

EB tresos[®] AutoCore Generic 8 Quality Level documentation

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Table of Contents

1. Modification history	. 4
2. Overview	. 5
3. Measurement	. 6
3.1. What is measured	6
3.1.1. Development checks	. 6
3.1.2. Release checks	. 6
4. Quality levels	7
4.1. Use of quality levels	. 7
4.2. Quality levels and criteria	. 7
4.2.1. Development drop	. 8
4.2.2. Ready for prototyping (RFP)	. 8
4.2.2.1. Ready for prototyping level metrics	8
4.2.3. Ready for development (RFD)	10
4.2.3.1. Ready for development level metrics	10
4.2.4. Ready for manufacturing (RFM)	11
4.2.4.1. Ready for manufacturing level metrics	11
Bibliography	14
Glossary	15



1. Modification history

Version	Date	Description
1.0.10	2011-05-20	Initial release.
2.0.0	2015-04-27	General updates for ACG-6 and ACG-7 releases. Introduced new naming of quality levels valid after this document release.
2.1.0	2017-02-27	Added EB tresos maintenance and support annex information.
3.0.0	2017-03-02	Added quality metrics for Java code. Reworked chapter <i>Measurement</i> .
3.1.0	2017-10-27	Added MISRA-C:2012 as standard.
3.1.1	2019-02-22	Added MISRA-C:2012 Amendment 1 as standard.

Table 1.1. Modification history



2. Overview

The purpose of this document is to explain in detail the terms, definitions and concepts used in the evaluation of releases of the product EB tresos AutoCore Generic and related projects.

This document is relevant for the development and verification processes of software units produced in the project EB tresos AutoCore Generic and related projects.

During software development, a number of <u>software quality metrics</u> are collected. These metrics are then used to assign a <u>quality level</u> to the software product.

The software metrics that are collected during software development are described further in Chapter 3, "Measurement". The quality levels and the measurement criteria required to achieve these levels are described in Chapter 4, "Quality levels"



3. Measurement

3.1. What is measured

The choice of collected <u>software quality metrics</u> is derived from standards that are applicable in the domain of automotive software. See for example [his metrics], [his subset], or [sqo].

The metrics used during ongoing product development are defined in <u>Section 3.1.1, "Development checks"</u>. The metrics that are used prior to each product release are described in <u>Section 3.1.2, "Release checks"</u>.

3.1.1. Development checks

During product development, the <u>software quality metrics</u> listed in chapter <u>Section 4.2, "Quality levels and criteria"</u> are collected.

These metrics are used in the definition of the product <u>quality level</u> and have specific targets that must be achieved. For each metric and for each quality level, a <u>quality criterion</u> is defined. The collected quality criteria are described for each quality level in <u>Chapter 4</u>, "<u>Quality levels</u>".

The software metrics are collected at different stages of the product development:

- During software unit testing on the <u>lead platform</u> for a software unit release.
- When the EB tresos AutoCore Generic is ported to other target hardware architectures. Only those metrics that depend on the execution of test cases on the target hardware are collected, e.g. the number of compiler warnings.

Software metrics are not collected for software modules that are supplied by other vendors and which are only integrated, e.g. <u>MicroController Abstraction Layer (MCAL)</u> modules.

3.1.2. Release checks

For each release which is independent of its associated <u>quality level</u>, the following items are reviewed and accepted by a project-independent third party:

- The compiler chosen, the compiler version and the compiler options used for the verification of the release.
- ► The values of software quality metrics.
- Further internal release checklists.



4. Quality levels

4.1. Use of quality levels

Each release has an associated <u>quality level</u> that is the basis for determining the *recommended use* of that specific release. The <u>quality level</u> for a particular release is defined in the document <u>quality statement</u>, which is contained in each delivery.

The <u>quality statement</u> aggregates all quality data obtained for a release into a single statement that maps quality data to the *recommended use* of the release.

There are two types of quality statement available:

- 1. The *generic* type <u>quality statement</u>: this provides the qualification for a Windows platform. The Windows version and toolchain (compiler/linker and settings) used are documented.
- The QP1 type quality statement: this provides the qualification for a specific hardware platform (uC) and toolchain (compiler/linker). This type of quality statement is always provided in addition to a generic quality statement. The generic type quality statement must exist in advance for the modules that are to be qualified for QP1.

The metrics which are used are different and are dependent on the type of <u>quality statement</u>. For the generic type, the qualification is dependent on the full set of metrics as defined in tables in <u>Section 4.2, "Quality levels and criteria"</u>. For the <u>QP1</u> type, the qualification is dependent on a reduced set of metrics. In the tables in <u>Section 4.2, "Quality levels and criteria"</u>, a note indicates when a metric is used for <u>QP1</u> qualification.

