SOFTWARE QUALITY OBJECTIVES FOR SOURCE CODE

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Revision table

Index	Date	Object of Modification
V1.0	2009/02/15	Initial version
V2.0	2010/03/05	• Improve formulation of SQRs • Explicit Code Metrics • Define systematic and potential runtime errors, safe and unreachable operations
V3.0	2012/05/02	• Add mapping with ISO 26262-6:2011 • Add Rule 5.2 in the 1st MISRA subset • Add MISRA AC AGC subset • Add MISRA C++ subset
V4.1	2021/06/28	• Updated to ISO 26262-6:2018 • Replace MISRA-C:2004 by MISRA-C:2012

Table of contents

REVISION TABLE 2

TABLE OF CONTENTS 3

1. REQUIREMENTS MAPPING TABLE 4

2. INTRODUCTION 4

3. SOFTWARE QUALITY OBJECTIVES (SQO) 5

3.1. SOFTWARE QUALITY OBJECTIVES OVERVIEW 5
3.2. QUALITY PLAN 5
3.2.1. Quality levels and number of deliveries 6
3.2.2. People and tools 7
3.2.3. Definitions of runtime errors 8
3.2.4. Standard comments and justifications 9
3.3. DETAILED DESIGN DESCRIPTION 11
3.3.1. Application level 11
3.3.2. Module level 11
3.3.3. File level 11
3.4. CODE METRICS 11
3.5. MISRA RULES SUBSETS 12
3.5.1. The first MISRA rules subset 12
3.5.2. The second MISRA rules subset 15
3.6. SYSTEMATIC RUNTIME ERRORS 21
3.7. NON TERMINATING FUNCTION CALLS AND LOOPS 22
3.8. UNREACHABLE BRANCHES 22
3.9. POTENTIAL RUNTIME ERRORS 23
3.10. DATAFLOW ANALYSIS 24

4. REQUIREMENT MAPPING WITH ISO 26262-6:2018 25

4.1. PURPOSE AND SCOPE 25
4.2. SUMMARY 25
4.3. DETAILS 26
4.3.1. Section 5: General topics for the product development at the software level 26
4.3.2. Section 8: Software unit design and implementation 27
4.3.3. Section 9: Software unit verification 28
4.3.4. Section 10: Software integration and verification 29
4.4. TRACEABILITY SQO LEVELS / ISO 26262-6:2018 REQUIREMENTS 29

5. TERMS AND ABBREVIATIONS 32

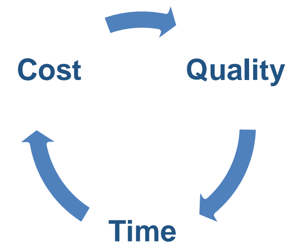
1. REQUIREMENTS MAPPING TABLE

Software Quality Requirements that are covered outside of the scope of this document can be mapped onto the requirements defined within this document. In this case the supplier shall provide a table detailing the mapping between the two set of requirements.

2. INTRODUCTION

The document defines a general and standard approach to measure the software quality of a product using criteria linked to code quality and dynamic execution errors.

The diagram on the right shows that the three properties: “Cost”, “Software Quality” and “Time” are interrelated. Changing the requirements for one property will impact the other two. In this context “Time” refers to the time Required to deliver the product, “Quality” is the quality of the final product, and “Cost” refers to the total cost of designing and building the product.



Once the requirements for these properties have been defined the question is how to achieve them? An approach where all modules are tested until they meet the Required quality could be applied, but the process of improving the quality is often stopped because the available time or budget has been used and not because we have obtained the quality objectives. A better verification process within the development process may help reduce time and cost to achieve quality.

3. SOFTWARE QUALITY OBJECTIVES (SQO)

This document defines six Software Quality Objectives (SQO) which are associated to four quality levels, level QL-1 (lowest quality) to level QL-4 (highest quality). Each Software Quality Objective consists of a set of Software Quality Requirements (SQR). Examples of SQR are complexity metrics, measure of unreachable code etc.

3.1. Software Quality Objectives overview

The following table shows the software quality criteria Required to reach each of the six Software Quality Objectives:

Criteria	SQR	Objectives					
		SQO-1	SQO-2	SQO-3	SQO-4	SQO-5	SQO-6
Quality Plan	SQR-10 → SQR-100	X	X	X	X	X	X
Detailed design description	SQR-110 → SQR-130	X	X	X	X	X	X
Code metrics	SQR-140 → SQR-150	X	X	X	X	X	X
First MISRA-C:2012 rules subset	SQR-160 → SQR-170	X	X	X	X	X	X
Systematic runtime errors	SQR-200 → SQR-210		X	X	X	X	X
Non terminating constructs	SQR-220		X	X	X	X	X
Unreachable branches	SQR-230			X	X	X	X
First subset of potential runtime errors	SQR-240				X	X	X
Second MISRA-C:2012 rules subset	SQR-180 → SQR-190					X	X
Second subset of potential runtime errors	SQR-250					X	X
Third subset of potential runtime errors	SQR-260						X
Dataflow Analysis	SQR-270						X

The different criteria are described in the following paragraphs (Quality Plan in §3.2, Detailed design description in §3.3, etc.).

3.2. Quality Plan

This section describes the general information which shall be provided by a supplier. It covers information about the methods, tools and teams involved in the Software Quality Requirement fulfillment, as well as information about the project itself. This information shall help to better understand who performs the work, and how and where the work is done.

Note: We will use the word “team” to describe people who are using the tools providing information for the documentation and/or the persons writing the document.

Regarding integration to the development process, information concerning the SQO should be delivered by the supplier during the project life cycle. It is advised to perform the relevant SQO activities during the code review phase. This will make it simpler and faster to consolidate and deliver the Software Quality document for a major delivery.

3.2.1. Quality levels and number of deliveries

SQR-10 The supplier shall associate a Quality Level for each module and justify their choices. This requirement encompasses all source code of the application, e.g. automatically generated code, legacy code, hand-written code and code produced by COTS

SQR-20 The supplier shall provide the number of software deliveries and a software quality plan

The software quality plan shall consist of a table showing for each module:

- the corresponding Quality Level (QL-1 to QL-4);
- the number of times the module will be delivered during the project;
- the Software Quality Objective for every delivery of this module.

Notes:

- The manufacturer shall validate the software quality plan and the decisions taken within it.
- It is not mandatory to have the same SQO improvement from one delivery to one other for all modules.

The following example table shows the possible progressions for each quality level to achieve the final Software Quality Objectives. The number of quality levels is fixed. The minimum SQO level associated to the first, last and penultimate deliveries are also fixed. The number of deliveries (table lines) is project dependent.

Delivery	Quality Level			
	QL-1	QL-2	QL-3	QL-4
First	SQO-1	SQO-2	SQO-3	SQO-4
X Intermediates	...	...	...	...
X Intermediates	SQO-2	SQO-3	SQO-4	SQO-5
X Intermediates	...	...	...	...
Penultimate	SQO-3	SQO-4	SQO-5	SQO-6
Last	SQO-3	SQO-4	SQO-5	SQO-6

Each cell gives the lowest Software Quality Objective acceptable

As shown by the above table, different quality levels can correspond to different quality objectives. When a project is composed with several modules, each module can have a different criticality. The final SQO level can therefore be different from one module to one other. This final SQO level allows selecting the corresponding Quality Level for the module. The modules being delivered multiple times during the project, the selected Quality Level also defines the SQO level of each delivery of the module.

