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Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE): cloud services —

Part 2: Quality measurement

Ingénierie des systèmes et du logiciel — Exigences de qualité et évaluation des systèmes et du logiciel (SQuaRE): services en nuage —

Partie 2: Mesure de la qualité

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Foreword

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Software and systems engineering*.

A list of all parts in the ISO/IEC 25052 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

In the standards on SQuaRE developed by ISO/IEC JTC 1/SC 7, there are well-defined quality models for measuring and evaluating system and software products, IT services, data, etc. Although the standards on SQuaRE developed by ISO/IEC JTC 1/SC 7 provide practical quality models, they do not fit new technologies well. To support the evaluation of new technologies, ISO/IEC TS 25052-1 defines the quality model of cloud services, which is an extension of the quality models defined in ISO/IEC 25010 to ISO/IEC 25019. To support the practical measurement of cloud services, this document provides quality measures based on the quality model defined in ISO/IEC TS 25052-1.

Compared to information and communication technology (ICT) systems, cloud computing has different characteristics. This document reflects the characteristics of cloud computing. The following are the key characteristics of cloud computing described in ISO/IEC 22123-2.

— Broad network access: physical and virtual resources are available over a network and accessed through standard mechanisms that promote the use of cloud service customers (CSC).

— Measured service: characteristic in which the metered delivery of cloud services is such that usage can be monitored, controlled, reported, and billed.

— Multi-tenancy: characteristic in which physical or virtual resources are allocated in such a way that multiple tenants and their computations and data are isolated from and inaccessible to one another.

— On-demand self-service: characteristic in which a CSC can provision cloud services, as needed, automatically or with minimal interaction with cloud service providers(CSP).

— Rapid elasticity and scalability: resources can be rapidly and elastically adjusted, in some cases automatically, to quickly increase or decrease capacity.

— Resource pooling: characteristic in which a CSP's physical or virtual resources can be aggregated to serve one or more CSCs.

The quality model in this document is to support the non-functional specification and evaluation of cloud services from different perspectives by those associated with cloud service selection, requirements analysis, development, use, evaluation, support, maintenance, quality assurance and control, and audit.

For example, activities during cloud service selection that can benefit from the use of the quality model include:

— identifying cloud services requirements;

— establishing cloud service selection criteria;

— defining service coverage and service objectives;

— establishing service level agreements;

— establishing measures of quality characteristics in support of these activities.

Activities during cloud service development that can benefit from the use of the quality model include:

— identifying cloud service requirements;

— validating comprehensiveness of requirement definitions;

— identifying cloud service design objectives;

— identifying cloud service testing objectives;

— identifying quality control criteria as part of quality assurance;

— identifying acceptance criteria for a cloud service;

— establishing measures of quality characteristics in support of these activities.

Figure 1 illustrates the organization of the standards on SQuaRE developed by ISO/IEC JTC 1/SC 7. Similar standards are grouped into divisions. Each division provides guidance and resources for performing a different function in ensuring system and software product quality. This document belongs to extension division 25050 to 25099.

