Application of ISO/IEC25000 (SQuaRE) Series to SI Projects

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Abstract

Our department has the role of promoting reform in the SI business of the NEC Group and improving the quality and productivity of products and services. To this end, we are working to manage technology and distribute know-how across organizations in relation to software and system production. This includes the drafting and implementing of policies for software and system engineering such as development methodologies.

As quality requirements for IT systems become increasingly complex and diversified, the need is felt for a mechanism that can logically and objectively explain quality. One means of perceiving quality is to apply the ISO/IEC 25000 (SQuaRE) series of international standards, but at present, they are not being sufficiently used on-site in IT system construction projects. Going forward, it will be necessary to perceive quality not only from the viewpoint of process quality but also in terms of product quality based on customer concerns. In this paper, we report on the results of our activities in testing the effectiveness of applying the ISO/IEC 25000 (SQuaRE) series to IT system construction projects and in devising ways of applying them.

Keywords

Software quality, quality evaluation, software development, System Integration, SQuaRE

1. Quality Management Trends in IT System Construction

In recent years, IT systems have become such an indispensable part of people's lives that failures in those systems have turned into major social problems. This state of affairs has forced the providers of IT systems and services to be held accountable and explain why those failures occurred.

At the same time, the role of IT systems in the corporate world is shifting from being just a tool to being a form of management itself, and as a result, the requirements placed on IT systems are becoming increasingly complex and diversified. Customers are becoming increasingly aware of quality, and a trend is emerging in which customers themselves are performing objective evaluations of IT system quality such as by using outside process management companies for development processes and quality management.

In Japan, the Information-technology Promotion Agency (IPA) has made recommendations on the need for suppliers of software products to explain software quality to users premised on the ISO/IEC 25000 (SQuaRE) series of international standards (referred to below as the "SQuaRE series") [1].

Additionally, on examining the situation at System Integration (SI) project sites involved in the construction of IT systems, it can be seen that factors like sudden changes in IT technologies and short delivery times are making it difficult to properly apply quality management techniques that use "statistical bug prediction and management techniques" specific to type of development project, type of language, and type of organization taking the number of bugs to be a prime indicator. Techniques that place importance on process quality aim to achieve an indicator value in terms of the number of bugs, but this results in a situation in which quality is managed only from the viewpoint of software developers.

At present, quality awareness is rising among customers, so product quality that presumes process quality management is being reconsidered and the need is being felt for quality management techniques that focus on quality of interest to customers.

2. Definitions of Quality of Interest to Customers

Quality of interest to customers is not limited to the presence or absence of bugs but covers a wide range of issues such as effectiveness in business tasks, ease of system use, and reliability. Definitions of these various aspects of quality have been made such as the Kano model [2], but as definitions of quality of interest to

Proceedings IWESQ 2023,5th International Workshop on Experience with SQuaRE series and its Future Direction, December 4, 2023, Seoul, Korea

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customers, we here focus on using the SQuaRE series to achieve explanations of quality for third parties.

The SQuaRE series, however, are international standards for quality requirements of software products and for evaluating those requirements targeting software overall, and as such, suffer from the following problems.

- The SQuaRE series cover a wide range of standards and target a variety of software products, so the descriptions in those standards tend to be generic in nature. As a result, project personnel engaged in IT system construction encounter expressions that they are not familiar with and find difficult to understand.
- Among Quality, Cost, and Delivery (QCD) in SI projects, cost and delivery are highly prioritized, and there are many cases in which they are decided on in advance, which makes it difficult to secure the cost and time to study and deal with the quality characteristics/subcharacteristics of all the quality models in the SQuaRE series.
- Applying the general-purpose SQuaRE series of standards to SI projects requires tailoring them to the actual circumstances surrounding a particular project along with a thorough knowledge of SQuaRE (we ourselves spent about one year in achieving an understanding of quality models in the SQuaRE series and holding discussions on their application to SI projects).

3. Learning about Quality Models and their Application to SI

On applying the SQuaRE series to SI project sites, we were aware of the above problems, but we began with “definitions of quality of interest to customers” in IT system construction using the Quality Model Division (ISO/IEC 2501x) of the SQuaRE series.

To begin with, we set up a study team to learn about the basics of the SQuaRE series using Japan’s JIS standards [3], IPA’s “Software Quality Guide for a Connected World” [4], and the results of academic research [5][6][7]. In this way, we made progress in achieving a mutual understanding of SQuaRE, but at the same time, there was some variation among team members in how to interpret the SQuaRE series, and this sometimes impeded discussions.

Additionally, for the quality characteristics /subcharacteristics of the ISO/IEC 25010 (product quality) and ISO/IEC 25012 (data quality) quality models, we discussed our understanding of each of those characteristics/subcharacteristics (57 quality characteristics in all) and examples of interpreting them for application to SI projects.

