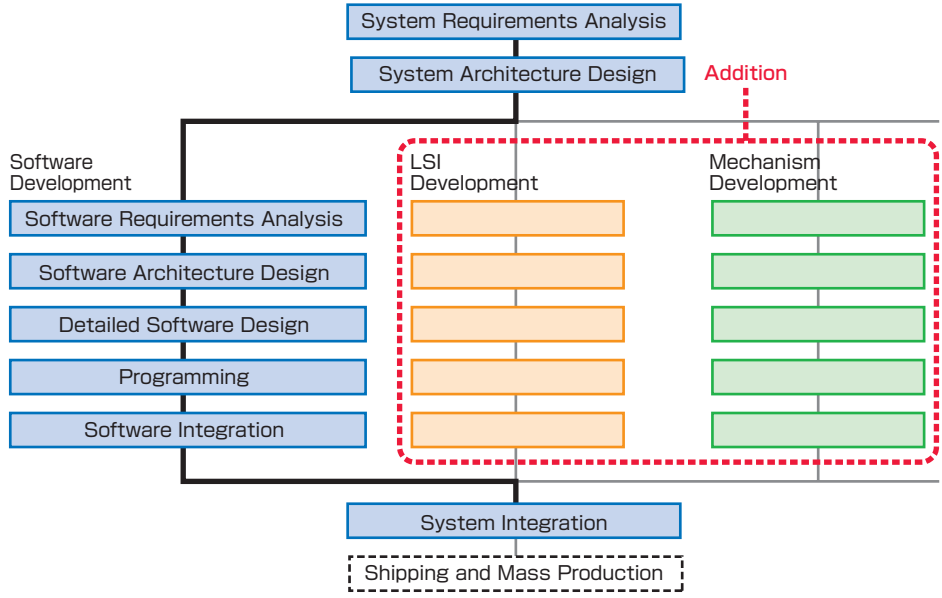


Figure F1.2: Application to development processes other than software

3. Application to Software Development for General-Purpose Computers

When applying ETSS to software development for general-purpose computers including device drivers and application software, the first layer of the development technologies category can be applied as it is because it includes activities concerning the development process of SLCP.

Define the required skills for each activity. The skills concerning the methods and tools used in software development for general-purpose computers should be arranged in a hierarchical structure for each activity.

When executing development activities in a development process other than SLCP, ETSS can be utilized by either rolling out the activities of the other development process to SLCP, or by creating an SLCP correspondence table.

Furthermore, activities other than those concerning software development in the development technologies category (such as activities concerning the system) can be applied at a common level.

The specific definitions of such activities are expected to be provided by industrial groups and communities, and put to widespread use.

Appendix

2

Career Specification (Version 1.2)

Appendix 2 is based on the Career Specification Version 1.2. Some expressions and phrases have been revised for publication.

I. Outline

1. Outline of Career Specification

The aim of the "Embedded Technology Skill Standards" (here after referred to as ETSS) is to enhance the capabilities of embedded software development. In the Standard, "career specification" defines job category names and duties relating to embedded software development in order to realize human resource development and the utilization of human resources.

The ETSS career specification illustrates the main job categories and specialty fields relating to software development for embedded system development, as well as the skills required of each category and field. The career specification is intended to be used as a standardized terminology across the industry for job categories and specialty fields.

Also, each job category and specialty field is represented using a common career framework.

This career specification framework was formulated to be used as an effective index or "yardstick" for human resource development and the utilization of human resources in the field of embedded software development.

2. Necessity of Career Specification

Currently, the job titles of engineers involved in embedded software development normally relate to their positions in the office organization, and do not correspond to their technological roles. Even in the recruitment of engineers, apart from designating domains such as "control system" and "embedded system," it is common just to designate general job category such as "programmer," "system engineer," and "software development." These facts show that in the

current situation, the technological roles of embedded engineers are not differentiated, and also that required expertise are not clearly defined. As a result, for recruitment, the qualification requirements and desired experience and capabilities are expressed in terms of number of years of experience and experience in development using technologies designated by specific technology names.

As such, in the current scenario, engineers are basically only able to prove technological capabilities gained from experiences in development projects in which they have participated, which can mean that guidelines for engineers to autonomously deepen their expertise are scarce.

The career specification specifies the main job categories and specialty fields of engineers required for embedded software development, and also provides an outline of each job category and specialty field, as well as the skills required.

When developing embedded software in a smaller organization, a single person will be executing the responsibilities and features of more than one job category and specialty field presented in the career specification. Furthermore, even in the case of larger organizations, one person may be performing the duties of more than a single job category or specialty field. Because the purpose of this career specification is to enhance the capabilities of embedded software development, such cases are not denied.

3. Expected Results of Career Specification

(1) Advantages for the Individual

Using the career specification, an individual can gain a bird's-eye view of future possibilities as an embedded engineer, and can aim at an overall development of capabilities in accordance with his/her aptitude and environment, including technological elements, development technologies, management technologies, business skills, and social skills. Furthermore, because the career specification has been formulated with cooperation of the government and industry, the acquired capabilities of an individual will be publicly acknowledged not only within his/

her company, but also in the entire industry and engineer community. Furthermore, this career specification enables identification of new skills to be acquired when an individual may want to change his/her job category for any reason, and also illustrates the education and training required thereof.

In short, this career specification can provide a more autonomous and intelligent career design for an engineer.

(2) Advantages for an Enterprise

When the job categories (roles) and specialty fields become clear, a more precise estimation can be made of the technological roles and number of engineers required in a specific development project. Furthermore, when it is necessary to employ engineers or temporarily procure external engineers, the capabilities required can be expressed more accurately than before. In the long term, identifying the job categories and specialty fields needed to be reinforced for the company's business strategy enables optimization and effective placement in human resource planning (such as recruitment, human resource development, and external procurement).

(3) Industrial and Government Policy Advantages

Through the clarifications of this career specification, individual embedded engineers can deepen their expertise in a planned manner, resulting in the enhancement of the development capabilities of the whole field. Furthermore, due to the existence of a common yardstick, the "circulation" of embedded engineers within and between companies will become easier, resulting in a more appropriate manpower arrangement. By identifying the job categories of embedded engineers and standardizing the terminology used to describe these categories, it is also expected that the shift of engineers from the IT profession (enterprise) will become more active. For example, job categories of embedded engineers that have previously been described simplistically are now described in a more multifaceted manner, allowing engineers of different

job categories from the IT profession (enterprise) to identify job categories where they can best exercise their skills.

II. Career Framework

1. Outline

The ETSS career specification stipulates a career framework that can be used across the industry to express the job categories and specialty fields relating to embedded software development.

The ETSS career framework consists of the following elements.

- Classification of job categories and specialty fields
- Definition of career levels
- Correspondence between job categories and specialty fields and skills
- Responsibilities of job categories and specialty fields

These components of the ETSS career framework are explained below.

1.1 Job Categories and Specialty Fields

The job categories and specialty fields relating to embedded system development are defined here, and career levels are defined for each category and field.

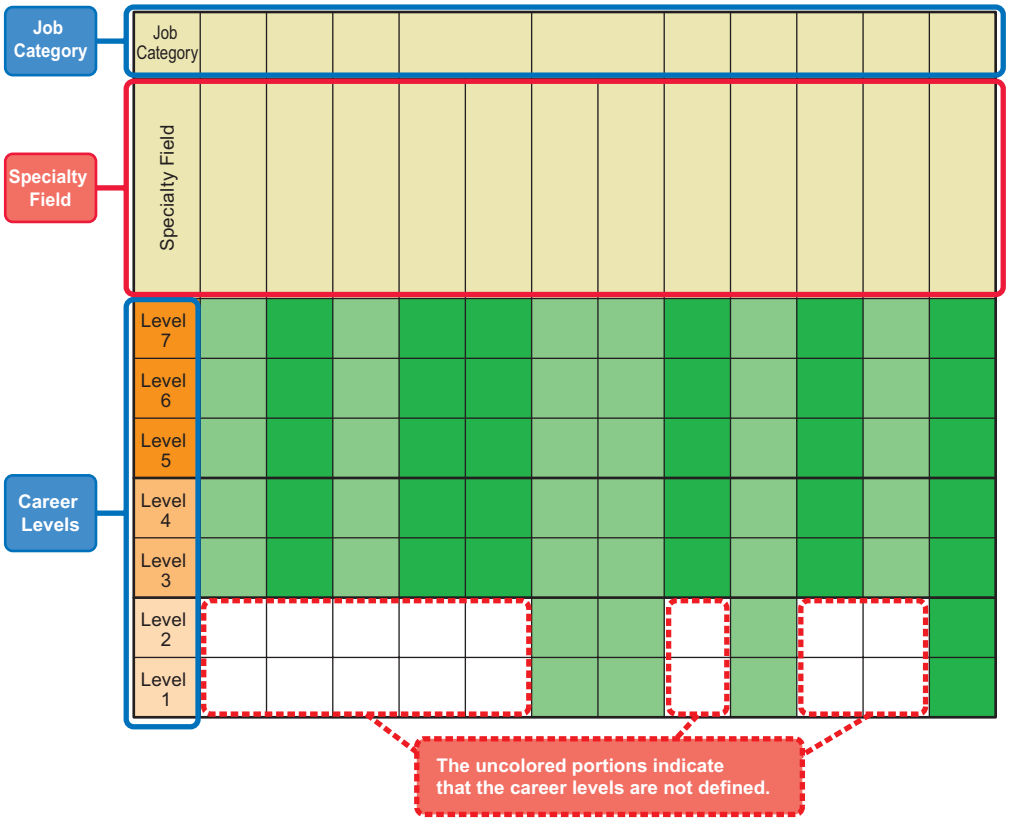


Figure F2.1: Job categories and specialty fields, and their career levels

1.2 Career Levels

The career levels conform to the Common Career Skills Framework.

2. Correspondence between Job Categories and Specialty Fields and Skills

The skills required for each job category and specialty field are correlated to the skills of the career specification and the skills defined in the career specification. The former are skills belonging to each of the skill categories of technological elements, development technologies, and management technologies, while the latter are social skills and business skills, such as "communication" and "marketing."

2.1 Social Skills and Business Skills

This career specification defines social skills and business skills. Although the skills specification is specified in the Embedded Technology Skill Standards, it is targeted at the technologies required for embedded software development. The career specification presents the degree of contribution by personnel as a business person and professional, which is not achieved just with technological skills.

Therefore, the career specification defines the "social skills" and "business skills" to achieve this contribution as a business person and professional. These skills are not requirements just for embedded software development, but may also be applied commonly to IT (for enterprise) system development as well as job categories other than development. These skills are presented as the basic skills to cover in order to reinforce the capabilities of embedded software development, and are mainly defined with the purpose of identifying targets for training (education, training, and practice).

For skill levels, the concept defined separately in "skills specification" is applicable.

Table F2.1: Definition of social skills and business skills

Skill Category	First Layer		Description
Social Skills	1	Communication	To speak, listen, write, etc.
	2	Negotiation	Questions, investigations, statements, etc.
	3	Leadership	Capability development, time management, motivation, etc.
	4	Problem-Solving	Observation, ideas, problem finding, analysis, logical reasoning, etc.
Business Skills	1	Management	Analysis, strategy, assessment, etc.
	2	Accounting	Financial analysis, accounts, etc.
	3	Marketing	Analysis, market investigation, strategies, etc.
	4	HCM*	Personnel strategies, personnel management, and capability development, etc

*HCM: Human Capital Management

Apart from the above skills, there are also other matters that developers are required to understand and realize, such as engineer ethics and compliance.

2.2 Method of Expressing Correspondence with Skills

The correspondence between job categories and specialty fields with the required skills is expressed in two ways. First is the "skills domain," which presents the skills for each job category or specialty field for which a career level of 3 or 4 is desired. Second is the "skills distribution characteristics" which present the skills and skill levels required for each job category and specialty field as well as each career level[*1].

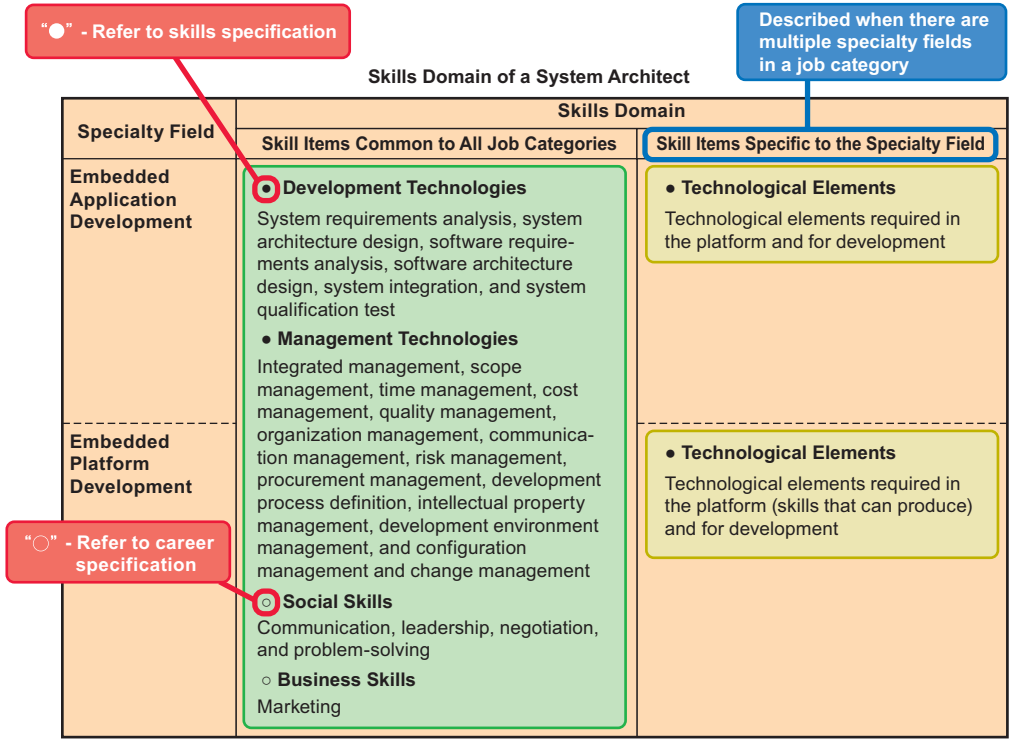
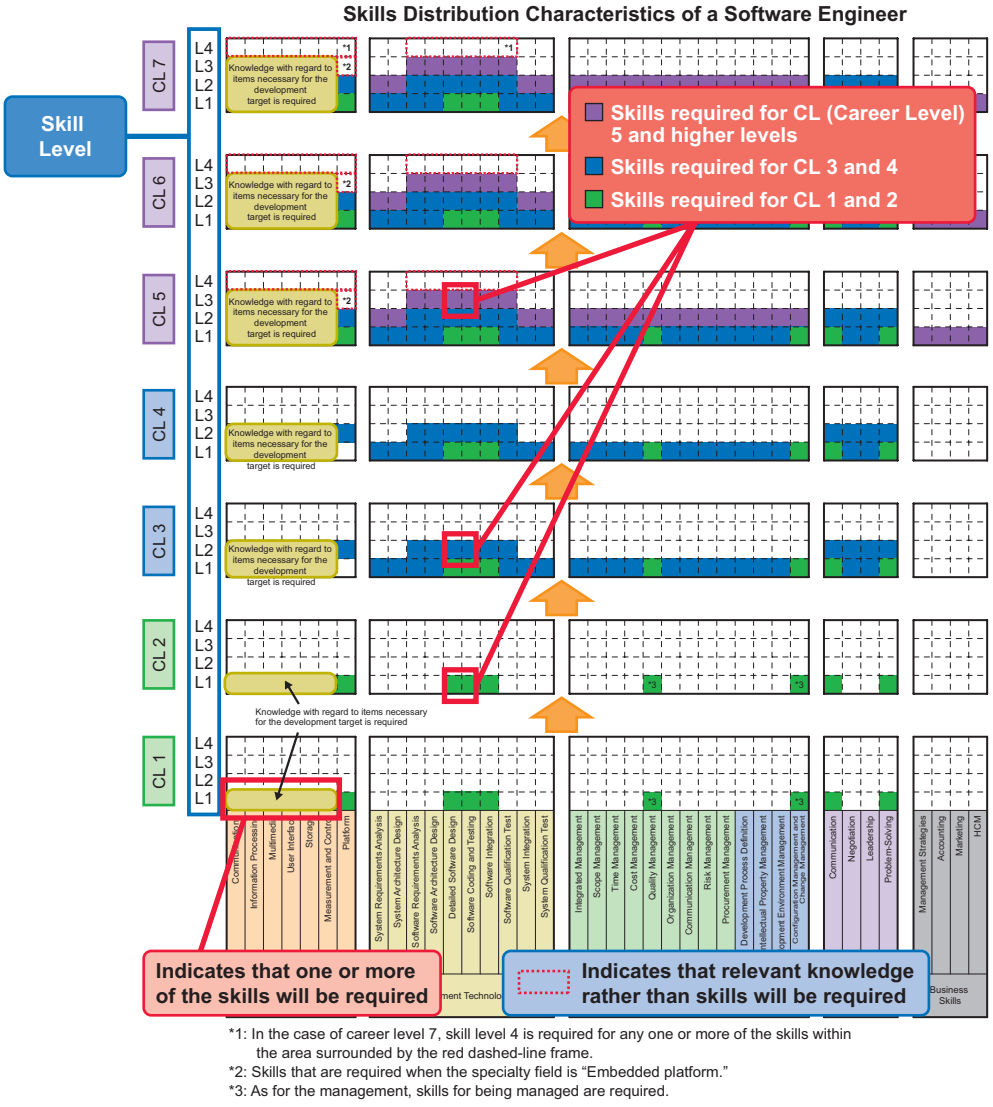


Figure F2.2: Description of the skills domain



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.
*2: Skills that are required when the specialty field is “Embedded platform.”
*3: As for the management, skills for being managed are required.

Figure F2.3: Description of skills distribution characteristics

3. Correspondence between Job Categories and Responsibilities

By presenting the scope and examples of responsibilities for each job category, the roles to be executed in each job category are identified. Skills are what are required to execute these responsibilities.

- Scope of responsibilities: Presents the scope of responsibilities that must be assumed in a job category.
- Examples of responsibilities: Presents measurable items as examples of responsibilities.

III. Career Specification

1. Job Category and Specialty Fields, and Their Career Levels

Job Category	Product Manager	Project Manager	Domain Specialist	System Architect		Software Engineer		Bridge SE	Development Environment Engineer	Development Process Improvement Specialist	QA Specialist	Test Engineer
Specialty Field	Embedded System	Embedded Software Development	Embedded-Related Technologies	Embedded Application Development	Embedded Platform Development	Embedded Application Development	Embedded Platform Development	Embedded Software Development	Embedded Software Development	Embedded Software Development	Specialty Field	Embedded System
Level 7												
Level 6												
Level 5												
Level 4												
Level 3												
Level 2												
Level 1												

Figure F2.4: Job category and specialty fields, and their career levels

- Job category

  For details about job categories, see each item in 3.

- Specialty field

  Embedded system: The entire product including hardware

  Embedded software: Software operating on the embedded system

  - Embedded application: Application software for achieving the purpose of the product
  - Embedded platform: Basic software supporting the implementation of product functions

  Embedded-related technologies: Technologies relating to the technological elements, product and application domain

- Meaning of colored levels of each job category and specialty field

  Colored parts indicate the existence of a career level for the corresponding job category or specialty field. In some job categories and specialty fields, low skill levels yield no value creation as a professional, and therefore these spaces are left blank.

