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Application Note
QP/C++™ MISRA-C++:2008 Compliance Matrix

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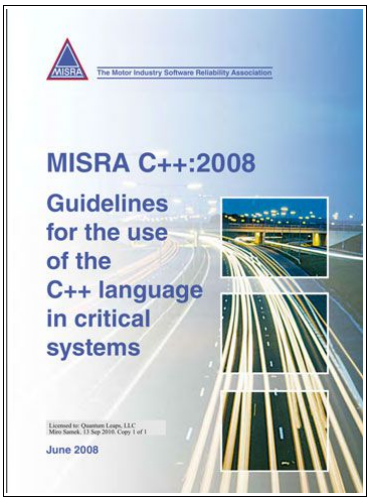
Table of Contents

1 Introduction

This Application Note describes the compliance of the QP/C++™ state machine framework version **4.5.04** or higher and the application code based on this framework with the Motor Industry Software Reliability Association (MISRA) Guidelines for the use of the C++ Language in Critical Systems [MISRA-C++:2008]. This Application Note is designed to be applied to production code in safety-related embedded systems.

1.1 About MISRA-C++:2008

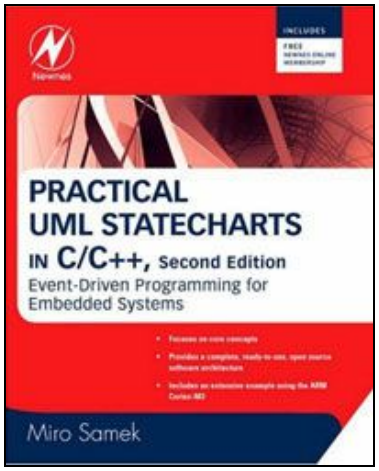


MISRA, the Motor Industry Software Reliability Association (www.misra.org.uk), is a collaboration between vehicle manufacturers, component suppliers, and engineering consultancies, which seeks to promote best practices in developing **safety-related electronic systems** in road vehicles and other embedded systems.

Since it's original publication in 1998 [MISRA-C:1998], the original MISRA-C guidelines have gained an unprecedented level of acceptance and use not only in the automotive industry, but in all kinds of embedded systems around the world. Following this initial success, in 2008 MISRA published a set of rules for using C++ in safety-critical embedded systems, known as the MISRA-C++:2008.

Due to the numerous idiosyncrasies, pitfalls, and undefined behavior of the standard C++ language, most experts agree that the full, unconstrained language should **not** be used for programming safety-critical systems. Consequently, the main objective of the MISRA-C++ guidelines was to define and promote a **safer subset** of the C++ language suitable for safety-related embedded systems. The [MISRA-C++:2008] guidelines define this language subset by means of 229 rules that restrict the use of the known problematic aspects of the language. For each of the rules the MISRA-C++ guidelines provide justification and examples.

1.2 About QP™



QP/C++™ is a lightweight, open source, state machine framework for developing event-driven embedded software. The QP/C++ framework enables software developers to build well-structured embedded applications as systems of concurrently executing hierarchical state machines (UML statecharts). QP has been described in great detail in the book *Practical UML Statecharts in C/C++, Second Edition: Event-Driven Programming for Embedded Systems* [PSiCC2 08] (Newnes, 2008).

The use of a tested framework, such as QP/C++, addresses the growing concern over the robustness of the **design**, not just the coding aspects of **safety-critical software**. To this end, a framework based on the proven concepts of state machines and active objects provides a more robust and safer design platform than a primitive “super-loop” or an unstructured design based on a traditional Real-Time Operating System (RTOS). The QP/C framework enforces **safe** design and encapsulates or eliminates the troublesome RTOS mechanisms, such as semaphores, which many programmers do not use correctly or safely.

2 Checking MISRA-C++ Compliance with PC-Lint/FlexeLint

The [MISRA-C++:2008] guidelines place great emphasis on the use of **static code analysts tools** to check compliance with the MISRA-C++ language subset. In fact, the automatic enforcement of as many rules as possible is mandated by MISRA-C++:2008 required rule 0-3-1.

> **NOTE:** The completely automatic enforcement of 100% of the MISRA-C++ rules is not possible and was never intended. Some of the rules are only enforceable by manual review of the code or checking the compiler/linker tools by other means.

This Application Note uses **PC-Lint/FlexeLint** version **9.00j** from Gimpel Software [www.Gimpel.com], which is a static analysis tool for C and C++ with one of the longest track records and best value of the money in the industry. PC-Lint has been supporting checks for the MISRA-C guidelines since early 2001, and MISRA-C++ since 2009. The company is committed to provide ongoing and increasing support for these guidelines (see [PC-Lint 08]).