These discussions were held over a period of about one year and included an exchange of opinions with a certain outside vendor that had experience in dealing with the SQuaRE series. Through these activities, we discovered the following policies in using the SQuaRE series of standards.

1. The objective is not strict classification or exhaustive use of quality characteristics /subcharacteristics
   To begin with, the quality models of the SQuaRE series cover a very wide range of quality characteristics and the need may be felt for using all quality characteristics /subcharacteristics in an exhaustive manner. However, it is often the case in SI projects that resources that can be allocated (cost) and delivery date are highly prioritized in addition to target quality. Consequently, it is realistic to just use these quality characteristics /subcharacteristics as a viewpoint in setting priorities for quality of interest to customers while keeping a QCD balance in mind (they can guide the thinking of personnel and be used as a reference for prioritizing quality requirements).
   Next, the objective of many SI projects is not to obtain ISO third-party certification, so strict classification of quality characteristics /subcharacteristics is not recommended (increases costs).

2. Systematic use of the SQuaRE series from the upstream in consensus building with customers
   The SQuaRE series can be used to form an agreement on vendor quality requirements with customers and stakeholders in the project proposal and planning stage.
   Quality management based on the management of indicator values such as number of bugs and review time are process-quality centric with respect to work results from reviews, tests, etc. In contrast, by focusing on product quality of interest to customers, we believe that applying the SQuaRE series to a project in a balanced manner from the viewpoint of product quality and managing quality from multiple perspectives in the upstream—where many waterfall projects incorporate quality—can provide an IT system of even higher quality.

3. Use in analysis when quality problems occur (not recommended)
   We believe that the quality model framework of the SQuaRE series can also be used for projects in progress or existing deliverables from the viewpoint of checking for excesses or deficiencies from a quality perspective along the way. From the beginning, however, it has been important to execute a project by turning quality requirements into specifications in consultation with customers and stakeholders from the project proposal/planning stage and reaching a consensus on assigning priorities and making measurements and evaluations. In this context, we do not recommend using the SQuaRE series when quality problems occur.

4. Using the relationships between quality characteristics
Relationships exist between ISO quality models and quality characteristics /subcharacteristics as reported in IPA's "Software Quality Guide for a Connected World" [4] and in the research of academic institutions [8].
We present the following guidelines to effectively use these relationships between quality characteristics in SI projects (described in detail later).

- Positive effect: Improves the return on investment of an SI project
- Negative effect: Results from implementing risk countermeasures in the operation of an SI project
- Quality derivation: Used in deriving related quality requirements (makes work more efficient and improves the accuracy of quality targets)

4. Explanation for SI Project Practitioners

We investigated how to efficiently convey the results of our study team activities to personnel at SI project sites and prepared a guide based on the following policies.

- Provide an SI-oriented explanation based on SQuaRE definitions of quality characteristics /subcharacteristics (original text)
- Illustrate quality characteristics /subcharacteristics in line with situations in IT system construction in a way that SI project personnel can easily visualize those characteristics/subcharacteristics
- Illustrate relationships between quality characteristics (positive effects, negative effects, quality derivation) and explain how to use them in an SI project

Specifically, we created a guide that, assuming SI projects, includes definitions of quality characteristics /subcharacteristics in the quality models of the SQuaRE series and explanations of those definitions from IPA's "Software Quality Guide for a Connected World" [4] plus interpretations of those quality characteristics/subcharacteristics assuming SI projects at NEC (Figure 1: Example of a quality model guide for SI project personnel).

Along with the above, we have added illustrations of quality subcharacteristics in NEC SI projects to help personnel in SI projects understand product quality models (Figure 2: Example of a quality model guide for SI project personnel (illustration of quality characteristics)).