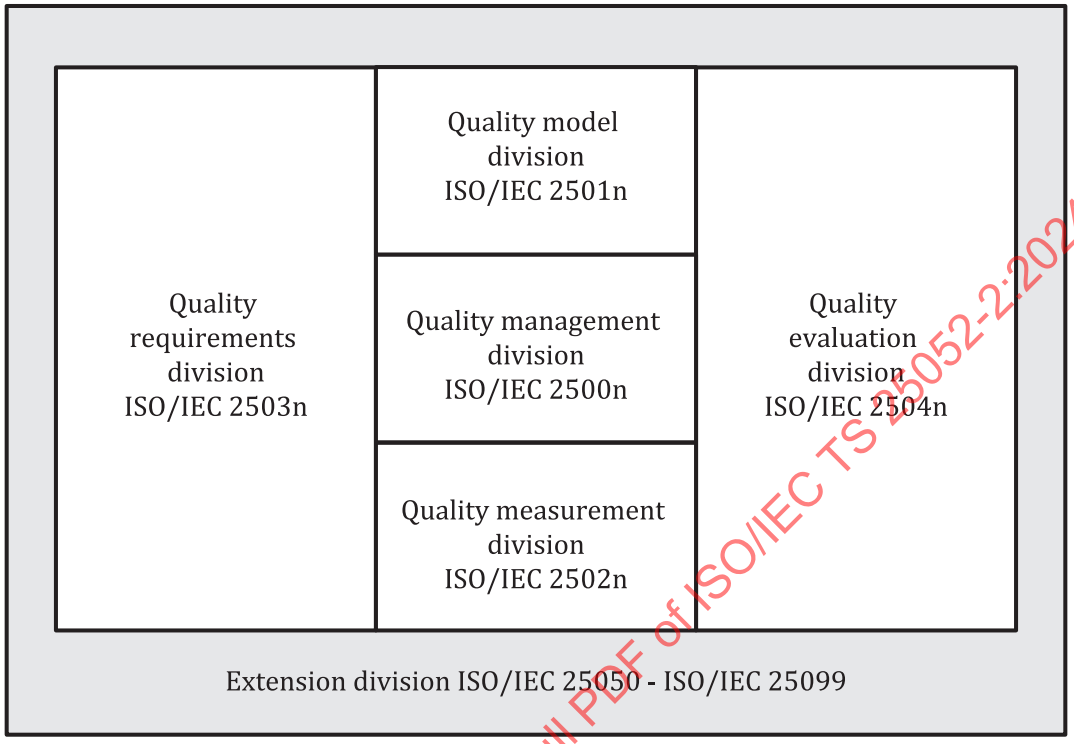

Figure 1 — Organization of the standards on SQuaRE developed by ISO/IEC JTC 1/SC 7

The divisions within standards on SQuaRE are:

— ISO/IEC 25000 to ISO/IEC 25009 - Quality management division. The International Standards that form this division define all common models, terms, and definitions referred to by all other standards on SQuaRE developed by ISO/IEC JTC 1/SC 7. This division also provides requirements and guidance for a supporting function that is responsible for the management of the requirements, specification, and evaluation of software product quality. Practical guidance on the use of the quality models is also provided.

— ISO/IEC 25010 to ISO/IEC 25019 - Quality model division. The International Standards that form this division present detailed quality models for computer systems and software products, data, IT services, and quality-in-use.

— ISO/IEC 25020 to ISO/IEC 25029 - Quality measurement division. The International Standards that form this division include a quality measurement framework, mathematical definitions of quality measures, and practical guidance for their application. Examples are given of quality measures for the internal and external properties of products, data, IT services, and quality-in-use. Quality measure elements (QME) forming foundations for quality measures for the internal and external properties of products are defined and presented.

— ISO/IEC 25030 to ISO/IEC 25039- Quality requirements division. The International Standards that form this division help specify quality requirements based on quality models and quality measures. These quality requirements can be used in the process of eliciting quality requirements for information systems and IT services to be developed or as input for an evaluation process.

— ISO/IEC 25040 to ISO/IEC 25049 - Quality evaluation division. The International Standards that form this division provide requirements, recommendations, and guidelines for software product evaluation,

whether performed by evaluators, acquirers, or developers. The guideline for documenting a measure as an evaluation module is also provided.

— ISO/IEC 25050 to ISO/IEC 25099 - SQuaRE extension division. These International Standards currently include requirements for quality of ready-to-use software product (RUSP), Common Industry Formats for usability reports, and quality models and measures for new technologies such as cloud services and artificial intelligence.

Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE): cloud services —

Part 2: Quality measurement

1 Scope

This document defines quality measures for quantitatively evaluating cloud services quality in terms of characteristics and sub-characteristics defined in ISO/IEC TS 25052-1 and is intended to be used together with ISO/IEC TS 25052-1.

This document contains the following:

— a basic set of quality measures for each characteristic and sub-characteristics;

— an explanation of how to apply quality measures to cloud services.

Since the quality model defined in ISO/IEC TS 25052-1 is the extension to the existing quality models defined in ISO/IEC 25010 to ISO/IEC 25019, it can be used with the product quality model, IT service quality model, data quality model, and quality-in-use model according to evaluation purposes. For the same reason, the quality measures defined in this document can also be used with the quality measures for software ICT products, IT services, data, and quality-in-use.

