



Elektrobit

# EB tresos<sup>®</sup> 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) .....             | 9  |
| 4.2.3.1. Ready for development level metrics .....   | 9  |
| 4.2.4. Ready for manufacturing (RFM) .....           | 11 |
| 4.2.4.1. Ready for manufacturing level metrics ..... | 11 |
| Bibliography .....                                   | 13 |
| Glossary .....                                       | 14 |

# 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.<br>Introduced new naming of quality levels valid after this document re-release. |
| 2.1.0   | 2017-02-27 | Added <i>EB tresos maintenance and support annex</i> information.  |
| 3.0.0   | 2017-03-02 | Added quality metrics for Java code.<br>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.  |
| 3.1.2   | 2020-07-31 | Removed references to old quality level identifier.  |
| 3.1.3   | 2020-09-01 | Updated quality levels regarding compiler warnings.  |

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 [software quality metrics](#) are collected. These metrics are then used to assign a [quality level](#) 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 [software quality metrics](#) 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 [Section 3.1.1, “Development checks”](#). The metrics that are used prior to each product release are described in [Section 3.1.2, “Release checks”](#).

#### 3.1.1. Development checks

During product development, the [software quality metrics](#) listed in chapter [Section 4.2, “Quality levels and criteria”](#) are collected.

These metrics are used in the definition of the product [quality level](#) and have specific targets that must be achieved. For each metric and for each quality level, a [quality criterion](#) is defined. The collected quality criteria are described for each quality level in [Chapter 4, “Quality levels”](#).

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

- ▶ During software unit testing on the [lead platform](#) 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. [MicroController Abstraction Layer \(MCAL\)](#) modules.

#### 3.1.2. Release checks

For each release which is independent of its associated [quality level](#), 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 [quality level](#) that is the basis for determining the *recommended use* of that specific release. The [quality level](#) for a particular release is defined in the document [quality statement](#), which is contained in each delivery.

The [quality statement](#) 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 [quality statement](#): this provides the qualification for a Windows platform. The Windows version and toolchain (compiler/linker and settings) used are documented.
2. 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 [quality statement](#). For the generic type, the qualification is dependent on the full set of metrics as defined in tables in [Section 4.2, “Quality levels and criteria”](#). For the [QP1](#) type, the qualification is dependent on a reduced set of metrics. In the tables in [Section 4.2, “Quality levels and criteria”](#), a note indicates when a metric is used for [QP1](#) qualification.

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**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.

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### 4.2. Quality levels and criteria

There are four possible quality levels defined:

- ▶ Development drop, defined in [Section 4.2.1, “Development drop”](#)
- ▶ Ready for prototyping (RFP), defined in [Section 4.2.2, “Ready for prototyping \(RFP\)”](#)
- ▶ Ready for development (RFD), defined in [Section 4.2.3, “Ready for development \(RFD\)”](#)
- ▶ Ready for manufacturing (RFM), defined in [Section 4.2.4, “Ready for manufacturing \(RFM\)”](#)

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 [quality level](#) *Development drop* is assigned to a release that does not fulfill any defined set of quality criteria. A release with the [quality level](#) *Development drop* is neither ready for development nor fully tested.

## 4.2.2. Ready for prototyping (RFP)

The [quality level](#) *ready for prototyping* is assigned to a release that is neither ready for development nor fully tested.

### 4.2.2.1. Ready for prototyping level metrics

The set of [software quality metrics](#) and associated criteria checked for a *generic* [quality statement](#) are as follows: the tables show the criteria defined for *ready for prototyping level*.

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

<sup>a</sup>This criterion is also measured for [QP1 quality statement](#).

Table 4.1. Ready for prototyping level: code metrics for C-code with [quality criterion](#)



| <a href="#">software quality metrics</a> for C-code         | <a href="#">quality criterion</a> |
|---|-----------------------------------|
| <a href="#">decision coverage</a>                           | $\geq 0.8$                        |
| <a href="#">generator coverage</a>                          | $\geq 0.7$                        |
| <a href="#">percentage of successful tests</a> <sup>a</sup> | $\geq 0.7$                        |

<sup>a</sup>This criterion is also measured for [QP1 quality statement](#).