Example using the table above for a project composed of 3 Modules Module-1, Module-2 and Module-3 of different criticalities:

- Module-1 is considered very critical: its Quality Level is the highest, QL-4. The first delivery of Module-1 should be at least SQO-4 and the two last deliveries should be SQO-6.
- Module-2 is considered not critical: its Quality Level is the lowest, QL-1. The first delivery of Module-2 should be at least SQO-1 and the two last deliveries should be at least SQO-3.
- Module-3 is considered of medium criticality: it has been agreed at the beginning of the project to set its Quality Level to QL-3. The first delivery of Module-2 should be at least SQO-3 and the two last deliveries should be at least SQO-5.

The following table gives the Quality Level and the minimum SQO level to reach for the three modules at the end of the project:

Module	Quality Level	Minimum SQO level to reach (end of project)
Module 1	QL-4	SQO-6
Module 2	QL-1	SQO-3
Module 3	QL-3	SQO-5

SQR-30 Once the quality levels for each module and the process to achieve them are defined by the supplier, the supplier shall justify all modifications to the plan

3.2.2. People and tools

SQR-40 The supplier shall provide information about people involved directly or indirectly in requirement fulfillment

This shall contain at least:

- Company name
- Department and division name
- Geographical location
- Work done:
  - data generation (tool user), data computation, validation, …
  - list of modules verified
  - list of requirements satisfied

SQR-50 The supplier shall provide the list of tools and methods used

This shall contain at least:

- Tool or method objectives
- Which requirements are affected and how
- Team responsible for the activity supported by the tool or method
- Tool or method experience, i.e. how long has the team been using the tools or methods and with what frequency. The frequency should be expressed as follows:
  - How many times has the team used these tools (or methods) per year?
  - Number of projects which used these tools or methods?

SQR-60 The supplier shall inform and justify any modifications regarding the requirement SQR-50

SQR-70 The supplier shall justify that methods and tools used are appropriate to achieve the requirements

This can be done, for example, by referencing the sections of the tools' documentation explaining what the tools provide, and how this helps to achieve the SQR.

SQR-80 Throughout the verification cycle the supplier shall maintain the same option set for tools used, to ease the comparison of different deliveries

3.2.3. Definitions of runtime errors

In the rest of the document, the following definitions for runtime errors are used:

- A **systematic runtime error** is an operation which will generate an error for all executions of the application. It will typically not depend on the values of inputs of the application.
  An example of a systematic runtime error is:

```
1: int foo (int a) {
2:   int b = 0;
3:   return (a / b);  // Systematic Division by Zero
4: }
```

- A **potential runtime error** is an operation which will generate an error that may happen under certain circumstances, for example depending on the values of inputs of the application.
  An example of a potential runtime error is:

```
1: int foo (int a) {
2:   int b = 4;
3:   return (b / a);  // Potential Division by Zero
4: }
```

  Note: the potential error line 3 cannot be proven safe or otherwise because the occurrence of the error depends on `a`, which is an input of the program.

- A **safe operation** is an operation (division, multiplication ...) which cannot produce a runtime error.
  An example of a safe operation is:

```
1: int bar () {
2:   int x = 3;
3:   return (x);
4: }
5: int foo (int a) {
6:   int b = 4, c;
7:   c = bar ();
8:   b = a / (b - c); // Safe Division
9:   return (b / 2);  // Safe Division
10:    }
```

  Note: the division line 8 can be proven safe by a tool or by a human review.
  Indeed, `(b - c)` = `(4 - 3)` = `1` and is different from zero. No division by zero may occur.

- An **unreachable operation** is an operation (division, multiplication ...) which cannot be reached during the execution of the application.
  An example of an unreachable operation is:

```
1: int bar () {
2:   int x = 3;
3:   return (x);
4: }
5: int foo (int a) {
6:   int b;
7:   b = bar ();
8:   if (b < 0)
9:     b = b / a;      // Unreachable operation
10:      return (b);
11:    }
```

  Note: line 9 cannot be reached because the condition `(b < 0)` is always false. Therefore, no division by zero can occur on this line.

3.2.4. Standard comments and justifications

Some of the SQRs defined in this document require some operation to be concluded as proven safe or justified:

- Coding rules violations shall be corrected or justified (SQR-160 , SQR-180);
- Reviews of potential runtime errors should be performed with a defined review coverage[1] depending on the objective, and deviations should be corrected or justified (SQR-240 SQR-250 SQR-260).

For runtime errors the review coverage is defined by a percentage, indicated after the runtime error category (example: “Division by zero: 80%”) which represents the number of operations concluded as proven safe or justified.

These conclusions could be performed:

- Automatically (with a tool);
- Partially automatically and completed manually;
- Totally manually.

Example: let’s take an application containing 60 divisions. Let’s assume that the review coverage objective is “Division by zero: 80%”. Then the 80% review coverage can be reached by proving that at least 80% of the divisions are “safe operations” or “potential runtime errors” that can be justified.

Let’s consider that a tool is used, which proves automatically that 45 divisions out of the 60 are “safe operations”. The review objective can be reached by demonstrating that at least 3 “potential errors” can be justified, because (45 + 3) / 60 = 80%.

To ease the justification review process:

- The **status** of the systematic and potential errors, and optionally the **next action** shall be provided;
- The **criticality** of the systematic and potential errors leading to the violation of a quality requirement shall be defined.

[1] Review coverage objectives are defined later in the document, in the paragraphs where corresponding SQR are described.

SQR-90 The supplier shall provide a normalized status for systematic and potential errors

This could be done by assigning a status to systematic and potential errors from the following list:

- "**Undecided**": no status assigned yet. This status is used to explicitly defer the decision about the systematic or potential error;
- "**Investigate**": the potential error should be investigated further. This status can be useful for example if the investigation has to be conducted by someone else later;
- "**Fix**": the error must be fixed;
- "**Modify code/model**": the code should be modified to make the systematic or potential error disappear. If the code is automatically generated from a model, the model should be modified. The status is different from "**Fix**" in that the reviewer may want the code to be modified even if the error does not lead to the violation of a quality requirement;
- "**Restart with different options**": in the case of a potential error produced by a tool, this status can be used when the tool should be used with a different set of options or a different configuration;
- "**Justify with code/model annotations**": this status may be used when the supplier wants the justification of the potential error to be persistent;
- "**No action planned**": this status may be used when the supplier doesn't plan to do any action with regards to the potential error. This status may be used in conjunction with a comment explaining why no action is planned.

Notes:

- A status of "**No action planned**" or "**Justify with code/model annotations**" leads to the potential error being justified in the sense of SQR-160 SQR-180 SQR-240 SQR-250 and SQR-260 .

- A status of "**Undecided**", "**Investigate**", "**Fix**", "**Modify code/model**" or "**Restart with different options**" leads to the potential error being not justified in the sense of SQR-160 SQR-180 SQR-240 SQR-250 and SQR-260 .