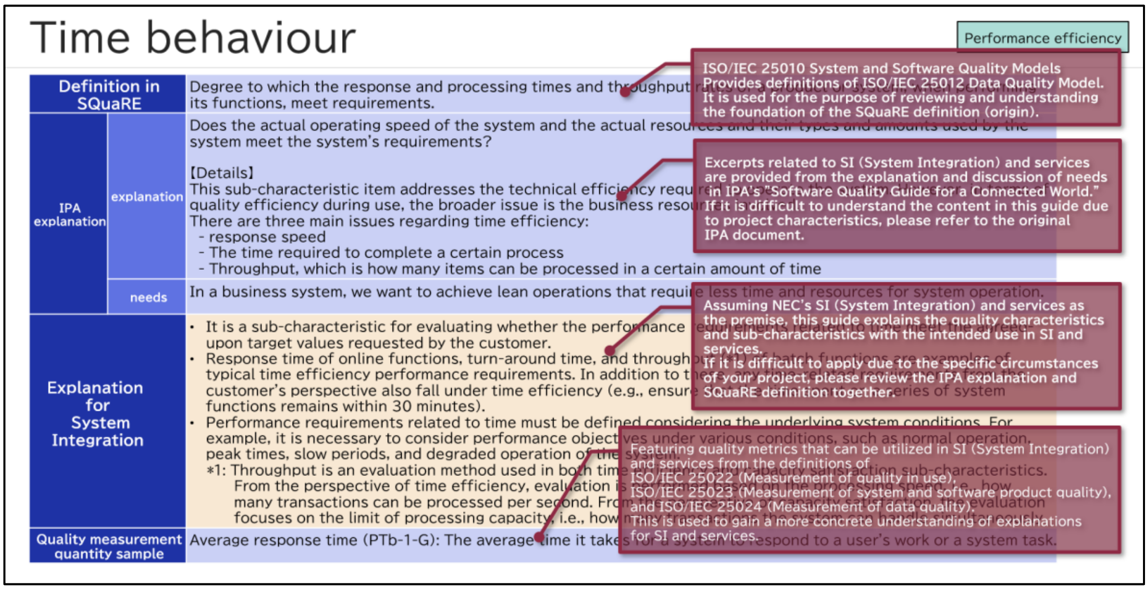


Figure 1: Example of a quality model guide for SI project personnel

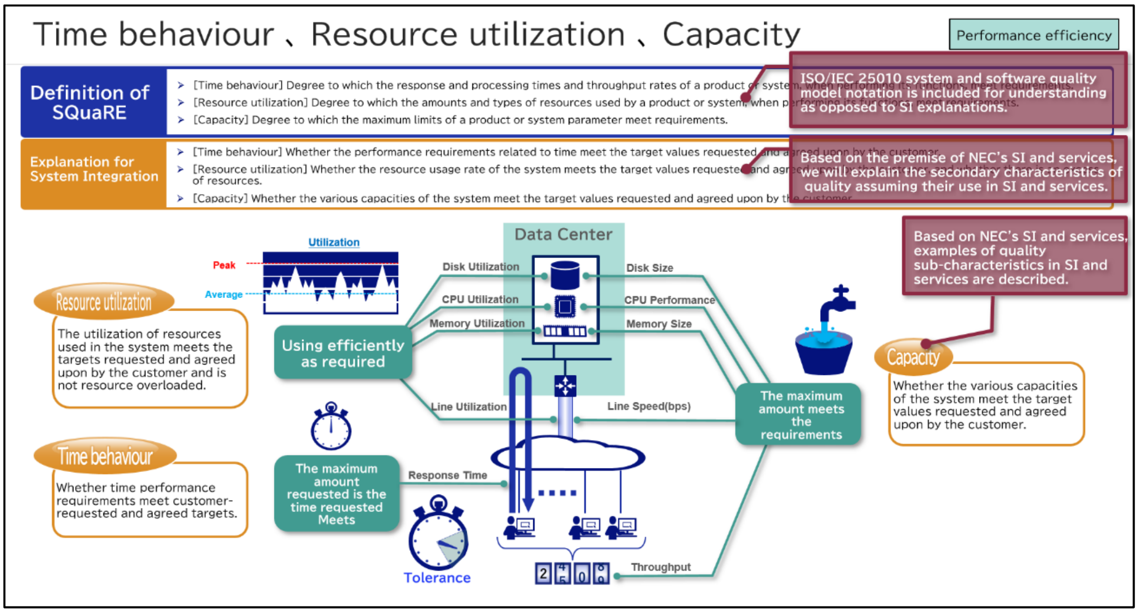


Figure 2: Example of a quality model guide for SI project personnel (with illustration of quality characteristics)

This guide also presents samples of the relationships between quality characteristics /subcharacteristics of different ISO quality models as reported by IPA's "Software Quality Guide for a Connected World" [4] and the research of academic institutions [8] to help personnel understand those relationships.

First, recognizing that the following types of relationships exist between quality characteristics of different quality models, we present an example (Figure 3: Example of relationships between quality characteristics of different quality models).

1. Achieved with product quality model
   Quality characteristics that achieve quality during use can be used to derive quality characteristics in the product quality model. These relationships can be used as reference when incorporating quality from the user's point of view in specific quality characteristics in the product quality model.

2. Supports quality during use
   In the case that quality in the product quality model is studied first, these relationships can be used as reference to study target quality during use in a retroactive manner.

3. Clarification of division between functions and data
   The division between quality achieved with functions (that include data) and quality achieved by data only can be clarified. These relationships can be used as reference when, for functions, an awareness of data characteristics is needed, and for data, when identifying characteristics to be linked with a function.