The primary way of activating MISRA checking for MISRA-C++:2008 guidelines in PC/Lint is via the option file [PC-Lint/MISRA-C++:2008]:

```
au-misra-cpp.lnt
```

This file contains the options to activate and annotate PC-Lint messages dealing with MISRA-C++:2008. PC-Lint can report deviations from several MISRA C++ rules with messages 1960 and 1963. Additional rules, are covered in other messages, the details of which you can find listed in the `au-misra-cpp.lnt` file.

> **NOTE:** The `au-misra-cpp.lnt` configuration file is also the best overall **documentation** on MISRA-C++:2008 coverage, including not just which rules are covered, but also **how** they are checked and what messages are produced.

2.1 Structure of PC-Lint Options for QP/C++

PC-Lint has several places where it reads its currently valid options:

- From special Lint option files (usually called `*.lnt`)
- From the command line
- From within the special lint-comments in the source code modules (**not** recommended)

The QP/C++ source code and example application code has been “linted” only by means of the first alternative (option files) with possibility of adding options via command line. The third alternative—lint comments—is **not** used and Quantum Leaps does not recommend this alternative.

> **NOTE:** The QP/C++ source code is completely **free** of lint comments, which are viewed as a contamination of the source code.

The structure of the PC-Lint option files used for “linting” QP/C++ follows exactly the Gimpel Software guidelines for configuring PC-Lint (See Section 3.2 “Configuration” in the PC-Lint/FlexeLint Manual). The design and grouping of the lint options also reflects the fact that static code analysis of a software **framework**, such as QP/C++, has really two major aspects. First, the source code of the framework itself has to be analyzed. But even more important and helpful to the users of the framework is providing the infrastructure to effectively analyze the **application-level** code based on the framework. With this in mind, Listing 1 shows that the PC-Lint options for static analysis of QP/C++ are divided into two groups, located

in directories `qpcpp\include\` and `qpcpp\ports\lint\`. These two groups are for analyzing QP/C++ applications and QP/C++ source code, respectively.

Listing 1: PC-Lint options for "linting" QP/C++ applications (qpcpp\include\) and "lining" QP/C++ source code itself (qpcpp\ports\lint\).

```
%QPCPP%\                - QP/C++ Root Directory (environment variable QPCPP)
 |
 +-include\             - QP/C++ platform-independent includes
 | +-au-ds.lnt          - Dan Saks recommendations
 | +-au-misra-cpp.lnt   - Main PC-Lint MISRA-C++:2008 compliance options
 | +-lib-qpcpp.lnt      - PC-Lint options for QP/C++ applications
 | +-std.lnt            - Standard PC-Lint settings recommended by Quantum Leaps
 | +-qassert.h          - QP/C++ header file
 | +-qep.h              - QP/C++ header file
 | +-. . .              - . . .
 | |
 | +-ports\             - QP/C++ ports directory
 | | +-lint\            - QP/C++ "port" to PC-Lint
 | | | +-lin.bat        - Batch file to invoke PC-Lint to run analysis of QP/C++ code
 | | | +-options.lnt    - PC/Lint options for "linting" QP/C++ source code
 | | | +-lint_qep.txt   - PC/Lint output for the QEP component of QP/C++
 | | | +-lint_qf.txt    - PC/Lint output for the QF component of QP/C++
 | | | +-lint_qk.txt    - PC/Lint output for the QK component of QP/C++
 | | | +-lint_qs.txt    - PC/Lint output for the QS component of QP/C++
 | | | +-qep_port.h     - QEP component "port" to a generic ANSI C++ compiler
 | | | +-qf_port.h      - QF component "port" to a generic ANSI C++ compiler
 | | | +-qk_port.h      - QK component "port" to a generic ANSI C++ compiler
 | | | +-qs_port.h      - QS component "port" to a generic ANSI C++ compiler
 | | | +-stdint.h       - Standard exact-width integers for an ANSI C++ compiler
 | |
 | +-examples\          - QP/C++ examples directory
 | | +-arm-cortex\      - QP/C++ examples for ARM Cortex
 | | | +-qk\            - QP/C++ examples for ARM Cortex with QK kernel
 | | | | +-gnu\         - QP/C++ examples with GNU compiler
 | | | | | +-dpp-qk-ev-lm3s811-lint\ - Lint-compatible example for GNU
 | | | | +-iar\         - QP/C++ examples with IAR compiler
 | | | | | +-dpp-qk-ev-lm3s811-lint\ - Lint-compatible example for IAR
```

NOTE: This Application Note assumes that the baseline distribution of the QP/C++ framework has been downloaded and installed and that the environment variable `QPCPP` has been defined to point to the QP/C++ installation directory.

