Guideline on the Accuracy of COSMIC Function Points

VERSION 1.1

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Foreword

Purpose of the Guideline

This Guideline provides an overview of the factors that influence the quality of a functional size measurement, particularly a COSMIC size measurement, and advises how to organize the measurement process so as to obtain accurate size measurements and/or to improve measurement accuracy.

Intended Readership of the Guideline

This Guideline is intended to be used by measurers and by the management of measurers, who have the task of organizing functional size measurement.

Readers of this Guideline are assumed to be familiar with the COSMIC Method.

This Guideline document is structured as follows:

- Chapter 1 presents three quality factors impacting the accuracy of measurements (i.e. the *measurers*, the *information sources* and the *measurement process*). It also proposes techniques for rating individually the quality from a measurement perspective of the information sources for each functional process, and next for a consolidated rating for a set of functional requirements.
- Chapter 2 discusses auditing issues and recommendations to improve the measurement process.
- Appendix A presents a checklist per measurement phase.
- Appendix B presents Acknowledgements, Version Control and Main Changes from the previous version information.

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1 INTRODUCTION

Quality assurance actions aim to improve quality and to help achieve desired quality levels: here, a quality aim of an organization will be to achieve a desired measurement accuracy level.

The desired accuracy of a measurement (see below for the definition of 'accuracy') will probably vary with the project circumstances:

- In the context of outsourced software contracts where a measurement may at some time become a matter of legal dispute, highly accurate measurements are likely to be essential.
- Early in the life of a new software project, only an approximate estimate of size may be possible, and it may still be an acceptable approximation.

In order to assure the desired accuracy of measurements, it is important to have:

- well-trained and experienced measurers,
- adequate documentation in input to measurement, and
- an adequate measurement process.

This points out to the three main quality factors for the quality of the measurement results mentioned in the Foreword:

1. Quality of the measurer(s)
2. Quality of the information sources
3. Quality of the measurement process

Conventions used in the Guideline

- Quality control and assurance efforts require a number of actions to be performed. Actions and points of interest are indicated by a '>' sign.
- There are many kinds of documentation and other artifacts used for measuring or estimating functional size, such as functional requirements, designs, definition studies, even the software itself (screens, reports, etc) or oral information. In this Guideline these are all referred to as 'information sources'. Where appropriate, the reader of this Guideline must judge which one (documentation, software, explanations or additions by a functional expert, etc.) applies.

Definitions used in the Guideline

- **Measurement accuracy**: is defined as the closeness of agreement between a measured quantity value and a true quantity value of a measurand.
- **Defect**: is defined as a product anomaly. A defect is introduced into a work-product when an error or mistake is made in a process.
- **Inspection**: is a close examination of something.
- **Auditing**: is the verification of something with respect to a documented procedure. Where there is no documented procedure, read 'inspection' where this Guideline mentions 'audit'.
- **Actionable item** is a synonym of 'action item'.

1.1 Quality of the Measurers

The quality of the measurers is determined by their knowledge of the COSMIC Method and by their experience in measurement. This quality factor pertains to ‘who’ is performing the measurement.

> Measurements may be carried out by a 'measurement team', i.e. a team of dedicated measurers. or by (some of the) developers. However measurement is organized, it is crucial that the measurers can obtain and maintain sufficient experience. For this same reason it is advised against having persons measure infrequently without a strong verification process to support them.

> Measurers should be trained in and if possible should be certified for the COSMIC Method.

> Periodical COSMIC measurement workshops should be performed for refreshing measurement knowledge and exchanging experience. Periodically requiring all measurers to measure the same piece of software to comparing the outcomes provides a good way of checking competence, mutual consistency of the measurers and of identifying specific measurement problems.

> Audits of measurements should be performed periodically in order to identify conformance to the mandated process, defects arising and variations in approach (see chapter 2).

> Measurers should regularly check on www.cosmic-sizing.org for the availability and relevance of ‘Method Update Bulletins’ (MUB’s) and any discussion of measurement issues.

1.2 Quality of the information sources

The quality of the information sources used for measurement is one of the important factors which determine the accuracy of the size measurement.

1.2.1 Determining the quality rating of each individual functional process

The quality rating of each functional process identified in the set of information sources on the scale (a) to (e) is done as follows – Table 1:

(a) The functional process is completely documented for COSMIC measurement purposes.