Next, there are positive effects and negative effects between quality characteristics /subcharacteristics. Given certain quality characteristics/subcharacteristics having a relationship, a positive effect occurs when improving the quality of one characteristic/subcharacteristic has a good effect on the quality of the other. In contrast, a negative effect occurs when improving the quality of one characteristic/subcharacteristic has a bad effect on the quality of the other.

For example, improving response time and raising performance so that screen transitions become smoother and user operability improves is considered to be a positive effect. On the other hand, introducing two-factor authentication to improve security increases the number of screens to be checked and the operations needed to reach the function one wants to use. This reduces user satisfaction and is therefore a negative effect.

We created a matrix showing these relationships and presented those relationships together with grounds explaining them (Figure 4: Relationship matrix between quality characteristics (Compatibility), Figure 5: Grounds explaining relationships between quality characteristics (Interoperability)).

We therefore believe that focusing on these relationships between quality characteristics and making designers aware of them can produce specifications for quality requirements that achieve a balance in a more efficient way.

However, the interpretation of quality characteristics and the relationships among them may change according to the nature of the target project, so tailoring them to the project is possible.

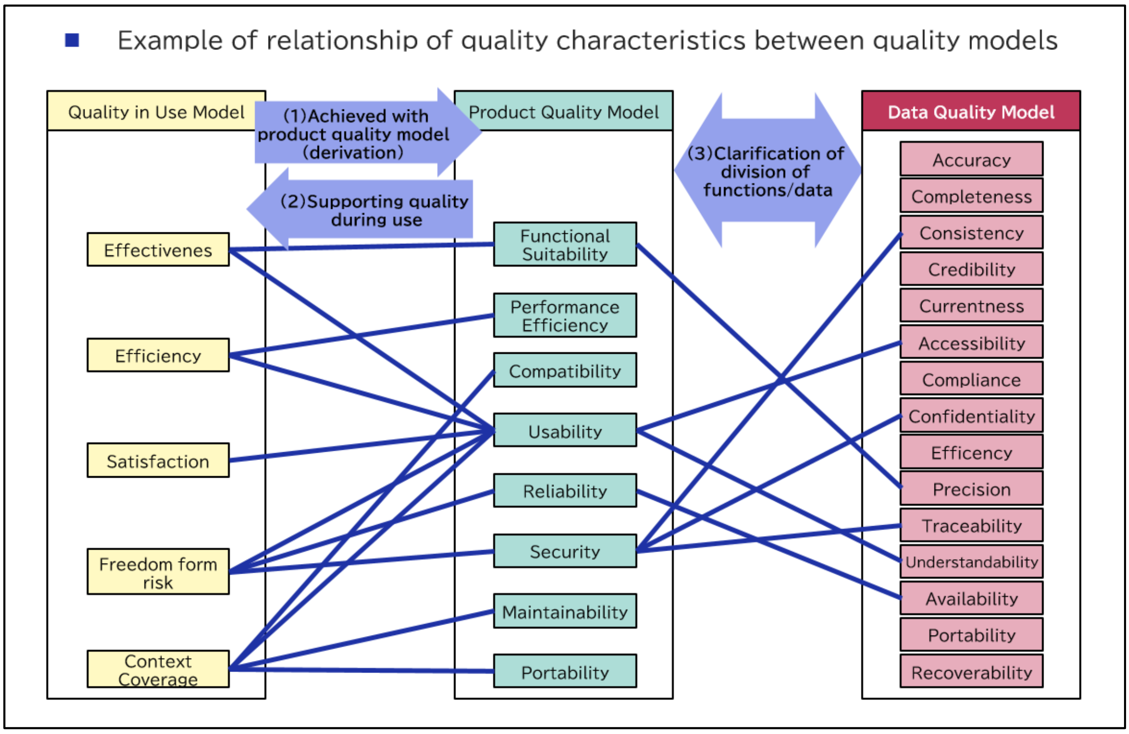


Figure 3: Example of relationships between quality characteristics of different quality models