As there are several cloud service categories, this document focuses on the quality model of SaaS (software as a service). This document does not address PaaS (platform as a service) and IaaS (infrastructure as a service).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 25000, *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Guide to SQuaRE*

ISO/IEC 22123-1, *Information technology — Cloud computing — Part 1: Vocabulary*

3 Terms and definitions

For this document, the terms and definitions given in ISO/IEC 25000, ISO/IEC 22123-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
measure
variable to which a value is assigned as the result of *measurement* (3.2)

Note 1 to entry: The plural form "measures" is used to refer collectively to base measures, derived measures and indicators.

[SOURCE: ISO/IEC/IEEE 15939:2017, 3.15]

3.2
measurement
set of operations having the object of determining a value of a *measure* (3.1)

Note 1 to entry: Adapted from the International Vocabulary of Metrology – Basic and General Concepts and Associated Terms, 2012.

[SOURCE: ISO/IEC/IEEE 15939:2017, 3.17]

3.3
measurement function
algorithm or calculation performed to combine two or more *quality measure* (3.4) elements

[SOURCE: ISO/IEC 25021:2012, 4.7]

3.4
quality measure
derived measure that is defined as a *measurement function* (3.3) of two or more values of quality measure elements

[SOURCE: ISO/IEC 25021:2012, 4.13]

4 Format used for documenting the quality measures

The following information is given for each quality measure from Table 1 to 30:

a) ID: identification code of quality measure; each ID consists of the following three parts:

— abbreviated alphabetic code representing the quality characteristics as capital X and sub-characteristics as one capital X followed by lowercase x (for example, "PTb" denotes "time behaviour" measures for "performance efficiency");

— serial number of sequential orders within quality sub-characteristic;

— G (generic) or S (specific) expressing potential categories of quality measure; where generic measures can be used whenever appropriate and specific measures can be used when relevant in a particular situation;

b) name: quality measure name;

c) description: the information provided by the quality measure;

d) measurement function: algorithm or calculation performed to combine two or more quality measure elements.

5 Cloud service quality measures

5.1 Overview

The quality measures in this clause are listed by quality characteristics and sub-characteristics, in the order used in ISO/IEC TS 25052-1; and the word "measures" in this clause means quality measures.

5.2 Service performance efficiency measures

5.2.1 General

Service performance efficiency measures are used to assess the degree to which a cloud service meets performance requirements under stated conditions.

5.2.2 Time behaviour measures

Time behaviour measures are used to assess the degree to which a cloud service meets the requirements of the response times and throughput rates of a cloud service when concurrent users take advantage of the cloud service. Time behaviour measures are measured in Table 1.

Table 1 — Time behaviour measures

ID	Name	Description	Measurement function
PTb-1-G	**Mean response time**	How long does it take to receive a response for user requests to cloud services?	$X = \sum_{i=1}^{n} (A_i) / n$ A_i = Time taken by the cloud service to respond to a user request n = Number of responses measured
PTb-2-G	**Response time adequacy**	How well does a cloud service meet response time requirements specified in SLA?	$X = 1 - A/B$ A = Number of responses that do not meet the response time requirements B = Number of responses
NOTE If X is less than 1, it means the system fails to meet response time requirements.			

5.2.3 Aggregated resource utilization measures

Aggregated resource utilization measures are used to the degree to which a cloud service utilizes efficiently aggregated resources from resource pooling to support multi-tenancy. Aggregated resource utilization measures are measured in Table 2.

Table 2 — Aggregated resource utilization measures

ID	Name	Description	Measurement function
PRu-1-G	**Aggregated resource utilization**	How efficiently are virtual resources, assigned from resource pools, utilized to provide a cloud service in a multi-tenant environment?	$X = A/B$ A = Amount of the resource used and returned after they are no longer in use B = Amount of the resource required to be used to provide a cloud service
NOTE 1 The efficient utilization of resources means that available virtual resources are used by users, and once they are no longer in use, the resources are returned. NOTE2 Resource utilization can be monitored using the special monitoring services provided by IaaS. The resource allocation and release can be indirectly monitored by observing the usage of resources such as CPU and memory. NOTE 3 Due to the characteristics of resource abstraction, it can be challenging to monitor resource utilization, which can make this quality measure inapplicable in some cases.			

5.2.4 Capacity measures

Capacity measures are used to assess the degree to which the maximum limits of a cloud service's parameters meet requirements in SLA (service level agreement). Capacity measures are measured in Table 3.

NOTE Parameters can include the limit of simultaneous cloud service connections, the limit of available cloud service resources, cloud service throughput, and cloud service bandwidth.