Table 4.2. Ready for prototyping level: test metrics for C-code with [quality criterion](#)

| <a href="#">software quality metrics</a> for Java code      | <a href="#">quality criterion</a> |
|---|-----------------------------------|
| <a href="#">statement coverage</a>                          | $\geq 0.7$                        |
| <a href="#">condition/decision coverage</a>                 | $\geq 0.6$                        |
| <a href="#">percentage of successful tests</a> <sup>a</sup> | $\geq 0.7$                        |

<sup>a</sup>This criterion is also measured for [QP1 quality statement](#).

Table 4.3. Ready for prototyping level: test metrics for Java code with [quality criterion](#)

| <a href="#">software quality metrics</a>                               | <a href="#">quality criterion</a> |
|--|-----------------------------------|
| <a href="#">number of test cases which are not required</a>            | $== 0$                            |
| <a href="#">number of tracing fulfillments which are not required</a>  | $== 0$                            |
| <a href="#">number of implemented tests without test specification</a> | $== 0$                            |
| <a href="#">number of bugs that are not analyzed on time</a>           | $== 0$                            |

Table 4.4. Ready for prototyping level: process metrics with [quality criterion](#)

### 4.2.3. Ready for development (RFD)

The [quality level](#) *ready for development* is assigned to a release that is ready for development, but not fully tested.

#### 4.2.3.1. Ready for development level metrics

The set of [software quality metrics](#) and associated criteria checked for a *generic quality statement* are as follows: the tables show the criteria defined for *ready for development level*.

| <a href="#">software quality metrics</a> for C-code | <a href="#">quality criterion</a> |
|---|-----------------------------------|
| <a href="#">called functions</a>                    | $\leq 15$                         |
| <a href="#">goto statements</a>                     | $== 0$                            |
| <a href="#">call levels</a>                         | $\leq 12$                         |

| <a href="#">software quality metrics</a> for C-code   | <a href="#">quality criterion</a> |
|---|-----------------------------------|
| <a href="#">function parameters</a>   | $\leq 8$                          |
| <a href="#">static path count</a>   | $\leq 2000$                       |
| <a href="#">return points</a>   | $\leq 1$                          |
| <a href="#">function statements</a>   | $\leq 75$                         |
| <a href="#">cyclomatic complexity</a>   | $\leq 20$                         |
| <a href="#">language scope</a>  | $\leq 12$                         |
| <a href="#">recursions</a>  | $= 0$                             |
| <a href="#">direct recursions</a>   | $= 0$                             |
| <a href="#">number of undocumented compiler warnings per 100 lines of code</a> <sup>a</sup>                                     | $\leq 1$                          |
| <a href="#">number of undocumented MISRA violations per 100 lines of code</a> based on [MISRA2012] with [MISRA2012_Amendment-1] | $\leq 1$                          |

<sup>a</sup>This criterion is also measured for [QP1 quality statement](#).

Table 4.5. Ready for development level: code metrics for C-code with [quality criterion](#)

| <a href="#">software quality metrics</a> for C-code         | <a href="#">quality criterion</a> |
|---|-----------------------------------|
| <a href="#">decision coverage</a>                           | $\geq 0.9$                        |
| <a href="#">generator coverage</a>                          | $\geq 0.8$                        |
| <a href="#">percentage of successful tests</a> <sup>a</sup> | $= 1.0$                           |

<sup>a</sup>This criterion is also measured for [QP1 quality statement](#).

Table 4.6. Ready for development level: test metrics for C-code with [quality criterion](#)

| <a href="#">software quality metrics</a> for Java code      | <a href="#">quality criterion</a> |
|---|-----------------------------------|
| <a href="#">statement coverage</a>                          | $\geq 0.8$                        |
| <a href="#">condition/decision coverage</a>                 | $\geq 0.7$                        |
| <a href="#">percentage of successful tests</a> <sup>a</sup> | $= 1.0$                           |

<sup>a</sup>This criterion is also measured for [QP1 quality statement](#).