2. Correspondence between Job Categories and Responsibilities

Table F2.2: Table showing the correspondence between job categories and responsibilities

Job Category Name	Responsibility	
	Scope of Responsibilities	Examples of Responsibilities
Product Manager	Product development business	Revenue and contribution
Project Manager	Project	Quality, cost, and delivery
Domain Specialist	Roll-out of technologies	Efficiency of product development
System Architect	System structure and implementation method	Development efficiency and quality
Software Engineer	Deliverables of software development	Quality, productivity, and delivery
Bridge SE	Joint operations with external organizations	Quality, cost, and delivery
Development Environment Engineer	Quality of the development environment	Usability and work efficiency
Development Process Improvement Specialist	Improvement of development processes of the organization	Process improvement effect
QA Specialist	Process quality Product quality*	Quality problems after shipment
Test Engineer	System validation and verification	Quality, test efficiency, and test delivery

*: The division manager may hold responsibility in some cases

3. Description of Job Categories

3.1 Product Manager

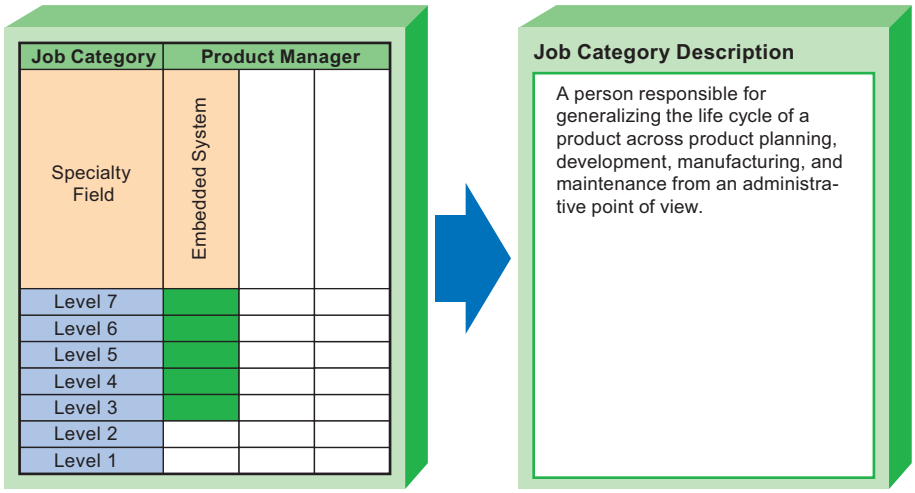
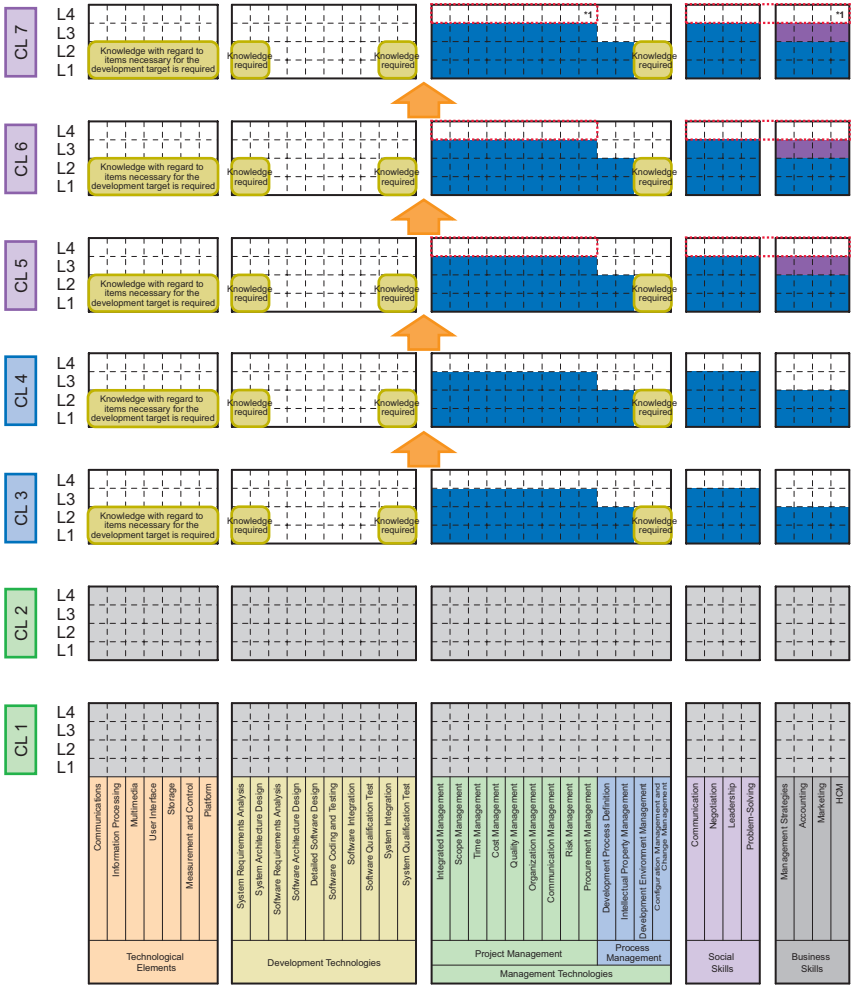


Figure F2.5: Outline of a product manager

Specialty Field	Skills Domain	
	Skill Items Common to All Job Categories	Skill Items Specific to the Specialty Field
Embedded System	Integrated management, scope management, time management, cost management, quality management, organization management, communication management, risk management, procurement management, development process definition, intellectual property management, development environment management, and configuration management and change management ○ **Social Skills** Communication, leadership, negotiation, and problem-solving ○ **Business Skills** Management, accounting, marketing, and HCM	

Note: For the skill items of the skills domain, describe the skill items required in career level 3 and career level 4 of the job category

Figure F2.6: Skills domain of a product manager



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.

* This information is created for the purpose of human resource development, and not for career level assessment

Figure F2.7: Skills distribution characteristics of a product manager

■ Supplementary Description

[Technological elements]

- Knowledge of the product is essential.
  - Knowledge of vital points is required instead of getting involved in the concrete steps of the development process.

[Development technologies]

- Knowledge of system requirements analysis, designing, and testing is essential.
  - Knowledge of vital points is required instead of getting involved in the concrete steps of the development process.
- **Software development skills are not mandatory.**
  - For example in the case of managers who do not come from a software background.

[Management technologies]

- Product management skills, including software and hardware development, are essential.
  - Understanding of software development processes is essential.
- For accurate decision-making during the development phase, information collection and analysis skills are essential.
- Definition of KPIs (Key Performance Indicators), such as intellectual property management from the perspective of both offence and defense, and configuration management based on the product line, is essential.

[Social skills and business skills]

- Exhibition of leadership for the promotion of business is essential.
- Business skills for business planning, creation of product value, and creation of

profits are essential.

- Resource who can act as excellent leaders in coordination with stakeholders.

3.2 Project Manager

Job Category	Product Manager		
Specialty Field	Embedded Software Development		
Level 7			
Level 6			
Level 5			
Level 4			
Level 3			
Level 2			
Level 1			

Job Category Description

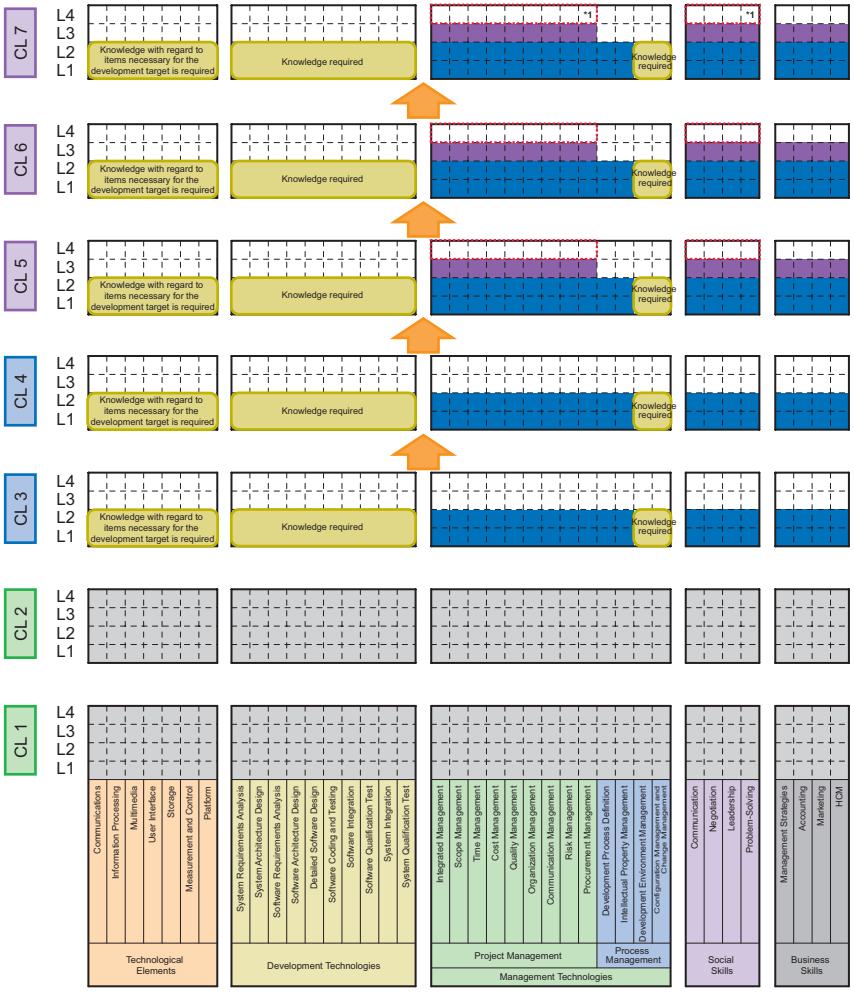
A person responsible for planning, commanding, and supervising a product development project during the course of its setup and accomplishment.

Figure F2.8: Outline of a project manager

Specialty Field	Skills Domain	
	Skill Items Common to All Job Categories	Skill Items Specific to the Specialty Field
Embedded Software Development	• **Management Technologies** Integrated management, scope management, time management, cost management, quality management, organization management, communication management, risk management, procurement management, development process definition, intellectual property management, development environment management, and configuration management and change management ○ **Social Skills** Communication, leadership, negotiation, and problem-solving ○ **Business Skills** Management, accounting, marketing, and HCM	

Note: For the skill items of the skills domain, describe the skill items required in career level 3 and career level 4 of the job category

Figure F2.9: Skills domain of a project manager



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.

* This information is created for the purpose of human resource development, and not for career level assessment

Figure F2.10: Skills distribution characteristics of a project manager

■ Supplementary Description

[Technological elements]

- Knowledge of the product as well as technological elements constituting the product is essential.
  - Knowledge of vital points is required instead of getting involved in the concrete steps of the development process.

[Development technologies]

- Although skills for software development are not mandatory, a comprehensive knowledge of development technologies that form the basis of judgments and analysis regarding promotion of the project is essential.

[Management technologies]

- Management skills targeting the range of responsibilities of the project are essential.
  - Examples: Schedule management, subcontract management, and risk management
- Skills for information collection and analysis for accurate decision-making during the development phase are essential.

[Social skills and business skills]

- Exhibition of leadership for the promotion of the development project is essential.
- Business skills for development planning, creation of product value, and creation of profits are essential.
- Professionals who can act as excellent leaders in coordination with the stakeholders.

3.3 Domain Specialist

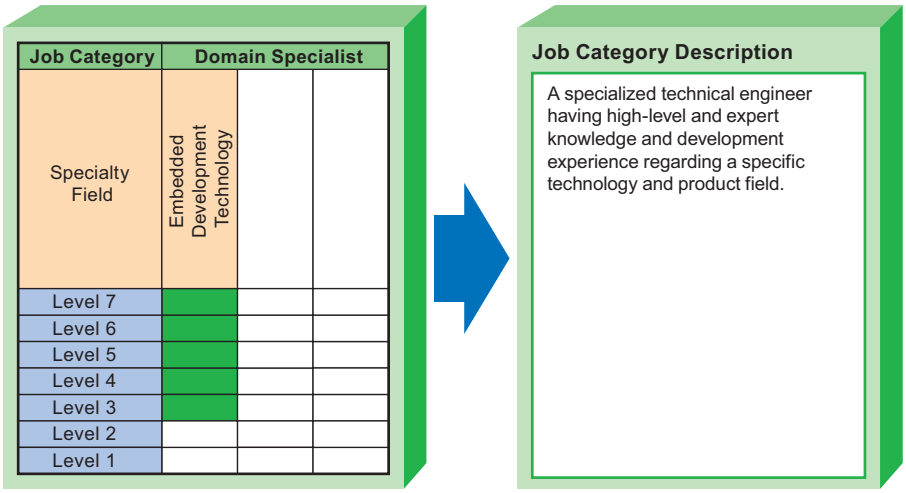
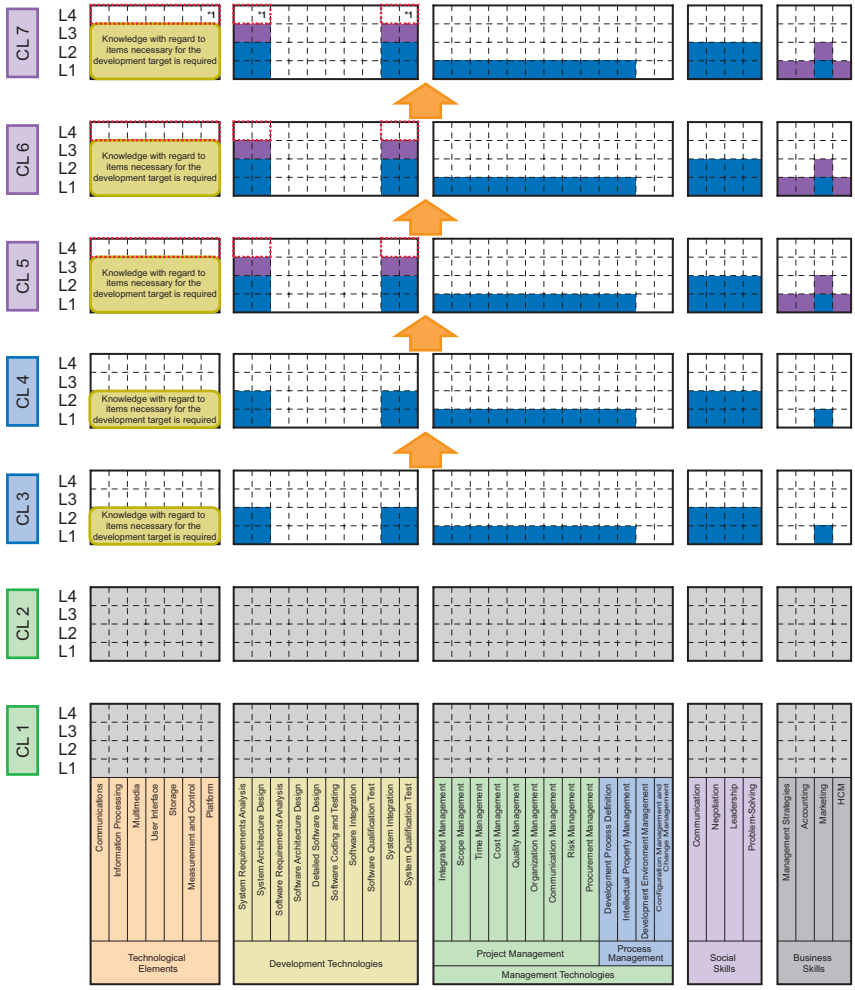


Figure F2.11: Outline of a domain specialist

Specialty Field	Skills Domain	
	Skill Items Common to All Job Categories	Skill Items Specific to the Specialty Field
Embedded Development Technology	• **Technological Elements** Professional technology • **Development Technologies** System requirements analysis, system architecture design, system integration, and system qualification test • **Management Technologies** Integrated management, scope management, time management, cost management, quality management, organization management, communication management, risk management, procurement management, development process definition, and intellectual property management ○ **Social Skills** Communication, leadership, negotiation, and problem-solving ○ **Business Skills** Marketing	

Note: For the skill items of the skills domain, describe the skill items required in career level 3 and career level 4 of the job category

Figure F2.12: Skills domain of a domain specialist



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.

* This information is created for the purpose of human resource development, and not for career level assessment

Figure F2.13: Skills distribution characteristics of a domain specialist

■ **Supplementary Description**

[Technological elements]

- Mastery technological skills relating to the product and the technological elements constituting the product are essential.
- If necessary, must be able to act as a reviewer in each process of development and maintenance.

[Development technologies]

- Skills for system requirements analysis, designing, testing, and maintenance of the product are essential.
  - The development tasks for the entire project are assigned to the project manager.

[Management technologies]

- Skills for project management, including software and hardware development, are essential.
  - The development tasks for the entire project are assigned to the project manager.

[Social skills and business skills]

- For recognizing and developing the value of technologies, marketing skills are essential.
  - Skills which reflect the direction of technological development in view of technological trends and the company's technologies are essential.

3.4 System Architect

Job Category	System Architect		
Specialty Field	Embedded Application Development	Embedded Platform Development	
Level 7			
Level 6			
Level 5			
Level 4			
Level 3			
Level 2			
Level 1			

Job Category Description

An engineer who designs the system structure and development processes fulfilling the requirements of system usage and development.

This job category is divided into the following specialty fields.

●Embedded Application Development

An engineer who develops the applications of the development target system using the platform.

●Embedded Platform Development

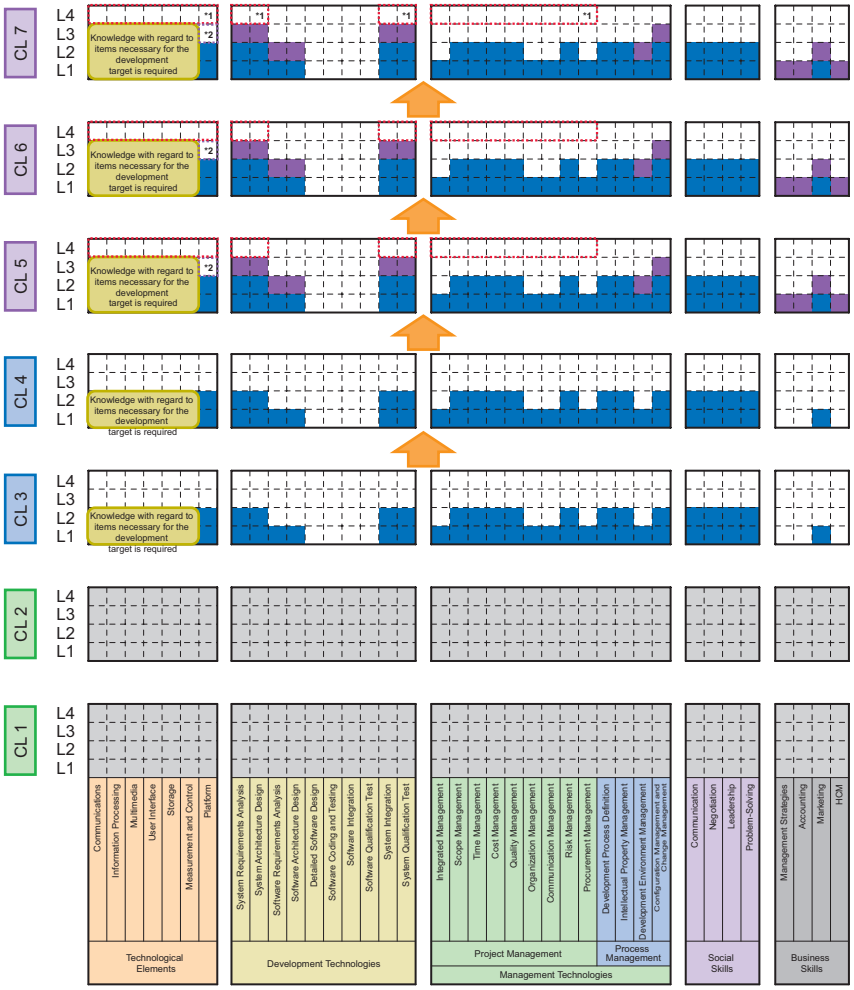
An engineer who creates the platform to be loaded in the development target system.

Figure F2.14: Outline of a system architect

Specialty Field	Skills Domain	
	Skill Items Common to All Job Categories	Skill Items Specific to the Specialty Field
Embedded Application Development	**● Development Technologies** System requirements analysis, system architecture design, software requirements analysis, software architecture design, system integration, and system qualification test **● Management Technologies** Integrated management, scope management, time management, cost management, quality management, organization management, communication management, risk management, procurement management, development process definition, intellectual property management, development environment management, and configuration management and change management **○ Social Skills** Communication, leadership, negotiation, and problem-solving **○ Business Skills** Marketing	**● Technological Elements** Technological elements required in the platform and for development
Embedded Platform Development		**● Technological Elements** Technological elements required in the platform (skills that can produce) and for development

Note: For the skill items of the skills domain, describe the skill items required in career level 3 and career level 4 of the job category

Figure F2.15: Skills domain of a system architect



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.
*2: Skills that are required when the specialty field is “Embedded platform.”

* This information is created for the purpose of human resource development, and not for career level assessment

Figure F2.16: Skills distribution characteristics of a system architect

■ Supplementary Description

[Technological elements]

- For the purpose of creating system architecture by assessing and selecting optimum technologies and methods, as much technological understanding as possible is required.
- Various technological skills required to achieve the product and platform technologies that constitute the infrastructure of the system are essential.

  <In the case of the specialty field “embedded platform”>

  - Skills for developing technologies (such as kernel and support functions) relating to the platform are essential.

  <In the case of the specialty field “embedded application”>

  - Skills for procuring and implementing technologies (such as kernel and support functions) relating to the platform are essential.

[Development technologies]

- Skills for system requirements analysis, designing, and testing of the product are essential.
  - The development tasks for the entire project are assigned to the project manager and product manager.
  - Identifies the needs of the stakeholders and supports the product concept definitions.
  - Chalks out the required form of the product keeping in mind the various constraints; selects and creates the optimum implementation method, and formulates the optimum system configuration.

[Management technologies]

- Because technology selection and system configuration affect QCD, development management skills backed by experience are essential.
- Skills in defining “make or buy” decisions in terms of technologies are essential.
- Skills for formulate the development schedule, cost, and quality plan are essential.
  - The development tasks for the entire project are assigned to the project manager.

[Social skills and business skills]

- Marketing skills for recognizing and developing the value of technologies are essential.
  - Skills which reflect the direction of technological development in view of technological trends and the company’s technologies are essential.
- Communication skills for maintaining and developing the human network are essential.
- To mobilize and bring together all the knowledge of each field and human resource into the architecture, and then understand and develop it, leadership is essential.