NOTE

Safe and correct use of the release



If you intend to use the release for purposes other than the *recommended use*, ensure that additional verification measures are conducted. These measures shall be sufficient to ensure the safe and correct use of the release for the purpose that is intended.

4.2. Quality levels and criteria

NOTE

Quality levels renamed



The names of the quality levels are changed with release 2.0.0 of the quality level documentation. The new names correspond to the old names as shown in the list below.

There are four possible quality levels defined:



- Development drop, defined in <u>Section 4.2.1, "Development drop"</u>
 - In the EB tresos maintenance and support annex, version 2.1 [support_annex] this quality level is also referenced as *Integration Snapshot*.
- Ready for prototyping (RFP), defined in <u>Section 4.2.2, "Ready for prototyping (RFP)"</u>
 - In the EB tresos maintenance and support annex, version 2.1 [support_annex] this quality level is also referenced as *Prototype Level*.
- Ready for development (RFD), defined in <u>Section 4.2.3, "Ready for development (RFD)"</u>
 - In the EB tresos maintenance and support annex, version 2.1 [support_annex] this quality level is also referenced as *Development Level*.
- Ready for manufacturing (RFM), defined in <u>Section 4.2.4, "Ready for manufacturing (RFM)"</u>
 - In the EB tresos maintenance and support annex, version 2.1 [support_annex] this quality level is also referenced as *Production Level*.

For information about the general terms for support and maintenance, see the EB tresos maintenance and support annex [support_annex].

4.2.1. Development drop

The <u>quality level</u> Development drop is assigned to a release that does not fulfill any defined set of quality criteria. A release with the <u>quality level</u> Development drop is neither ready for development nor fully tested.

Note: In quality statements, which were created before 04-2015 and in the [support_annex] version 2.1, this quality level is referenced as *integration snapshot*.

4.2.2. Ready for prototyping (RFP)

The <u>quality level</u> ready for prototyping is assigned to a release that is neither ready for development nor fully tested.

Note: In quality statements, which were created before 04-2015 and in the [support_annex] version 2.1, this quality level is referenced as *prototype level*.

4.2.2.1. Ready for prototyping level metrics

The set of <u>software quality metrics</u> and associated criteria checked for a *generic* <u>quality statement</u> are as follows: the tables show the criteria defined for *ready for prototyping level*.



software quality metrics for C-code	quality criterion
called functions	<= 20
goto statements	== 0
call levels	<= 16
function parameters	<= 8
static path count	<= 4000
return points	<= 1
function statements	<= 100
cyclomatic complexity	<= 30
language scope	<= 20
recursions	== 0
direct recursions	== 0
number of compiler warnings per 100 lines of code ^a	<= 10
number of undocumented MISRA violations per 100 lines of code based on [MISRAC2012] with [MISRAC2012_Amendment-1]	<= 10

^aThis criterion is also measured for QP1 quality statement.

Table 4.1. Ready for prototyping level: code metrics for C-code with quality criterion

software quality metrics for C-code	quality criterion
decision coverage	>= 0.8
generator coverage	>= 0.7
percentage of successful tests a	>= 0.7

^aThis criterion is also measured for QP1 quality statement.

Table 4.2. Ready for prototyping level: test metrics for C-code with quality criterion

software quality metrics for Java code	quality criterion
statement coverage	>= 0.7
condition/decision coverage	>= 0.6
percentage of successful tests a	>= 0.7

^aThis criterion is also measured for QP1 quality statement.

Table 4.3. Ready for prototyping level: test metrics for Java code with <u>quality criterion</u>

software quality metrics	quality criterion
number of test cases which are not required	== 0
number of tracing fulfillments which are not required	== 0



software quality metrics	quality criterion
number of implemented tests without test specification	== 0
number of bugs that are not analyzed on time	== 0

Table 4.4. Ready for prototyping level: process metrics with quality criterion

4.2.3. Ready for development (RFD)

The <u>quality level</u> ready for development is assigned to a release that is ready for development, but not fully tested.

Note: In quality statements, which were created before 04-2015 and in the [support_annex] version 2.1, this quality level is referenced as *development level*.

4.2.3.1. Ready for development level metrics

The set of <u>software quality metrics</u> and associated criteria checked for a *generic* <u>quality statement</u> are as follows: the tables show the criteria defined for *ready for development level*.

software quality metrics for C-code	quality criterion
called functions	<= 15
goto statements	== 0
call levels	<= 12
function parameters	<= 8
static path count	<= 2000
return points	<= 1
function statements	<= 75
cyclomatic complexity	<= 20
language scope	<= 12
recursions	== 0
direct recursions	== 0
number of compiler warnings per 100 lines of code a	<= 1
number of undocumented MISRA violations per 100 lines of code based on	<= 1
[MISRAC2012] with [MISRAC2012_Amendment-1]	

^aThis criterion is also measured for QP1 quality statement.