As shown in Listing 1, the directory `%QPCPP%\include\`, contains the PC-Lint options for "linting" the **application** code along with all platform-independent QP/C++ header files required by the applications. This collocation of lint options with header files simplifies "linting", because specifying just `-i%QPCPP%\include\` include directory to PC-Lint accomplishes both inclusion of QP/C++ header files and PC-Lint options.

Note that the `%QPCPP%\include\` directory contains **all** PC-Lint option files used in "linting" the code, including the standard MISRA-C++:2008 `au-misra-cpp.lnt` option file as well as Dan Saks' recommendations `au-ds.lnt`, which are copied from the PC-Lint distribution. This design freezes the lint options for which the compliance has been checked.

2.1.1 The std.lnt option file

According to the Gimpel Software PC-Lint configuration guidelines, the file `%QPC%\include\std.lnt` file, shown in Listing 2,contains the top-level options, which Quantum Leaps recommends for all projects. These options include the formatting of the PC-Lint messages and making two passes to perform better cross-module analysis. However, the most important option is `-restore_at_end`, which has the effect of surrounding each source file with options `-save` and `-restore`. This precaution prevents options from "bleeding" from one file to another.

Listing 2: Top-level option file std.lnt

```
// output: a single line, file info always, use full path names
-hF1
+ffn
-"format=%(\q%f\q %l %C%) %t %n: %m"

-width(0,0)        // do not break lines
+flm               // make sure no foreign includes change the format

-zero(99)          // don't stop make because of warnings

-passes(2)         // make two passes (for better error messages)

-restore_at_end    // don't let -e<nn> options bleed to other files

-summary()         // produce a summary of all produced messages
```

2.1.2 The `lib-qpcpp.lnt` option file

The most important file for "linting" QP/C++ applications is the `lib-qpcpp.lnt` option file. This file handles all deviations from the MISRA-C++:2008 rules, which might arise at the **application-level** code from the use of the QP/C++ framework. In other words, the `lib-qpcpp.lnt` option file allows completely clean "linting" of the application-level code, as long as the application code does not deviate from any of the MISRA-C++:2008 rules.

At the same time, the `lib-qpcpp.lnt` option file has been very carefully designed **not** to suppress any MISRA-C++:2008 rule checking outside the very specific context of the QP/C++ API. In other words, the `lib-qpcpp.lnt` option file still supports **100% of the MISRA-C++:2008 rule checks** that PC-Lint is capable of performing.

For example, for reasons explained in Section 5.12, QP/C++ extensively uses function-like macros, which deviates from the MISRA-C++:2008 advisory rule 19.7 and which PC-Lint checks with the warning 961. However, instead of suppressing this warning globally (with the `-e961` directive), the `lib-qpcpp.lnt` option file suppresses warning 961 **only** for the specific QP function-like macros that are visible to the application level. So specifically, the `lib-qpcpp.lnt` file contains directives `-estring(961, Q_TRAN, Q_SPUER, ...)`, which suppresses the warning only for the specified macros, but does not disable checking of any other macros in the application-level code.