- The supplier may add other statuses, and negotiate with the car manufacturer to determine if the statuses allow the justification or not of a potential error.

SQR-100 The supplier shall provide the criticality of systematic and potential errors leading to the violation of a quality requirement

A criticality shall be provided for all systematic and potential errors leading to the violation of a quality requirement:

- The possible criticalities are high, medium and low.
- The criticality shall at least be provided for systematic and potential errors with statuses "Fix" and "Modify code/model".

3.3. Detailed design description

The information provided in this section will help evaluate the architecture of the application and its maturity. This will form the basis for the following sections of the document.

3.3.1. Application level

SQR-110 The supplier shall describe the architecture of the application

This shall contain at least:
- List of software modules
- How modules relate to one another
- Number of source files
- Number of header files

3.3.2. Module level

SQR-120 The supplier shall describe the structure of each module

This shall contain at least:
- List of source files used by each module
- List of header files with the file scope. Scope can be one of private, public or external.
  - 'Private' means used only by one module
  - 'Public' means used by several modules but developed internally
  - 'External' means header files provided by the operating system, compiler, device drivers or other header files which are not the intellectual property of the supplier.

3.3.3. File level

SQR-130 For each file the supplier shall provide information describing it

This shall contain at least:
- File (source and header) version based on the file management (revision control) system of the supplier.

  N.B.: If the versioning is only managed at module level the supplier should only provide this information.
- Indicate the origin of each file, for example:
  - COTS
  - generated code
  - hand-written code
  - if other, give details

  N.B.: If the entire module has the same origin the information should be provided at the module level.
- Number of lines.

3.4. Code metrics

This paragraph shall help the automotive manufacturer evaluate the module characteristics and better understand the methods and tools used to demonstrate the application quality regarding the absence of runtime errors.

A recommended way is to provide the following metrics:
- Comment Density: relationship of the number of comments to the number of statements;
- Number of paths;
- Number of `goto` statements;
- Cyclomatic complexity "v(G)";
- Number of Calling Functions per Function;
- Number of Called Functions per Function;

- Number of Function Parameters;
- Number of Instructions per Function;
- Number of call Levels;
- Number of return points within a function;
- Stability index: supplies a measure of the number of changes between two versions of a piece of software;
- Language Scope: indicator of the cost of maintaining/changing functions;
- Number of recursions.

Note 1: requirements related to comments in the code are optional on generated code and COTS.

Note 2: following metrics above would provide a high coverage of the metrics defined by the HIS[1] initiative.

SQR-140 The automotive manufacturer and the supplier shall choose at the beginning of the project the code metrics that will be used

SQR-150 For the chosen metrics, the supplier shall demonstrate that the modules comply with the agreed boundary limits, or justify the deviations

3.5. MISRA rules subsets

Two subsets of MISRA rules are defined. These two subsets correspond to different quality objectives; they are not to be used as different steps in reaching the final quality.

3.5.1. The first MISRA rules subset

Here is the first MISRA rules subset for C code, according to MISRA-C:2012.
A part of this subset is applicable for automatically generated code according to Appendix E of MISRA-C:2012.

MISRA-C:2012			
Requirement	**Ident**	**Category**	**Applicability to MISRA AC AGC**
The *static* storage class specifier shall be used in all declarations of objects and functions that have internal linkage	8.8	Required	Required
When an array with external linkage is declared, its size should be explicitly specified	8.11	Advisory	Advisory
A pointer should point to a const-qualified type whenever possible	8.13	Advisory	Advisory
Conversions shall not be performed between a pointer to a function and any other type	11.1	Required	Required
Conversions shall not be performed between a pointer to an incomplete type and any other type	11.2	Required	Required

[1] **HIS: Hersteller Inititiative Software.** Initiative from German automotive manufacturers (Audi, BMW Group, DaimlerChrysler, Porsche and Volkswagen) whose goal is the production of agreed standards within the area of standard software modules for networks, development of process maturity, software test, software tools and programming of ECU's. HIS specifies a fundamental set of Software Metrics to be used in the evaluation of software. See http://portal.automotive-his.de/images/pdf/SoftwareTest/his-sc-metriken.1.3.1_e.pdf

MISRA-C:2012			
Requirement	**Ident**	**Category**	**Applicability to MISRA AC AGC**
A conversion should not be performed between a pointer to object and an integer type	11.4	Advisory	Advisory
A conversion should not be performed from pointer to *void* into pointer to object	11.5	Advisory	Advisory
A cast shall not be performed between pointer to *void* and an arithmetic type	11.6	Required	Required
A cast shall not be performed between pointer to object and a non-integer arithmetic type	11.7	Required	Required
A loop counter shall not have essentially floating type	14.1	Required	Advisory
A *for* loop shall be well-formed	14.2	Required	N/A
The *goto* statement should not be used	15.1	Advisory	Advisory
The *goto* statement shall jump to a label declared later in the same function	15.2	Required	Advisory
Any label referenced by a *goto* statement shall be declared in the same block, or in any block enclosing the *goto* statement	15.3	Required	Required
A function should have a single point of exit at the end	15.5	Advisory	Advisory
The features of *<starg.h>* shall not be used	17.1	Required	Required
Functions shall not call themselves, either directly or indirectly	17.2	Required	Required
The relational operators >, >=, < and <= shall not be applied to objects of pointer type except where they point into the same object	18.3	Required	Required
The +, -, += and -= operators should not be applied to an expression of pointer type	18.4	Advisory	Advisory
Declarations should contain no more than two levels of pointer nesting	18.5	Advisory	N/A
The address of an object with automatic storage shall not be copied to another object that persists after the first object has ceased to exist	18.6	Required	Required
The *union* keyword should not be used	19.2	Advisory	Advisory
The memory allocation and deallocation functions of *<stdlib.h>* shall not be used	21.3	Required	Required

C++ code, according to MISRA-C++:2008:

MISRA-C++:2008		
Requirement	**Ident**	**Category**
Identifiers declared in an inner scope shall not hide an identifier declared in an outer scope.	2-10-2	Required
When an array is declared, its size shall either be stated explicitly or defined implicitly by initialization.	3-1-3	Required
The One Definition Rule shall not be violated.	3-3-2	Required
The underlying bit representations of floating-point values shall not be used.	3-9-3	Required
Array indexing shall be the only form of pointer arithmetic.	5-0-15	Required