(b) The functional process is partially documented but the description of the data moved is unclear-incomplete.

(c) The functional process is identified only.

(d) The number of the functional processes is given but they are not specified.

(e) The functional process is not mentioned in the information sources but is implicit or is missing.

Explanation of the ratings of a functional process:

(a) Each functional process is fully documented, together with its data movements by type (Entry, Exit, Read and Write) including the objects of interest and their attributes.

EXAMPLE of a functional requirement. ‘The system will produce a monthly file. The interface format details are provided in the Interface ID v2.8 in an Excel format document and the entity relationship diagram that shows each attribute is in the ER.gif document version 2.1.’

(b) Each functional process is partially documented. The input, output, stores and retrievals of each functional process are also described but not clearly enough to identify all the data movements

EXAMPLE of a functional requirement. A yearly report will be provided to the manager with the following information: administration category, name of the administration, origin, amount of sales by month, type of product and sales by product, etc. (In this case the reference to the data groups is not clear.)

(c) Functional processes can be identified but not their data movements.

EXAMPLE of a functional requirement. The sales representative will provide a monthly report to the manager.

(d) The number of the functional processes is given but they are not specified.

EXAMPLE of a functional requirement. Five reports will be provided to the manager.

(e) The functional process is not mentioned in the information sources but is implicit or is missing.

EXAMPLE. A screen that allows modification of data about an object of interest within a functional process usually requires the display of the information before modifying the data. Sometimes this display requirement is not documented.

Table 1: Quality rating of an individual functional process

Rating	Functional Process Quality Level	Quality of the functional process definition
(a)	Completely defined	The functional process and its data movements are completely defined
(b)	Partially Documented	The functional process is partially documented: not in sufficient detail to identify all the data movements
(c)	Identified	The functional process is listed but no details are given of its data movements
(d)	Counted	A count of the functional processes is given, but there are no more details
(e)	Implied (a 'known unknown'), not mentioned or missing (an 'unknown unknown')	The functional process is implied in the actual requirements but is not explicitly mentioned, or is missing

Note 1. A functional process rating may be increased if access to the actual system and/or to a system expert can provide reliable information that is not available in the information sources.

Note 2. *Capturing the functional process ratings at the time of the measurement requires very little extra effort.*

Note 3: To promote good documentation, it may be helpful to record two functional process ratings: one using the documentation only, and the other taking into account information from an expert and/or from examining the actual system.

1.2.2 Determining the Consolidated Quality of the Information Sources

This section describes a simple technique to obtain three ratings (Good, Fair or Poor) for a set of the inputs to a measurement process by combining the set of individual quality ratings from each of the functional processes measured.

The distribution of the quality ratings for the set of measurement inputs corresponds to the percentage of functional processes in each rating – see Table 2 and Figure 1. Table 3 shows an example of the ratings of a set of information sources, describing 50 functional processes measured with COSMIC.

From these distribution of the quality ratings across the set of each functional process, some criteria should be defined to assign a quality rating to the overall set of the measurement inputs to obtain an overall rating of 'Good', 'Fair' or 'Poor' for the set of the information sources used for measurement. Table 4 presents a set of criteria as a suggested way of deriving this consolidated quality rating of the information sources.

Table 2: Example of ratings of individual functional processes

Rating	Number of functional processes	Percentage
(a)	24	48.0%
(b)	16	32.0%
(c)	4	8.0%
(d)	2	4.0%
(e)	4	8.0%
Total	**50**	**100.0%**

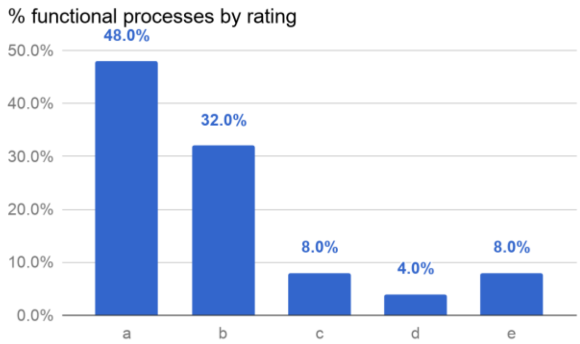

Figure 1: Example of a distribution of ratings of individual functional processes

Table 3: Criteria for the consolidated quality rating of information sources

Rating	Quality of the functional process definition
Good	A distribution of individual ratings with more than 70% of the functional processes rated as (a: Completely functionally defined).
	A distribution of individual ratings of 80% or more of the functional processes rated as (a: Completely functionally defined) or (b: partially defined), of which at least 50% (a: Completely functionally defined).
Fair	A distribution of individual ratings with 60% or more of the functional processes rated as (a) or (b) **and** at least 30% (a).
	A distribution of individual ratings with 70% or more of the functional processes rated as (b) **and** less than 10% rated as (a).
Poor	A distribution of individual ratings with less than 50% of the functional processes rated as (a) or (b), **and** less than 10% rated as (a).