3.5 Software Engineer

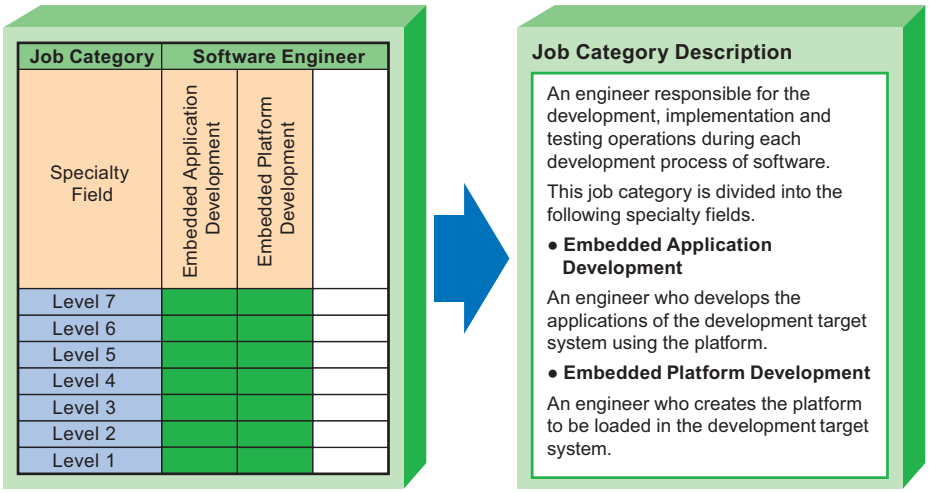
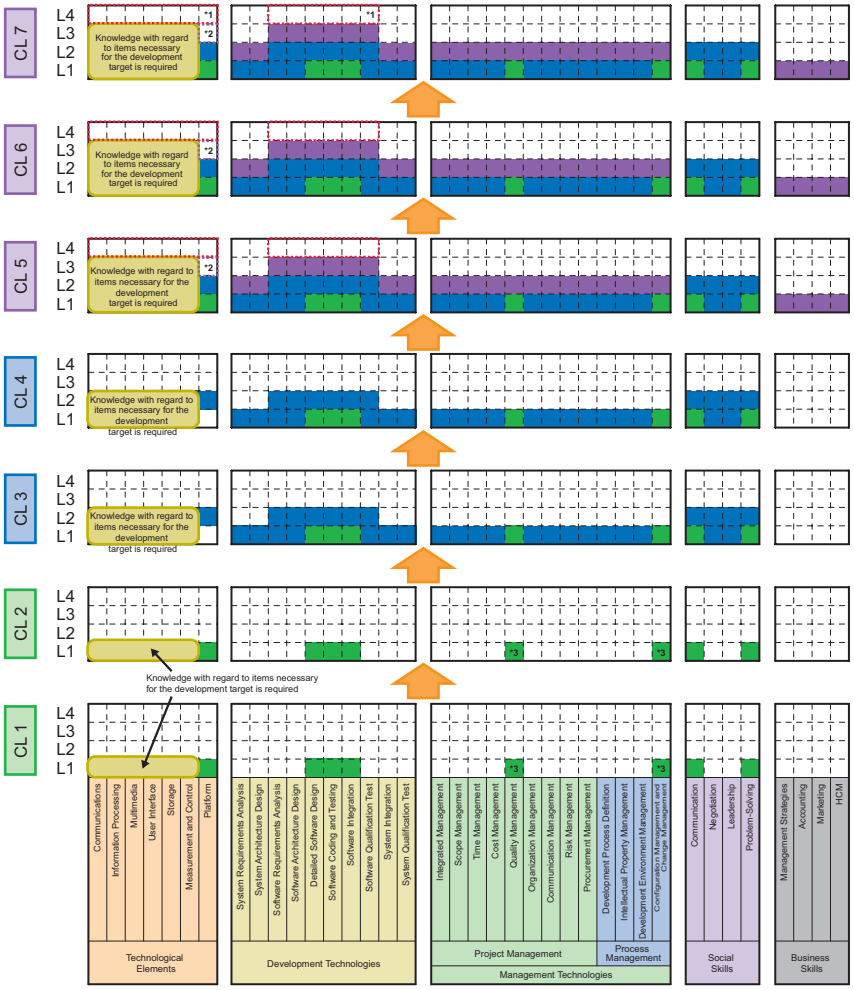


Figure F2.17: Outline of a software engineer

Specialty Field	Skills Domain	
	Skill Items Common to All Job Categories	Skill Items Specific to the Specialty Field
Embedded Application Development	• **Development Technologies** System requirements analysis, system architecture design, software requirements analysis, software architecture design, detailed software design, software coding and testing, software integration, software qualification test, system integration, and system qualification test • **Management Technologies** Integrated management, scope management, time management, cost management, quality management, organization management, communication management, risk management, procurement management, development process definition, intellectual property management, development environment management, and configuration management and change management ○ **Social Skills** Communication, leadership, negotiation, and problem-solving	• **Technological Elements** Technological elements required in the platform and for development
Embedded Platform Development		• **Technological Elements** Technological elements required in the platform (skills that can produce) and for development

Note: For the skill items of the skills domain, describe the skill items required in career level 3 and career level 4 of the job category

Figure 2.18: Skills domain of a software engineer



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.
*2: Skills that are required when the specialty field is "Embedded platform."
*3: As for the management, skills for being managed are required.

* This information is created for the purpose of human resource development, and not for career level assessment

Figure F2.19: Skills distribution characteristics of a software engineer

■ Supplementary Description

[Technological elements]

- In order to implement the development target platform and the functional requirements he or she is responsible for, the relevant skills in technological elements are essential.

  <In the case of the specialty field “embedded platform”>

  - Skills for self-creation of technologies (such as kernel and support functions) relating to the platform are essential.

  <In the case of the specialty field “embedded application”>

  - Skills for procuring the technologies (such as kernel and support functions) relating to the platform and implementing the required functions are essential.

[Development technologies]

- Development technology skills to implement the requirements of the subsystem under charge giving consideration to the various constraints and features are essential.
  - In the middle level, skill levels for autonomous implementation of processes from “software requirements analysis” to “software qualification test” concerning the area under charge within the development project are essential.
  - In the high level, skill levels for executing the role of leading the organization in connection with the technologies of the previously mentioned corresponding processes are required.

[Management technologies]

- Skills for executing supporting management tasks based on the guidance of the project manager or higher-level engineer are essential.

- In managing the area under charge, the instructions stipulated by the project manager are to be followed in connection with collection of information and reporting.
- When maintaining compatibility with the system specifications and configuration and also with the version, and in managing the area under charge, the instructions stipulated by the project are to be followed in connection with collection of information, tool operation, and reporting.
- In the high level, skill levels for autonomous execution of project management within the area under charge are essential.

[Social skills and business skills]

- Skills for smooth accomplishment of tasks including problem-solving and communication are essential.
- When guiding subordinates and acting as the team leader, leadership and negotiation skills are essential.

3.6 Bridge SE

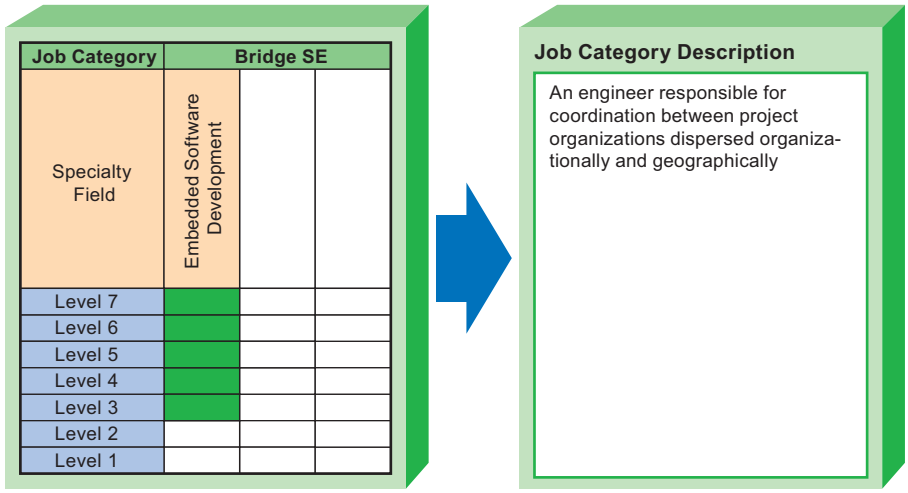
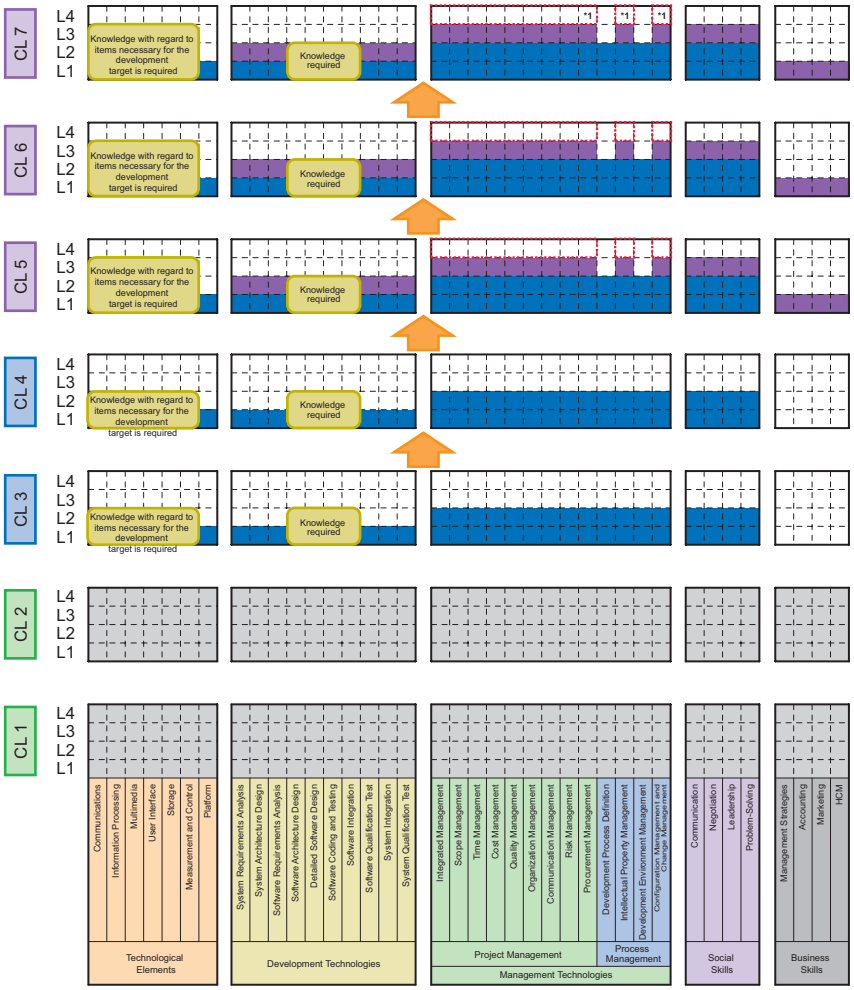


Figure F2.20: Outline of a bridge SE

Specialty Field	Skills Domain	
	Skill Items Common to All Job Categories	Skill Items Specific to the Specialty Field
Embedded Software Development	● **Technological Elements** Professional technology and platform ● Development Technologies System requirements analysis, system architecture design, software requirements analysis, software qualification test, system integration, and system qualification test ● **Management Technologies** Integrated management, scope management, time management, cost management, quality management, organization management, communication management, risk management, procurement management, development process definition, intellectual property management, development environment management, and configuration management and change management ○ **Social Skills** Communication, leadership, negotiation, and problem-solving	

Note: For the skill items of the skills domain, describe the skill items required in career level 3 and career level 4 of the job category

Figure F2.21: Skills domain of a bridge SE



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.

* This information is created for the purpose of human resource development, and not for career level assessment

Figure F2.22: Skills distribution characteristics of a bridge SE

■ Supplementary Description

[Technological elements]

- Various technological skills required for achieving the product are essential.
  - Knowledge of vital points is required instead of physical performance.

  Specialized technological skills of more than one field are desired to gain the confidence of engineers.

[Development technologies]

- Skills for “system requirements analysis,” “system designing,” “software requirements analysis,” and “system integration” of the product are essential.
  - Skills for requirements definition are particularly essential.
- Knowledge of “software architecture design,” “detailed software design,” “coding and testing,” and “software integration” required for resolving the various gaps arising among projects distributed organizationally and geographically is essential.
- Knowledge and skills for adjustment of specifications between the entrustee and entruster are essential.
  - Knowledge for improving quality through review work is essential.

[Management technologies]

- Industry-level management skills that can be put to use even outside one’s company are essential. (For example, modern project management)
- Knowledge and understanding of software development processes is essential.
- Skills relating to the contract are essential.
- Intellectual property rights and copyright are important for offshore development.

[Social skills and business skills]

- Communication skills must be high, and the capability to perform motivation management must be present.
- Must have enough experience and achievements in connection with development and management, and must possess skills for coordinating with stakeholders.

[Others]

- A generalist who has experience as one or more specialists is desired.

3.7 Development Environment Engineer

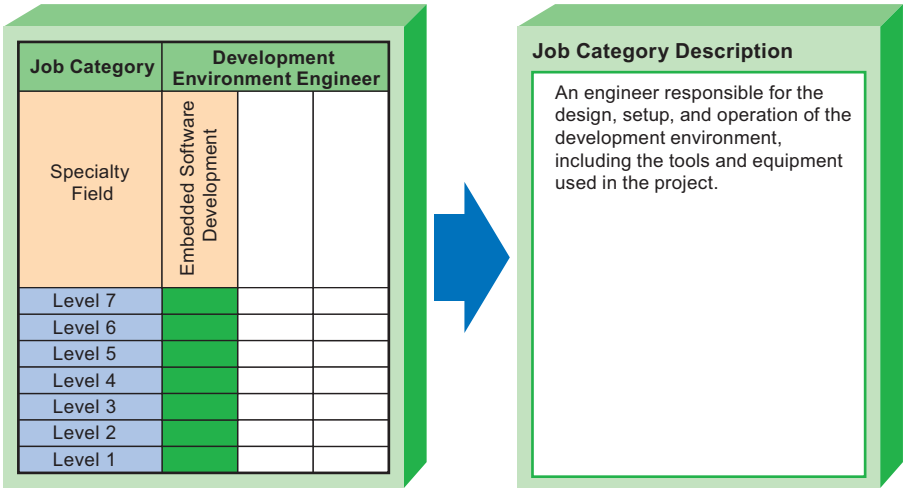
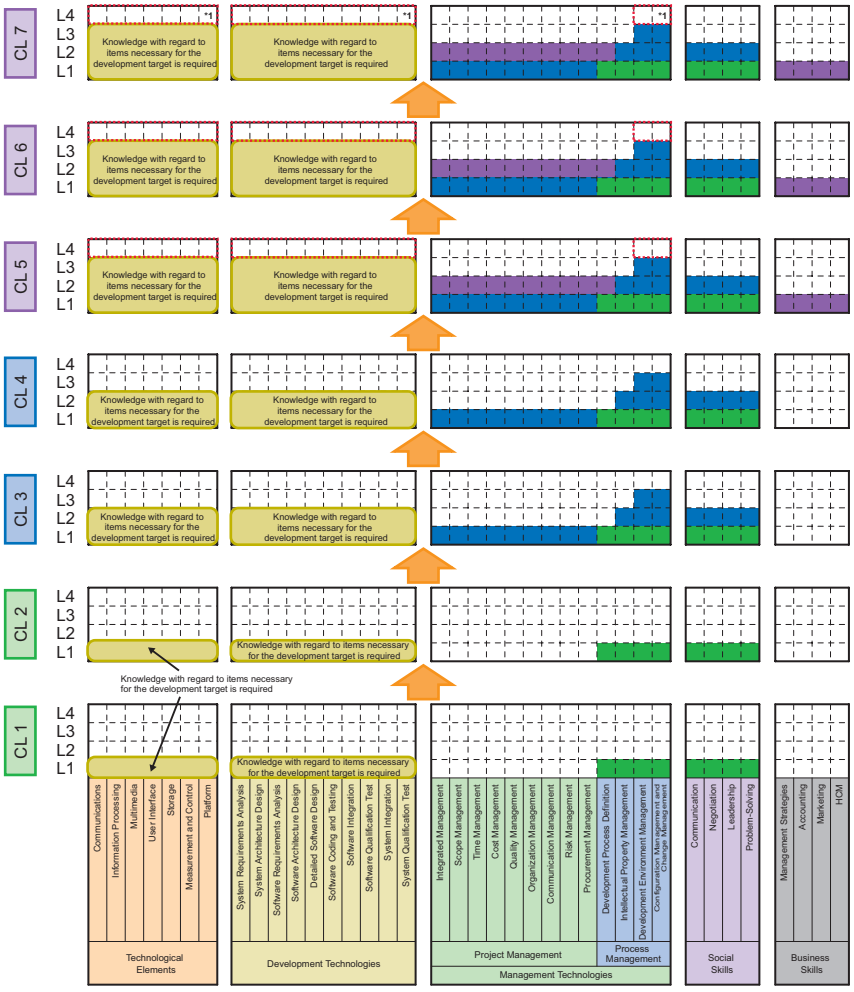


Figure F2.23: Outline of a development environment engineer

Specialty Field	Skills Domain	
	Skill Items Common to All Job Categories	Skill Items Specific to the Specialty Field
Embedded Software Development	• **Management Technologies** Integrated management, scope management, time management, cost management, quality management, organization management, communication management, risk management, procurement management, development process definition, intellectual property management, development environment management, and configuration management and change management ○ **Social Skills** Communication, leadership, negotiation, and problem-solving	

Note: For the skill items of the skills domain, describe the skill items required in career level 3 and career level 4 of the job category

Figure F2.24: Skills domain of a development environment engineer



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.

* This information is created for the purpose of human resource development, and not for career level assessment

Figure F2.25: Skills distribution characteristics of a development environment engineer

■ Supplementary Description

[Technological elements]

- Because a development environment engineer must give consideration to the technological features, knowledge of technological elements required for providing the development environment is essential.
  - In the case of a development environment that supports the development of technological elements, deep knowledge of the target technological elements is required.

[Development technologies]

- Skills for creating and providing a development environment are essential.
  - Instead of skills for embedded software development, skills for building (developing, procuring, and introducing) the development environment are essential.
- The development environment must be provided in consideration of the production efficiency of the actual development workplace.
  - In the case of a development environment that supports the development technologies, deep knowledge of the target technologies is required.

[Management technologies]

- Management skills for which cooperation with the actual development workplace is a prerequisite are essential.
  - Particularly high level of skills is required for development environment management, and configuration management and change management.
- The development environment must be provided in consideration of the production efficiency of the actual development workplace.
  - In the case of a development environment that supports the management

technologies, deep knowledge of the target technologies is required.

[Social skills and business skills]

- Social skills for achieving cooperation with the actual development workplace are essential.

3.8 Development Process Improvement Specialist

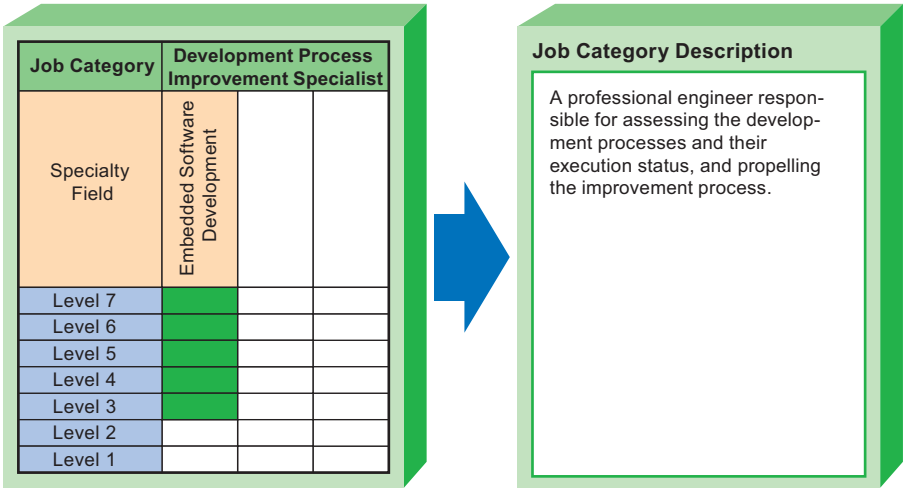
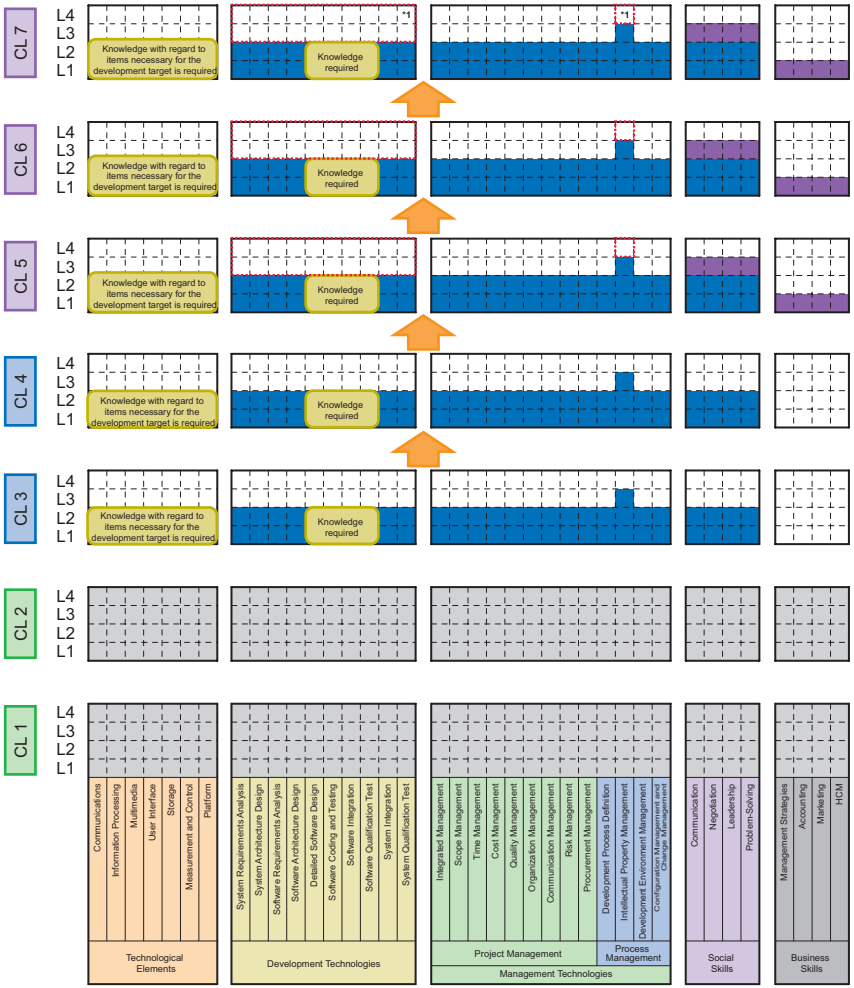


Figure F2.26: Outline of a development process improvement specialist

Specialty Field	Skills Domain	
	Skill Items Common to All Job Categories	Skill Items Specific to the Specialty Field
Embedded Software Development	• **Development Technologies** System requirements analysis, system architecture design, software requirements analysis, software architecture design, system integration, and system qualification test • **Management Technologies** Integrated management, scope management, time management, cost management, quality management, organization management, communication management, risk management, procurement management, development process definition, intellectual property management, development environment management, and configuration management and change management ○ **Social Skills** Communication, leadership, negotiation, and problem-solving	

Note: For the skill items of the skills domain, describe the skill items required in career level 3 and career level 4 of the job category

Figure F2.27: Skills domain of a development process improvement specialist



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.