>, >=, <, <= shall not be applied to objects of pointer type, except where they point to the same array.	5-0-18	Required
The declaration of objects shall contain no more than two levels of pointer indirection.	5-0-19	Required
An object with integer type or pointer to void type shall not be converted to an object with pointer type.	5-2-8	Required
A cast should not convert a pointer type to an integral type.	5-2-9	Advisory
Floating-point expressions shall not be directly or indirectly tested for equality or inequality.	6-2-2	Required
A for loop shall contain a single loop-counter which shall not have floating type.	6-5-1	Required
If loop-counter is not modified by -- or ++, then, within condition, the loop-counter shall only be used as an operand to <=, <, > or >=.	6-5-2	Required
The loop-counter shall not be modified within condition or statement.	6-5-3	Required
The loop-counter shall be modified by one of: --, ++, -=n, or +=n ; where n remains constant for the duration of the loop.	6-5-4	Required
Any label referenced by a goto statement shall be declared in the same block, or in a block enclosing the goto statement.	6-6-1	Required
The goto statement shall jump to a label declared later in the same function body.	6-6-2	Required
For any iteration statement there shall be no more than one break or goto statement used for loop termination.	6-6-4	Required
A function shall have a single point of exit at the end of the function.	6-6-5	Required
A function shall not return a reference or a pointer to an automatic variable (including parameters), defined within the function.	7-5-1	Required
The address of an object with automatic storage shall not be assigned to another object that may persist after the first object has ceased to exist.	7-5-2	Required
Functions should not call themselves, either directly or indirectly.	7-5-4	Advisory
Functions shall not be defined using the ellipsis notation.	8-4-1	Required
Unions shall not be used.	9-5-1	Required
A base class shall only be declared virtual if it is used in a diamond hierarchy.	10-1-2	Required
An accessible base class shall not be both virtual and non-virtual in the same hierarchy.	10-1-3	Required
There shall be no more than one definition of each virtual function on each path through the inheritance hierarchy.	10-3-1	Required
Each overriding virtual function shall be declared with the virtual keyword.	10-3-2	Required
A virtual function shall only be overridden by a pure virtual function if it is itself declared as pure virtual.	10-3-3	Required
Control shall not be transferred into a try or catch block using a goto or a switch statement.	15-0-3	Required
An empty throw (throw;) shall only be used in the compound- statement of a catch handler.	15-1-3	Required
Handlers of a function-try-block implementation of a class constructor or destructor shall not reference non-static members from this class or its bases.	15-3-3	Required
A class type exception shall always be caught by reference.	15-3-5	Required
Where multiple handlers are provided in a single try-catch statement or function-try-block for a derived class and some or all of its bases, the handlers shall be ordered most-derived to base class.	15-3-6	Required
Where multiple handlers are provided in a single try-catch statement or function-try-block, any ellipsis (catch-all) handler shall occur last.	15-3-7	Required
If a function is declared with an exception-specification, then all declarations of the same function (in other translation units) shall be declared with the same set of type-ids.	15-4-1	Required
A class destructor shall not exit with an exception.	15-5-1	Required
Where a function's declaration includes an exception-specification, the function shall only be capable of throwing exceptions of the indicated type(s).	15-5-2	Required
Dynamic heap memory allocation shall not be used.	18-4-1	Required

As a summary, the numbers of coding rules for the first subset are:

- 23 for C language
- 21 for automatically generated code
- 38 for C++ language

SQR-160 The supplier shall demonstrate that all the files within a module are compliant with the "first MISRA rules subset". The supplier shall correct or justify all violations of the rules

The objective is to correct or justify all violations, i.e. zero remaining violations produced by the tool or remaining violations unjustified.

In this example 78.49% of violated MISRA-C:2012 rules listed in the first subset are justified:

Rule	violation	commented
8.8	0	0
8.11	10	10
8.13	0	0
11.1	150	120
11.2	0	0
11.4	0	0
11.5	10	8
11.6	0	0
11.7	2	2
14.1	0	0
14.2	0	0
15.1	2	1
15.2	0	0
15.3	0	0
15.5	5	5
17.1	0	0
17.2	6	0
18.3	0	0
18.4	0	0
18.5	1	0
18.6	0	0
19.2	0	0
21.3	0	0
Total	186	146
	ratio	78,49%

SQR-170 Any modification of the first subset used shall be agreed between the supplier and the automotive manufacturer

3.5.2. The second MISRA rules subset

Here is the second MISRA rules subset for C code, according to MISRA-C:2012.

A part of this subset is applicable for automatically generated code according to Appendix E of MISRA-C:2012.

This subset is applicable to C++ code also, according to MISRA-C++:2008: for each C rule, the applicability is provided in the last column of the table.

MISRA-C:2012			
Requirement	**Ident**	**Category**	**Applicability to MISRA AC AGC**
The static storage class specifier shall be used in all declarations of objects and functions that have internal linkage	8.8	Required	Required

MISRA-C:2012			
Requirement	**Ident**	**Category**	**Applicability to MISRA AC AGC**
When an array with external linkage is declared, its size should be explicitly specified	8.11	Advisory	Advisory
A pointer should point to a const-qualified type whenever possible	8.13	Advisory	Advisory
Conversions shall not be performed between a pointer to a function and any other type	11.1	Required	Required
Conversions shall not be performed between a pointer to an incomplete type and any other type	11.2	Required	Required
A conversion should not be performed between a pointer to object and an integer type	11.4	Advisory	Advisory
A conversion should not be performed from pointer to void into pointer to object	11.5	Advisory	Advisory
A cast shall not be performed between pointer to void and an arithmetic type	11.6	Required	Required
A cast shall not be performed between pointer to object and a non-integer arithmetic type	11.7	Required	Required
A cast shall not remove any const or volatile qualification from the type pointed to by a pointer	11.8	Required	Required
The precedence of operators within expressions should be made explicit	12.1	Advisory	Advisory
The comma operator should not be used	12.3	Advisory	Advisory
The value of an expression and its persistent side effects shall be the same under all permitted evaluation orders	13.2	Required	Required
The result of an assignment operator should not be used	13.4	Advisory	Advisory
A loop counter shall not have essentially floating type	14.1	Required	Advisory
A for loop shall be well-formed	14.2	Required	N/A
The controlling expression of an if statement and the controlling expression of an iteration-statement shall have essentially Boolean type	14.4	Required	Required
The goto statement should not be used	15.1	Advisory	Advisory
The goto statement shall jump to a label declared later in the same function	15.2	Required	Advisory
Any label referenced by a goto statement shall be declared in the same block, or in any block enclosing the goto statement	15.3	Required	Advisory
A function should have a single point of exit at the end	15.5	Advisory	Advisory
The body of an iteration- statement or a selection- statement shall be a compound- statement	15.6	Required	Required
All if … else if constructs shall be terminated with an else statement	15.7	Required	N/A
Every switch statement shall have a default label	16.4	Required	Advisory
A default label shall appear as either the first or the last switch label of a switch statement	16.5	Required	Advisory

MISRA-C:2012			
Requirement	**Ident**	**Category**	**Applicability to MISRA AC AGC**
The features of <starg.h> shall not be used	17.1	Required	Required
Functions shall not call themselves, either directly or indirectly	17.2	Required	Required
All exit paths from a function with non-void return type shall have an explicit return statement with an expression	17.4	Required	Required
The relational operators >, >=, < and <= shall not be applied to objects of pointer type except where they point into the same object	18.3	Required	Required
The +, -, += and -= operators should not be applied to an expression of pointer type	18.4	Advisory	Required
Declarations should contain no more than two levels of pointer nesting	18.5	Advisory	N/A
The address of an object with automatic storage shall not be copied to another object that persists after the first object has ceased to exist	18.6	Required	Required
The union keyword should not be used	19.2	Advisory	Advisory
A macro shall not be defined with the same name as a keyword	20.4	Required	Required
Tokens that look like a preprocessing directive shall not occur within a macro argument	20.6	Required	Required
Expressions resulting from the expansion of macro parameters shall be enclosed in parentheses	20.7	Required	Required
All identifiers used in the controlling expression of #if or #elif preprocessing directives shall be #define'd before evaluation	20.9	Required	Required
A macro parameter immediately following a # operator shall not immediately be followed by a ## operator	20.11	Required	Required
The memory allocation and deallocation functions of <stdlib.h> shall not be used	21.3	Required	Required