Table 3 — Capacity measures

ID	Name	Description	Measurement function
PCa-1-G	**Cloud service connection capacity**	How many simultaneous connections can a cloud service accommodate over a given period with the available resources?	$X = A/B$ A = Maximum amount of simultaneous connections that a cloud service can accommodate B = Maximum amount of simultaneous connections according to capacity requirements of SLA
PCa-2-G	**Cloud service resource capacity**	How much resource can be used for the cloud service compared to the resource allocated?	$X = A/B$ A = Maximum amount of the resource used B = Amount of the resource allocated according to capacity requirements specified in SLA
PCa-3-G	**Cloud service throughput capacity**	How many transactions can a cloud service process within a given period?	$X = A/B$ A = Maximum amount of transactions processed by a cloud service B = Capacity requirements specified in SLA
PCa-4-G	**Cloud service bandwidth capacity**	How much data can be transferred at a period?	$X = A/B$ A = Maximum amount of data transferred B = Observation time

5.2.5 Scalability measures

Scalability measures are used to assess the degree to which physical and virtual resources are available automatically and immediately when they are needed, subject to constraints of service agreements. Scalability measures are measured in Table 4.

Table 4 — Scalability measures

ID	Name	Description	Measurement function
PSa-1-G	**Scale-out (horizontal scaling)**	To what extent do a cloud service support scale-out compared to configuration settings?	$X = A/B$ A = Number of the resources that are available automatically and immediately B = Number of the resources according to configuration settings
PSa-2-G	**Scale-up (vertical scaling)**	To what extent does a cloud service support scale-up compared to configuration settings?	$X = A/B$ A = Amount of the resource that is available automatically and immediately B = Amount of the resource according to configuration settings
A cloud service should be designed to handle larger workloads and is capable of accommodating additional resources to support scalability. NOTE "Scale out" involves adding multiple identical servers or nodes to handle larger workloads or traffic, with each additional server or node performing the same tasks, and new servers being added as the load increases. In contrast, "scale up" is a method of improving the hardware performance of a single server or node by upgrading components such as CPU, memory, storage, and so on to enhance the performance of that single server.			

5.2.6 Elasticity measures

Elasticity measures are used to assess the degree to which a cloud service adjusts rapidly and elastically the amount of resource that are allocated to an instance of the service. Elasticity measures are measured in Table 5.

Table 5 — Elasticity measures

ID	Name	Description	Measurement function
PEl-1-G	**Manual elasticity Speed**	How fast a cloud service can react manually to resource requests?	$X = A$ A = Time duration to allocate additional resources manually when the allocation is requested
PEl-2-G	**Automatic elasticity speed**	How fast a cloud service can react automatically to resource requests when the workload is increased or decreased?	$X = A$ A = Time duration to allocate additional resources automatically when workload is increased or decreased
PEl-3-G	**Elasticity precision**	How precisely does the manual or automatic resource allocation meet elasticity precision requirements?	$X = A/B$ A = Amount of the actually allocated resource that meets elasticity precision requirements B = Amount of the resource required to be allocated according to elasticity precision requirements

5.3 Service compatibility measures

5.3.1 General

Service compatibility measures are used to assess the degree to which a cloud service can exchange information with CSC's systems or other cloud services and/or perform its required functions.

5.3.2 Cloud interoperability measures

Cloud interoperability measures are used to assess the degree to which a cloud service interacts with CSC's systems, or interacts with other cloud services, by exchanging information according to a prescribed method to obtain predictable results. Cloud interoperability measures are measured in Table 6.

Table 6 — Cloud interoperability measures

ID	Name	Description	Measurement function
CIn-1-G	**Transport interoperability**	What proportion of the same protocols of data transfer is supported to exchange data between systems?	$X = A/B$ A = Number of protocols of data transfer that supported B = Number of protocols of data transfer required to be supported
CIn-2-G	**Syntactic interoperability**	What proportion of the exchanged information is structurally understandable?	$X = A/B$ A = Number of exchanged information structurally understandable B = Number of exchanged information
CIn-3-G	**Semantic interoperability**	What proportion of the exchanged information is meaningfully understandable?	$X = A/B$ A = Number of information meaningfully understandable B = Number of exchanged information
NOTE According to ISO/IEC 19941, behavioural and policy facets can also be considered to measure cloud interoperability.			