* This information is created for the purpose of human resource development, and not for career level assessment

Figure F2.28: Skills distribution characteristics of a development process improvement specialist

■ Supplementary Description

[Technological elements]

- Knowledge of the technological elements required for the development target is essential.
  - The features and issues of development relating to technology must be considered.

[Development technologies]

- Skills for system requirements analysis, designing, and testing are essential.
- Skills for software requirements analysis and architecture design are essential.
- Knowledge of the development technologies required for creating and improving the development processes is essential.

[Management technologies]

- Management skills relating to the entire organization and project are essential.
  - Example: Management technologies of projects, quality, progress, outsourcing, configuration, and risk; and quantification technologies.
- Knowledge of the software development process and tailoring is essential.
- Knowledge and application skills of software engineering, and process assessment knowledge and skills are essential.
- Knowledge and skills of metrics for software development are essential.

[Social skills and business skills]

- Consultation skills are essential.
- Social skills for implementing cooperation with the actual development workplace are essential.
- Skills for education development and implementation are essential.

3.9 QA Specialist

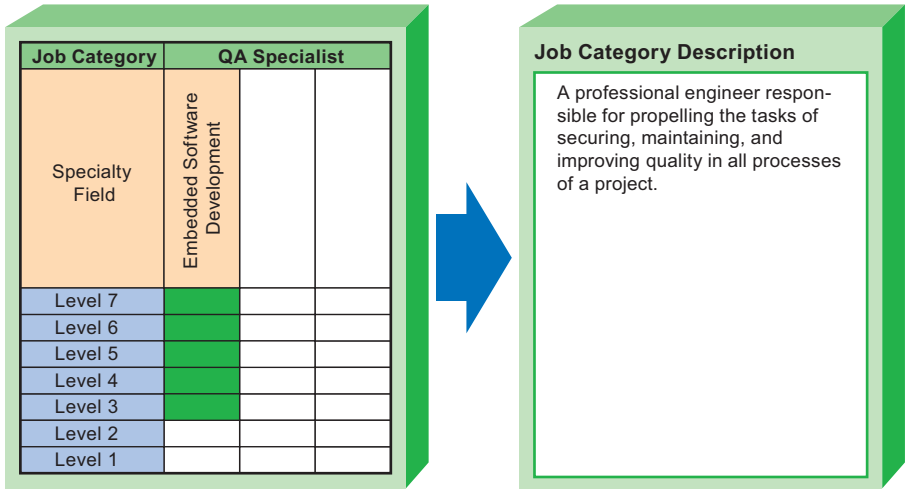
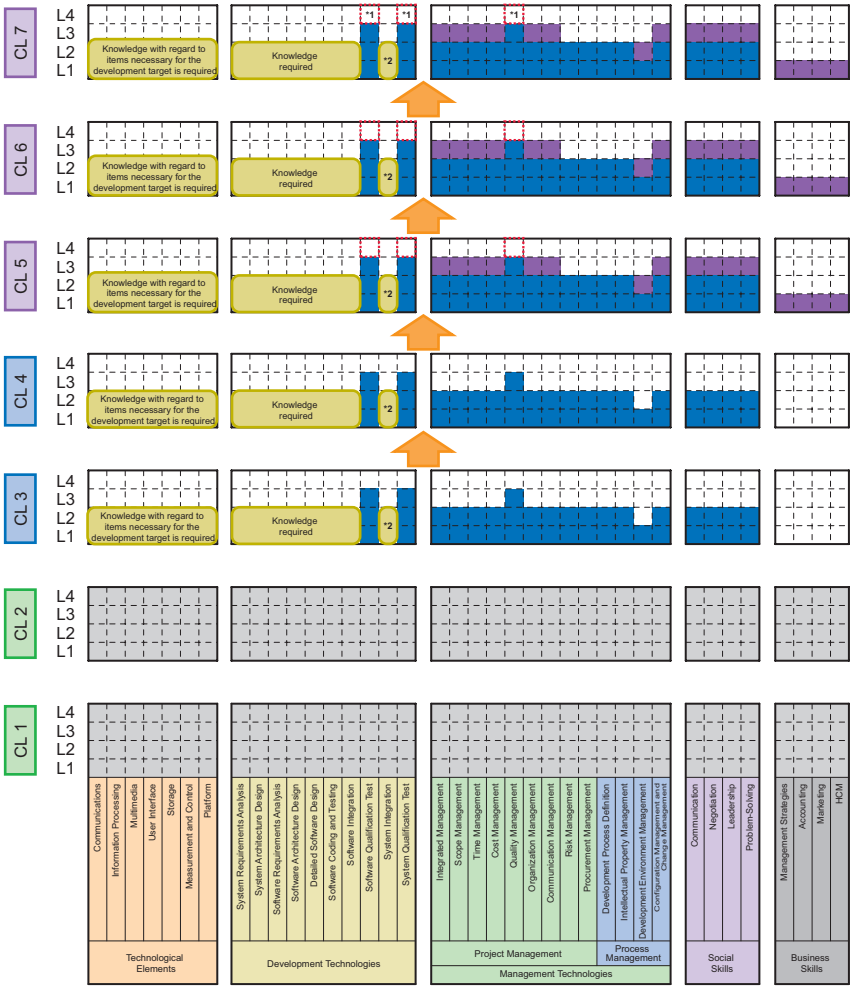


Figure F2.29: Outline of a QA specialist

Specialty Field	Skills Domain	
	Skill Items Common to All Job Categories	Skill Items Specific to the Specialty Field
Embedded Software Development	• **Development Technologies** Software qualification test and system qualification test • **Management Technologies** Integrated management, scope management, time management, cost management, quality management, organization management, communication management, risk management, procurement management, development process definition, intellectual property management, development environment management, and configuration management and change management ○ **Social Skills** Communication, leadership, negotiation, and problem-solving	

Note: For the skill items of the skills domain, describe the skill items required in career level 3 and career level 4 of the job category

Figure F2.30: Skills domain of a QA specialist



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.
*2: Knowledge required

* This information is created for the purpose of human resource development, and not for career level assessment

Figure F2.31: Skills distribution characteristics of a QA specialist

■ Supplementary Description

[Technological elements]

- Skills for the management target product are essential to understand the quality properties required in the product.
  - Particularly, validity assessment of testing of explicit and implicit actions of the user is essential.
  - Understand the environment in which the test is executed, and assess the validity of the test environment.
  - Although the test environment varies with the product, a platform that serves as knowledge of the common technological elements is essential.

[Development technologies]

- To assess that the test process is being implemented from an efficient perspective, knowledge of the development processes and test methods is essential.
- To judge the validity of target settings in the test plan and the test design, design document reading skills are essential.
- To execute design quality assessment, skills for reviewing the design output are essential.
- To execute manufacturing quality assessment, skills for reviewing the development output are essential.

[Management technologies]

- Skills for judging the validity of processes and products through milestone reviews are essential.
- To secure QCD, skills for time management, cost management, and quality management are essential.

- Management of the scope and risks of the entire product is assigned to the project manager.

- To check the validity of the development product and test specifications, skills for configuration management of the specifications are essential.
- Skills for coordination with stakeholders regarding quality requirements and for implementation of QCD management are essential.
- Skills for proposing and executing appropriate methods for quality requirements by getting familiar with the development processes and verification processes are essential.
  - Execution of an objective judgment and assessment of the level of achievement of quality targets is essential.

[Social skills and business skills]

- Communication skills for implementing regular quality improvement actions are essential.

3.10 Test Engineer

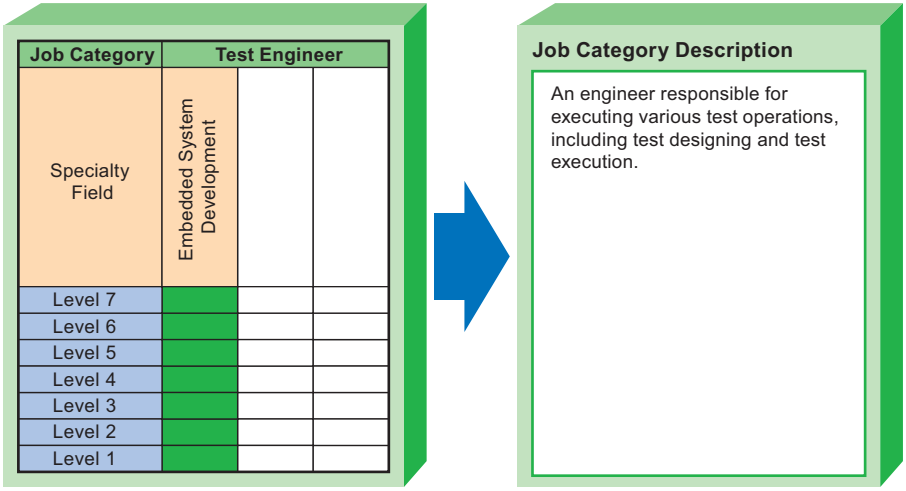
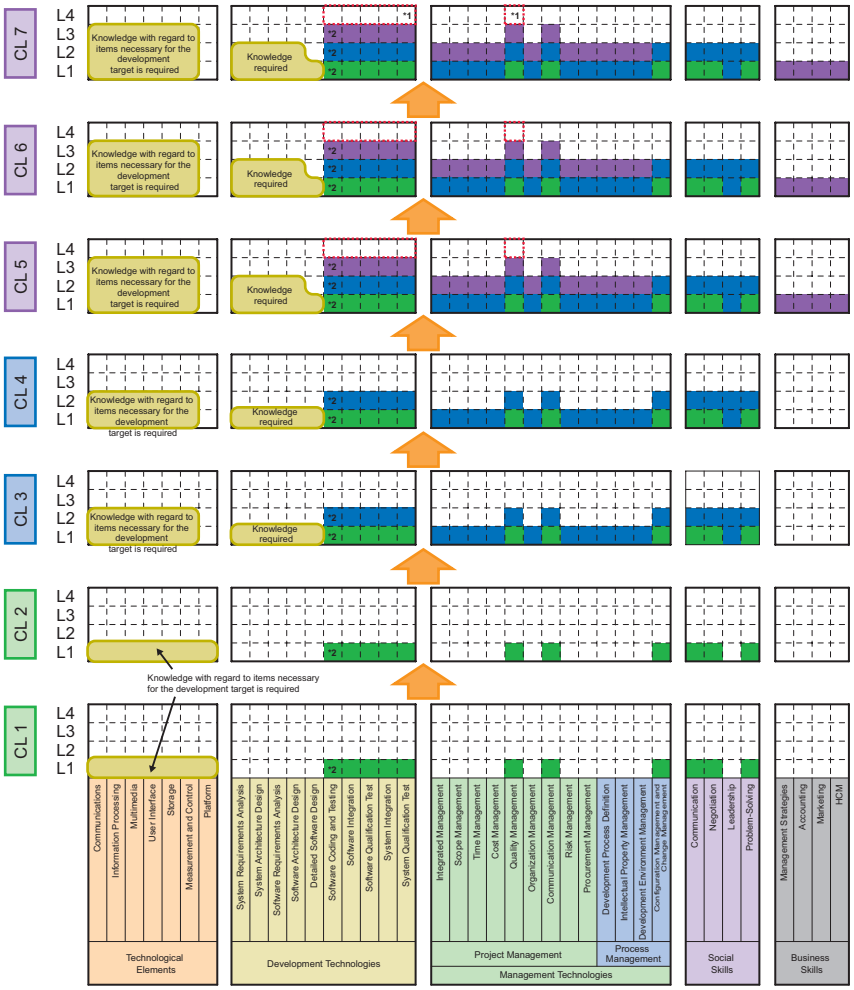


Figure F2.32: Outline of a test engineer

Specialty Field	Skills Domain	
	Skill Items Common to All Job Categories	Skill Items Specific to the Specialty Field
Embedded System Development	• **Development Technologies** Software coding and testing, software integration, software qualification test, system integration, and system qualification test • **Management Technologies** Integrated management, scope management, time management, cost management, quality management, organization management, communication management, risk management, procurement management, development process definition, intellectual property management, development environment management, and configuration management and change management ○ **Social Skills** Communication, leadership, negotiation, and problem-solving	

Note: For the skill items of the skills domain, describe the skill items required in career level 3 and career level 4 of the job category

Figure F2.33: Skills domain of a test engineer



*1: In the case of career level 7, skill level 4 is required for any one or more of the skills within the area surrounded by the red dashed-line frame.
*2: Coding is not applicable. Only for testing (such as static analysis)

* This information is created for the purpose of human resource development, and not for career level assessment

Figure F2.34: Skills distribution characteristics of a test engineer

■ Supplementary Description

[Technological elements]

- Knowledge of the management target product is essential to understand the quality properties required in the product.
  - Understand the environment in which the test is executed, and assess the validity of the test environment.
  - Although the test environment varies with the product, a platform that serves as knowledge of the common technological elements is essential.

[Development technologies]

- Knowledge of system requirements and software requirements analysis, and also of external designs such as software architecture design is essential.
- To confirm the expected results in the test design and test execution, development document reading skills are essential.
  - In the case of career level 3 and higher, knowledge of the development processes is essential for test coverage and test assessment.

[Management technologies]

- Quality management skills are essential.
  - At the same time, scope management for achieving the quality targets, as well as time management and cost management for delivery are essential.
- To appropriately migrate the product specifications change management to the test, configuration management skills are essential.
  - The capability to secure traceability of testware and change the target testware along with changes in the specifications is essential.

[Social skills and business skills]

- Communication skills for incident management are essential.
- In the case of career level 3 and higher, leadership skills are essential.
- Negotiation skills for procurement of equipment are essential.

Appendix. Examples of Definition of Domain Specialist

A domain specialist is a specialized technical engineer who has expertise in contributing to the development of embedded software with various application fields and technological elements. The target technologies are not restricted to software, but extend up to hardware and the overall system including hardware.

The example of definition of the domain specialist is described here. The users of the career specification may use this example of definition for a specific definition. Although ideally the definition must be provided in the career specification according to the aim of the career specification, this is difficult in the case of embedded software development having various application fields and technological elements. It is expected that industrial groups and communities will define the required specialty fields and apply the specifications in human resource development and utilization of such resources.

The domain specialist of the ETSS career specification is defined as follows as a specialty field:

> Embedded-related technologies: Technological elements, as well as technology relating to the product and application domain.

The following three examples of definition are provided here for the above-mentioned "embedded-related technologies."

RTOS: It is one of the technological elements, and although software is the main target, it targets the system as well.

Image processing: It is one of the technological elements with the system and algorithm being the main targets.

Printer: It is one of the products with the system being the main target.

1. RTOS Specialist

A domain specialist (RTOS specialist) with expertise in RTOS (Real Time OS), which is one of the technological elements, is defined below. RTOS is an important software component of embedded software, and functions as the core of the platform.

An RTOS specialist is required to have not only skills relating to RTOS software, but also skills relating to hardware such as the operation target processor, and to features of the applicable system.

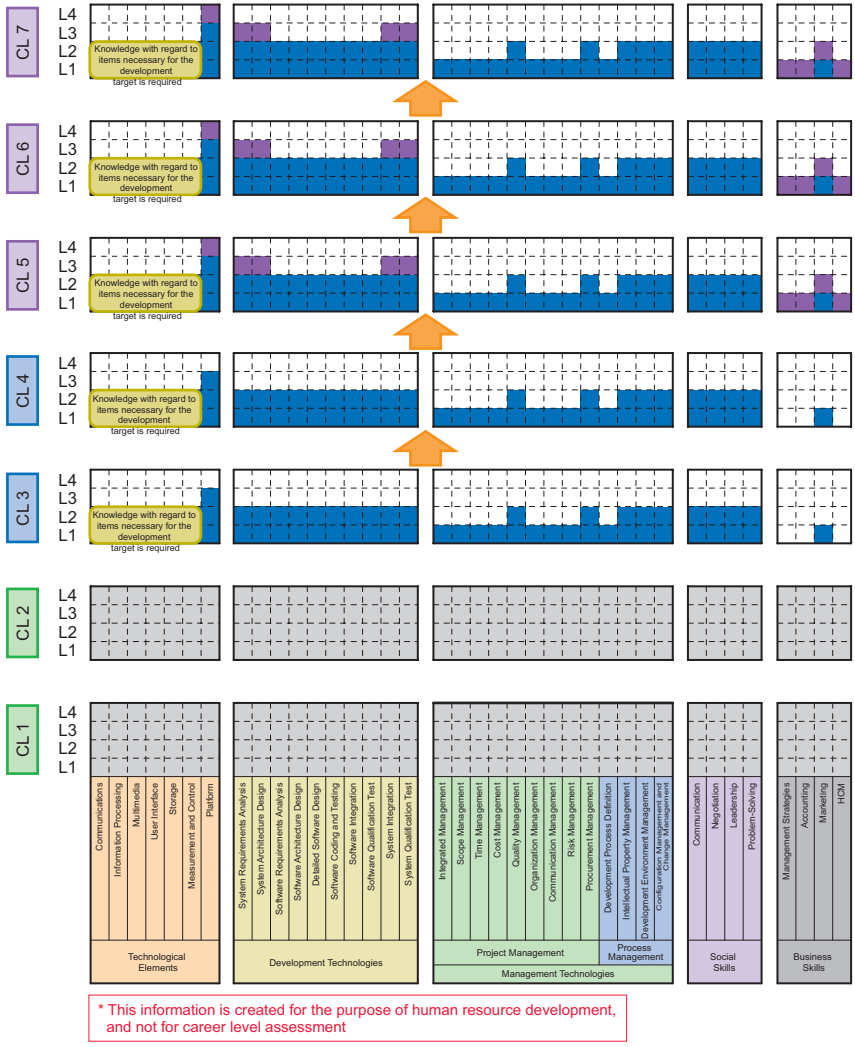


Figure F2.35: Skills distribution characteristics of a domain specialist (RTOS)

■ **Supplementary Description**

[Technological elements]

- Professional knowledge and experience of RTOS is essential.

  Skills for implementation of real time features

  Skills for implementation of resource conservation

  Skills for implementation of the development environment

[Development technologies]

- Skills of all domains are essential, ranging from system requirements analysis to system qualification.

[Management technologies]

- Particularly, quality management skills are essential.
  - These are particularly important if the product is to be marketed as middleware or software components.
- Configuration management skills are important when providing multiple platforms and multiple editions.

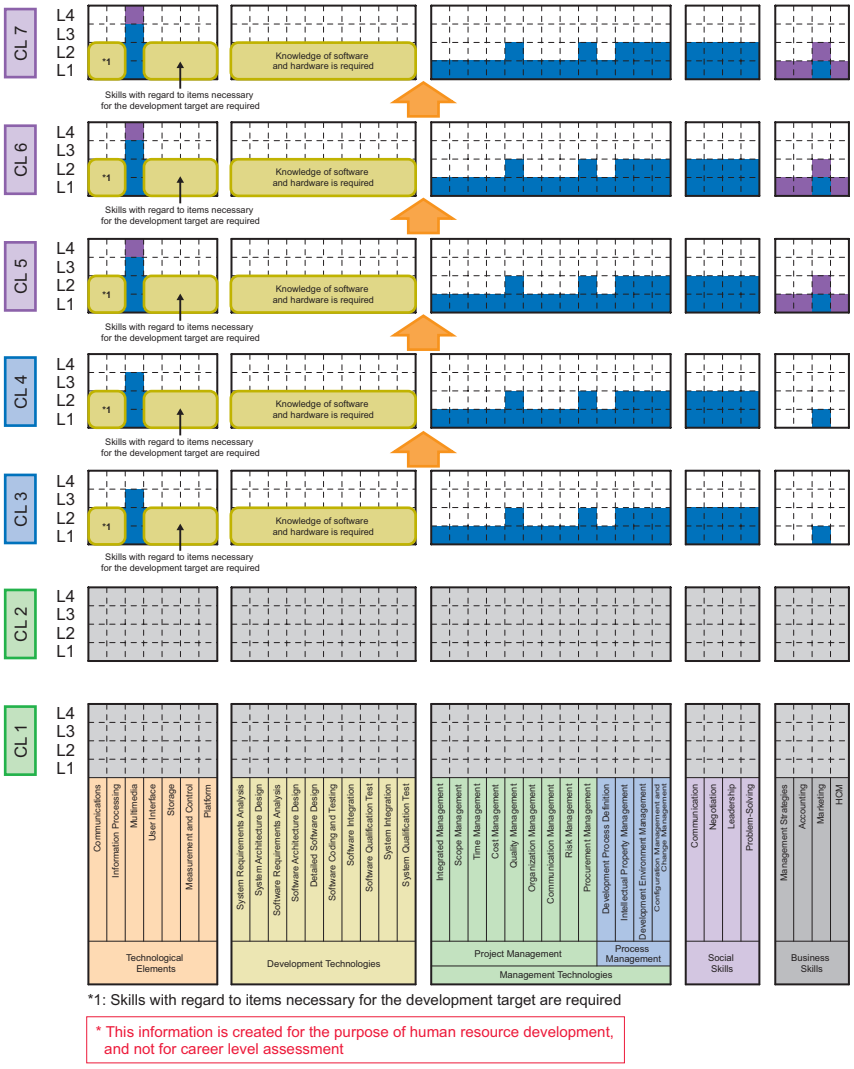
[Social skills and business skills]

- Marketing skills are essential for recognizing and developing the value of technologies.
  - Skills which reflect the direction of technological development in view of technological trends and the company's technologies are essential.