Table 4.5. Ready for development level: code metrics for C-code with quality criterion



software quality metrics for C-code	quality criterion
decision coverage	>= 0.9
generator coverage	>= 0.8
percentage of successful tests a	== 1.0

^aThis criterion is also measured for QP1 quality statement.

Table 4.6. Ready for development level: test metrics for C-code with quality criterion

software quality metrics for Java code	quality criterion
statement coverage	>= 0.8
condition/decision coverage	>= 0.7
percentage of successful tests ^a	== 1.0

^aThis criterion is also measured for QP1 quality statement.

Table 4.7. Ready for development level: test metrics for Java code with quality criterion

software quality metrics	quality criterion
percentage of implemented requirements	>= 0.85
percentage of tested requirements	>= 0.75
number of test cases which are not required	== 0
number of tracing fulfillments which are not required	== 0
number of implemented tests without test specification	== 0
number of bugs that are not analyzed on time	== 0

Table 4.8. Ready for development level: process metrics with quality criterion

4.2.4. Ready for manufacturing (RFM)

The <u>quality level</u> *ready for manufacturing* is assigned to a release that is ready for development and fully tested. This is the only quality level that can be used in the software production phase.

Note: In quality statements, which were created before 04-2015 and in the [support_annex] version 2.1, this quality level is referenced as *production level*.

4.2.4.1. Ready for manufacturing level metrics

The set of <u>software quality metrics</u> and associated criteria checked for a *generic* <u>quality statement</u> are as follows: the tables show the criteria defined for *ready for manufacturing level*.



software quality metrics for C-code	quality criterion
called functions	<= 15
goto statements	== 0
call levels	<= 12
function parameters	<= 8
static path count	<= 2000
return points	<= 1
function statements	<= 75
cyclomatic complexity	<= 20
language scope	<= 12
recursions	== 0
direct recursions	== 0
number of compiler warnings per 100 lines of code ^a	== 0
number of undocumented MISRA violations per 100 lines of code based on [MISRAC2012] with [MISRAC2012_Amendment-1]	== 0

^aThis criterion is also measured for QP1 <u>quality statement</u>.

Table 4.9. Ready for manufacturing level: code metrics for C-code with quality criterion

software quality metrics for C-code	quality criterion
decision coverage	== 1.0
generator coverage	>= 0.9
percentage of successful tests a	== 1.0

^aThis criterion is also measured for QP1 quality statement.

Table 4.10. Ready for manufacturing level: test metrics for C-code with quality criterion

software quality metrics for Java code	quality criterion
statement coverage	>= 0.9
condition/decision coverage	>= 0.8
percentage of successful tests a	== 1.0

^aThis criterion is also measured for QP1 quality statement.

Table 4.11. Ready for manufacturing level: test metrics for Java code with $\underline{\text{quality criterion}}$

software quality metrics	quality criterion
percentage of implemented requirements	== 1.0
percentage of tested requirements	== 1.0



software quality metrics	quality criterion
number of not implemented requirements	== 0
number of not tested requirements	== 0
number of test cases which are not required	== 0
number of tracing fulfillments which are not required	== 0
number of implemented tests without test specification	== 0
number of test cases which are not implemented	== 0
number of requirement tracing rules violations	== 0
number of bugs that are not analyzed on time	== 0

Table 4.12. Ready for manufacturing level: process metrics with quality criterion

For a release with *ready for manufacturing level* all structural code branches that are not covered in module tests are reviewed and accepted by an independent third party. Such branches are usually the result of <u>defensive programming</u>.



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[sqo] Software Quality Objectives for Source Code, <u>72337_Software_Quality_Objectives_V3.0.pdf</u>, Version 3.0, 2012-05-02

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[support_annex] EB tresos maintenance and support annex

Glossary

AUTOSAR See <u>AUTomotive Open System ARchitecture</u>.

calling functions Number of distinct callers of a function.

Taken from [his metrics].

Taken from [his_metrics].

call levels Depth of function nesting. Maximum depth of control structures within a func-

tion body. The value of 1 means either no control structure exists within a function body or all existing control structures are not nested within another

control structure.

Taken from [his metrics].

comment density Relationship of the number of comments (outside and within functions) to the

number of statements.

Taken from [his_metrics].

cyclomatic complexity The cyclomatic complexity of a function is the count of the number of linearly

independent paths through the source code. It is a measure about the struc-

tural complexity of a function.

See <u>Cyclomatic_complexity</u> for further information.

Taken from [his_metrics].

statement coverage The statement coverage is a measure for structural code coverage. Based on

the control flow graph of a program, it measures, if each statement has been

executed by at least one test case.

See Code coverage for further information.

decision coverage The decision coverage or branch coverage is a measure for structural code

coverage. Based on the control flow graph of a program, it measures if each

edge has been executed by at least one test case.