5.4 Service usability measures

5.4.1 General

Service usability measures are used to assess the degree to which a cloud service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use.

5.4.2 Accessibility measures

Accessibility measures are used to assess the degree to which a cloud service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use. Accessibility measures are measured in Table 7.

Table 7 — Accessibility measures

ID	Name	Description	Measurement function
UAc-1-G	**Device accessibility**	To what extent can various kinds of client devices access a cloud service using a network through standard mechanisms?	$X = A/B$ A = Number of devices that accessed a cloud service through a standard mechanism B = Number of devices that are required to access a cloud service through a standard mechanism

5.5 Service reliability measures

5.5.1 General

Service reliability measures are used to assess the degree to which a cloud service performs specified functions under specified conditions for a specified period.

5.5.2 Availability measures

Availability measures are used to assess the degree to which cloud service is available and usable upon demand by an authorized entity. Availability measures are measured in Table 8.

Table 8 — Availability measures

ID	Name	Description	Measurement function
RAv-1-G	**Service availability**	What proportion of time cloud service is accessible and usable at a certain period?	$X = A/B$ A = Operation time that a cloud service is accessible and usable B = Operation time specified in SLA

5.5.3 Resilience measures

Resilience measures are used to assess the degree to which a cloud service recovers operational conditions quickly after a fault occurs. Resilience measures are measured in Table 9.

Table 9 — Resilience measures

ID	Name	Description	Measurement function
RRs-1-G	**Mean fault recovery time**	How quickly does a cloud service recover its service after a fault occurs?	$X = \sum_{i=1}^{n} (A_i) / n$ A_i = Total time to recover a cloud service after a fault occurs n = Number of faults
RRs-2-G	**Resilience adequacy**	How well does a cloud service meet the specified resilience requirements under specified conditions?	$X = 1 - A/B$ A= Number of test cases that do not meet resilience requirements B= Number of test cases regarding resilience requirements

5.5.4 Recoverability measures

Recoverability measures are used to assess the degree to which a cloud service supports its critical business functions to an acceptable level within a predetermined period of time following a disaster. Recoverability measures are measured in Table 10.

Table 10 — Recoverability measures

ID	Name	Description	Measurement function
RRc-1-G	**Mean disaster recovery time**	How long does it take to recover a cloud service after a failure or a disaster?	$X = \sum_{i=1}^{n}(A_i)/n$ A_i = Total time to recover a cloud service after a failure or a disaster n = Number of a failure or a disaster
RRc-2-G	**Mean data loss time**	How long data is lost after a failure or a disaster?	$X = 1 - A/B$ A= Total time of data loss B = Specified RPO (recovery point objective)
RRc-3-G	**Backup interval adequacy**	How often does a cloud service perform backups?	$X = A/B$ A = Frequency of actual backup interval B = Frequency of specified backup interval
RRc-4-G	**Retention period for backup data adequacy**	How long does a cloud service retain backup data?	$X = A/B$ A = Retention period of actual backup data B = Retention period of specified backup data

5.6 Service security measures

5.6.1 General

Service security measures are used to assess the degree to which a cloud service protects information and data so that persons or other products or systems have the degree of data access appropriate to their types and levels of authorization.

5.6.2 Confidentiality measures

Confidentiality measures are used to assess the degree to which a cloud service ensures that data are accessible only to those authorized to have access. Confidentiality measures are measured in Table 11.

Table 11 — Confidentiality measures

ID	Name	Description	Measurement function
SCo-1-G	**Access controllability**	What proportion of confidential data items is protected from unauthorized access?	$X = 1 - A/B$ A = Number of confidential data items that can be accessed without authorization B = Number of data items that require access control
SCo-2-G	**Data encryption correctness**	How correctly is the encryption/decryption of data items implemented as stated in the requirement specification?	$X = A/B$ A = Number of data items encrypted/decrypted correctly B = Number of data items that require encryption/decryption
SCo-3-G	**Strength of cryptographic algorithms**	What proportion of cryptographic algorithms has been well-vetted?	$X = 1 - A/B$ A = Number of cryptographic algorithms broken or unacceptably risky in use B = Number of cryptographic algorithms used

5.6.3 Accountability measures

Accountability measures are used to assess the degree to which the actions of an entity can be traced back uniquely to the entity. Accountability measures are measured in Table 12.