2. Image Processing Specialist

A domain specialist (image processing specialist) with expertise in image processing – one of the technological elements – is, for example, defined below.

An algorithm is required for image processing, which requires high-level, high-speed information processing. Furthermore, in an embedded system, processing is mostly performed primarily using hardware-based function allocation. Thus, an image processing specialist is required to have knowledge and skills relating to not only software but also hardware.



*1: Skills with regard to items necessary for the development target are required

* This information is created for the purpose of human resource development, and not for career level assessment

Figure F2.36: Skills distribution characteristics of a domain specialist (image processing)

■ Supplementary Description

[Technological elements]

- Specialized knowledge and skills relating to image processing are essential.
  - Skills for achieving high-speed processing
  - Skills for achieving high-quality image processing
  - Skills for creation of a validation environment

[Development technologies]

- Knowledge of all domains is essential, ranging from system requirements analysis to system qualification.
  - Definition of value for system requirements analysis
  - Appropriate function allocation for hardware and software during system architecture design
  - Creation of the validation environment and setting of assessment items in connection with system integration and system qualification

[Management technologies]

- Quality management skills are essential.
- Configuration management skills are important when providing multiple platforms and multiple editions.

[Social skills and business skills]

- Marketing skills are essential for recognizing and developing the value of technologies.
  - Skills which reflect the direction of technological development in view of technological trends and the company's technologies are essential.

3. Printer Specialist

A domain specialist (printer specialist) with expertise of printers, one of the products of an embedded system, is defined below. A printer is a product of an embedded system and, in terms of software development, also can be viewed as an application.

The printer is a device for printing information stored in a PC. A printer specialist is required to have skills relating to various technological elements including communications, image processing, and mechatronics control, as well as skills to create systems combining all of these. In terms of software, a printer specialist is required to have not only skills relating to the embedded software loaded in the printer device, but also skills and knowledge of the device drivers and application software installed in the PC. The combined capabilities of the software and hardware determine the value of a product.

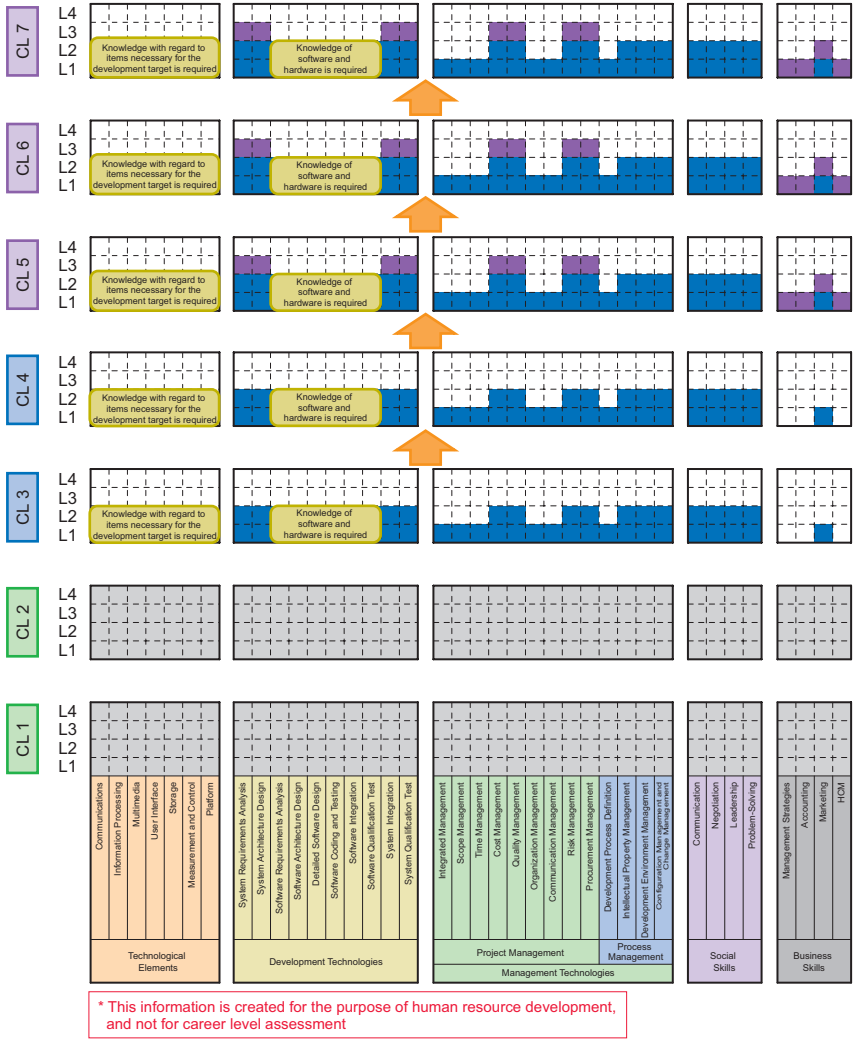


Figure F2.37: Skills distribution characteristics of a domain specialist (printer)

■ **Supplementary Description**

[Technological elements]

- Professional knowledge and experience of printers is essential.
  - Knowledge required to achieve image quality
  - Knowledge required to achieve usage quality
  - Knowledge required to achieve cost performance

[Development technologies]

- Knowledge of all domains is essential, ranging from technology development and product planning to system qualification.
  - Particularly, skills are required for system-related domains.

[Management technologies]

- Quality management and procurement management skills are essential.

[Social skills and business skills]

- Marketing skills for recognizing and developing the value of technologies and products are essential.
  - Skills which reflect the direction of technological development in view of technological trends and the company's technologies are essential.

Appendix

3

Education and Training Specification (Version 1.2)

This appendix is a revised version based on education and training specification Version 1.2, wherein expressions have been modified during the course of rewriting for publishing.

I. Overview

The “education and training specification” of Embedded Technology Skill Standards (hereinafter abbreviated as ETSS) defines the structure and mechanism of education and training to implement human resource development in the field of embedded software development.

1. Overview of the Education and Training Specification

The ETSS education and training specification comprises the “Education Program[*1] Framework” and the education programs based thereon.

The education program framework defined in the ETSS education and training specification illustrates the structure of the education method used to implement human resource development, including skills and career upgrade, for engineers engaged in the development of embedded systems.

Furthermore, the education and training specification provides an Education Program for People Inexperienced in Embedded System Development using this education program framework.

*1: The “educational curriculum” mentioned in ETSS education and training specification version 1.0 and earlier versions has been changed to “education program” from version 1.1.

2. Necessity of the Education and Training Specification

(1) Difficulties in Human Resource Development in the Field of Embedded Software Development

Embedded systems are used across various product fields through the implementation of numerous technologies. It is difficult to have a standardized education system due to the existence of various technologies including those specific to a product field, those with high novelty, and those with high confidentiality.

Furthermore, as the development systems have grown larger along with the increase in size and complexity of embedded software, management and development depending on an individual way of work has become difficult. Thus, introduction of development methodology and management techniques for embedded software through an approach based on software engineering has become necessary.

These factors have made it difficult to implement an education program suitable for embedded software development.

Education programs suitable for embedded system development have been scarce until now, and developers acquired the required technologies through practical experience and independent study. However, when the software development scale increases and the development time shrinks to its shortest limits, singular methods like OJT (On-the-Job Training) become limiting for acquiring the appropriate knowledge and skills in terms of time and methodology.

Until now, there was no standard system for job categories and technological skills that could be employed as a common standard in the embedded software field even for the development of a new education program suitable for career and skills upgrade for human resource development. Because of the lack of such a basic index (yardstick), the setting of educational targets and training objectives for the education program became ambiguous. Such ambiguity caused a gap to appear between the technological level of the participants and the technological level expected by the education program, and made it difficult to achieve the original educational objectives.

For the same reason, even if the training provided by education service companies was employed, it was difficult for the participants to judge whether the training contents were effective in achieving the desired improvement in skills and career level.

(2) Visualizing the Education Program

To deal with such a situation, skills specification for systematic classification and diagnosis of skills in the field of embedded software, and career specification for stipulating the job categories and specialty fields as well as the required skills were formulated in ETSS.

These specifications defined in ETSS can be used as indices for quantitatively setting up the targets of human resource development to be implemented through education programs, as well as training objectives.

Furthermore, by defining the structure and mechanism of the education programs used as a means for human resource development, human resource development can be visualized and integrated throughout the field of embedded software development.

Visualizing education programs in such a way, makes it possible to select and assess the appropriate education program, and also improve upon it.

3. Expected Effects of Education and Training Specification

(1) Advantages for the Individual

At present, engineers in the field of embedded software development must upgrade their skills and career level within a limited period of time. By visualizing an education program, as a specific measure for upgrading skills and career level, users can select an education program that would benefit them. Furthermore, depending on the purpose and requirement of the participants, the participating courses constituting the education program can be added and deleted.

By customizing a program without any unnecessary components, each user can make effective use of his/her time, and can upgrade his/her level. The purpose of the training is for each

individual to improve their skills and to advance in their career.

(2) Advantages for the Company

The education program framework, defined in the education and training specification, is an index for implementing an education program suited to the organization's human resource development plan (technological objectives and human resource development objectives) and in line with their company strategy. The company may then plan resource transfers or training for leading technology resource in accordance with market trends and technology trends.

The education program framework can be used as an index for selecting and assessing education suited to the purpose of human resource development of the company from among the education programs provided by an external education service company. Furthermore, when a company entrusts the development of an education program to an external company according to this framework, it can provide the targets and objectives of accurate education.

(3) Industrial and Political Advantages

By disseminating this education program for upgrading skills and career advancement throughout various job categories, we can train professionals with high level of expertise for their corresponding job category.

Furthermore, due to the popularity of education programs aimed towards various career shifts, the concept of "the right man in the right place" is being promoted among engineers in the field of embedded software development who were until now stagnating in their company's product field.

For example, education programs that do not limit itself to a particular field are possible, allowing inflow of engineers from other fields such as enterprise system software. Training a large number of human resources with high-level of expertise as well as resources with high skill application capability and experience in various fields will strengthen overall software development capabilities.

II. Education Program Framework

The structure and mechanism of the education program for human resource development is defined as the "education program framework" in Embedded Technology Skill Standards (ETSS).

In the education program framework of ETSS, human resource development is implemented as follows:

- Quantitatively visualizing the "entry" point and "exit" point of the education program for human resource development using the skills specification and career specification of ETSS.

  Entry point: A human resource model who is the targets (participants) of education program training

  Exit point: A human resource model who is the objectives (to-be model) of education program training

- Analyzing the quantified educational targets and educational objectives, and determining what disparity exists between them.
- Arranging the courses in the appropriate order to fill in the gaps (disparity) between the educational targets and the educational objectives.

1. Overview

Figure 3.1 shows an outline of the elements constituting the education program framework.

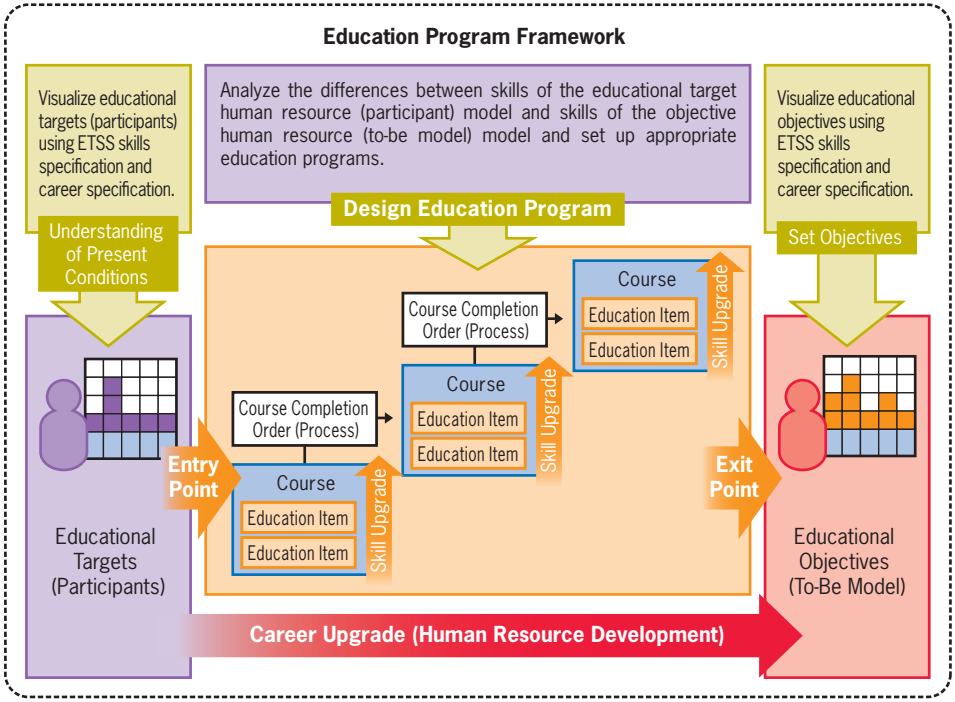


Figure F3.1: Components of the education program framework

The components of the education program framework of ETSS are enumerated below.

1.1 Educational Targets

Educational targets refer to the human resource participating in the education program. The educational targets are visualized quantitatively using the framework of the ETSS skills specification and career specification.

1.2 Educational Objectives

Educational objectives refer to the human resources who are the objectives of the education program. Similar to educational targets, the educational objectives are visualized quantitatively using the framework of the ETSS skills specification and career specification.

1.3 Education Program

An education program is a combination of courses and appropriate course completion order required to train the educational target human resource (participants) to become the objective human resource (to-be model).

The disparity between the educational targets and objectives are analyzed, and one or more course corresponding to the knowledge and skill acquisition in which differences are found is implemented in an appropriate course completion order (process), as a component.

Courses

A course is a combination of education items required to acquire the knowledge and skills concerning a specific technological field.

Education Items

An education item is a technological item that must be acquired through education and training.

The education items are expressed in a format conforming to the skills categories defined by the skills specification and career specification in the ETSS education program framework.

2. Components

2.1 Education Program

2.1.1 What Is an Education Program?

In the education and training specification of Embedded Technology Skill Standards (ETSS,) an education program is defined as a "combination of courses and appropriate course completion order required to train the educational target human resource (participants) to become the objective human resource (to-be model)."

The education program consists of appropriate courses and course completion order in conformance to the "education program framework" of the education and training specification.

2.1.2 Concept of Course Arrangement in an Education Program

The ETSS education program quantitatively analyzes the educational target human resource models and educational objective human resource models using the framework of ETSS skills specification and career specification to understand what kind of knowledge and skills are required up to what extent, and then implements education accordingly.

The courses required to supplement the knowledge and skills in order to train educational target human resource (participants) in becoming educational objective human resource (to-be model) are combined together to constitute the education program. The education program is created in accordance with the human resource taken as educational targets and human resource taken as educational objectives.

Therefore, if there are any changes in the contents that are set as educational targets and educational objectives, a different education program will have to be reconstructed.

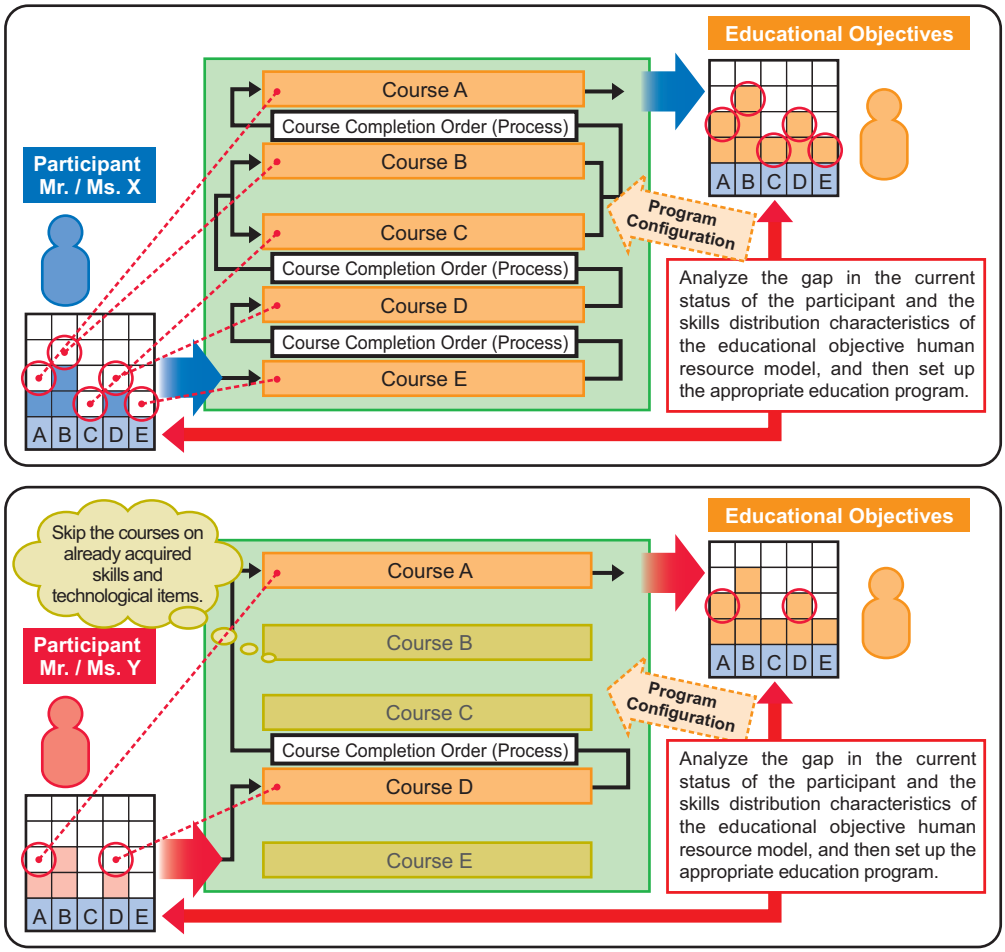


Figure F3.2: The contents of an education program differ with changes in the educational targets or educational objectives

2.1.3 Relationship between an Education Program and Career Specification

The ETSS career specification (Version 1.0 and later) provides the skills distribution characteristics required for each career level of the job categories in the field of embedded software.

By using the skills distribution characteristics presented in the ETSS career specification, an education program can be set up to realize career-level upgrades and career shifts for the educational objectives and educational targets of the program.

Figure F3.3 is an image showing the approach towards creating an education program aiming at career-level upgrade in a specific job category using the skills distribution characteristics presented in the career specification.

- Educational targets and educational objectives are defined for each job category in the ETSS career specification, and are set based on the skills distribution characteristics.
- The gap between the educational targets and educational objectives is analyzed, and the elements which are necessary for human resource development, such as technologies and skills, are quantitatively identified.
- If deficiencies are found in any technologies and skills after the disparity analysis, an education program is set up by combining the courses required to compensate for any deficiencies.
- A plan with an effective and realistic course completion order (process) is chalked out and implemented for the courses in the education program.