Listing 3: file `lib-qpcpp.lnt`

```
// general (event.h)
-estring(1960,          // 11-0-1(req) non-private data member
 sig,
```

```
 poolId_,
 refCtr_)
-estring(1927,          // 8-5-1(req) not in the ctor initializer
 *QEvt::poolId_,
 *QEvt::refCtr_)
-estring(1923,          // 16-2-2(req) could become const variable
 Q_USE_NAMESPACE,
 Q_EVT_CTOR,
 Q_SIGNAL_SIZE,
 QP_VERSION)
-emacro(923, Q_UINT2PTR_CAST) // 5-2-7, 5-2-8 cast from int to pointer
-estring(1960,          // 16-0-4(req) function-like macro
 Q_DIM,
 Q_UINT2PTR_CAST)
-esym(1790,             // Base class has no virtual functions
 *QEvt)
-estring(1712, QEvt)    // default constructor not defined
-estring(1401,          // member not initialized in the ctor
 *QEvt::poolId_,
 *QEvt::refCtr_)
-emacro(866, Q_DIM)     // Unusual use of 'SYM' in argument to sizeof
-estring(970,bool)      // Use of 'bool' outside of a typedef

// Assertions
-estring(1960,          // 16-0-4 function-like macro
 Q_ASSERT,
. . .
 Q_DEFINE_THIS_MODULE)
. . .
-function(exit, Q_onAssert)  // give Q_onAssert() the semantics of "exit"


// QEP
-emacro(929,           // 5-2-7(req) cast pointer to pointer
 Q_STATE_CAST,
 Q_EVENT_CAST)
-emacro(1939,          // 5-2-2, Down cast detected
 Q_EVENT_CAST,
 Q_NEW)
-esym(1960,            // 16-0-4 function-like macro
 Q_ROM_BYTE,
 Q_TRAN,
 Q_SUPER,
 Q_STATE_CAST,
 Q_EVENT_CAST)
-esym(1712,            // default constructor not defined
 QFsm,
 QHsm)

// QF
-emacro(929, Q_NEW)    // 5-2-7 cast from pointer to pointer
-esym(1927,            // 8-5-1 Symbol not in the ctor initializer list
 *QActive::m_prio,
 *QActive::m_eQueue,
 *QActive::m_osObject,
```

```
 *QActive::m_thread)
-estring(1923,        // 16-2-2 could become const variable
 QF_MAX_ACTIVE,
 . . .)
-esym(1960,           // 16-0-4 function-like macro
 QF_QS_CRIT_EXIT,
 . . .)
-estring(1963, Q_NEW) // 16-3-2(adv) '#/##' used in macro
-esym(1790,           // Base class has no virtual functions
 *QHsm,
 *QFsm,
 *QActive)
-esym(1401,           // member not initialized by constructor
 *QActive::m_prio,
 *QActive::m_eQueue,
 *QActive::m_osObject,
 *QActive::m_thread)
-esym(1712,           // default constructor not defined for class
 *QActive,
 *QTimeEvt)
-esym(641, *Signals)  // Converting enum '*Signals' to 'int'

// QK
-esym(1960,           // 16-0-4 function-like macro
 QK_ISR_ENTRY,
 . . .)

// QS
-emacro(506, QS_*)    // 0-1-1 constant value boolean
-emacro(774, QS_*)    // 0-1-1 'if' always True
-emacro(930, QS_*)    // 5-2-7 cast from enum to unsigned char
-emacro(923,          // 5-2-7, 5-2-8 cast from pointer to int
 QS_OBJ_,
 QS_FUN_)
-estring(1923,        // 16-2-2 macro could become const variable
 QS_TIME_SIZE,
 . . .)
-esym(1960,           // 16-0-4 function-like macro
. . .)
-esym(1923,           // 16-2-2 could become const variable
 QS_INIT,
 QS_EXIT,
 . . .)
-esym(1963,           // 16-3-2, '#/##' operator used in macro
 QS_SIG_DICTIONARY,
 . . .)
-emacro(717, QS_*)    // do ... while(0);
-emacro(725, QS_END*) // Expected positive indentation
-esym(641, *QSType)   // Converting enum '*QSType' to 'int'

// Miscallaneous
-estring(793,6)       // ANSI/ISO limit of 6 significant chars exceeded
-e546                 // Suspicious use of &
```

NOTE: Any changes to the PC-Lint option files (e.g., as part of upgrading PC-Lint) must be done with **caution** and must be always followed by regression analysis of all source code.

2.2 The QP:: Namespace

The MISRA-C++:2008 group of required rules **7-3**-x ("Namespaces") is concerned with avoiding name conflicts by applying C++ namespaces. To comply with these rules, QP/C++ source code must be configured to place all declarations and definitions in the `QP::` namespace. Starting with QP/C++ version **4.5.02** QP/C++ applies the `QP::` namespace by defining default.

> **NOTE:** The configuration macro **`Q_NNAMESPACE`** suppresses generation of the `QP::` namespace. If you don't want the namespace, you should define this macro in the `qep_port.h` header file in the QP/C++ port.

Please note also that compliance with the rules **7-3**-x requires also the **application-level code** to use a specific namespace as opposed to contaminate the global namespace. The application-level code can either extend the `QP::` namespace, or it can use its own distinct namespace. Either way, all QP elements must be explicitly qualified with the `QP::` namespace prefix, as the "`using namespace QP`" directive is not allowed by the required rules 7-3-4, 7-3-5, and 7-3-6.

> **NOTE:** To comply with MISRA-C++:2008, the applications must explicitly qualify all QP/C++ elements with the `QP::` namespace prefix. The MISRA-compliant application examples (see Listing 1) show how to use the `QP::` namespace prefix.

2.3 QS Software Tracing and the Spy (Q_SPY) Configuration

As described in Chapter 11 of the book "Practical UML Statecharts in C/C++" [PSiCC2], all components of the QP/C++ framework contain software tracing instrumentation (called Quantum Spy, or QS). This instrumentation code is inactive in the Debug and Release build configurations, but becomes active in the **Spy** configuration.