With 5 functional process ratings there are 31 possibilities[1], so the measurer will need to use some judgment when applying these suggestions.

EXAMPLE. The example results given in the table and graph above, with 48% (a) and 32% (b), could lead for this set in this example to a rating of:

- *'Good', applying the suggestion of the second row of 'Good' or*
- *Fair', applying the suggestion of the first row of 'Fair'*

Because 48% is not too far from 50% and the total is 80% the rating could be 'Good'.

Note: The rating method could be further refined by taking into account the size of the functional processes as well as their percentages: then, the rating of larger functional processes would carry more weight than smaller functional processes.

1.2.3 Actionable items by a measurer

> Checks of the quality of an information source should be made. See Appendix A for checklists.

> Controlled tests have often shown that the most common errors made by measurers are to miss (i.e. fail to recognise) functionality that should be measured, so that measured sizes are often less than the actual size. Inexperienced measurers miss more functionality than experienced measurers. Measurers therefore should check particularly that the information sources they are given represent the best knowledge available at the time and are as complete as possible.

> Take particular care early in the life of an information source when the requirements are not yet known in all the detail needed for an accurate measurement and when they may not be stable. When the information sources are defined coarsely, at a 'high level', approximation techniques may be used (see COSMIC 'Early & Rapid Sizing' Guideline document [3], Chapter 1).

> At all times, but especially early in the life of a software product, it is valuable to estimate and to report the uncertainty in a measured size. This is achieved by expressing the estimated size as a range.

EXAMPLE: A range can be determined for instance as follows. Given an information source, identify 1) the parts that can be measured accurately and 2) the parts that cannot be measured accurately:

1. *Measure the size of the parts 1), resulting in say S CFP.*
2. *For the parts 2), estimate the lower and the upper limit of the size (say L respectively U CFP). The true size is then expected to be between S+L and S+U CFP.*

1.2.4 Actionable items by management for process improvement

The authors of information sources may not know which aspects must be made clear for COSMIC sizing. Therefore the following recommendations are made to develop information sources of better quality.

> Authors of information sources, and those who will use them as information sources, should be knowledgeable about the generalities of Functional Size Measurement and its uses and, at least in outline, knowledgeable about the COSMIC Method.

The organisation will benefit from such an investment in know-how because estimates and measurements will be made earlier, more consistently, be more repeatable, with fewer defects, necessitating less rework.

(Experience shows that information sources that cannot be measured almost certainly have defects such as omissions, ambiguities, etc. Measuring using the COSMIC method therefore provides a valuable quality control of the information sources. See [11]).

[1] The possibilities correspond with the 31 non-empty subsets of the set {a, b, c, d, e}.

> Local instructions should be issued to advise authors how to express information sources in a form that is suitable for COSMIC size measurement and/or to adapt information sources for measurement purposes.

  In particular, it should be easy to identify in the information sources the central concepts of the COSMIC Method. A few simple examples of what the measurer means with these concepts should encourage authors to capture the required aspects.

  The measurers should offer assistance to the authors in capturing these aspects, if desired.

1.3 Quality of the measurement process

This quality factor pertains to 'how' the measurements has been performed.

1.3.1 Actionable items by a measurer

> For each measurement, a Measurement Report should be drawn up. This can be very simple, but should capture the Measurement Strategy parameters as well as the measurement results. Also, measurers should record defects and ambiguities found in the information sources as well as any functional assumptions made from the information sources. Such reports will serve as the basis for audits and for future measurement process improvement activities. For details, see the chapter 'Measurement Reporting' of the Measurement Manual [1].

> For each measurement, the Measurement Report and the related information sources should be stored in such a way as to preserve their relationship. These documents serve as 'witnesses' of the measurement and enable audits afterwards. They establish the audit trail that is beneficial during subsequent enhancement and support and maintenance activities.