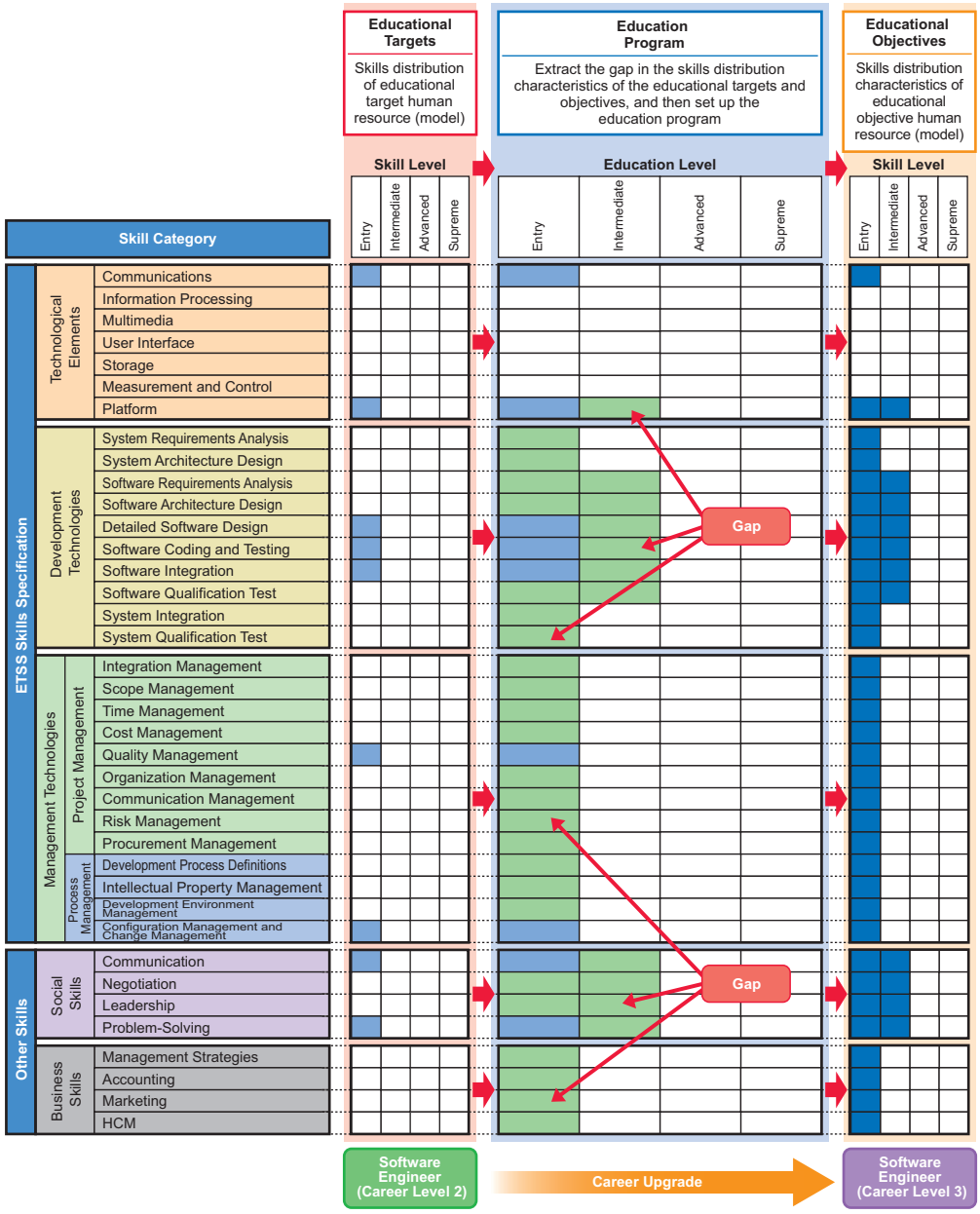


Figure F3.3: Creating an education program plan using the ETSS career framework

An education program for shifting careers to another job category can be implemented with the same procedure by setting the skills distribution characteristics to the educational objectives of the job category to which the career is to be shifted.

The use of the ETSS career framework is also applicable in the case of job categories that are not defined in the ETSS career specification.

2.2 Courses

2.2.1 What Is a Course?

In the education program framework of Embedded Technology Skill Standards (ETSS,) a course is defined as a "combination of education items required to acquire the knowledge and skills concerning a specific technological field."

2.2.2 Relationship between a Course and Skills Specification

In the ETSS education program framework, the category classification and acquisition level of technological items of the educational targets and educational objectives of a course are defined using the skills framework of the ETSS skills specification.

The classification of the technological items to be educated in a course, and the setting of the assessment criteria of acquisition level of educational targets and educational objectives is performed in a format conforming to the ETSS skills specification.

Therefore, when an organization in which skill management is performed using each framework of ETSS develops new courses or selects the existing courses, integrating with the skill diagnosis results of human resource and with the training strategies becomes easier.

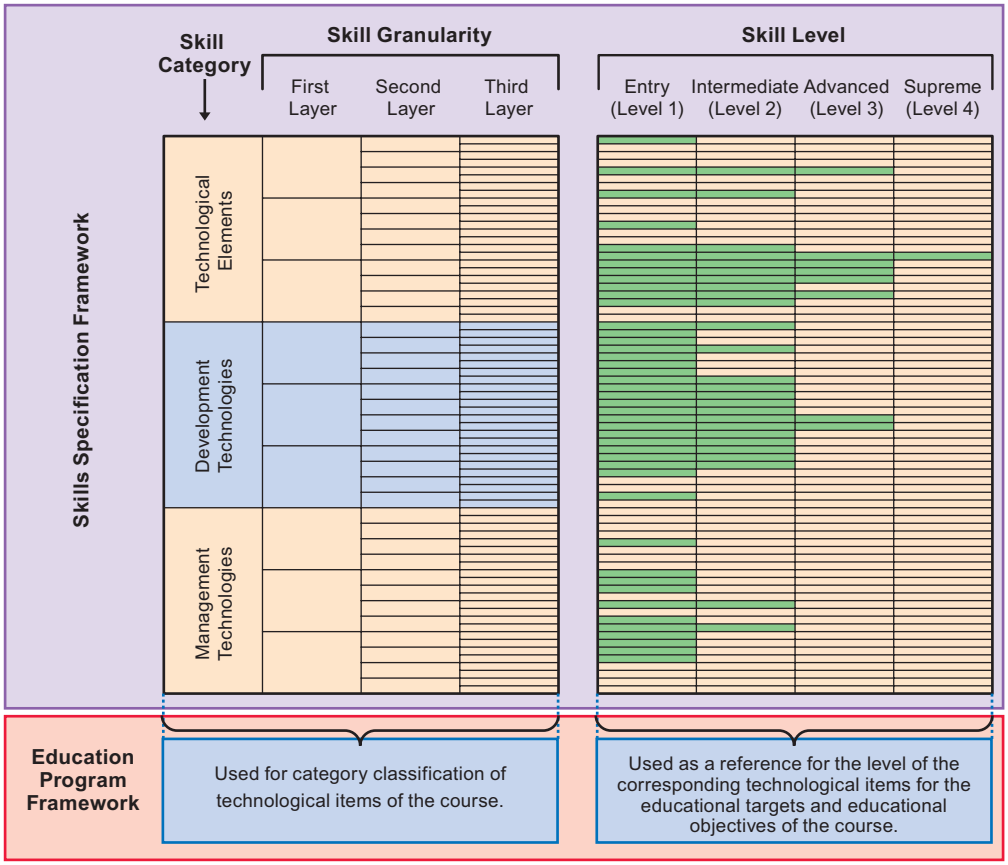


Figure F3.4: Relationship between a course and ETSS skills specification

To achieve higher education results and efficiency, a course is generally implemented by combining together multiple education items.

For example, instead of just training by combining the technologies of the same field to improve skill application capabilities to similar technologies, and teaching the grammar of programming language through training in programming, effectiveness is improved by combining the items, such as the tools and platforms used, and other peripheral technologies.

"Intermediate Internet Technology" Course

Skill Category	Education Item	Education Target Level →	Education Objective Level
Technological Element	TCP/IP	Entry (level 1)	Intermediate (level 2)
Technological Element	UDP	Entry (level 1)	Intermediate (level 2)
Technological Element	Socket Communication	Entry (level 1)	Intermediate (level 2)
Technological Element	FTP	Entry (level 1)	Intermediate (level 2)
⋮	⋮		

Figure F3.5: Image of a course comprising items from similar technological fields

"Entry-Level Embedded C Language Programming" Course

Skill Category	Education Item	Education Target Level →	Education Objective Level
Technological Element	System Call	-	Entry (level 1)
Development Technology	Structured Design	-	Entry (level 1)
Development Technology	C Language	Entry (level 1)	Intermediate (level 2)
Development Technology	Debugging Methods	Entry (level 1)	Intermediate (level 2)
⋮	⋮		

Figure F3.6: Image of a course comprising peripheral technologies related to the core technological items

2.2.3 Education Levels of a Course

To present a standard index for the level of the course's educational targets and educational objectives, establish an education level corresponding to the skills level of the ETSS skills specification.

The definition of course classification is shown below:

Table F3.1: Education levels of a course

Education Levels of a Course	Skills Level as Educational Objective	Definition of Skills Level as Educational Objective*
Supreme	Level 4 (Supreme)	Capable of developing new technologies Capable of creating new technologies that can be used on a general basis
Advanced	Level 3 (Advanced)	Capable of analyzing and improving tasks Capable of organizing the available technologies and skills systematically so as to enable usage by other engineers to improve the work efficiency
Intermediate	Level 2 (Intermediate)	Capable of performing tasks on one's own Possesses the required skills and can perform tasks on one's own
Entry	Level 1 (Entry)	Capable of performing tasks with support Capable of performing tasks with support from other people

*Definition of skills level: From Embedded Technology Skill Standards (ETSS) Skills Specification Version 1.1

2.3 Forms of Implementation of Courses

To achieve the educational objectives of the education program, design a course by selecting the most appropriate form of implementation from among various forms of implementation. For this, the features and advantages and disadvantages of each form of implementation of a course must be understood, and an implementation form matching each of the conditions such as the technological level of the educational targets and educational objectives, implementation location and scale of training, etc. must be selected accurately.

2.3.1 List of Forms of Implementation

Table F3.2 shows the forms of implementation assumed in the education program framework.

The purpose of presenting this list is to avoid confusion resulting from operation of different forms of implementation with the same name.

Table F3.2: List of forms of Implementation of a course

Classification	Form of Implementation	Contents
Self-Study Form	CBT (Computer Based Training)	Training methods through self efforts using a computer. Training contents stored in various media, such as network and CDs / DVDs are used. It is also possible to receive answers to questions, and get consultation and guidance on how to proceed with learning indirectly through a tutor (supervising instructor).
	Remote Education	Form of implementation in which rather than receiving instructions face to face, education is received indirectly, learning through text, videos, etc. sent through broadcast, communication and post. Similarly answers and correction results are sent through post and telecommunications.
Lecture Form	Lectures	A face-to-face type of form of instruction in which many students participate under a single lecturer.
Practical-Training Type	Workshops	In contrast to a lecture, in this form of implementation, the participants participate and gain experience through discussions, and mainly engage themselves in interactive communication with the lecturer and other participants of the group (generally, the number of participants is less as compared to lecture).
	Real Machine Practice	Practical form of implementation in which actual operations are performed and experienced using a microcomputer board, etc. (not just real machines but a simulation environment may also be used).
	Project Type Exercises	A form of implementation carried out just like a project of actual embedded software development in which knowledge and skills acquired so far are put to use through integrated exercises constituting group exercises.
	OJT (On-the-Job Training)	Form of implementation in which the required technologies, capabilities, knowledge, or attitude and sense of values is learned through the actual tasks. The administrator provides man-to-man intentional or premeditated guidance and training to one's subordinates by assigning them duties.
Others	Community Activities	Competitive studying by deepening relationship with other professionals in both in-house and external community activities. Also, improving one's own skills and knowledge by contributing to the society through community activities and by training others.

The forms of implementation of education in the field of embedded software are not limited to the above list of training methods.

3. Document

The following articles explain the documents that are utilized to implement education and training.

3.1 Using Document Format Examples

The documents conforming to the ETSS education program framework are illustrated below.

The aim is not to operate these formats strictly. One is expected to first understand the items described in these formats and their necessity. Then choose the items and put them to use accordingly.

Depending on the form of operation of the education program, unnecessary items can be omitted, and conversely, if any items are lacking, they can be added or expanded, as and when necessary.

3.2 Document Format Examples

3.2.1 Education Program Outline

Outline

Document presenting an outline of the education program.

Illustrates the educational targets and educational objectives that are set in the education program.

Document Image

Education Program Name	
Purpose	
Human Resource as the Educational Targets	
Human Resource as the Educational Objectives	

Figure F3.7: Education program outline

Description Items

The items that should be described in "Education Program Outline" are as follows:

- Education Program Name

  Describe the name of the education program.

- Outline

  Provide a specific description of the outline and purpose of the education program.

- Human Resource as the Educational Targets

  Provide a specific description of the human resource that is set as target participant of the training of the education program.

- Human Resources as the Educational Objectives

  Provide a specific description of the human resource as the educational objectives of the education program.

  The education system by means of which human resources who are the educational targets are trained to become the educational objectives is the education program.

  Also specify an image of the activities envisioned for the human resources who are the educational objectives of the program.

<Image showing activities of human resources as the educational objectives of the education program>

- Capable of designing, creating, and debugging programs to be operated on the embedded platforms (MCU and RTOS).
- Capable of acquiring fundamental technologies, such as hardware and control theories, with regard to the technological element items and fields used in one's company products, and capable of performing software designing and implementation.
- Capable of performing operations ranging from detailed designing of embedded software to integration testing (including documentation).
- Capable of contributing to team activities by learning basic behavior as a project member.
- Capable of performing quality assurance (review and testing) of the applicable software, and capable of understanding and reporting the quality status.

3.2.2 Course Schematic

Outline

This outline presents the relative positional relationship among the education program, the educational targets and educational objectives of human resource development.

It also displays the skills distribution characteristics corresponding to the courses constituting the education program and specifies the applicability of the education program.

Document Image

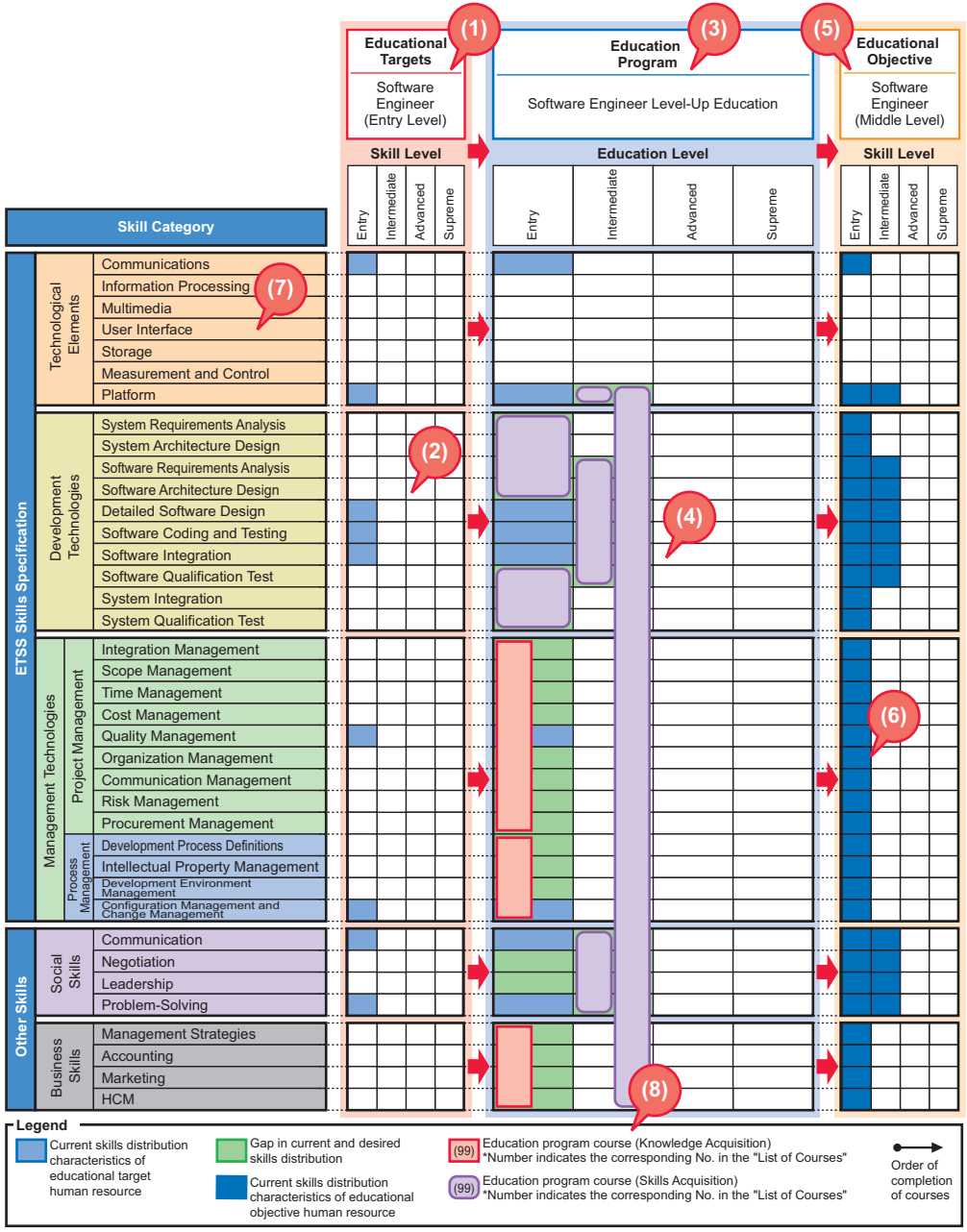


Figure F3.8: Course schematic

Description Items

The items that should be described in "Course Schematic" are as follows:

- Educational Targets (1)

  Provide a brief description of the human resources that are set as educational targets of the education program.

- Range of Educational Targets (2)

  The current technologies and skills distribution characteristics of the human resource assumed as educational targets of the education program are represented in the form of a rectangle.

  Similar to the range of educational objectives, if the job categories and career levels of the ETSS career specification are used for the educational targets, the skills distribution characteristics of career levels of the corresponding job categories defined in the career specification are expressed in the form of a rectangle.

- Education Program (3)

  Describe the name of the education program.

- Range of the Education Program (4)

  The disparity between the skills distribution characteristics of the educational targets and objectives are expressed in the form of a rectangle, and the range of technologies and skills that must be adopted for human resource development in the education program is identified.

  The technological items corresponding to the courses provided by the education program are expressed in the form of a rectangle, and the corresponding range of the education program is expressed by superimposing the above differences

- Educational Objectives (5)

Provide a brief description of the human resources that are set as educational objectives of the education program.

- Range of Educational Objectives (6)

  The technologies and skills distribution characteristics required to accomplish the roles and responsibilities to be executed by the human resources that are set as educational objectives of the education program are represented in the form of a rectangle.

  When the ETSS career specification job categories and career levels are set for the objective human resource, the skills distribution characteristics for career levels of the corresponding job categories defined in the career specification are displayed in a rectangle. The skills distribution characteristics are defined in a format conforming to the ETSS career framework even for human resource who are not defined in the ETSS career specification, and these human resource are set as educational objectives.

- Skill Category (7)

  Category items of the technologies and skills corresponding to the education program.

  The skills categories defined by the ETSS skills specification and career specification, and presented in a format conforming to the framework of these specifications. The previously mentioned technology distribution range, and the technological domain for the courses, are represented in a rectangle for each of these categories.

- Legend (8)

  Describe the legend for the rectangle used to express the skills distribution characteristics of the educational targets and educational objectives of the courses constituting the education program.

3.2.3 List of Courses

Outline

List of courses constituting the education program.

The outline information of the courses is listed up.

Document Image

Education Program Name:

No	Course Name	Outline	Training Hours	Educational Target Level	Educational Objective Level	Education Items		Form of Implementation

Figure F3.9: List of courses

Description Items

The items that should be described in “List of Courses” are as follows:

- Education Program Name

  Describe the name of the education program.

- No

  Describe the serial number used in the education program.

- Course Name

  Describe the course name.

- Outline

  Provide an outline of the courses constituting the education program

- Training Hours

  Describe the standard number of hours of the course.

- Educational Target Level

  Acquisition level of technologies and skills concerning the corresponding technological field possessed by an educational target (participant) that is set for a course.

  Skills level assessment requirements and level delineation are set in a format conforming to the ETSS skills specification. However, if the educational target level is "-" (hyphen), it indicates that the course is targeted for human resource whose skills level of the corresponding technological domain does not fulfill level 1 (entry) of the ETSS skills specification.

- Educational Objective Level

  Desired level of technologies and skills to be acquired in the fields related to the course.

  Similar to the educational target level, skill level assessment requirements, and levels are set in a format conforming to the ETSS skills specification.

- Education Items

  Describe the technological items and skills categories of the education items included in the course.

  The selection of technological items and skills categories is classified in a format conforming to the ETSS skills framework.

- Form of Implementation

  Describe the form of implementation of the course.[*2] If more than one form of implementation is applicable to a single education item, enumerate the forms.

  Select the name of a form of implementation with reference to “2.3 Forms of Implementation of Courses.”

3.2.4 Syllabus

Outline

Describes the education contents for the courses constituting the education program.

The syllabus consists of the following two formats:

- “Course Outline” that provides a general outline of the courses
- “Education Items” that describe the education items to be implemented in a course

*2: The form of implementation must be set up independently depending on the situation and purpose of the education program implementing organization. Therefore, in this document, no uniform definition is provided for this entry column.

Document Image (Syllabus: Course Outline)

Syllabus: Course Outline

Course Name		**No**	
Education Levels of a Course	☐ Entry ☐ Intermediate ☐ Advanced ☐ Supreme		
Skill Category	☐ Technological elements ☐ Development technologies ☐ Management technologies ☐ Social ☐ Business ☐ Others ( )		
Outline			
Target Participants of the Training (Educational Targets)			
Prerequisites			
Educational Objectives	[Meaning and aim]		
Form of Implementation	☐ CBT ☐ Remote education ☐ Lectures ☐ Workshops ☐ Real machine practices ☐ OJT ☐ Others ( )		
Training Hours		**Scheduled Dates**	
Education Materials	Textbooks		
	Hardware environment		
	Software environment		
	Other education materials		
Assessment Method of Education Results	☐ Assess the research results		
	Assessment method	☐ Written tests ☐ Practical tests ☐ Oral assessment ☐ Taking accreditation tests [ ] ☐ Others ( )	

Figure F3.10: Syllabus: course outline

Description Items (Syllabus: Course Outline)

The items that should be described in "Syllabus: Course Outline" are as follows:

- Course Name

  Describe the name of the course.

- Education Levels of the Course

  Describe the education level corresponding to the education contents of the course.

  For details on the criteria of education levels, see "2.2.3 Education Levels of

a Course."

- Skill Category

  Describe the skills categories of the education items constituting the course. Use the skills categories defined in the ETSS skills specification and career specification.

- Outline

  Describe an outline of the education covered by the course.