In case of C++ code, the above list is completed by the following subset of MISRA-C++:2008:

MISRA-C++:2008		
Requirement	**Ident**	**Category**
Identifiers declared in an inner scope shall not hide an identifier declared in an outer scope.	2-10-2	Required
When an array is declared, its size shall either be stated explicitly or defined implicitly by initialization.	3-1-3	Required
The One Definition Rule shall not be violated.	3-3-2	Required
An identifier declared to be an object or type shall be defined in a block that minimizes its visibility.	3-4-1	Required
typedefs that indicate size and signedness should be used in place of the basic numerical types.	3-9-2	Advisory

The underlying bit representations of floating-point values shall not be used.	3-9-3	Required
Expressions with type bool shall not be used as operands to built-in operators other than the assignment operator =, the logical operators &&, ||, !, the equality operators == and !=, the unary & operator, and the conditional operator.	4-5-1	Required
Limited dependence should be placed on C++ operator precedence rules in expressions.	5-0-2	Advisory
There shall be no explicit floating-integral conversions of a cvalue expression.	5-0-7	Required
An explicit integral or floating-point conversion shall not increase the size of the underlying type of a cvalue expression.	5-0-8	Required
An explicit integral conversion shall not change the signedness of the underlying type of a cvalue expression.	5-0-9	Required
If the bitwise operators ~ and << are applied to an operand with an underlying type of unsigned char or unsigned short, the result shall be immediately cast to the underlying type of the operand.	5-0-10	Required
The condition of an if-statement and the condition of an iteration- statement shall have type bool.	5-0-13	Required
Array indexing shall be the only form of pointer arithmetic.	5-0-15	Required
>, >=, <, <= shall not be applied to objects of pointer type, except where they point to the same array.	5-0-18	Required
The declaration of objects shall contain no more than two levels of pointer indirection.	5-0-19	Required
Each operand of a logical && or || shall be a postfix - expression.	5-2-1	Required
A pointer to a virtual base class shall only be cast to a pointer to a derived class by means of dynamic_cast.	5-2-2	Required
A cast shall not remove any const or volatile qualification from the type of a pointer or reference.	5-2-5	Required
A cast shall not convert a pointer to a function to any other pointer type, including a pointer to function type.	5-2-6	Required
An object with pointer type shall not be converted to an unrelated pointer type, either directly or indirectly.	5-2-7	Required
An object with integer type or pointer to void type shall not be converted to an object with pointer type.	5-2-8	Required
A cast should not convert a pointer type to an integral type.	5-2-9	Advisory
The comma operator, && operator and the || operator shall not be overloaded.	5-2-11	Required
The unary minus operator shall not be applied to an expression whose underlying type is unsigned.	5-3-2	Required
The unary & operator shall not be overloaded.	5-3-3	Required
The comma operator shall not be used.	5-18-1	Required

Assignment operators shall not be used in sub-expressions.	6-2-1	Required
Floating-point expressions shall not be directly or indirectly tested for equality or inequality.	6-2-2	Required
The statement forming the body of a switch, while, do ... while or for statement shall be a compound statement.	6-3-1	Required
All if ... else if constructs shall be terminated with an else clause.	6-4-2	Required
The final clause of a switch statement shall be the default-clause.	6-4-6	Required
A for loop shall contain a single loop-counter which shall not have floating type.	6-5-1	Required
If loop-counter is not modified by -- or ++, then, within condition, the loop-counter shall only be used as an operand to <=, <, > or >=.	6-5-2	Required
The loop-counter shall not be modified within condition or statement.	6-5-3	Required
The loop-counter shall be modified by one of: --, ++, -=n, or +=n ; where n remains constant for the duration of the loop.	6-5-4	Required
Any label referenced by a goto statement shall be declared in the same block, or in a block enclosing the goto statement.	6-6-1	Required
The goto statement shall jump to a label declared later in the same function body.	6-6-2	Required
For any iteration statement there shall be no more than one break or goto statement used for loop termination.	6-6-4	Required
A function shall have a single point of exit at the end of the function.	6-6-5	Required
A function shall not return a reference or a pointer to an automatic variable (including parameters), defined within the function.	7-5-1	Required
The address of an object with automatic storage shall not be assigned to another object that may persist after the first object has ceased to exist.	7-5-2	Required
Functions should not call themselves, either directly or indirectly.	7-5-4	Advisory
Functions shall not be defined using the ellipsis notation.	8-4-1	Required
All exit paths from a function with non- void return type shall have an explicit return statement with an expression.	8-4-3	Required
A function identifier shall either be used to call the function or it shall be preceded by &.	8-4-4	Required
Braces shall be used to indicate and match the structure in the non- zero initialization of arrays and structures.	8-5-2	Required
In an enumerator list, the = construct shall not be used to explicitly initialize members other than the first, unless all items are explicitly initialized.	8-5-3	Required
Unions shall not be used.	9-5-1	Required
A base class shall only be declared virtual if it is used in a diamond hierarchy.	10-1-2	Required
An accessible base class shall not be both virtual and non-virtual in the same hierarchy.	10-1-3	Required
There shall be no more than one definition of each virtual function on each path through the inheritance hierarchy.	10-3-1	Required
Each overriding virtual function shall be declared with the virtual keyword.	10-3-2	Required

A virtual function shall only be overridden by a pure virtual function if it is itself declared as pure virtual.	10-3-3	Required
Member data in non- POD class types shall be private.	11-0-1	Required
An object's dynamic type shall not be used from the body of its constructor or destructor.	12-1-1	Required
The copy assignment operator shall be declared protected or private in an abstract class.	12-8-2	Required
Control shall not be transferred into a try or catch block using a goto or a switch statement.	15-0-3	Required
An empty throw (throw;) shall only be used in the compound- statement of a catch handler.	15-1-3	Required
Handlers of a function-try-block implementation of a class constructor or destructor shall not reference non-static members from this class or its bases.	15-3-3	Required
A class type exception shall always be caught by reference.	15-3-5	Required
Where multiple handlers are provided in a single try-catch statement or function-try-block for a derived class and some or all of its bases, the handlers shall be ordered most-derived to base class.	15-3-6	Required
Where multiple handlers are provided in a single try-catch statement or function-try-block, any ellipsis (catch-all) handler shall occur last.	15-3-7	Required
If a function is declared with an exception-specification, then all declarations of the same function (in other translation units) shall be declared with the same set of type-ids.	15-4-1	Required
A class destructor shall not exit with an exception.	15-5-1	Required
Where a function's declaration includes an exception-specification, the function shall only be capable of throwing exceptions of the indicated type(s).	15-5-2	Required
Arguments to a function-like macro shall not contain tokens that look like preprocessing directives.	16-0-5	Required
In the definition of a function-like macro, each instance of a parameter shall be enclosed in parentheses, unless it is used as the operand of # or ##.	16-0-6	Required
Undefined macro identifiers shall not be used in #if or #elif preprocessor directives, except as operands to the defined operator.	16-0-7	Required
C++ macros shall only be used for: include guards, type qualifiers, or storage class specifiers.	16-2-2	Required
There shall be at most one occurrence of the # or ## operators in a single macro definition.	16-3-1	Required
Dynamic heap memory allocation shall not be used.	18-4-1	Required

As a summary, the numbers of coding rules for the first subset are:
- 39 for C language
- 36 for automatically generated code
- 72 for C++ language

SQR-180 The supplier shall demonstrate that all the files within a module are compliant with the "second MISRA rules subset". The supplier shall correct or justify all violations of the rules

The objective is to correct or justify all violations, i.e. zero remaining violations produced by the tool or remaining violations unjustified.