> When a (supposed) shortcoming of the COSMIC Method has been encountered, a Comment or Change Request should be submitted as described in Appendix B. The editors of the COSMIC Method will review the Comment or Change Request and issue a solution to a shortcoming, if appropriate, e.g. a Method Update Bulletin, as quickly as possible. Questions can also be asked on the COSMIC sizing forum: https://cosmic-sizing.org/forums/.

1.3.2 Actionable items by management for process improvement

A document describing an organization's measurement process should provide both an overview to the organization and the detail needed by measurers.

> Aspects to be considered are:

- The policies for measurement, i.e. purpose of measuring, stakeholders and their benefits.
- The policy for the main quality factors
- The organization of the measurement process: its activities, who initiates, who is involved, expected effort of the involvement, what data is registered, which information sources produced for whom, and their expected reaction.
- At what stage(s) of the development process measurements are required, on which work-products, how they will be used, the minimum standards expected for their accuracy and whether and why measurements are mandatory.
- Local variations on the standard COSMIC measurement process, if applicable.
- The steps of each measurement activity and the tools and facilities to be used, with an explanation.
- The allocation of responsibilities for measurement data capture and its quality, the organization, maintenance and use of the repository.

- The intended uses of the measurement data, e.g. for improving organizational performance, estimating, etc. Requirements for the presentation of the results of measurements, respecting the interests of the various stakeholders in the measurement activities.

> As there are many possible ways in which requirements are expressed, there are no general rules for mapping the information sources to the COSMIC concepts. Therefore, the way of mapping the local types of information sources should be documented.

> Data concerning the measurement process are a source for improvement. Therefore results of the COSMIC measurements should be adequately registered. For details, see section 'Archiving COSMIC measurement results' in chapter 5, 'Measurement Reporting', of the Measurement Manual.

> Measurement data may be stored either centrally (one central measurement data repository) or de-centrally (a number of local collections of measurement data). It must be considered carefully how to organize the storage of the measurement data, taking into account future use of the data. If data are stored de-centrally, procedures must ensure compatibility of the data across the de-central repositories.

> The measurement process should aim to ensure traceable version control of measurement (input) documents. For instance, to ensure that the latest available documents are used for the final Measurement Report, rather than preliminary documents.

> Several tools exist to support the measurement process, ranging from simple spreadsheets to more sophisticated tools for registering measurement data and relating them to the information sources used (see www.cosmic-sizing.org for examples). More sophisticated tools exist that combine capturing measurement-data and project planning or for capturing functional user requirements which can be measured automatically. However, the quality of these tools should be verified, especially the quality of non-transparent tools. No tool should be used that is not fully understood by its users. Otherwise, defects of the tool itself and errors made during use of the tool will not be noticed.

1.4 Determining the consolidated quality rating of a specific measurement

All COSMIC measurements should be accompanied by a quality rating consolidating the rankings of the three quality factors identified in Chapter 1 (i.e. measurers, information sources and measurement process). The consolidated rating technique and criteria presented in this chapter are pragmatic, is quick and easy to use and has been applied successfully in practice. The consolidated rating level gives an indication of the probable accuracy of the measurement (see below).

To determine the quality rating of a measurement, use the following steps:

1. Assign a rating of 'Good', 'Fair', or 'Poor' to each of the three quality factors (measurers, sources, process) using the criteria listed in Table 3.
2. For the consolidated quality rating of the measurement: select the **lowest** of the three ratings.

Table 4: Consolidated Quality Rating: technique and criteria

Quality Aspect and Ratings	**System ID:**
1. **Quality of the measurer(s)** Good = Entry-level certified and >2 years experience in COSMIC measurement or 10,000 CFP measured; measures at least once a week Fair = Entry-level certified AND measures at least once per month* Poor = Beginner OR measures only occasionally* * But if the measurement is audited by an independent, experienced measurer assign 'Good'	

2. **Quality of the information sources**	
Good	= Excellent documentation; access to the actual system AND to a system expert
Fair	= Reasonable documentation AND access to the actual system OR to a system expert
Poor	= Limited or poor documentation; no access to the actual system or to a system expert
3. **Quality of the measurement process**	
Good	= The measurement process is documented with its compliance implemented AND measurement results are registered and measurement data stored
Fair	= One of these applies
Poor	= None applies

EXAMPLE. If in step 1 the ratings of the three aspects are 'Good', 'Good' and 'Poor', then in step 2 the consolidated quality rating of the measurement is rated as 'Poor'.