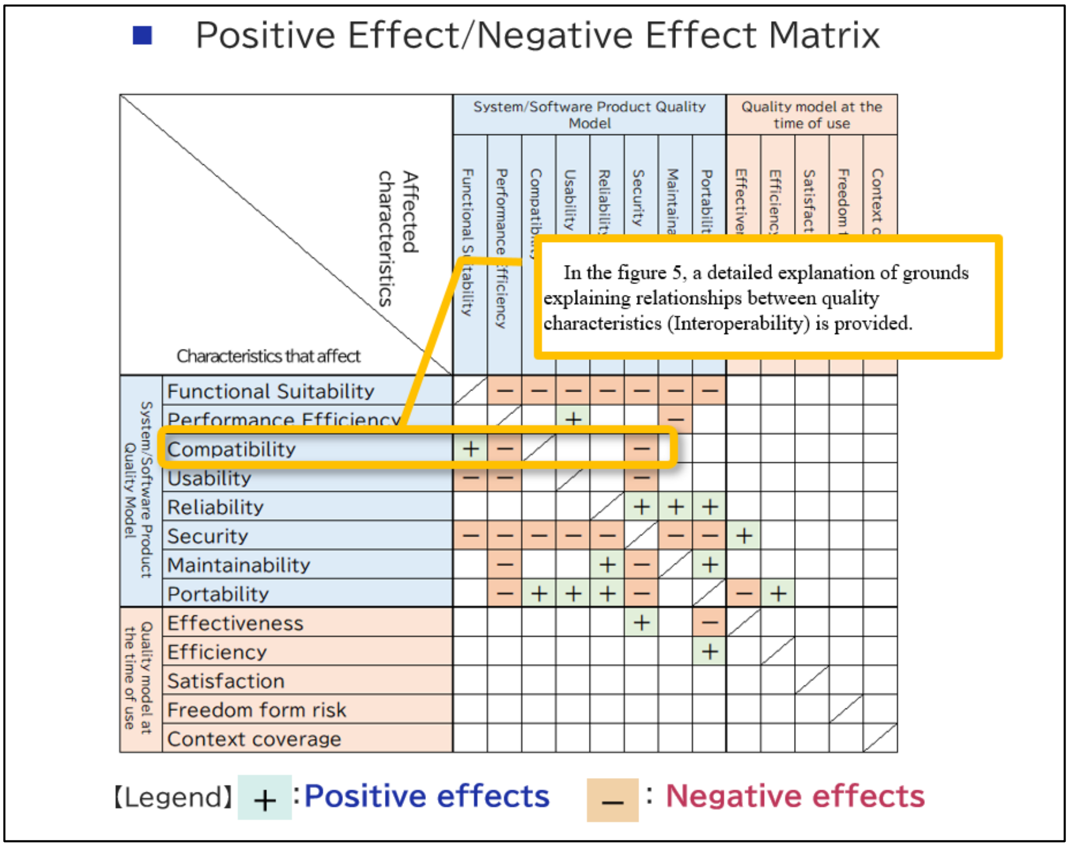


Figure 4: Relationship matrix between quality characteristics (Compatibility)

■ Examples of explanations of relationships

Characteristics that affect		Affected characteristics or sub-characteristics			
sub-characteristics	Description of JIS X 25010	Quality Model	characteristic	Relationships	grounds
Interoperability	Degree to which two or more systems, products or components can exchange information and use the information that has been exchanged.	product	Functional Suitability	+	Enhancing interoperability with other systems can sometimes contribute to better functional fitness by collaborating with other systems. On the other hand, it may cause some performance efficiency issues and incorporate some security flaws due to heavy and vulnerable communication protocols. (Source: JIS X 25030:2021)
Interoperability	Degree to which two or more systems, products or components can exchange information and use the information that has been exchanged.	product	Performance Efficiency	–	Enhancing interoperability with other systems can sometimes contribute to better functional fitness by collaborating with other systems. On the other hand, it may cause some performance efficiency issues and incorporate some security flaws due to heavy and vulnerable communication protocols. (Source: JIS X 25030:2021)
Interoperability	Degree to which two or more systems, products or components can exchange information and use the information that has been exchanged.	product	Security	–	Enhancing interoperability with other systems can sometimes contribute to better functional fitness by collaborating with other systems. On the other hand, it may cause some performance efficiency issues and incorporate some security flaws due to heavy and vulnerable communication protocols. (Source: JIS X 25030:2021)

Figure 5: Grounds explaining relationships between quality characteristics (Interoperability)

5. Evaluation of the Use of Quality Models in SI Projects

We ourselves conducted proof of concept (PoC) trials for several projects to gain insights from a quality perspective in executing the project and to check the effectiveness of risk management. In these trials, we used the viewpoints expressed by quality models in the SQuaRE series of standards in actual SI projects and classified and organized quality requirements (explicit/implicit needs).

5.1. Purpose of PoC

Our purpose in conducting these PoC trials was to test the following hypotheses.

1. Visualization of quality requirements using quality models
   Can quality requirements that must be satisfied by a project be further clarified by classifying quality in terms of quality characteristics/subcharacteristics?

   - Can the state of quality be clearly recognized compared with that before quality classification?
   - Can excesses or deficiencies in quality requirements be noticed?

2. Checking effectiveness in an SI project
   Could measures be taken to avoid project risk from quality problems extracted from the relationships among quality characteristics?

5.2. Target Projects

The projects targeted for PoC trials are summarized below. The time period of each trial was about a month and a half to two months according to each project's schedule.

- Software as a Service (SaaS) development project
  PoC execution phase: planning phase
- IT system construction project including construction of machine facilities, etc.
  PoC execution phase: basic design phase
- Government-related IT system construction project
  PoC execution phase: basic design phase

5.3. PoC Procedure

On performing a PoC trial, we ourselves as persons knowledgeable about the SQuaRE series classified and analyzed quality requirements based on materials provided from each project.