See <u>Code_coverage</u> for further information.

condition coverage The condition coverage is a measure for structural code coverage. Based

on the control flow graph of a program, it measures if each Boolean sub-

expression evaluated both to true and false by at least one test case.

For further information, see Code_coverage.

condition/decision coverage

The condition/decision coverage (JaCoCo calls it branch-coverage) is a measure for structural code coverage. It is a combination of condition coverage and decision coverage. Based on the control flow graph of a program, it measures if each edge has been executed and each Boolean sub-expression evaluated both to true and false by at least one test case. It is less strict than modified condition/decision coverage.

For further information, see Code_coverage.

modified condition/decision coverage

The *modified condition/decision coverage* is a measure for structural code coverage. Based on the control flow graph of a program, it measures if the <u>condition/decision coverage</u> extended by the requirement that each condition should affect the decision outcome independently has been satisfied by at least one test case.

For further information, see **Code coverage**.

defensive programming See <u>Defensive programming</u> for further information.

direct recursions Number of direct recursions.

Taken from [his metrics].

tion interface.

Taken from [his_metrics].

function statements Number of statements of a function, which is a measure of function complexity.

Taken from [his_metrics].

generator coverage The generator coverage is a measure for coverage of the configuration space

of a software module.

The generated configuration is generated using a template language. In analogy to the <u>decision coverage</u>, the template language is instrumented at decision points. The measurement checks if the generated configuration uses a

decision point in the template language.

Taken from [his metrics].

language scope The language scope is an indicator of the cost of maintaining or changing

functions.

language scope := (N1+N2) / (n1+n2)

where:

▶ n1 = number of different operators

№ N1 = sum of all operators

n2 = number of different operands

№ N2 = sum of all operands

Taken from [his metrics].

lead platform The lead platform is a target hardware for which the EB tresos AutoCore

Generic is actively developed. The software product is then only ported to

other target hardware architectures.

lines of code

The lines of code is a software metric used to measure the size of a program.

See <u>Source_lines_of_code</u> for further information.

lines of comment The number of lines containing comments.

MicroController Abstraction The MCAL contains AUTOS

Layer (MCAL)

The MCAL contains AUTOSAR basic software modules that abstract the mi-

crocontroller specifics (drivers).

number of header file inclu-

sions

Number of directly and indirectly included header files per software unit.

executable statement.

number of requirements The number of requirements per software unit.

number of requirements that

need implementation

The number of requirements that need implementation per software unit.

number of requirements that

are implemented

The number of requirements that are implemented per software unit.

number of requirements that

need testing

The number of requirements that need testing per software unit.

number of requirements that

are tested

The number of requirements that are tested per software unit.

number of not implemented

requirements

The number of requirements that need implementation, but have not been

implemented or are only partially implemented.

number of not tested require- ments	The number of requirements that need testing, but have not been tested or are only partially tested.
number of test cases which are not required	The number of test cases that are specified and do not trace correctly to requirements.
number of test cases which are not implemented	The number of test cases that are specified and have not been implemented.
number of tracing fulfillments which are not required	The number of coverages in requirement tracings that are not required, e.g. there exists a test specification, but the requirement does not need a test case.
number of implemented tests without test specification	The number of implemented test cases that are not derived from a test specification.
number of bugs that are not analyzed on time	The number of bugs that are not analyzed within 5 days.
number of requirement trac- ing rules violations	The number of requirement tracing rules that are violated.
number of compiler warnings per 100 <u>lines of code</u>	The number of compiler warnings per 100 <u>lines of code</u> .
number of undocumented MISRA violations per 100 lines of code	The number of unjustified violations against [MISRAC2012] with [MISRAC2012_Amendment-1] per 100 lines of code.
percentage of implemented requirements	The percentage of requirements that need implementation and have been implemented.
percentage of tested require- ments	The percentage of requirements that need testing and have been tested.
percentage of successful tests	Percentage of implemented tests that have been executed with a successful result.
QP1	module qualification package
	For a detailed description see [autosar_solutions].
quality criteria	See quality criterion.
quality criterion	A <i>quality criterion</i> is a definition of the lowest acceptable value for <u>software</u> <u>quality metrics</u> . This value is dependent on the <u>quality level</u> .
quality level	A <i>quality level</i> defines a set of <u>quality criteria</u> that shall be satisfied by a module. The module is then said to have this quality level.

quality statement is a document created by quality assurance that testifies

that a release satisfies a quality level.

recursions Call graph recursions. Number of call cycles over one or more functions. If

one function is at the same time directly recursive (it calls itself) and indirectly

recursive, the call cycle is counted only once.

See also direct recursions.

Taken from [his_metrics].

return points Number of return points of a function.

Taken from [his metrics].

software quality metrics A software quality metric defines a method to determine a value for a particular

attribute of the software.

static path count Estimated static path count of a function.

Taken from [his metrics].