When a functional size measurement is based on either an approximate method or on a known incomplete information source the functional size measurement is assigned a rating 'Approximate'. Note that measurements with this rating may be suitable for purposes where rough estimates suffice.

2

2 AUDITING: DEFECT-DETECTION

Audits are also necessary to check and to assure ongoing accuracy. Defect-detection that only *identifies* defects may not help much to prevent their reoccurrence. Rather, audits should identify defects *and* determine the causes of the defects that have been made when measuring. Systematically determining the root conditions and analyzing the causes of defects will encourage those responsible to improve the measurement process and in future avoid time wasted in audits and defect corrections.

The purposes of auditing can be:

- to determine the accuracy of a particular measurement, by revealing defects
- to determine how well the measurer has conformed to the measurement process, and to identify opportunities to improve the measurer's skill, experience and inter-measurer consistency
- to verify and validate the measurement process, its effectiveness, cost and timeliness, so that it can be improved

It is common for defects in a measurement to have been caused by defects in the information sources, and/or by errors by the measurer in mapping from the information sources to COSMIC concepts. For example, vagueness or lack of clarity of the information sources may lead the measurer to make wrong functional assumptions and functional interpretations (implicit or explicit). A research study has shown that a faulty information source lead to lower measurement accuracy levels (performed manually or automated) [13].

Whatever the cause may be, a very important point is that with a well-organized process for recording and processing any functional defects found, the *causes* of functional defects can be analysed, enabling the organization to take action to prevent future defects of similar type, in priority order of their importance and/or frequency. Besides, it enables both auditors and measurers to judge themselves and identify the strong and weak points in the inputs to the measurement, and how to tackle these.

Research has shown that performing functional size measurement itself can be helpful in detecting defects in information sources, by revealing omissions or inconsistencies in functional processes that are difficult to detect with regular audit procedures [14].

See also the Checklists in Appendix A which are designed to assist defect detection.

2.1 Auditing of measurements

A complete audit of a particular measurement may have three components.

1. An audit of *methodological correctness*: it is usually carried out by a fellow-measurer.
2. An audit to verify the *accuracy* of the measurement of the given information sources; it is usually carried out by the measurer working with the author of the information sources or a system expert.
3. An audit of the *measurement documentation*; it is usually carried out by a fellow-measurer.

> Methodological correctness. The purpose of the first component is to verify, preferably on the basis of a random sample[2] of the information sources, that the measurement

[2] Do not use a sample of the *measured* functionality, as in that case functionality that has been forgotten to be measured will not be detected.

complies with the requirements of the COSMIC Method. After correction, the measurement should be 'methodologically correct'.

After the first component, the fellow measurer and the measurer should discuss the (supposed) defects. When both agree on some defect[3], its cause can be analysed. This information is captured. When auditor and measurer differ in opinion about the cause of the defect, both causes should be recorded.

The defects found and their causes should be registered and may be categorized as shown in the Table 5. The findings and a Pareto analysis of the results (i.e. the causes in decreasing number of errors per category) should be presented periodically to the measurers and other stakeholders and should be the basis of recommendations and/or actions.

Table 5: Defect Causes

Defect Cause (to be entered by the auditor)	**Explanation**	**Possible action to prevent re-occurrence**
Measurer	The measurer knows how the situation should have been measured but made a mistake, or the measurer doesn't know how to measure a situation although the COSMIC Method deals with it.	Periodical workshops (see section 1.1) and/or train the measurer.
Information source	The information source describes a functional situation admitting of more than one interpretation because of ambiguous or missing functional details, perhaps leading the auditor and the measurer to different solutions.	Require the author to correct the defect and re-measure. Draw up detailed requirements for information sources to be measurable.
Measurement process	Any aspect of the measurement process, (e.g. a local rule for mapping from FUR to COSMIC concepts admits of more than one interpretation).	Depends on the aspect. If the cause is the local set of mapping rules, make the necessary improvements.