1. Visualization of quality status by quality classification
   Using project documents including the proposal and definitions of requirements, we classified quality based on quality models of the SQuaRE series and visualized the quality status of the target project.

2. Analysis of quality status
   We clarified the quality problems (including speculations) and countermeasures that should be considered in the target project from quality status classified as described above and from relationships between quality characteristics (based on ISO definitions, research results, and SI considerations).

3. Project-directed proposals
   Based on the results of analysis, we proposed the following countermeasures (including speculations) such as risk hedges in executing a project.

   - Proposed that the presence of excesses or deficiencies in terms of completeness be checked from a quality perspective (prevent omission of requirements).

- "Deficiencies" from a quality perspective may indicate implicit needs, so we proposed that deficient points be checked to see whether they are indeed implicit needs.
- Proposed that "outside the scope" from a quality perspective may be excluded from the project (eliminate waste).
- Proposed that quality goals be explained to stakeholders including customers using a visualized quality perspective (objective explanation of quality).

5.4. Main Deliverables

1. Quality status report (Figure 6: Sample of project quality report)
   This deliverable reported on the classification and analysis of quality requirements, proposals for risk countermeasures to be taken by the project from the perspective of quality characteristics, etc. Specifically, we focused on groups of related quality characteristics based on project characteristics from system requirements and analyzed why those trends occurred (Figure 6: Sample of project quality report (example of visualizing trends in quality characteristics) and Figure 7: Sample of project quality report (example of analyzing trends in quality characteristics)).
   Next, among various quality characteristics (explicit/implicit), we visualized quality characteristics that have little mention in system requirements and proposed measures for future projects from the relationships between quality characteristics, etc. (Figure 8: Sample of project quality report (analysis of trends in quality characteristics: quality characteristics of concern) and Figure 9: Sample of project quality report (example of quality characteristics that a project should consider)).

2. Quality perspective checklists by type of design specification
   This deliverable for the basic design phase includes design perspectives and review points that take into account quality characteristics.

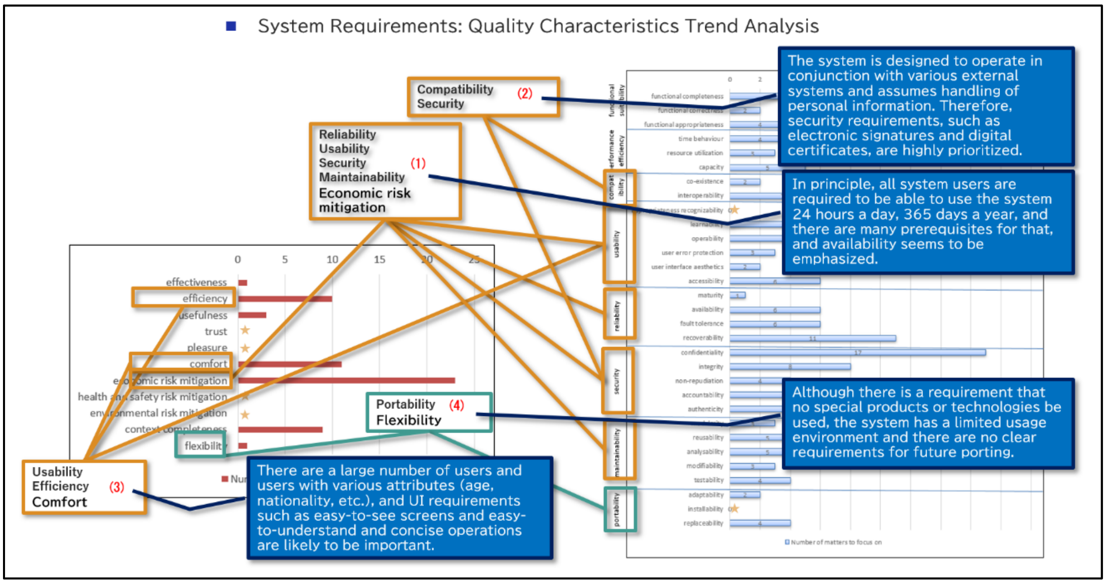
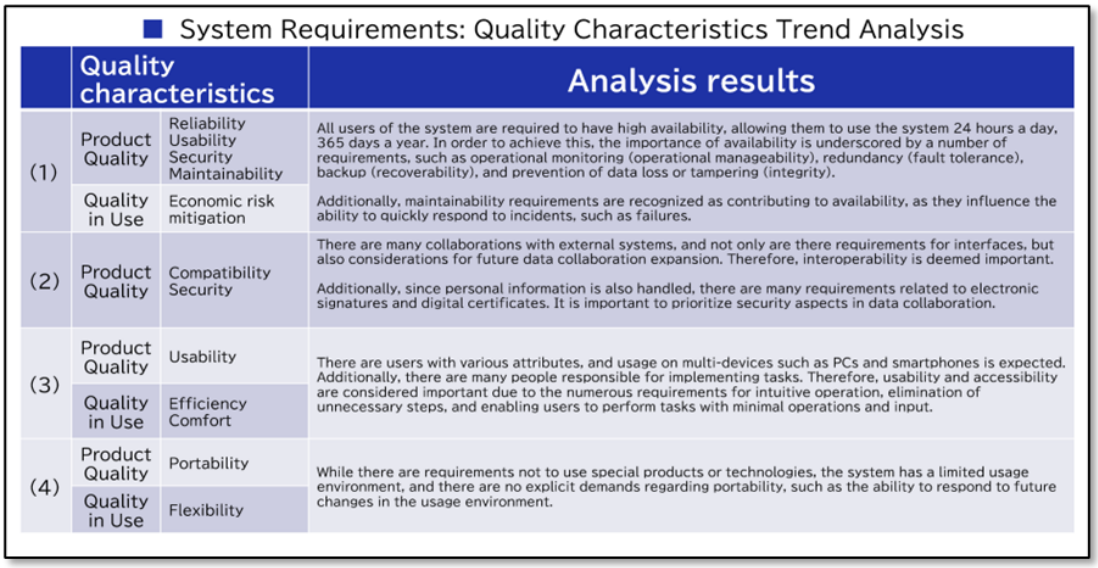