Table 12 — Accountability measures

ID	Name	Description	Measurement function
SAc-1-G	**User audit trail completeness**	How complete is the audit trail concerning the user access to a cloud service?	$X = A/B$ A = Number of accesses recorded in all logs B = Number of accesses to a cloud service
SAc-2-G	**Service log retention**	How long is the service log retained in stable storage compared to the required period?	$X = A/B$ A = Duration for which a cloud service log is retained in stable storage B = Retention period specified for keeping a cloud service log in stable storage

5.6.4 Isolation measures

Isolation measures are used to assess the degree to which computations and data of a cloud service are isolated from or inaccessible to one another in the situation that physical and virtual resources are shared by multi-tenants. Isolation measures are measured in Table 13.

Table 13 — Isolation measures

ID	Name	Description	Measurement function
SIo-1-G	**Computation isolation**	How well does the computation isolation meet the specified isolation requirements?	$X = 1 - A/B$ A = Number of test cases that do not meet computation isolation requirements B = Number of test cases regarding computation isolation requirements
SIo-2-G	**Data isolation**	How well does the data isolation meet the specified isolation requirements?	$X = 1 - A/B$ A = Number of test cases that do not meet data isolation requirements B = Number of test cases regarding data isolation requirements

5.6.5 PII protection conformance measures

PII (personally identifiable information) protection conformance measures are used to assess the degree to which a cloud service conforms to the standards, laws or regulations applied to the collection, processing and disposal of PII. PII protection conformance measures are measured in Table 14.

NOTE The scope of PII is determined by laws or regulations of the country where a cloud service is provided. If privacy data, such as race, religion, and health, are considered PII, a cloud service is provided to protect the privacy data.

Table 14 — PII protection conformance measures

ID	Name	Description	Measurement function
SPi-1-G	**PII protection rules conformity**	What proportion of a cloud service conformed to the standards, laws or regulations applied to the collection, processing and disposal of PII?	$X = 1 - A/B$ A = Number of data items considered PII that do not conform to the standards, laws, or regulations B = Number of data items considered PII that is required to conform to the standards, laws, or regulations governing the collection, processing, and disposal of PII
NOTE ISO/IEC 19086-4 provides SLOs (service level objectives) and SQOs (service qualitative objectives) for cloud service agreements regarding PII protection.			

5.6.6 Security responsibility measures

Security responsibility measures are used to assess the degree to which the security responsibilities of both CSC and CSP are clearly defined and security incidents are detected and reported by either party. Security responsibility measures are measured in Table 15.

Table 15 — Security responsibility measures

ID	Name	Description	Measurement function
SRe-1-G	**Security responsibility definition**	What proportion of security responsibility of CSC and CSP is clearly defined with consideration of the type of service?	$X = A/B$ A = Number of resources for which security responsibility is defined B = Number of resources used by CSCs
SRe-2-G	**Security incident notification**	What proportion of detected security incidents is notified by either party?	$X = A/B$ A = Number of notified security accidents B = Total number of detected security accidents
NOTE 1 Information about the organization of information security components can be found in ISO/IEC 27002 and ISO/IEC 27017. NOTE 2 Examples of resources are physical infrastructure, virtual machines, operating systems, networks, applications, data.			

5.6.7 Asset protection measures

Asset protection measures are used to assess the degree to which a cloud service has processes to protect physical facilities used to provide the covered services from loss of data, connectivity, and availability of necessary infrastructure and IT equipment, and to secure the covered services during operation. Asset protection measures are measured in Table 16.

Table 16 — Asset protection measures

ID	Name	Description	Measurement function
SAp-1-G	**Data loss protection**	To what extent are defined actions being taken to protect against loss of data?	$X = A/B$ A = Number of actions being taken to protect against loss of data B = Number of defined actions to protect against loss of data
SAp-2-G	**Connectivity protection**	To what extent are defined actions being taken to protect connectivity?	$X = A/B$ A = Number of actions being taken to protect connectivity B = Number of defined actions to protect connectivity
SAp-3-G	**Availability protection**	To what extent are defined actions being taken to protect availability?	$X = A/B$ A = Number of actions being taken to protect availability B = Number of defined actions to protect availability

5.7 Service maintainability measures

5.7.1 General

Service maintainability measures are used to assess the degree of effectiveness and efficiency with which a cloud service can be modified by the intended maintainers.