SQR-190 **Any modification of the second subset used shall be agreed between the supplier and the automotive manufacturer**

3.6. Systematic runtime errors

SQR-200 **The supplier shall demonstrate that for all files within a module a review of systematic runtime errors has been performed and that errors which have not been corrected are justified, for the following categories:**

- Out-of-bounds array access
- Division by zero
- Read access to non-initialized data
- Function returning non initialized value
- Integer overflow
- Float overflow
- De-referencing through null or out-of-bounds pointer
- Usage (read or dereference) of a non-initialized pointer
- Shift amount in 0..31 (0..63) and left operand of left shift is negative
- Wrong type for argument passed to a function pointer
- Wrong number of arguments passed to a function pointer
- Wrong return type of a function or a function pointer
- Wrong return type of an arithmetic function
- Non null `this`-pointer (C++ application only)
- Positive array size (C++ application only)
- Incorrect `typeid` argument (C++ application only)
- Incorrect `dynamic_cast` on pointer (C++ application only)
- Incorrect `dynamic_cast` on reference (C++ application only)
- Invalid pointer to member (C++ application only)
- Call of pure virtual function (C++ application only)
- Incorrect type for `this`-pointer (C++ application only)

SQR-210 **For each kind of runtime error the supplier shall justify the method and the process applied during the development phase to ensure the error's absence**

3.7. Non terminating function calls and loops

SQR-220 The supplier shall justify the method and the process applied during the development phase to ensure the absence of non terminating calls and loops

Note: if the code intentionally contains:

- Non terminating loops like '`while(1)`' or '`for(;;)`'
- Non terminating of calls like '`exit`', '`stop`', '`My_Non_Returning_Function`'

these should be justified.

3.8. Unreachable branches

SQR-230 The supplier shall demonstrate that files do not contain any unjustified dead code branches

Note: all defensive code and dead code intentionally contained in the application shall be justified.

3.9. Potential runtime errors

SQR-240 **The supplier shall demonstrate that for all files within a module, a review of potential runtime errors with review coverage level 1 (lowest) has been performed and that potential errors which have not been corrected are justified.** See second column in table below.

SQR-250 **The supplier shall demonstrate that for all files within a module, a review of potential runtime errors with review coverage level 2 (medium) has been performed and that potential errors which have not been corrected are justified.** See third column in table below.

SQR-260 **The supplier shall demonstrate that for all files within a module, a review of potential runtime errors with review coverage level 3 (highest) has been performed and that potential errors which have not been corrected are justified.** See last column in table below.

For each SQR, the supplier shall at least reach the following objectives identified in corresponding columns:

Potential runtime error	SQR-240	SQR-250	SQR-260
Out-of-bounds array access	80%	90%	100%
Division by zero	80%	90%	100%
Read access to local non-initialized data	80%	90%	100%
Read access to non local non-initialized data	60%	70%	80%
Function returning non initialized value	80%	90%	100%
Integer overflow	60%	80%	100%
Float overflow	60%	80%	100%
De-referencing through null or out-of-bounds pointers	60%	70%	80%
Usage (read or dereference) of a non-initialized pointer	60%	70%	80%
Shift amount in 0..31 (0.63) and left operand of left shift is negative	80%	90%	100%
Wrong type for argument passed to a function pointer	60%	80%	100%
Wrong number of arguments passed to a function pointer	60%	80%	100%
Wrong return type of a function or a function pointer	60%	80%	100%
Wrong return type for arithmetic functions	60%	80%	100%
Non null `this`-pointer (C++ application only)	50%	70%	90%
Positive array size (C++ application only)	50%	70%	90%
Incorrect `typeid` argument (C++ application only)	50%	70%	90%
Incorrect `dynamic_cast` on pointer (C++ application only)	50%	70%	90%
Incorrect `dynamic_cast` on reference (C++ application only)	50%	70%	90%
Invalid pointer to member (C++ application only)	50%	70%	90%
Call of pure virtual function (C++ application only)	50%	70%	90%
Incorrect type for `this`-pointer (C++ application only)	50%	70%	90%

3.10. Dataflow Analysis

SQR-270 The supplier shall provide for each module the data flow analysis results

This shall contain at least:

- Component call tree
- Dictionary containing read/write accesses to global variables
- List of shared variables and their associated concurrent access protection (if any)

4. REQUIREMENT MAPPING WITH ISO 26262-6:2018

4.1. Purpose and scope

This section describes a possible way to fulfill some ISO 26262:2018 part 6 objectives at the software level.

It provides guidance for compliance with methods defined by ISO 26262-6:2018. It describes how and in which detail to comply with ISO requirements, includes methods to verify code, and traces with ISO 26262-6:2018 tables and paragraphs.

4.2. Summary

The table below summarizes the proposed mapped sections or tables of ISO 26262-6:2018 with SQR groups. It also summarizes in the comment column what the SQO document can help achieving in context of the ISO 26262-6:2018 verification process.

The mapping with the ISO standard can be of two different kinds:

- Mapping with tables: the SQR can trace with some specific methods of the tables.
- Mapping with sections: the SQR can help address part of the requirements of the sections.

The proposed requirements which the document helps to fulfill are the following:

- Avoid non-deterministic, implementation-defined, or undefined behavior.
- Achieve non functional requirement such as software robustness.

	ISO 26262-6:2018 section	*ISO ref*	*SQR*	*Comment*
Mapping with tables	#5. General topics for the product development at the software level	• Table 1	• 140 to 190 • 270	The application of these SQRs can help support the correctness of the design and implementation
	#8. Software unit design and implementation	• Table 6 •	• 50 to 80 • 140 to 200 • 240 to 270	The application of the SQO document enables to comply with the requirements defined in table 6
	#9. Software unit verification	• Table 7 •	• 70 • 110 to 190 • 200 to 270	The application of the SQO document enables to comply with the requirements defined in table 7
	#10. Software integration and verification	• Table 10	• 70 • 110 to 190 • 200 to 270	The application of the SQO document enables to comply with the requirements defined in table 10
Mapping with sections	#9. Software unit testing	• Section 9.4.2	• 200 to 270	The application of the SQO document enables to reduce unit tests, such as • absence of unintended functionality; • robustness; The note h of Table 7 mentions the need to detect errors in case of “corrupting values of variables”. This is covered by SQR-200 to SQR-260 if full range is used for inputs of the application
	#10. Software integration and verification	• Section 10.4.2	• 230	The application of the SQO document enables to reduce integration testing, such as • Robustness The example for 10.4.2.d mentions the need of reliability due to absence of inaccessible software, robustness against erroneous inputs, dependability due to effective error detection and handling. This is covered by SQR-200 to SQR-260 if full range is used for inputs of the application

4.3. Details

Note 1: in this section, MISRA-C:2012 rules are provided as examples. The equivalent mapping is available for C++ by looking at the MISRA-C++:2008 corresponding rules in section 3.5.