> Measurement accuracy. The purpose of the second component is to verify that the measurement faithfully represents the functionality. For this, the measurement should be discussed with the author of the information sources that have been measured (or with another functional expert representative of the commissioner of the measurement). Their first task is to ensure that the measured information sources are still the correct ones[4]. Subsequently, parts of the information sources that are lacking the necessary functional details for COSMIC measurement must be clarified by the author and the measurer's functional assumptions and functional interpretations must be verified. Finally, the author must verify that no (change of) functionality has been neglected, nor that functionality has been included in the measurement that is not within the scope. After correction, and when the corrected measurement has been checked by the author, it inputs to measurement should be 'functionally correct' and the measurement results should be accurate. Relevant data can now be registered. Defects found should be recorded as per the table above, actions taken and analysed as per the first component.

> Measurement documentation adequacy. The purpose of the third component is to verify that the measurement is correctly finished. For instance, are data correctly registered,

[3] Check the (supposed) defects found by the auditor, an auditor can also make mistakes!

[4] In practice, sometimes information sources have been added, removed or changed without the measurers having been informed.

are all relevant documents present, have superfluous documents been removed? It should be carried out by a fellow-measurer at the end of the measurement activities. This component may seem trivial but has been found to be very effective in practice. For, once the measurement activities are completed a defect won't be noticed as such anymore, resulting in confusing reports and calculations. Moreover, if a defect is noticed long after registration it is often difficult to reconstruct the original situation and repair it, thus undermining the reliability of the measurement and the output based on the data.

2.2 Auditing of the measurers

Besides the audits described in the previous section, the measurers may expect occasional audits to assess their quality, for a number of purposes. For these audits a well-organized registration and document storage is indispensable, because it enables the measurers to supply a sample of documents, as specified by the auditors, to be audited and/or re-measured.

> Periodically (once or twice a year) an audit may be held on behalf of the management of the measurers. The object of this audit is to assess the quality of the measurers. Ideally it should be held by an independent and certified third party. The audit consists of re-measuring a sample of the measurements for a selected period. Such audits are especially held in situations of outsourced software development, when payments depend on functional sizes, but may also be held for 'training needs analysis'.

2.3 Root cause analysis of defects

If certain types of defects continue to arise repeatedly, in spite of taking the recommended remedial action, then an analysis of the 'root cause' will become necessary to assure the quality of the measurements. Examples might be:

- The information sources made available for measurement continue to be of poor quality. Action may be needed to improve the organization's documentation standards (to meet measurement needs) or from higher management to enforce their observance
- The training given to measurers and/or to those who produce documentation needed for measurement may be inadequate, requiring either improvement of the training material (e.g. by adding better case studies) or action by the trainers to improve their presentation skills.

LITERATURE

All the COSMIC documents listed below, including translations into other languages, can be found on www.cosmic-sizing.org .

[1] COSMIC - Measurement Manual (The COSMIC Implementation Guide for ISO/IEC 19761).

[2] COSMIC - Guideline for Sizing Business Application Software.

[3] COSMIC - Guideline for Early & Rapid Sizing.

[4] COSMIC - Guideline for Sizing Service-Oriented Architecture Software.

[5] COSMIC - Guideline for Sizing Data-Warehouse Software

[6] Abran, A. 'Software Metrics and Software Metrology', Wiley, 2010.

[7] Ungan, E, Demirörs, O., Top, Ö.Ö., Özkan, B., 'An Experimental Study of the Reliability of COSMIC Measurement Results', Middle East Technical University, Turkey, 2010.

[8] Desharnais J.M., Abran, A., 'Assessment of the quality of functional user requirements documentation using criteria derived from measurement with COSMIC – ISO 19761'. IWSM/Metrikon conference, Stuttgart, November 2010.

[9] ISO/IEC 15939 - Software Measurement Process.

[10] ISO/IEC TR 14143-3 - Verification of functional size measurement methods.

[11] Rule. P.G., 'Compliant, Correct, Consistent, Complete. UKSMA's Improvement Plan', The Guild of Independent Function Points Analysts, Ltd., International Function Point User Group Conference, Washington, 1998.

[12] Trudel, S., Abran, A., 'Functional size measurement quality challenges for inexperienced measurers', International Workshop on Software Measurement, Amsterdam, Nov. 4-6 2009.

[13] Verifying the Accuracy of Automation Tools for the Measurement of Software with COSMIC – ISO 19761 including an AUTOSAR-based Example and a Case Study. Joint 24th International Workshop on Software Measurement & 9th MENSURA Conference Rotterdam (The Netherlands), Oct. 6-8, 2014, IEEE CS Press, pp. 23-31

[14] Trudel, S., Abran, A., 'Improving quality of functional requirements by measuring their functional size', International Workshop on Software Measurement, Munich, Nov. 17-19 2008.