Figure 6: Sample of project quality report (example of visualizing trends in quality characteristics)



■ System Requirements: Quality Characteristics Trend Analysis

	Quality characteristics		Analysis results
(1)	Product Quality	Reliability Usability Security Maintainability	All users of the system are required to have high availability, allowing them to use the system 24 hours a day, 365 days a year. In order to achieve this, the importance of availability is underscored by a number of requirements, such as operational monitoring (operational manageability), redundancy (fault tolerance), backup (recoverability), and prevention of data loss or tampering (integrity).
	Quality in Use	Economic risk mitigation	Additionally, maintainability requirements are recognized as contributing to availability, as they influence the ability to quickly respond to incidents, such as failures.
(2)	Product Quality	Compatibility Security	There are many collaborations with external systems, and not only are there requirements for interfaces, but also considerations for future data collaboration expansion. Therefore, interoperability is deemed important. Additionally, since personal information is also handled, there are many requirements related to electronic signatures and digital certificates. It is important to prioritize security aspects in data collaboration.
(3)	Product Quality	Usability	There are users with various attributes, and usage on multi-devices such as PCs and smartphones is expected. Additionally, there are many people responsible for implementing tasks. Therefore, usability and accessibility are considered important due to the numerous requirements for intuitive operation, elimination of unnecessary steps, and enabling users to perform tasks with minimal operations and input.
	Quality in Use	Efficiency Comfort	
(4)	Product Quality	Portability	While there are requirements not to use special products or technologies, the system has a limited usage environment, and there are no explicit demands regarding portability, such as the ability to respond to future changes in the usage environment.
	Quality in Use	Flexibility	

Figure 7: Sample of project quality report (example of analyzing trends in quality characteristics)

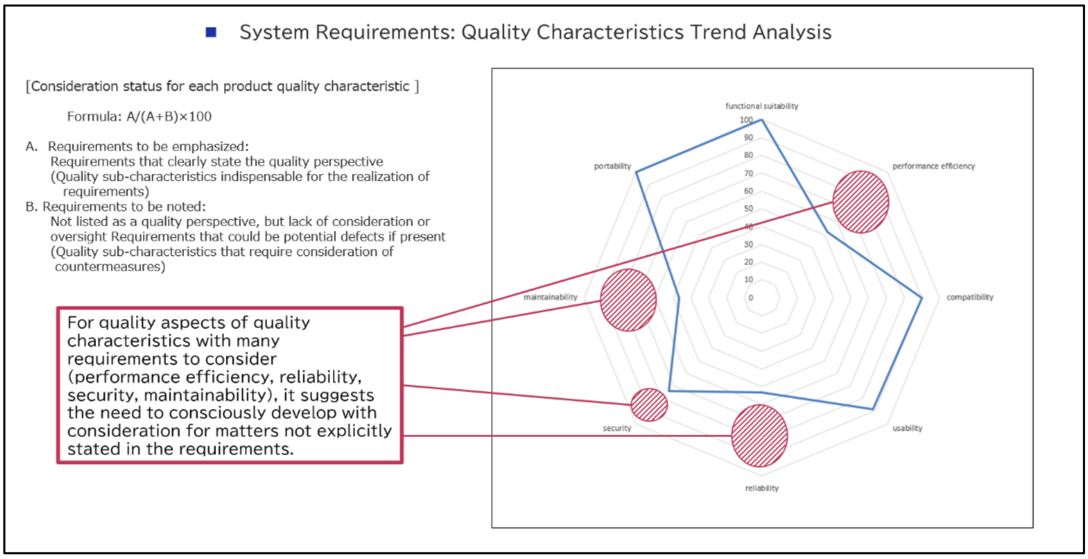


Figure 8: Sample of project quality report (analysis of trends in quality characteristics: quality characteristics of concern)