Note 2: all SQRs from column "Related SQRs" shall be applied to cover the corresponding ISO 26262-6:2018 Method or Section.

4.3.1. Section 5: General topics for the product development at the software level

Table 1 – Topics to be covered by modeling and coding guidelines

Methods		Related SQRs	Comments
1a	Enforcement of low complexity	140, 150	One purpose of code metrics and their boundaries is to ensure a low complexity of software
1b	Use of a language subsets	160, 170, 180, 190	Both MISRA subsets defined in paragraph 3.5 contain rules ensuring the use of a subset of C and C++ languages. For example: 12.10, 13.1, 14.4, 18.4, …
1c	Enforcement of strong typing	160, 170, 180, 190	Both MISRA subsets defined in paragraph 3.5 contain rules ensuring a strong typing in C and C++ languages. For example: 6.3, 8.12, 11.1, 16.7, 17.5, …
1d	Use of defensive implementation techniques	160, 170, 180, 190	Second MISRA subset defined in paragraph 3.5 contain rules ensuring defensive programming in C and C++ languages. For example: 14.10, 15.3, …
1e	Use of well-trusted design principles	160, 170 180, 190	Both MISRA subsets defined in paragraph 3.5 contain rules ensuring the use of established design principles. For example: 8.7, 16.2, 16.8, 17.5, …
1h	Use of naming conventions	270	The Data Dictionary enables to review naming conventions on global variables
1i	Concurrency aspects	270	The data dictionary enables detection of unprotected variables.

4.3.2. Section 8: Software unit design and implementation

Table 6 – Design principles for software unit design and implementation

Methods		Related SQR	Comments
1a	One entry and one exit point in subprograms and functions	160, 170	MISRA-C:2012 rule 15.5
1b	No dynamic objects or variables, or else online test during their creation	160, 170	MISRA-C:2012 rule 21.3
1c	Initialization of variables	200, 240, 250, 260	This measure of the table can be traced with the runtime errors results, such as • "Read access to local non-initialized data" • "Read access to non local non-initialized data"
1d	No multiple use of variables names	160, 170	The enforcement of MISRA-C:2012 rules 5.1, 5.2, 5.3. 5.8 and 5.9 help detect variables with same name in nested scopes
1e	Avoid global variables or else justify their usage	160, 170, 180, 190, 270	• The Data Dictionary containing read/write accesses to global variables provided during Dataflow analysis can help in implementing this rule • The enforcement of MISRA-C:2012 rules 8.7 and 8.9 can help detect variables whose scope should not be global
1f	Limited use of pointers	160, 170, 180, 190	Both MISRA subsets defined in paragraph 3.5 contain rules ensuring the use of established design principles. For example: 11.1, 11.2, 11.4, 11.5, 16.7, 17.3, 17,4, 17.5, 17.6, …
		200, 240, 250, 260	This measure of the table can be traced with the runtime errors results, such as • "De-referencing through null or out-of-bounds pointer " • "Usage (read or dereference) of a non-initialized pointer" • Function pointer with invalid dynamic arguments
1g	No implicit type conversions	160, 170, 180, 190	Both MISRA subsets defined in paragraph 3.5 contain rules ensuring the use of established design principles related to Pointer Type Conversion. For example: 11.1, 11.2, 11.3, 11.5 MISRA-C:2012 rules 10.* enforce the use of implicit conversion of *essential type model*
1h	No hidden data flow or control flow	160, 170	MISRA-C:2012 rule 5.3
1i	No unconditional jumps	160, 170	MISRA-C:2012 rule 15.1
1j	No recursions	140, 150 160, 170	MISRA-C:2012 rule 17.2

4.3.3. <u>Section 9: Software unit verification</u>

Table 7 - Methods for software unit verification

Methods		Related SQR	Comments
1a	Walk-through	200, 240	This measure of the table can be partially supported by output of SQRs 200 and 240: as soon as the list of potential runtime errors is produced, it can be walked through
1c	Inspection	200, 240, 250, 260, 270	This measure of the table can be partially supported by output of SQRs 200, 240 to 260 and 270. The code can be inspected with a highlight of systematic and potential runtime errors. Data Dictionary and Call Tree of the component can also be inspected to detect any issue.
1e	Formal verification	200, 240, 250, 260	Absence of runtime errors such as divisions by zero or overflows is an implicit specification of systems. Proving their absence is part of proving the correctness of a system against this implicit specification. This method is partially covered, because C and C++ are not formal notations.
1f	Control flow analysis	110-120	This measure of the table can be partially provided by output of SQR 110 – 120 (application level and file level description) Remark: as mentioned in note ‘c’ of Table 9, this requirement can be covered by using a method based on Formal verification (‘1d’) or Semantic code analysis (‘1h’)
1g	Data flow analysis	270	It is the aim of SQR 270 Remark: as mentioned in note ‘c’ of Table 9, this requirement can be covered by using a method based on Formal verification (‘1d’) or Semantic code analysis (‘1h’)
1h	Static code analysis	140, 160, 170, 180, 190	Complexity metrics and MISRA rules checking help to fulfill this measure of the table
1i	Static analyses based on abstract interpretation	70, 200, 240, 250, 260	Runtime error detection by Abstract Interpretation is a Semantic Code Analysis, as defined by the note ‘d’ of Table 9.

If SQR 200 to 260 are fulfilled, the applicant might consider focusing the software unit testing methods listed in tables 7 (1j to 1n), 8 and 9 on the other objectives defined in section 9.4.2. These objectives are listed below for information:

a. compliance with the requirements regarding the unit design and implementation
b. the compliance of the source code with its design specification
c. compliance with the specification of the hardware-software
e. Sufficient resources to support their functionality and properties
f. implementation of the safety measures resulting from the safety-oriented

There is no need to focus on objective d (*confidence in the absence of unintended functionality and properties*) as this objective is achieved if SQR 200 to 260 are fulfilled.

4.3.4. Section 10: Software integration and verification

Table 10 - Methods for verification of software integration

Methods		Related SQR	Comments
1f	Verification of the control flow and data flow	110-120	This measure of the table can be partially provided by output of SQR 110 – 120 (application level and file level description) Remark: as mentioned in note 'c' of Table 9, this requirement can be covered by using a method based on Formal verification ('1d') or Semantic code analysis ('1h')
		270	It is the aim of SQR 270 Remark: as mentioned in note 'c' of Table 9, this requirement can be covered by using a method based on Formal verification ('1d') or Semantic code analysis ('1h')
1g	Static code analysis	140, 160, 170, 180, 190	Complexity metrics and MISRA rules checking help to fulfill this measure of the table
1h	Static analyses based on abstract interpretation	70, 200, 240, 250, 260	Runtime error detection by Abstract Interpretation is a Semantic Code Analysis, as defined by the note 'd' of Table 9.