Table 4.7. Ready for development level: test metrics for Java code with [quality criterion](#)

| <a href="#">software quality metrics</a>                               | <a href="#">quality criterion</a> |
|--|-----------------------------------|
| <a href="#">percentage of implemented requirements</a>                 | $\geq 0.85$                       |
| <a href="#">percentage of tested requirements</a>                      | $\geq 0.75$                       |
| <a href="#">number of test cases which are not required</a>            | $= 0$                             |
| <a href="#">number of tracing fulfillments which are not required</a>  | $= 0$                             |
| <a href="#">number of implemented tests without test specification</a> | $= 0$                             |

| <a href="#">software quality metrics</a>                     | <a href="#">quality criterion</a> |
|--|-----------------------------------|
| <a href="#">number of bugs that are not analyzed on time</a> | == 0                              |

Table 4.8. Ready for development level: process metrics with [quality criterion](#)

## 4.2.4. Ready for manufacturing (RFM)

The [quality level](#) *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.

### 4.2.4.1. Ready for manufacturing level metrics

The set of [software quality metrics](#) and associated criteria checked for a *generic* [quality statement](#) are as follows: the tables show the criteria defined for *ready for manufacturing level*.

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

<sup>a</sup>This criterion is also measured for [QP1 quality statement](#).

Table 4.9. Ready for manufacturing level: code metrics for C-code with [quality criterion](#)

| <a href="#">software quality metrics</a> for C-code | <a href="#">quality criterion</a> |
|---|-----------------------------------|
| <a href="#">decision coverage</a>                   | == 1.0                            |

| <a href="#">software quality metrics</a> for C-code         | <a href="#">quality criterion</a> |
|---|-----------------------------------|
| <a href="#">generator coverage</a>                          | >= 0.9                            |
| <a href="#">percentage of successful tests</a> <sup>a</sup> | == 1.0                            |

<sup>a</sup>This criterion is also measured for [QP1 quality statement](#).

Table 4.10. Ready for manufacturing level: test metrics for C-code with [quality criterion](#)

| <a href="#">software quality metrics</a> for Java code      | <a href="#">quality criterion</a> |
|---|-----------------------------------|
| <a href="#">statement coverage</a>                          | >= 0.9                            |
| <a href="#">condition/decision coverage</a>                 | >= 0.8                            |
| <a href="#">percentage of successful tests</a> <sup>a</sup> | == 1.0                            |

<sup>a</sup>This criterion is also measured for [QP1 quality statement](#).

Table 4.11. Ready for manufacturing level: test metrics for Java code with [quality criterion](#)

| <a href="#">software quality metrics</a>                               | <a href="#">quality criterion</a> |
|--|-----------------------------------|
| <a href="#">percentage of implemented requirements</a>                 | == 1.0                            |
| <a href="#">percentage of tested requirements</a>                      | == 1.0                            |
| <a href="#">number of not implemented requirements</a>                 | == 0                              |
| <a href="#">number of not tested requirements</a>                      | == 0                              |
| <a href="#">number of test cases which are not required</a>            | == 0                              |
| <a href="#">number of tracing fulfillments which are not required</a>  | == 0                              |
| <a href="#">number of implemented tests without test specification</a> | == 0                              |
| <a href="#">number of test cases which are not implemented</a>         | == 0                              |
| <a href="#">number of requirement tracing rules violations</a>         | == 0                              |
| <a href="#">number of bugs that are not analyzed on time</a>           | == 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 [defensive programming](#).