[15] Ungan, E., Demirörs, O, Top, Ö.Ö, Özkan, B., An experimental study on the reliability of COSMIC measurement results, International Workshop on Software Measurement, 321-336, 2009.

[16] Turetken, O., Top, Ö.Ö, Ozkan, B., Demirors, O., The impact of individual assumptions on functional size measurement, Software Process and Product Measurement, 155-169, 2008.

[17] Top, Ö.Ö., Demirors, O., Ozkan, B., Reliability of COSMIC functional size measurement results: A multiple case study on industry cases, 35th Euromicro Conference on Software Engineering and Advanced Applications, 2009. SEAA'09.

Appendix A

CHECKLISTS

The three checklists in this appendix can be used together or separately.

- Checklist A.1 concerns the form and content of the information sources to the measurement.
- The three checklists of A.2 can be used to enable a systematic check of measurements.
- Checklist A.3 focuses on areas where errors are commonly made and may be used when time is limited.

A.1 Checks on the quality of the information sources for the measurement

> Do all information sources presented to the measurers (in one measurement or in measurements over time) conform to local organization standards and have the same format? The same content? (i.e. the same way of specifying the events, functional processes, the objects of interest). The same way of diagramming data models or other concepts? The same level of granularity? Do they describe software at the same level of decomposition? (A lack of consistency of documentation across the organization may be an indicator of quality problems.)

> Does each information source describe the purpose of the software and the (business) process that it must support?

> Does each information source contain all the information that the measurer needs for the COSMIC measurement (can events, functional processes etc. easily be identified)? Is this information clear and unambiguous?

> Plausibility checks (for instance in a business or MIS application): the CRUDL check relates to the expectation that for each object of interest for which data is stored persistently there will be at least one functional process that Creates (i.e. stores persistently) the data describing the object, one that Reads the data, one (often more than one) that Updates the persistently stored data, one that Deletes the data and one that Lists all instances of the object of interest.

> Cross-checks. Is each functional process identified reflected in the information sources (i.e. is the information source complete)?

A.2 Checks on the quality of measurements

A.2.1 Checklist for the Measurement Strategy Phase

> Is it stated why the measurement is required, what the result will be used for and what is the target accuracy?

> Is the purpose clear (i.e. measure all the delivered software or just the newly developed or enhanced software)?

> Is the overall scope stated? Are the measurement scopes stated (the scopes of the individual pieces of software to be measured separately)?

> If within the overall scope the components of a piece of software are distinguished, are their levels of decomposition also identified?

> Does the overall scope include software in more than one layer? If so, is the scope of any one measurement limited to one layer?

> For each piece of software to be measured, are all its functional users identified? Are the functional users in agreement with the purpose of the measurement?

> If the overall scope of the measurement contains several information sources, have their levels of granularity been identified? Are the measurements made at the same level of granularity?

- If a measurement was scaled to the level of granularity of functional processes or if an approximate sizing method was used, has the accuracy of the resulting size been estimated?

A.2.2 Checklist for the Mapping Phase

- Is each functional process associated with a triggering event and a functional user? Does each identified event trigger at least one functional process?
- Does each functional process represent a view of the software of the functional user that triggered it?
- Does every functional user either detect at least one event, and/or receive data from a functional process?
- Is each functional process indivisible, i.e. there is no part of the functional process that can be triggered by a separate event?
- Is each functional process complete (i.e. does it include all that is required to be done in response to the triggering event)?
- Are the objects of interest identified? Is each object of interest identified really an object *of interest* to a functional user?
- Is each attribute in the data movements related to exactly one object of interest?
- For each functional process, is it clear which data it has to store persistently or retrieve from persistent storage itself and for which data it must call other software to store or retrieve it?