5.7.2 Maintenance compliance and versioning measures

Maintenance compliance and versioning measures are used to assess the degree to which a cloud service provides maintenance according to SLA, and a new version is assigned and published after maintenance. Maintenance compliance and versioning measures are measured in Table 17.

Table 17 — Maintenance compliance and versioning measures

ID	Name	Description	Measurement function
MMa-1-G	**Maintenance suitability**	Within the scope of SLA, what proportion of maintenance activities is provided upon user requests?	$X = A/B$ A = Number of maintenance activities that are provided B = Number of maintenance activities that are requested by users within the scope of SLA
MMa-2-G	**Cloud service versioning**	What proportion of new versions is assigned and published after maintenance?	$X = A/B$ A = Number of new versions assigned and published after maintenance B = Number of maintenance

5.7.3 Reversibility measures

Reversibility measures are used to assess the degree to which a cloud service provides the process for the CSC to retrieve their data and application artefacts and for the CSP to delete all CSC data as well as contractually specified cloud service derived data after the agreed upon period. Reversibility measures are measured in Table 18.

Table 18 — Reversibility measures

ID	Name	Description	Measurement function
MRe-1-G	**Data retrieval**	What proportion of data and application artefacts can be retrieved by CSCs after the agreed upon service period?	$X = A/B$ A = Number of data and application artefacts retrieved after the agreed upon service period B = Number of user data and application artefacts that require retrieval after the agreed upon service period
MRe-2-G	**Data deletion process**	What proportion of a cloud service has processes to delete all CSC data as well as cloud service derived data, which is contractually specified, after the agreed upon period?	$X = A/B$ A = Number of processes that are defined B = Number of processes required to define the deletion of all CSC data as well as cloud service-derived data

5.7.4 Monitorability measures

Monitorability measures are used to assess the degree to which a cloud service provides monitoring parameters and tools to monitor the performance of the service. Monitorability measures are measured in Table 19.

Table 19 — Monitorability measures

ID	Name	Description	Measurement function
MMo-1-G	**Monitoring parameters**	What proportion of monitoring parameters is provided to monitor the performance of the service?	$X = A/B$ A = Number of monitoring parameters implemented B = Number of monitoring parameters required to monitor performance service
MMo-2-G	**Monitoring mechanisms**	What proportion of monitoring mechanisms is provided to monitor the performance of the service?	$X = A/B$ A = Number of monitoring mechanisms implemented B = Number of monitoring mechanisms required to monitor performance service

5.8 Portability measures

5.8.1 General

Portability measures are used to assess the degree to which a cloud service provides the ability to move data and migrate applications from one cloud service to another.

5.8.2 Cloud data portability measures

Cloud data portability measures are used to assess the degree to which a cloud service provides the ability to move its data from one cloud service to another. Cloud data portability measures are measured in Table 20.

Table 20 — Cloud data portability measures

ID	Name	Description	Measurement function
PDp-1-G	**Data syntactic portability**	What proportion of data is transferred from a source cloud service to a target using data formats that can be decoded on the target?	$X = A/B$ A = Number of transferred data items that can be decoded on the target B = Number of data items that are required to be transferred from a source cloud service to a target using data formats that can be decoded on the target
PDp-2-G	**Data semantic portability**	What proportion of data is transferred from a source cloud service to a target such that the meaning of the data model is understood within the context of a subject area by the target?	$X = A/B$ A = Number of transferred data items understandable within the context of a subject area by the target B = Number of data items that are required to be transferred from a source cloud service to a target such that the meaning of the data model is understood within the context of a subject area by the target
PDp-3-G	**Data policy portability**	What proportion of data is transferred from a source cloud service to a target while complying with the legal, organizational, and policy frameworks applicable to the source and target?	$X = A/B$ A = Number of transferred data items that comply with the legal, organizational, and policy frameworks applicable to the source and target B = Number of data items that are required to be transferred from a source cloud service to a target while complying with the legal, organizational, and policy frameworks applicable to the source and target

5.8.3 Cloud application portability measures

Cloud application portability measures are used to assess the degree to which a cloud service provides the ability to migrate its applications from one cloud service to another. Cloud application portability measures are measured in Table 21.