■ Quality characteristics to consider (maintainability)

	Impact of Quality Characteristics (Challenges point)	Measures for general SI projects	Measures in this project
1	There is a possibility of worsening performance efficiency. For example, the chosen method for achieving a non-complex process (improvement of testability) may require additional processing, which could deteriorate performance efficiency (time efficiency).	When improving maintainability, it is necessary to address performance considerations as well. Performance is clarified by the basic design process based on non-functional requirements, but maintainability is generally a concern during the detailed design and manufacturing stages, unless it is the purpose of the system or project (when the basic design process is already complete). If you want to improve maintainability, either properly, design it from the beginning as a requirement, or implement a system architecture and implementation methodology during standardization activities that do not negatively affect performance efficiency, rather than considering it on a case-by-case basis for individual business functions.	Proposal of measures for project
2	Security may be compromised. For example, it may become possible to easily tamper with information through the interface (authenticity).	When improving maintainability, it is also necessary to address security considerations. Security is clarified by the basic design process based on non-functional requirements, but maintainability is generally a concern during the detailed design and manufacturing stages unless it is the purpose of the system or project (when the basic design process is already complete). If you want to improve maintainability, either properly design it from the beginning as a requirement, or implement a system architecture and implementation methodology during standardization activities that do not negatively affect security, rather than considering it on a case-by-case basis for individual business functions.	

Figure 9: Sample of project quality report (example of quality characteristics that a project should consider)
* “Measures in this project” relate to individual project and are not displayed here.

5.5. Results from the PoC Verification

The following results were obtained for each of the test objectives in the PoC verification.

1. Visualization of quality requirements using quality models
   Classifying and visualizing system requirements based on ISO quality models made it possible to grasp trends in the current state of the project and locations that require countermeasures while increasing the resolution for studying quality improvements.

2. Checking effectiveness in an SI project
   We were able to offer new insights for a project by mentioning things initially not noticed such as the possibility of degrading a subsequent process or negatively affecting other characteristics.

3. Other
   By proposing not only general measures for quality characteristics but also measures that consider project characteristics, we could increase motivation for risk avoidance in the project.

4. Things that could not be confirmed
   Since an understanding of the quality models and quality characteristics /subcharacteristics of the SQuaRE series would normally be assumed to complete quality perspective checklists for different deliverables, only check items with abstract expressions were created for personnel in PoC projects, so effects could not be confirmed.
   However, if a checklist is created that assumes no knowledge at all of the SQuaRE series, a huge amount of checklists including a variety of explanations would be created and there would be doubts as to whether such an amount of checklists could be realistically checked.
   Consequently, to enable the use of checklists from a quality perspective, we determined that it would be best if SI project personnel were to first obtain an understanding of the quality models and quality characteristics/subcharacteristics of the SQuaRE series and to then use those checklists at the beginning of each phase with the aim of checking off specific design points.

6. Conclusion

Through activities that lasted for a year and a half, we found the following effects to be true by applying the SQuaRE series of standards to SI projects involved in the construction of IT systems.

- The visualization of quality requirements (classifying and presenting quality status) is effective in further clarifying quality status.
- The application of SQuaRE series is effective in improving return on investment and avoiding risk in achieving project QCD.

In the above way, we confirmed that explaining IT system quality in SI projects is effective, but as described in policies on using the SQuaRE series in SI projects, building a consensus with the customer from the project proposal and planning stage is important and that the SQuaRE series should be used as a manual or bible for project quality during project execution and up to project completion.

This can be taken to mean “quality strategy,” and going forward, we plan to use not only the Quality Model Division (ISO/IEC 2501x) of the SQuaRE series but also the Quality Measurement Division (ISO/IEC 2502x), Quality Requirements Division (ISO/IEC 2503x), Quality Management Division (ISO/IEC 2500x), and Quality Evaluation Division (ISO/IEC 2504x). Furthermore, in addition to SI projects using a waterfall type of development, we plan to apply the SQuaRE series to DevOps (SI projects of the type in which factors such as agile development, sudden changes in IT technologies, and short delivery times make it difficult to properly apply “statistical bug prediction and management techniques” specific to type of development project, type of language, and type of organization taking the number of bugs to be a major indicator).

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