- Target Participants of the Training

  Describe the human resource as a target participant of the training in the course.

  Emphatically describe the acquisition status of the knowledge and skills of technological fields related to the course.

- Prerequisites

  Describe the conditions that must have been fulfilled before participating in the course.

  If necessary, describe the education that must have been completed beforehand, and the practical experience required.

- Educational Objectives

  Describe the knowledge and skills objectives of the technological fields that are the targets of the course.

  Specify an action image of what kind of knowledge and skills can be put to use by achieving the educational objectives.

<Example of action image of the human resource that are course educational objectives>

- Capable of programming to control MCU and MCU peripheral functions (such as timers).
- Capable of performing multi-task programming.
- Capable of performing detailed software designing (such as structured design).
- Capable of performing program development tasks in an integrated development environment.
- Capable of designing, executing and managing unit tests.
- Capable of performing unit debugging using hardware and software debugging tools.

Furthermore, the intentions of implementing the course are specified in the column "Meaning and aim."[*3]

- Form of Implementation

  Describe the form of implementation in which the course is to be executed. Select the form of implementation with reference to "2.3 Forms of Execution of Courses."[*4]

- Training Hours

  Describe the target value for the training hours when implementing the course.

*3: The "Meaning and aim" of educational objectives must be set independently depending on the situation and purpose of the organization implementing the education program. Therefore, in this document, no uniform definition is provided in this entry column.

*4: The form of implementation must be set independently depending on the status and purpose of the organization implementing the education program. Therefore, in this document, no uniform definition is provided in this entry column.

- Scheduled Dates

  Describe the (expected) dates for the course.[*5]

- Education Materials

  Describe the educational materials to be used in the course.

  If the names of any specific materials documents or products are available, mention those names.[*6]

- Evaluation Method of Education Results

  Describe the method of evaluating the education results at the time of completion of the course.[*7]

*5: The scheduled dates must be set independently depending on the situation and purpose of the organization implementing the education program. Therefore, in this document, no uniform definition is provided in this entry column.

*6: The education materials must be set independently depending on the situation and purpose the organization implementing the education program. Therefore, in this document, no uniform definition is provided in this entry column.

*7: The evaluation method of education results must be set independently depending on the situation and purpose of the organization implementing the education program. Therefore, in this document, no uniform definition is provided in this entry column.

Document Image (Syllabus: Education Items)

Syllabus: Education Items

Course Name:					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			

Figure F3.11: Syllabus: education items

Description Items (Syllabus: Education Items)

The items that should be described in "Syllabus: Education Items" are as follows:

- Course Name

  Describe the course name.

- Skill Category

  Describe the classification of related technological items included in education items.

  Use skills categories conforming to the framework of ETSS skills specification and career specification.

- Related Technological Items

  Describe the classification of related technological items included in education items.

  Use skills categories conforming to the framework of ETSS skills specification and career specification.

- Time

  Describe the target time value (in minutes) in connection with the education items of the course.[*8]

- Remarks

  Describe the supplementary items concerning education items for the course.Particularly, in the "Education Program for People Inexperienced in Embedded System," any items in common with the education items of "IT Fundamentals 1" and "IT Fundamentals 2" of the Skill Standards for IT Professionals Training Road map are noted as such in the Remarks column

*8: The time of education items in the course must be set independently depending on the situation and purpose of the organization implementing the education program. Therefore, in this document, no uniform definition is provided in this entry column.

In education programs whose educational targets are human resource who have already participated in “IT Fundamentals 1” and “IT Fundamentals 2,” these common education items can be skipped.

Ⅲ. Education Program for People Inexperienced in Embedded System Development

1. Points to Be Noted during Use

This section describes the points to be considered when using the Education Program for People Inexperienced in Embedded System Development (hereinafter referred to as "Education Program for the Inexperienced") in companies and institutions for advanced education.

1.1 About Educational Objectives

The main aim of the Education Program for the Inexperienced is to provide training to engineers who can be assigned in embedded software development workplaces. Therefore, with the educational objective as "training human resources who can be engaged in embedded software development tasks," specific job categories and career levels are not applicable.

When using the Education Program for the Inexperienced, to set educational objectives for the job categories of the ETSS career specification, perform differential analysis of the skills distribution characteristics that constitute the prerequisites for the ETSS career specification, and the skills distribution characteristics for the objectives of the Education Program for the Inexperienced. For areas with disparities, consider the circumstances and features of the target application domain and company, and customize them as required by adding or omitting courses.

1.2 Items That Should Be Defined by the Education Provider

During the implementation of the Education Program for the Inexperienced, the contents are bound to vary depending on various conditions, and standardization of some items may be difficult (shaded items from "2.4 Syllabus" onwards).

Until the actual commencement of the education program, these items should be entered by the education program provider, and should be made clear to the participants.

1.3 Non-Applicable Education Items

The Education Program for the Inexperienced targets the range correlated to the skill items defined in the ETSS skills specification and career specification. Educations such as business manners and engineer (member of the society) ethics, and compliance, which are required not only in field of embedded software development but for all members of society, are not included as education items. These should be added separately, if needed.

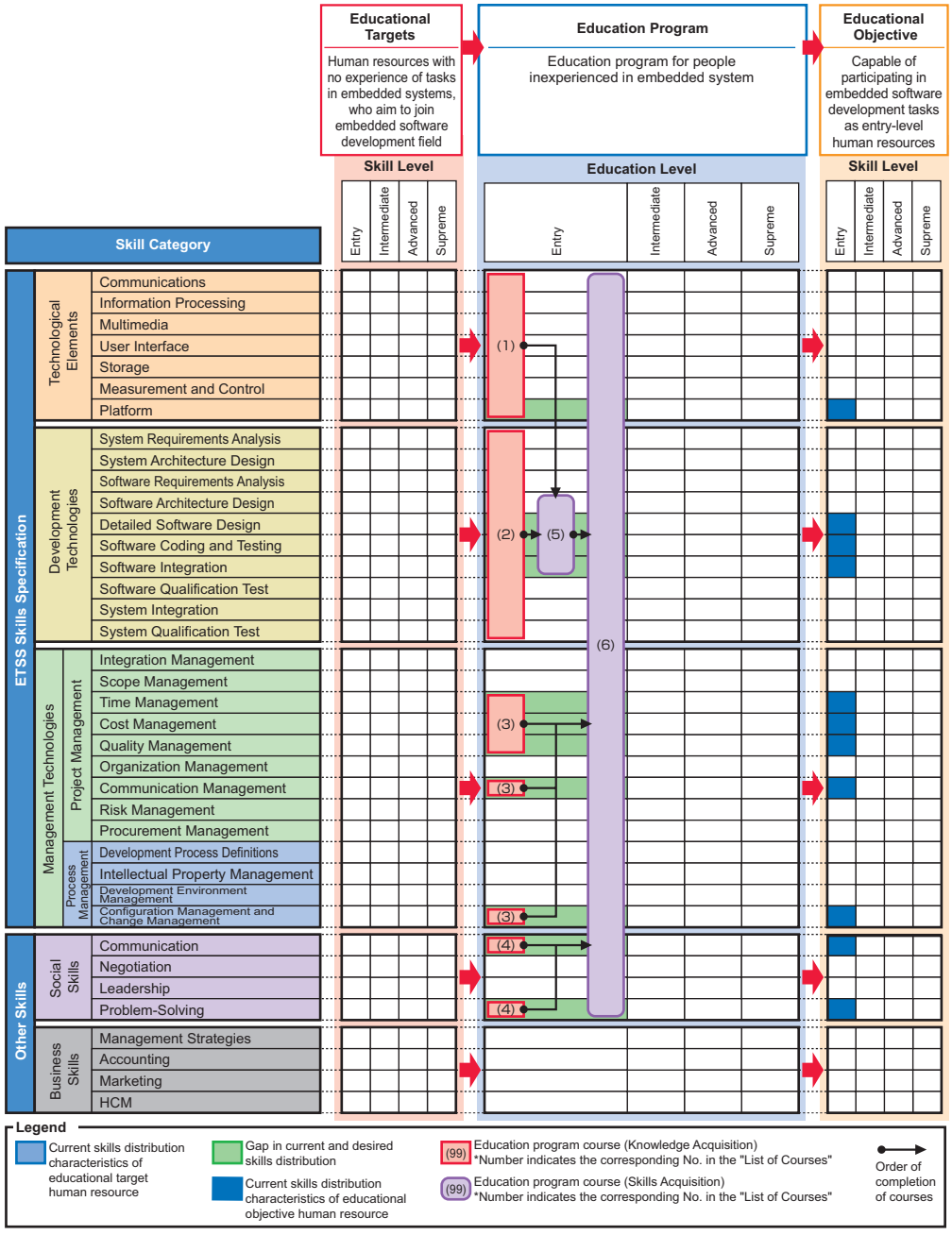
2. Education Program

2.1 Outline

Education Program Outline

Education Program Name	Education Program for People Inexperienced in Embedded System Development (ET Introductory Course)
Purpose	To strengthen the software development capabilities in the field of embedded software development, the purpose of this program is to assume human resources inexperienced in embedded system development as the target of education, and train them to become resource who can be engaged in embedded software development tasks.
Model Human Resource as Educational Targets	Human resources with no experience in embedded system development tasks who aim to start working as engineers in the field of embedded software development. This applies to the following resources: • New employees who have joined companies engaged in embedded software development • Students who have registered in universities and professional schools with courses related to embedded software • Software engineers from other fields who want to enter the field of embedded software development • Other human resources wanting to participate in the field of embedded software development
Model Human Resource as Educational Objectives	The model human resources who are the educational objectives of this education program are expected to be able to do the following: • Capable of the following activities concerning embedded software development tasks: ◆ Capable of performing tasks of software implementation and debugging, under guidance, by using platforms used in product development, and other technological elements ◆ Capable of accurately reporting the prospect in working hours and the work progress status to seniors for all applicable tasks ◆ Capable of collecting and reporting quality management indices for all applicable tasks under the guidance of seniors and by using tools and methods ◆ Capable of identifying and reporting risk items for all applicable tasks under the guidance of seniors and on the basis of check lists ◆ Capable of executing, under guidance, tools and procedures for configuration management and change project management ◆ Capable of reporting, under guidance, the status of applicable tasks, and understanding the status of projects by using communication tools and methods

2.2 Course Schematic



2.3 List of Courses

Education Program Name: Education Program for People Inexperienced in Embedded System Development (ET Introductory Course)

No	Course Name	Outline	Training Hours	Educational Target Level	Educational Objective Level	Education Items		Implementation Form
1	Technological Elements (Entry)	To acquire fundamental technologies (knowledge) concerning the technological elements “outline,” “communications,” “measurement and control,” and “platform” that are required to perform embedded software development tasks	15.0 hours	-	Entry	Technological elements	Outline Communications Measurement and control Platform	
2	Development Technologies (Entry)	To acquire fundamental technologies (knowledge) concerning the development technologies (overall embedded system development technologies from system requirement analysis to system qualification test) that are required to perform embedded software development tasks	15.0 hours	-	Entry	Development technologies	System requirements analysis System architecture design Software requirements analysis Software architecture design Detailed software design Software coding and testing Software integration Software qualification test System integration System qualification test	

No	Course Name	Outline	Training Hours	Educational Target Level	Educational Objective Level	Education Items		Implementation Form
3	Management Technologies (Entry)	To acquire fundamental knowledge of management technologies required to perform embedded software development tasks, focusing mainly on “time management,” “cost management,” “quality management,” “communication management,” and “configuration management and change management”	15.0 hours	-	Entry	Management technologies	Time management	
							Cost management	
							Quality management	
							Communication management	
							Configuration management and change management	
4	Social (Entry)	To acquire the fundamental technology (knowledge) concerning social skills that are required to perform embedded software development tasks, with main focus on “communication” and “problem-solving”	7.5 hours	-	Entry	Social	Communication	
							Problem-solving	
5	Embedded Programming Exercises (Entry)	To acquire usage techniques and tools to implement embedded software development tasks and debug (from software architecture design to software integration) using real-machine practices focusing on C language programming	52.5 hours	-	Entry	Technological elements	Platform	
						Development technologies	Software architecture design	
							Detailed software design	
							Software coding and testing	
							Software integration	

No	Course Name	Outline	Training Hours	Educational Target Level	Educational Objective Level	Education Items		Implementation Form
6	Embedded Software Development Project Exercises	To acquire through project-type exercises the technologies and practical skills required in embedded software development as an overall conclusion of the Education Program for People Inexperienced in Embedded System Development.	75.0 hours	-	Entry	Technological elements	Communications	
							Platform	
						Development technologies	System requirements analysis	
							System architecture design	
							Software requirements analysis	
							Software architecture design	
							Detailed software design	
							Software coding and testing	
							Software integration	
							Software qualification test	
							System integration	
							System qualification test	
						Management technologies	Time management	
							Cost management	
							Quality management	
							Communication management	
							Configuration management and change management	
						Social	Communication	
							Problem-solving	

* The shaded parts in the table should be defined independently.
* The values of time indicated in the “Training hours” column are sample values. The actual training hours should be defined independently.

2.4 Syllabus

2.4.1 Technological Elements (Entry)

(1) Course Outline

Course Name	Technological Elements (Entry)	**No**	1
Education Levels of a Course	■ Entry ☐ Intermediate ☐ Advanced ☐ Supreme		
Skill Category	■ Technological elements ☐ Development technologies ☐ Management technologies ☐ Social ☐ Business ☐ Others ( )		
Outline	To acquire fundamental technologies (knowledge) concerning the technological elements "outline," "communications," "measurement and control," and "platform" that are required to perform embedded software development tasks. The embedded software tasks in this course correspond to the level at which they are executed under the guidance of seniors (entry level of the ETSS skills specification).		
Target Participants of the Training (Educational Targets)	Does not have any experience in embedded system development, and aims to join the field of embedded software development.		
Prerequisites	None in particular.		
Educational Objectives	The educational objectives of this course are to acquire the technologies (knowledge) of technological elements needed to get trained to become a human resource who can accomplish the following tasks: ● Capable of accomplishing the tasks of software implementation and debugging, under guidance, by using platforms used in product development, and other technological elements (such as communications, and measurement and control.)		
	[Meaning and aim]		
Form of Implementation	☐ CBT ☐ Remote education ☐ Lectures ☐ Workshops ☐ Real machine practices ☐ OJT ☐ Project-type exercises ☐ Others ( )		
Training Hours	15.0 hours	**Scheduled Dates**	
Education Materials	Textbooks		
	Hardware environment		
	Software environment		
	Other education materials		
Assessment Method of Education Results	☐ Assess the research results		
	Assessment method	☐ Written tests ☐ Practical tests ☐ Oral assessment ☐ Taking accreditation tests [ ] ☐ Others ( )	

* The shaded parts in the table should be defined independently.
* The values of time indicated in the "Training hours" column are sample values.
The actual training hours should be defined independently.

(2) Education Items

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Technological Elements	Outline (items, history, and outline from across skills categories of technological elements)	Computer Science fundamentals	Basic theory of information		Same education items as those in "IT Fundamentals 1" and "IT Fundamentals 2" of Skill Standards for IT Professionals Training Roadmap
			Data structure and algorithms		
		Computer systems	Hardware		
			Basic software		
			System configuration and architecture		
			System applications		
	Communications	Outline (items, history, and outline from across skills categories of communications)	Protocol and transmission control		
			Encoding and transmission		
			Communication device		
			Network-related regulations		
			Network security		
			Network software		
			Technologies related to transmission circuits		
	Measurement and control	Physical and chemical input	External input device		
			Sensor		
		Physical and chemical output	External output device		
			Actuator		
	Platform	Processor	MPU peripheral technology		
			Basic I/O technology		
		Basic software	Real-time processing		
			Real-time kernel		
			System call		
			Interrupt processing		
			Device driver		
			Middleware		
			Multi-task processing		
			Memory management		
			Exception handling		

* The shaded parts in the table should be defined independently.

2.4.2 Development Technologies (Entry)

(1) Course Outline

Course Name	Development Technologies (Entry)	**No**	2
Education Levels of a Course	■ Entry ☐ Intermediate ☐ Advanced ☐ Supreme		
Skill Category	☐ Technological elements ■ Development technologies ☐ Management technologies ☐ Social ☐ Business ☐ Others ( )		
Outline	To acquire fundamental technologies (knowledge) concerning the development technologies (overall embedded system development technologies from System requirement analysis to system qualification test) that are required to perform embedded software development tasks. The embedded software tasks in this course correspond to the level at which they are executed under the guidance of seniors (entry level of the ETSS skills specification).		
Target Participants of the Training (Educational Targets)	Does not have any experience in embedded system development, and aims to join the field of embedded software development.		
Prerequisites	None in particular.		
Educational Objectives	The educational objective of this course is to acquire the technologies (knowledge) of technological elements needed to get trained to become professionals who can accomplish the following tasks: ● Capable of accomplishing tasks of requirements definition and software design, under guidance, by using platforms used in product development, and other technological elements (such as communications, and measurement and control.)		
	[Meaning and aim]		
Form of Implementation	☐ CBT ☐ Remote education ☐ Lectures ☐ Workshops ☐ Real machine practices ☐ OJT ☐ Project-type exercises ☐ Others ( )		
Training Hours	15.0 hours	**Scheduled Dates**	
Education Materials	Textbooks		
	Hardware environment		
	Software environment		
	Other education materials		
Assessment Method of Education Results	☐ Assess the research results		
	Assessment method	☐ Written tests ☐ Practical tests ☐ Oral assessment ☐ Taking accreditation tests [ ] ☐ Others ( )	

* The shaded parts in the table should be defined independently.
* The values of time indicated in the “Training hours” column are sample values.
The actual training hours should be defined independently.

(2) Education Items

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Development Technologies	System requirements analysis	Review of system analysis and requirements definition	High reliability design		
			Design for safety		
			Requirements analysis methods		
	System architecture design	Implementability verification and design review	System architecture design technology		
		Design method	Object-oriented design		Same education items as those in “IT Fundamentals 2” of Skill Standards for IT Professionals Training Roadmap
			Structured design		
			Data-oriented design		
		Development support tools	Development environment		
	Software requirements analysis	Software requirements definition	Function analysis methods		
			Requirements analysis methods		
	Software architecture design	Design method	Object-oriented design		Same education items as those in “IT Fundamentals 2” of Skill Standards for IT Professionals Training Roadmap
			Structured design		
			Data-oriented design		
		Software structure design	Structured design		
			Architecture design		
	Detailed software design	Detailed software design	Module specifications		
			Module design technology		
			Structured design		
			Specification change		
			Design quality		

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Development Technologies	Software coding and testing	Program creation and identification of program testing items	Software development environment		
			Coding techniques		
			Configuration management tools		
			Programming language		
		Development support tools	Development environment		Same education items as those in "IT Fundamentals 2" of Skill Standards for IT Professionals Training Roadmap
			Various application development tools		
			Configuration management tools		
			Debugger		
			Simulator		
			Emulator		
		Code review and program test item design review	Code review		
			Coding manner		
			Module test techniques		
		Program test implementation	Module test technologies		
			Debugging techniques		
	Software integration	Software integration test specification design	Testing methods		
		Software integration test implementation	Embedded system technology		
			Debugging techniques		
	Software qualification test	Software qualification test preparation and review	Measuring equipment (logic analyzer and oscilloscope)		
			Bug management tool		
		Software qualification test implementation	Real-machine test		
			Bug management tool		
			Measuring equipment (logic analyzer and oscilloscope)		
	System integration	Test item selection, test procedure determination and review	Hardware requirement specifications		
			Software requirement specifications		
			Measuring equipment (logic analyzer and oscilloscope)		
			Bug management tool		
		System integration test implementation	Measuring equipment (logic analyzer and oscilloscope)		
			Failure management report		
			Bug management tool		

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Development Technologies	System qualification test	System qualification test preparation and review	System requirement specifications		
			Configuration management tool		
			Bug management tool		
		System qualification test implementation	Failure management report		
			Bug management tool		

* The shaded parts in the table should be defined independently.

2.4.3 Management Technologies (Entry)

(1) Course Outline

Course Name	Management Technologies (Entry)	**No**	3
Education Levels of a Course	■ Entry ☐ Intermediate ☐ Advanced ☐ Supreme		
Skill Category	☐ Technological elements ☐ Development technologies ■ Management technologies ☐ Social ☐ Business ☐ Others ( )		
Outline	To acquire fundamental knowledge of management technologies required to perform embedded software development tasks, focusing mainly on “time management,” “cost management,” “quality management,” “communication management,” and “configuration management and change management” The embedded software tasks in this course correspond to the level at which they are executed under the guidance of seniors (entry level of the ETSS skills specification).		
Target Participants of the Training (Educational Targets)	Does not have any experience in embedded system development, and aims to join the field of embedded software development.		
Prerequisites	None in particular.		
Educational Objectives	The educational objective of this course is to acquire the technologies (knowledge) needed to get trained to become human resources who can accomplish the following tasks: ● Capable of accurately reporting the prospect in working hours and the work progress status to seniors for all applicable tasks ● Capable of collecting quality management indices for all applicable tasks under the guidance of seniors and by using tools and techniques, and reporting them ● Capable of extracting risk items for all applicable tasks under the guidance of seniors and on the basis of checklists, and reporting them ● Capable of executing, under guidance, tools and procedures for configuration management and change management used by development teams		
	[Meaning and aim]		
Form of Implementation	☐ CBT ☐ Remote education ☐ Lectures ☐ Workshops ☐ Real machine practices ☐ OJT ☐ Project-type exercises ☐ Others ( )		
Training Hours	15.0 hours	**Scheduled Dates**	
Education Materials	Textbooks		
	Hardware environment		
	Software environment		
	Other education materials		
Assessment Method of Education Results	☐ Assess the research results		
	Assessment method	☐ Written tests ☐ Practical tests ☐ Oral assessment ☐ Taking accreditation tests [ ] ☐ Others ( )	

* The shaded parts in the table should be defined independently.
* The values of time indicated in the “Training hours” column are sample values. The actual training hours should be defined independently.