If SQR 200 to 260 are fulfilled, the applicant might consider focusing the software integration testing methods listed in tables 10 (1a to 1e), 11 and 12 on the other objectives defined in section 10.4.2. These objectives are listed below for information:

a. compliance with the software architectural design
b. compliance with the hardware-software interface specification
c. the specified functionality
e. Sufficient resources to support the functionality
f. effectiveness of the safety measures resulting from the safety-oriented analysis

There is no need to focus on objective d (*the specified properties; EXAMPLE Reliability due to absence of inaccessible software, robustness against erroneous inputs, dependability due to effective error detection and handling*) as this objective is achieved if SQR 200 to 260 are fulfilled.

4.4. Traceability SQO levels / ISO 26262-6:2018 requirements

To ease the reading of the traceability matrix next page, the SQRs associated with each SQO level are provided again in the following table:

SQO level	SQRs
SQO-1	10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170
SQO-2	Idem SQO-1, 200, 210, 220
SQO-3	Idem SQO-2, 230
SQO-4	Idem SQO-3, 240
SQO-5	Idem SQO-4, 180, 190, 250
SQO-6	Idem SQO-5, 260, 270

The following table lists which ISO 26262-6:2018 requirements are covered for different SQO levels. It is also mentioned if the requirement is not, fully or partially covered.

ISO 26262-6:2018 objective								SQO level Required	No/Partial/ Full coverage
Table		**Method**		**ASIL-A**	**ASIL-B**	**ASIL-C**	**ASIL-D**		
Table 1	*Topics to be covered by modeling and coding guidelines*	1a	Enforcement of low complexity	++	++	++	++	SQO-1	Full
		1b	Use of language subsets	++	++	++	++	SQO-5	Full
		1c	Enforcement of strong typing	++	++	++	++	SQO-5	Full
		1d	Use of defensive implementation techniques	+	+	++	++	SQO-5	Partial
		1e	Use of well-trusted design principles	+	+	++	++	SQO-5	Partial
		1f	Use of unambiguous graphical representation	+	++	++	++	N/A	No
		1g	Use of style guides	+	++	++	++	N/A	No
		1h	Use of naming conventions	++	++	++	++	SQO-6	Partial
		1i	Concurrency aspects	+	+	+	+	SQO-6	Full
Table 2	*Notations for software architectural design*							N/A	No
Table 3	*Principles for software architectural design*							N/A	No
Table 4	*Methods for the verification of the software architectural design*							N/A	No
Table 5	*Notations for software unit design*							N/A	No
Table 6	*Design principles for software unit design and implementation*	1a	One entry and one exit point in subprograms and functions	++	++	++	++	SQO-1	Full
		1b	No dynamic objects or variables, or else online test during their creation	+	++	++	++	SQO-1	Partial
		1c	Initialization of variables	++	++	++	++	SQO-6	Full
		1d	No multiple use of variables names	++	++	++	++	SQO-1	Partial
		1e	Avoid global variables or else justify their usage	+	+	++	++	SQO-6	Partial
		1f	Restricted use of pointers	+	++	++	++	SQO-6	Full
		1g	No implicit type conversions	+	++	++	++	SQO-5	Full
		1h	No hidden data flow or control flow	+	++	++	++	SQO-1	Partial
		1i	No unconditional jumps	++	++	++	++	SQO-1	Full
		1j	No recursions	+	++	++	++	SQO-1	Full
Table 7	*Methods for software unit verification*	1a	Walk-through	++	+	O	O	SQO-4	Partial
		1b	*Pair programming*	+	+	+	+	N/A	No
		1c	Inspection	+	++	++	++	SQO-6	Partial
		1d	*Semi-formal verification*	+	+	++	++	N/A	No
		1e	Formal verification	O	O	+	+	SQO-6	Partial
		1f	Control flow analysis	+	+	++	++	SQO-1	Partial
		1g	Data flow analysis	+	+	++	++	SQO-6	Full
		1h	Static code analysis	++	++	++	++	SQO-5	Full
		1i	Static analyses based on abstract interpretation	+	+	+	+	SQO-6	Full
		1j	*Requirement-based test*	++	++	++	++	N/A	No
		1k	*Interface test*	++	++	++	++	N/A	No
		1l	*Fault injection*	+	+	+	++	N/A	No
		1m	*Resource usage evaluation*	+	+	+	++	N/A	No
		1n	*Back-to-back comparison test between model and code, if applicable*	+	+	++	++	N/A	No
Table 8	*Methods for deriving test cases for software unit testing*							N/A	No
Table 9	*Structural coverage metrics at the software unit level*							N/A	No
Table 10	*Methods*	*1a*	*Requirements-based test*	++	++	++	++	N/A	No
		1b	*Interface test*	++	++	++	++	N/A	No
		1c	*Fault injection test*	+	+	++	++	N/A	No
		1d	*Resource usage evaluations*	++	++	++	++	N/A	No
		1e	*Back-to-back comparison test between model and code, if applicable*	+	+	++	++	N/A	No
		1f	Verification of the control flow and data flow	+	+	++	++	SQO-6	Full
		1g	Static code analysis	++	++	++	++	SQO-5	Full
		1h	Static analyses based on abstract interpretation	+	+	+	+	SQO-6	Full
Table 11	*Methods for deriving test cases for software integration testing*							N/A	No
Table 12	*Structural coverage at the software architectural level*							N/A	No

Table 13	*Test environments for conducting the software testing*					N/A	No
Table 14	*Methods for tests of the embedded software*					N/A	No
Table 15	*Methods for deriving test cases for the test of the embedded software*					N/A	No

5. TERMS AND ABBREVIATIONS

MISRA AC AGC: Guidelines for the application of MISRA-C:2004 in the context of automatic code generation.

COTS: **Commercial, off-the-shelf** is a term for software or hardware, generally technology or computer products, that are ready-made and available for sale, lease, or license to the general public. They are often used as alternatives to in-house developments or one-off government-funded developments. The use of COTS is being mandated across many government and business programs, as they may offer significant savings in procurement and maintenance. However, since COTS software specifications are written by external sources, government agencies are sometimes wary of these products because they fear that future changes to the product will not be under their control.

Manufacturer: is a company that uses a component made by a second company in its own product, or sells the product of the second company under its own brand. It constitutes a federally-licensed entity Required to warrant and/or guarantee their products, unlike "aftermarket" which is not legally bound to a government-dictated level of liability.

HIS: Hersteller Inititiative Software. Initiative from German automotive manufacturers (Audi, BMW Group, DaimlerChrysler, Porsche and Volkswagen) whose goal is the production of agreed standards within the area of standard software modules for networks, development of process maturity, software test, software tools and programming of ECU’s.

HIS specifies a fundamental set of Software Metrics to be used in the evaluation of software.

Supplier: automotive components manufacturer.

SQO: Software Quality Objectives

SQR: Software Quality Requirement