Table 21 — Cloud application portability measures

ID	Name	Description	Measurement function
PAp-1-G	**Application syntactic portability**	What proportion of applications, which are used to provide a cloud service, is migrated from a source cloud service to a target in a format that can be decoded on the target?	$X = A/B$ A = Number of migrated applications decoded on the target B = Number of applications that are required to be migrated from a source cloud service to the target in a format that can be decoded on the target
PAp-2-G	**Application instruction portability**	What proportion of applications, which are used to provide a cloud service, is migrated from a source cloud service to a target so that its instruction set executes on the target?	$X = A/B$ A = Number of migrated applications whose instruction set is executed on the target B = Number of applications that are required to be migrated from a source cloud service to the target so that its instruction set executes on the target
PAp-3-G	**Application metadata portability**	What proportion of applications, which are used to provide a cloud service, is migrated from a source cloud service to a target so that the application metadata is understood on the target?	$X = A/B$ A = Number of migrated application metadata understood on the target B = Number of applications that are required to be migrated from a source cloud service to the target so that the application metadata is understood on the target
PAp-4-G	**Application behaviour portability**	What proportion of applications, which are used to provide a cloud service, is migrated from a source cloud service to a target so that execution on the target produces equivalent results to those produced on the source?	$X = A/B$ A = Number of migrated applications with execution results equivalent to the source B = Number of applications that are required to be migrated from a source cloud service to the target so that execution on the target produces equivalent results to those produced on the source
PAp-5-G	**Application policy portability**	What proportion of applications, which is used to provide a cloud service, is migrated from a source cloud service to a target while complying with the applicable legal, organizational, and policy frameworks of both the source and target?	$X = A/B$ A = Number of migrated applications that comply with the legal, organizational, and policy frameworks applicable to the source and target B = Number of applications that are required to be migrated from a source cloud service to the target while complying with the applicable legal, organizational and policy frameworks of both the source and target

5.9 Service provisionability measures

5.9.1 General

Service provisionability measures are used to assess the degree to which a cloud service is provisioned by the CSC, as needed, automatically, or with minimal interaction with the CSP.

5.9.2 Service measurability measures

Service measurability measures are used to assess the degree to which a cloud service provides metered delivery of cloud services such that usage can be monitored, controlled, reported and billed. Service measurability measures are measured in Table 22.

Table 22 — Service measurability measures

ID	Name	Description	Measurement function
PSm-1-G	**Usage monitoring correctness**	How correctly does a cloud service provide usage monitoring?	$X = A/B$ A = Amount of usage correctly monitored B = Amount of usage used
PSm-2-G	**Usage controlling correctness**	How correctly does a cloud service provide usage controlling?	$X = A/B$ A = Number of resources controlled B = Number of resources that are required to be controlled
PSm-3-G	**Usage reporting correctness**	How correctly does a cloud service provide usage reporting?	$X = A/B$ A = Number of data is correctly reported B = Number of data that should be included in usage reports
PSm-4-G	**Usage billing correctness**	How correctly does a cloud service provide usage billing?	$X = A/B$ A = Amount of usage correctly billed B = Amount of usage used
NOTE 1 To support usage monitoring, a cloud service tracks how much resource users are consuming, such as virtual machines, storage and network bandwidth. NOTE 2 To support usage control, a cloud service allows users to allocate resources and limits resource usage based on these allocations. For example, users can allocate a specific amount of CPU and memory for a virtual machine, and resource usage can be controlled according to these limits. NOTE 3 To support usage reporting, a cloud service generates reports on how much users have utilized resources, including virtual machines, storage, network bandwidth, etc. The report can include a detailed analysis of costs.			

5.9.3 Auditability measures

Auditability measures are used to assess the degree to which a cloud service collects and provides available necessary evidential information related to the operation and use of a cloud service to conduct an audit. Auditability measures are measured in Table 23.

Table 23 — Auditability measures

ID	Name	Description	Measurement function
PAu-1-G	**Evidential information completeness**	What proportion of data items are collected and provided concerning the operation and use of cloud services required to conduct audits?	$X = A/B$ A = Number of data items collected and provided B = Number of data items required to be collected and provided to conduct audits

5.9.4 Governability measures

Governability measures are used to assess the degree to which a cloud service supports on-demand self-service. Governability measures are measured in Table 24.