A.2.3 Checklist for the Measurement Phase

- If a functional process must store data persistently or retrieve data from persistent storage, are one or more Write or Read data movements identified respectively?
- If a functional process must communicate with another piece of software (i.e. a functional user) to store or retrieve data, is one Exit per object of interest identified for the request and one Entry per object of interest identified for the returned data or message?
- Does the data stored persistently for each object of interest get Read by a functional process of the software being measured or by some other software?
- If a functional process must obtain data from a functional user but the latter does not need to be told what data to send, is one Entry and no Exit identified?
- If the FUR require a functional process to output messages without data about an object of interest (e.g. error messages), is a single Exit identified?
- If data attributes of one object of interest must be entered into a functional process, is one Entry identified (unless a COSMIC rule specify otherwise)? In like manner for Read, Write or Exit data movement?
- (In the business application domain only) Are control commands ignored (e.g. navigation commands, page up/down, clicking ‘OK’ for confirmation, etc)?
- Have clock and timing triggering events been identified?
- For an enhancement project, has the analysis identified all data movements that have been added, changed or deleted?

A.3 Checks on areas of commonly-made errors

- Identify assumptions and interpretations on functionality, check their validity and check the relevant parts of the measurement, especially with regard to:

- the data model, e.g. an entity-relationship model, a relational data model or a model of object classes
- data that are not attributes of an object (that is normally) of interest, e.g. standard screen headings, data on a report such as page numbers
- parameter tables
- drop-down lists
- objects of interest sub-types
- multiple occurrences of the same type of data movement
- recursive relationships between objects of interest
- re-use of functionality
- omitted ‘list before update’ (i.e. measuring physical not logical screens)
- log-on functionality
- drill-down functionality
- the confirmation/error messages Exit
- clock and timing triggering events

> (For functional processes incorrectly combined into one functional process) Identify missing functional processes by verifying that any triggering event corresponds with a functional process.

> (For functional processes incorrectly split up into functional processes) Identify redundant functional processes by verifying that any functional process corresponds with one triggering event.

Appendix B

ACKNOWLEDGEMENTS

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VERSION CONTROL

The following table gives the history of the versions of this document.

DATE	REVIEWER(S)	Modifications / Additions
28-2-2011	COSMIC Measurement Practices Committee	First version 1.0 issued
30-7-2018	COSMIC Measurement Practices Committee	Version 1.1 structured as a tutorial. Action-oriented for Measurers and for Management

MAIN CHANGES IN V1.1 FROM V1.0 OF THIS GUIDELINE

Note. The nature of a change is indicated by

- 'Method' when a definition or rule of the COSMIC method has been changed
- 'Editorial' when the description of the guidance was changed to improve ease of understanding.
- 'Correction' when an error in the previous version v1.0 of this Guideline has been corrected.

References in version 1.1	Nature of change	Comment
-	Editorial	Many minor editorial improvements and corrections have been made in addition to those listed below.
-	Editorial	Where appropriate, 'software artifact' has been replaced by the more general term 'information source'. This term is explained in the paragraph 'Conventions used in the Guideline' in chapter 1.
	Correction	Where appropriate 'FUR' replaced by 'functional requirement', as FUR has a specific meaning in COSMIC
Ch. 1	Editorial	The actions to be taken by either the measurer or by the management have been grouped in separate sub-sections, marked as 'Actionable items', its explanation added to the list of 'Conventions used in the Guideline'
1.4	Editorial	Chapter 3 of v1.0 ('Determining the quality rating of a measurement') explains the 'self-audit checklist'. This checklist is generalized to become a 'quality rating of a specific measurement' in the new section 1.4 'Quality of the information sources to the measurement process'.
1.4	Correction	The quality rating of the 'Quality of the measurement process' has been corrected by specifying process-oriented criteria for the measurement process.
2	Editorial	The phrase 'leading to defects in the measurement' replaced by 'A research study has shown that a faulty information source lead to lower measurement accuracy levels (performed manually or automated)' with reference added'.
1.2.1	Method	Quality ratings (e) and the previous (f) combined, extending quality rating (e). Relevant descriptions adapted accordingly.
1.4	Editorial	In Quality of the Measurer(s) rating 'Good' specified by replacing 'regularly' by 'at least once a week'.
Literature	Correction	Updated and the references corrected.

CHANGE REQUESTS, COMMENTS, QUESTIONS

Where the reader believes there is a defect in the text, a need for clarification, or that some text needs enhancing, please send an email to: mpc-chair@cosmic-sizing.org

You can use the forum on cosmic-sizing.org/forums to post your questions and receive answers from our world-wide community. The quality of any answers will depend on the knowledge and experience of the community member that writes the answer; the MPC cannot guarantee the correctness. Commercial organizations exist that can provide training and consultancy or tool support for the method. Please consult the www.cosmic-sizing.org web-site for further detail.