(2) Education Items

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Management Technologies	Project management	Time management	Analogous estimating		
			Precedence diagramming method		
			Arrow diagramming method		
			Conditional diagramming method		
			Project management tools		
			Backup time (contingency)		
			Schedule differential analysis		
		Cost management	Analogous estimating		
			Parametric modeling estimation		
			Bottom-up estimating		
			Cost performance measurement		
			Cost management tool		
		Quality management	Cost-benefit analysis		
			Benchmarking		
			Flowchart presentation		
			Quality cost		
			Pareto diagram		
			Trend analysis		
			Quality Audit		
		Communication management	Stakeholder analysis		
			Information search system		
			Information distribution method		
			Performance report		
			Differential analysis		
			Project report		
			Presentation		
	Process management	Configuration management and change management	Configuration management and operation guide		
			Configuration management tool		
			Baseline management		
			Change management and operation guide		
			Change management tool		

* The shaded parts in the table should be defined independently.

2.4.4 Social (Entry)

(1) Course Outline

Course Name	Social (Entry)	**No**	4
Education Levels of a Course	■ Entry ☐ Intermediate ☐ Advanced ☐ Supreme		
Skill Category	☐ Technological elements ☐ Development technologies ☐ Management technologies ■ Social ☐ Business ☐ Others ( )		
Outline	To acquire the fundamental technologies (knowledge) concerning social skills that are required to perform embedded software development tasks, with main focus on "Communication" and "Problem-solving." The embedded software tasks in this course correspond to the level at which they are executed under the guidance of seniors (entry level of the ETSS skills specification).		
Target Participants of the Training (Educational Targets)	Does not have any experience in embedded system development, and aims to join the field of embedded software development.		
Prerequisites	None in particular.		
Educational Objectives	The educational objective of this course is to acquire the technologies (knowledge) of technological elements needed to get trained to become human resources who can accomplish the following tasks: ● Capable of reporting, under guidance, the status of applicable tasks and understanding the status of projects using communication tools and methods ● Capable of logically resolving problems in the applicable tasks with support of seniors		
	[Meaning and aim]		
Form of Implementation	☐ CBT ☐ Remote education ☐ Lectures ☐ Workshops ☐ Real machine practices ☐ OJT ☐ Project-type exercises ☐ Others ( )		
Training Hours	7.5 hours	**Scheduled Dates**	
Education Materials	Textbooks		
	Hardware environment		
	Software environment		
	Other education materials		
Assessment Method of Education Results	☐ Assess the research results		
	Assessment method	☐ Written tests ☐ Practical tests ☐ Oral assessment ☐ Taking accreditation tests [ ] ☐ Others ( )	

* The shaded parts in the table should be defined independently.
* The values of time indicated in the "Training hours" column are sample values.
The actual training hours should be defined independently.

(2) Education Items

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Social	Communication	-	2-way communication		
			Transmission of information		
			Organization, analysis and retrieval of information		
			Presentation		
	Problem-solving	-	Observation		
			Ideas		
			Problem-solving		
			Logical thinking		

* The shaded parts in the table should be defined independently.

2.4.5 Embedded Programming Exercises (Entry)

(1) Course Outline

Course Name	Embedded Programming Exercises (Entry)	**No**	5
Education Levels of a Course	■ Entry ☐ Intermediate ☐ Advanced ☐ Supreme		
Skill Category	■ Technological elements ■ Development technologies ☐ Management technologies ☐ Social ☐ Business ☐ Others ( )		
Outline	To acquire usage techniques and tools to implement embedded software development tasks and debug (from software architecture design to software integration) using real-machine practices focusing on C language programming. The embedded software tasks in this course correspond to the level at which they are executed under the guidance of seniors (entry level of the ETSS skills specification).		
Target Participants of the Training (Educational Targets)	Does not have any experience in embedded system development, and aims to join the field of embedded software development.		
Prerequisites	Must have participated in the “Development Technologies (Entry)” and “Technological Elements (Entry)” courses of the educational curriculum (ET introductory course) of the Education Curriculum for People Inexperienced in Embedded System Development, or must have already acquired equivalent technologies (knowledge) and skills.		
Educational Objectives	The educational objective of this course is to acquire the technologies (knowledge) needed to get trained to become human resources who can accomplish the following tasks: ● Capable of accomplishing tasks of software implementation and debugging, under guidance, by using platforms used in product development, and other technological elements		
	[Meaning and aim]		
Form of Implementation	☐ CBT ☐ Remote education ☐ Lectures ☐ Workshops ☐ Real machine practices ☐ OJT ☐ Project-type exercises ☐ Others ( )		
Training Hours	52.5 hours	**Scheduled Dates**	
Education Materials	Textbooks		
	Hardware environment		
	Software environment		
	Other education materials		
Assessment Method of Education Results	☐ Assess the research results		
	Assessment method	☐ Written tests ☐ Practical tests ☐ Oral assessment ☐ Taking accreditation tests [ ] ☐ Others ( )	

* The shaded parts in the table should be defined independently.
* The values of time indicated in the “Training hours” column are sample values.
The actual training hours should be defined independently.

(2) Education Items

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Technological Elements	Outline (items, history, and outline from across skills categories of technological elements)	Computer science fundamentals	Basic theory of information		Same education items as those in "IT Fundamentals 1" and "IT Fundamentals 2" of Skill Standards for IT Professionals Training Roadmap
			Data structure and algorithms		
		Computer systems	Hardware		
			Basic software		
			System configuration and architecture		
			System applications		
	Platform	Processor	MPU peripheral technology		
			Basic I/O technology		
		Basic software	Real-time processing		
			Real-time kernel		
			System call		
			Interrupt processing		
			Device driver		
			Middleware		
			Multi-task processing		
			Memory management		
			Exception handling		
Development Technologies	Software architecture design	Design method	Object-oriented design		Same education items as those in "IT Fundamentals 2" of Skill Standards for IT Professionals Training Roadmap
			Structured design		
			Data-oriented design		
		Software structure design	Structured design		
			Architecture design		
	Detailed software design	Detailed software design	Module specifications		
			Module design technology		
			Structured design		
			Specification change		
			Design quality		

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Development Technologies	Software coding and testing	Program creation and identification of program testing items	Software development environment		
			Coding techniques		
			Configuration management tools		
			Programming language		
		Development support tool	Development environment		Same education items as those in “IT Fundamentals 2” of Skill Standards for IT Professionals Training Roadmap
			Various application development tools		
			Configuration management tools		
			Debugger		
			Simulator		
			Emulator		
		Code review and program test item design review	Code review		
			Coding manner		
			Module test techniques		
		Program test implementation	Module test technologies		
			Debugging techniques		
	Software integration	Software integration test specification design	Testing methods		
		Software integr ation test implementation	Embedded system test technology		
			Debugging techniques		

* The shaded parts in the table should be defined independently.

2.4.6 Embedded Software Development Project Type Exercises (Entry)

(1) Course Outline

Course Name	Embedded Software Development Project Type Exercises (Entry)	**No**	6
Education Levels of a Course	■ Entry ☐ Intermediate ☐ Advanced ☐ Supreme		
Skill Category	■ Technological elements ■ Development technologies ■ Management technologies ■ Social ☐ Business ☐ Others ( )		
Outline	To acquire through project-type exercises the technologies and practical skills required in embedded software development as an overall conclusion of the Education Curriculum for People Inexperienced in Embedded System Development. The embedded software tasks in this course correspond to the level at which they are executed under the guidance of seniors (entry level of the ETSS skills specification).		
Target Participants of the Training (Educational Targets)	Does not have any experience in embedded system development, and aims to join the field of embedded software development.		
Prerequisites	Must have participated in the following courses of the Education Curriculum for People Inexperienced in Embedded System Development (ET introductory course), or must have already acquired equivalent technologies (knowledge) and skills: ● Technological Elements (Entry) ● Development Technologies (Entry) ● Embedded Programming Exercises (Entry) ● Management Technologies (Entry) ● Social (Entry)		
Educational Objectives	The educational objective of this course is to acquire the technologies (knowledge) of technological elements needed to get trained to become human resources who can accomplish the following tasks: ● Capable of executing tasks of software implementation and debugging, under guidance, by using platforms used in product development, and other technological elements. ● Capable of accurately reporting the prospect in working hours and the work progress status to seniors for all applicable tasks ● Capable of collecting quality management indices for all applicable tasks under the guidance of seniors and by using tools and techniques, and reporting them ● Capable of extracting risk items for all applicable tasks under the guidance of seniors and on the basis of checklists, and reporting them ● Capable of executing, under guidance, tools and procedures for configuration management and change management used in projects ● Capable of reporting, under guidance, the status of applicable tasks and understanding the status of projects using communication tools and methods		
	[Meaning and aim]		

Form of Implementation	☐ CBT ☐ Remote education ☐ Lectures ☐ Workshops ☐ Real machine practices ☐ OJT ☐ Project-type exercises ☐ Others ( )		
Training Hours	75.0 hours	**Scheduled Dates**	
Education Materials	Textbooks		
	Hardware environment		
	Software environment		
	Other education materials		
Assessment Method of Education Results	☐ Assess the research results		
	Assessment method	☐ Written tests ☐ Practical tests ☐ Oral assessment ☐ Taking accreditation tests [ ] ☐ Others ( )	

* The shaded parts in the table should be defined independently.
* The values of time indicated in the “Training hours” column are sample values. The actual training hours should be defined independently.

(2) Education Items

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Technological Elements	Outline (items, history, and outline from across skills categories of technological elements)	Computer science fundamentals	Basic theory of information		Same education items as those in “IT Fundamentals 1” and “IT Fundamentals 2” of Skill Standards for IT Professionals Training Roadmap
			Data structure and algorithm		
		Computer systems	Hardware		
			Basic software		
			System configuration and architecture		
			System applications		
	Communications	Outline (items, history, and outline from across skills categories of communications)	Protocol and transmission control		
			Encoding and transmission		
			Communication device		
			Network-related regulations		
			Network security		
			Network software		
			Technologies related to transmission circuits		
	Measurement and control	Physical and chemical input	External input device		
			Sensor		
		Physical and chemical output	External output device		
			Actuator		
	Platform	Processor	MPU peripheral technology		
			Basic I/O technology		
		Basic software	Real-time processing		
			Real-time kernel		
			System call		
			Interrupt processing		
			Device driver		
			Middleware		
			Multi-task processing		
			Memory management		
			Exception handling		

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Development Technologies	System requirement analysis	Review of system analysis and requirements definition	High reliability design		
			Design for safety		
			Requirements analysis methods		
	System architecture design	Implementability verification and design review	System architecture design technology		
		Design methods	Object-oriented design		Same education items as those in "IT Fundamentals 2" of Skill Standards for IT Professionals Training Roadmap
			Structured design		
			Data-oriented design		
		Development support tools	Development environment		
	Software requirements analysis	Software requirements definition	Function analysis methods		
			Requirements analysis methods		
	Software architecture design	Design methods	Object-oriented design		Same education items as those in "IT Fundamentals 2" of Skill Standards for IT Professionals Training Roadmap
			Structured design		
			Data-oriented design		
		Software structure design	Structured design		
			Architecture design		
	Detailed software design	Detailed software design	Module specifications		
			Module design technology		
			Structured design		
			Specification change		
			Design quality		

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Development Technologies	Software coding and testing	Program creation and identification of program testing items	Software development environment		
			Coding techniques		
			Configuration management tools		
			Programming language		
		Development support tools	Development environment		Same education items as those in "IT Fundamentals 2" of Skill Standards for IT Professionals Training Roadmap
			Various application development tools		
			Configuration management tools		
			Debugger		
			Simulator		
			Emulator		
		Code review and program test item design review	Code review		
			Coding manner		
			Module test techniques		
		Program test implementation	Module test technologies		
			Debugging techniques		
	Software integration	Software integration test specification design	Testing methods		
		Software integration test implementation	Embedded system test technology		
			Debugging techniques		
	Software qualification tests	Software qualification test preparation and review	Measuring equipment (logic analyzer and oscilloscope)		
			Bug management tools		
		Software qualification test implementation	Real-machine test		
			Bug management tools		
			Measuring equipment (logic analyzer and oscilloscope)		
	System integration	Test item selection, test procedure determination and review	Hardware requirement specifications		
			Software requirement specifications		
			Measuring equipment (logic analyzer and oscilloscope)		
			Bug management tools		
		System integration test implementation	Measuring equipment (logic analyzer and oscilloscope)		
			Failure management report		
			Bug management tools		

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Development Technologies	System qualification tests	System qualification test preparation and review	System requirement specifications		
			Configuration management tools		
			Bug management tools		
		System qualification test implementation	Failure management report		
			Bug management tools		
Management Technologies	Project management	Time management	Analogous estimating		
			Precedence diagramming method		
			Arrow diagramming method		
			Conditional diagramming method		
			Project management tools		
			Backup time (contingency)		
			Schedule differential analysis		
		Cost management	Analogous estimating		
			Parametric modeling estimation		
			Bottom-up estimating		
			Cost performance measurement		
			Cost management tools		
		Quality management	Cost-benefit analysis		
			Benchmarking		
			Flowchart presentation		
			Quality cost		
			Pareto diagram		
			Trend analysis		
			Quality audit		
		Communication management	Stakeholder analysis		
			Information search system		
			Information distribution method		
			Performance report		
			Differential analysis		
			Project report		
			Presentation		
	Process management	Configuration management and change management	Configuration management and operation guideline		
			Configuration management tools		
			Baseline management		
			Change management and operation guideline		
			Change management tools		

Course Name: Technological Elements (Entry)					
Skill Category			Related Technological Items	Time (Min.)	Remarks
Category	First Layer	Second Layer			
Social	Communication	-	2-way communication		
			Transmission of information		
			Organization, analysis and retrieval of information		
			Presentation		
	Problem-solving	-	Observation		
			Ideas		
			Problem-solving		
			Logical thinking		

* The shaded parts in the table should be defined independently.

Appendix. Correlation with the Skill Standards for IT Professionals Training Roadmap

Training Items Required to Be Completed Beforehand for the "Education Program for People Inexperienced in Embedded System Development" (This is for reference only.)

No	ITSS		Training Items to Be Completed Beforehand	Training Items
	IT Fundamentals 1	IT Fundamentals 2		
001	X	X	X	**Computer Science Fundamentals**
002	X	X	X	Basic Theory of Information
003	X	X	X	Data Structure and Algorithm
004	X	X	X	**Computer Systems**
005	X	X	X	Hardware
006	X	X	X	Operating System
007	X	X	X	System Structure and Architecture
008	X	X	X	System Applications
009	X			**System Development Environment**
010	X			System Development Techniques
011	X			Understanding and Utilization of Languages, Tools, and Software Packages
012	X	X	X	**Understanding and Utilization of Network Technologies**
013	X	X	X	Protocol and Transmission Control
014	X	X	X	Encoding and Transmission
015	X	X	X	Network Related Regulations
016	X	X	X	Network Security
017	X	X	X	Internet
018	X	X	X	Communication Equipment
019	X	X	X	Network Software
020	X	X	X	Techniques for Lines such as ATM, Frame Relay, LAN, WAN
021	X	X		**Database Technologies**
022	X	X		Database Model
023	X	X		Database Languages
024	X	X		Database Control
025	X		X	**Standardization**
026	X		X	Standardization of Process for Development and Deals
027	X		X	Standardization of the Information System Infrastructure

No	ITSS		Training Items to Be Completed Beforehand	Training Items
	IT Fundamentals 1	IT Fundamentals 2		
028	X		X	Data Standardization
029	X		X	Design and Management of Standard Organizations
030	X			**System Audit**
031	X			System Audit Fundamentals
032	X			System Audit Planning
033	X			System Audit Implementation and Report
034	X	X		**Security and Privacy**
035	X	X		Security Measures (Secret Preservation, Measures for Prevention of Falsification, Intrusion Prevention, Computer Virus, Integrity Measures, Availability Measures, Safety Measures, Social Engineering)
036	X	X		Privacy Protection
037	X			Risk Management
038	X			Guidelines and Relevant Regulations
039	X			**Informatization and Management**
040	X			Information Strategy
041	X			Corporate Accounting
042	X			Management Engineering
043	X			Utilization of Information System in Engineering System Area and Business System Area
044	X			Understanding and Compliance of Relevant Regulations
045	X		X	**Leadership**
046	X		X	Fundamentals and Principles of Leadership
047	X		X	Teamwork and Communication
048	X		X	Project Objective Setting
049	X		X	Project Promotion
050	X		X	Project Execution
051	X		X	Project Management
052	X		X	Collaboration Between Team Members
053	X			Motivating Team Members and Provision for Feelings of Accomplishment
054	X		X	**2-Way Communication**
055	X		X	Dialogue and Interview
056	X		X	Information Transfer
057	X		X	Communication Technique
058	X		X	Effective Speaking and Listening
059	X			**Transmission of Information**
060	X			Presentation Technique
061	X			Creation of Official and Nonofficial Documents
062	X			Technical Writing
063	X			Media Selection
064	X			Persuasion Technique
065	X			**Organization, Analysis and Retrieval of Information**
066	X			Development and Practice of Status Response Capabilities to Understand Situations

No	ITSS		Training Items to Be Completed Beforehand	Training Items
	IT Fundamentals 1	IT Fundamentals 2		
067	X			Capabilities to Understand Situations
068	X			Meeting Management Techniques
069	X			**Negotiation**
070	X			Negotiation Process
071	X			Effective Negotiation Techniques
072	X			Establishment of Trust Relationship
073	X			Objective Setting
074	X			Common Interest
075	X			Logical Thinking
076	X			Problem Solving Techniques
077		X		**System Platform Technology**
078		X		Utilization and Practice of Operating System Techniques (Mainframe, Dispersion (Office Computer), UNIX, WINDOWS, Linux, etc.)
079		X		**Internet Technologies**
080		X		Internet History
081		X		Techniques for Web
082		X		Techniques for Emails
083		X		Encoding Techniques
084		X		Techniques for Digital Media (VoIP, Streaming, QoS, etc)
085		X		**Platform Technologies**
086		X		Hardware Architecture
087		X		Storage Management
088		X		Operating System
089		X		Communication Control
090		X		Understanding and Utilization of Transaction Processing, Distribution Processing and Parallel Processing
091		X	**X**	**Programming Techniques**
092		X	**X**	Utilization and Practice of Various Programming Language Techniques and Notation
093		X		**Testing techniques**
094		X		Test Case Design
095		X		Specification Determination
096		X		Test Environment Set-Up
097		X		Management
098		X		Test Data Preparation
099		X		Test Tool Utilization
100		X		**Debugging Methods**
101		X		Utilization and Practice of Debugging Tools
102		X	**X**	**Reuse Methods**
103		X	**X**	Utilization of Software Components
104		X	**X**	Deliverables Utilization of Advanced Project
105		X	**X**	Utilization and Practice of Reuse Methods

No	ITSS		Training Items to Be Completed Beforehand	Training Items
	IT Fundamentals 1	IT Fundamentals 2		
106				Architectural Pattern
107				Design Pattern
108				Framework, etc.
109		X		**Implementation and Inspection of Security Systems**
110		X		Selection and Installation of Security Products and Tools
111		X		Security System Development
112		X		Security Technology Implementation
113		X	X	**Design Methods**
114		X	X	Object-Oriented Design
115		X	X	Structured Design
116		X	X	Data Oriented Design
117		X		**External Design**
118		X		System Function Design
119		X		Data Model Design
120		X		Creation of External Specification
121		X		**Internal Design**
122		X		Function Design
123		X		Interface Design
124		X		Internal Data Design
125		X		Identification and Role-Definition of Subcomponents
126		X		Relationship Definition among Subcomponents
127		X		Creation of Internal Specification
128		X	X	**Object-Oriented Development**
129		X	X	Object-Oriented Basic Concept
130		X	X	UML
131		X	X	Object-Oriented Development Process
132		X	X	Analysis, Design and Implementation
133		X	X	Main Object-Oriented Techniques
134		X		**Analysis of Technical Requirements**
135		X		Analysis of Existing IT Environment
136		X		Understanding of New Technical Requirements
137		X		Needs Analysis and Prioritization
138		X	X	**Programming Languages / Markup Languages**
139		X	X*1	Various Languages such as C, C++, COBOL, Java, UML, HTML, XML
140		X	X*1	Characteristics of Notation
141		X		Usage of Graphical Development Environment
142		X		**Design of Development Environment**
143		X		Definition of Development Environment Requirements
144		X		Platform Selection

*1 Necessary for at least C and C++ languages

No	ITSS		Training Items to Be Completed Beforehand	Training Items
	IT Fundamentals 1	IT Fundamentals 2		
145		X		**Program Design**
146		X		Selection of Development Methods and Platform
147		X		Program Design Criteria
148		X		Program Specification Creation
149		X		Creation of Test Plan and Specification
150		X	**X**	**Development Methods**
151		X		Development Methods Selection
152		X		Utilization and Practice of Development Technique
153		X	**X**	Waterfall Model, RAD (Rapid Application Development) Model, Spiral Model
154		X		Application Package Specific Development Techniques
155		X	**X**	**Utilization of Development Support Tools**
156		X	**X**	Development Environment
157		X	**X**	Various Application Development Tools
158		X	**X**	Configuration Management Tools
159		X	**X**	Debugger, Simulator, etc.