# Bibliography

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[support\_annex] *EB tresos maintenance and support annex*

# Glossary

|                       |   |
|-----------------------|---|
| AUTOSAR               | See <a href="#">AUTomotive Open System ARchitecture</a> .   |
| calling functions     | <p>Number of distinct callers of a function.</p> <p>Taken from <a href="#">[his_metrics]</a>.</p>   |
| called functions      | <p>Number of distinct functions called by a function.</p> <p>Taken from <a href="#">[his_metrics]</a>.</p>  |
| call levels           | <p>Depth of function nesting. Maximum depth of control structures within a function 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.</p> <p>Taken from <a href="#">[his_metrics]</a>.</p>                 |
| comment density       | <p>Relationship of the number of comments (outside and within functions) to the number of statements.</p> <p>Taken from <a href="#">[his_metrics]</a>.</p>  |
| cyclomatic complexity | <p>The <i>cyclomatic complexity</i> of a function is the count of the number of linearly independent paths through the source code. It is a measure about the structural complexity of a function.</p> <p>See <a href="#">Cyclomatic_complexity</a> for further information.</p> <p>Taken from <a href="#">[his_metrics]</a>.</p> |
| statement coverage    | <p>The <i>statement coverage</i> 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.</p> <p>See <a href="#">Code_coverage</a> for further information.</p>   |
| decision coverage     | <p>The <i>decision coverage</i> or <i>branch coverage</i> 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.</p> <p>See <a href="#">Code_coverage</a> for further information.</p>                                    |
| condition coverage    | <p>The <i>condition coverage</i> 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.</p>  |

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 [condition/decision coverage](#) 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 [Defensive\\_programming](#) for further information.

**direct recursions** Number of direct recursions.

Taken from [\[his\\_metrics\]](#).

**function parameters** Number of parameters per function. A measure of the complexity of the function 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 [decision coverage](#), the template language is instrumented at decision points. The measurement checks if the generated configuration uses a decision point in the template language.

**goto statements** Number of `goto` statements per function.

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 <i>lead platform</i> 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.<br><br>See <a href="#">Source_lines_of_code</a> for further information.   |
| lines of comment                                | The number of lines containing comments.   |
| MicroController Abstraction Layer (MCAL)        | The <i>MCAL</i> contains <a href="#">AUTOSAR</a> basic software modules that abstract the microcontroller specifics ( <i>drivers</i> ).  |
| number of source files                          | Number of source files per software unit.  |
| number of header file inclusions                | Number of directly and indirectly included header files per software unit.   |
| number of statement lines                       | The <i>number of statement lines</i> is the number of <a href="#">lines of code</a> that include an 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 requirements  | 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 tracing rules violations                                 | The number of requirement tracing rules that are violated.  |
| number of undocumented compiler warnings per 100 <a href="#">lines of code</a> | The number of undocumented compiler warnings per 100 <a href="#">lines of code</a> .  |
| number of undocumented MISRA violations per 100 <a href="#">lines of code</a>  | The number of unjustified violations against <a href="#">[MISRAC2012]</a> with <a href="#">[MISRAC2012_Amendment-1]</a> per 100 <a href="#">lines of code</a> .                         |
| percentage of implemented requirements   | The percentage of requirements that need implementation and have been implemented.  |
| percentage of tested requirements  | 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<br><br>For a detailed description see <a href="#">[autosar_solutions]</a> .  |
| quality criteria   | See <a href="#">quality criterion</a> .   |
| quality criterion  | A <i>quality criterion</i> is a definition of the lowest acceptable value for <a href="#">software quality metrics</a> . This value is dependent on the <a href="#">quality level</a> . |

|                          |   |
|--------------------------|---|
| quality level            | A <i>quality level</i> defines a set of <a href="#">quality criteria</a> that shall be satisfied by a module. The module is then said to have this quality level.   |
| quality statement        | The <i>quality statement</i> is a document created by quality assurance that testifies that a release satisfies a <a href="#">quality level</a> .   |
| recursions               | <p>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.</p> <p>See also <a href="#">direct recursions</a>.</p> <p>Taken from <a href="#">[his_metrics]</a>.</p> |
| return points            | <p>Number of <code>return</code> points of a function.</p> <p>Taken from <a href="#">[his_metrics]</a>.</p>   |
| software quality metrics | A <i>software quality metric</i> defines a method to determine a value for a particular attribute of the software.  |
| static path count        | <p>Estimated static path count of a function.</p> <p>Taken from <a href="#">[his_metrics]</a>.</p>  |