In the context of MISRA-C++ compliance it is important to note that, by the nature of software tracing, the QS code embedded in the QP/C++ framework contributes disproportionately to the total number of deviations from the MISRA-C++ rules, both in the QP/C++ source code and in the application-level code. However, these deviations occur only in the Spy build configuration, which is **not** the code shipped within a product.

> **NOTE:** Many of the deviations from the MISRA-C++:2008 rules reported in the upcoming MISRA Compliance Matrix do **not** pertain to the production code.

2.4 Checking MISRA Compliance of a QP/C++ Source Code

The directory `%QPCPP%\ports\lint\` (see Listing 1) contains the `lin.bat` batch file for "linting" the QP/C++ source code. The `lin.bat` batch file invokes PC-Lint and directs it to generate the diagnostic to specific output files. As shown in Listing 1, the lint output is collected into four text files `lint_qep.txt`, `lint_qf.txt`, `lint_qk.txt`, and `lint_qs.txt`, for QEP, QF, QK, and QS components of the QP/C++ framework, respectively.

> **NOTE:** In order to execute the `lin.bat` file on your system, you might need to adjust the symbol `PC_LINT_DIR` at the top of the batch file, to the PC-Lint installation directory on **your** computer.

The `lin.bat` batch file invoked without any command-line options checks the code in the default configuration corresponding to Run or Debug build of a project. But the `lin.bat` batch can also be invoked with the option `-dQ_SPY` to check the QP/C++ code in the QS configuration with software tracing.

> **NOTE:** By the nature of software tracing, the `Q_SPY` configuration transgresses many more MISRA-C++:2008 rules than the standard configuration. However, the `Q_SPY` configuration is never used for production code, so the MISRA-C++ compliance of the QP/C++ framework should **not** be judged by the deviations that happen only in the `Q_SPY` configuration.

According to the PC-Lint guidelines, the `lin.bat` uses two option files: the `std.lnt` option file discussed before and the `options.lnt` option file that covers all deviations from the MISRA-C++ rules in the QP/C++ source code. Section 3 (MISRA compliance matrix) cross-references all these deviations, while Section 5 (deviation procedures) describes the reasons for deviations in those, very specific contexts.

2.5 Checking MISRA Compliance of a QP/C++ Application Code

The QP/C++ baseline code (for versions QP/C++ 4.4.00 and higher) contains two examples of MISRA-C++ compliance checking with PC/Lint:

- The DPP example for the EK-LM3S811 Cortex-M3 board with the IAR ARM compiler, located in the directory `qpcpp\examples\arm-cortex\qk\`**`iar`**`\dpp-qk-ev-lm3s811-lint\`; and
- The DPP example for the EK-LM3S811 Cortex-M3 board with the GNU ARM compiler, located in the directory `qpcpp\examples\arm-cortex\qk\`**`gnu`**`\dpp-qk-ev-lm3s811-lint\`.

The PC-Lint analysis is very simple and requires invoking the `lin.bat` file from the `lint\` subdirectory in each of the application folders.

> **NOTE:** In order to execute the `lin.bat` file on your system, you might need to adjust the symbol `PC_LINT_DIR` at the top of the batch file, to the PC-Lint installation directory on **your** computer. You

The `lint\` subdirectory in each of the application folders contains also the `options.lnt` with the PC-Lint options specific to linting the application. This file specifies the include directory for the specific embedded compiler used to compile the application, and you most likely need to adjust it for your system.

Running PC-Lint on embedded projects (such as the DPP example for ARM Cortex-M) requires option files for the specific compilers (`co-iar-arm.lnt` file for IAR ARM and `co-gnu-arm.lnt` file GNU ARM, respectively). These option files are provided in the **Qtools** collection. The location of the **Qtools** directory in your system is specified in the `options.lnt` file, and you most likely need to adjust it for your system.

> **NOTE:** The **Qtools** collection is available for a separate download from http://www.state-machine.com/downloads/index.php#QTools. Quantum Leaps is committed to keep adding more and more PC-Lint option files for various embedded C/C++ cross-compilers in the **Qtools** collection.

3 MISRA-C++:2008 Compliance Matrix

As recommended in Section 4.3.1 of the [MISRA-C++:2008] guidelines, this section presents the compliance matrix, which lists each MISRA-C++:2008 rule and indicates the compliance status and how the rule has been checked. The meaning of the compliance matrix columns is as follows:

1. **Rule No.** column lists the MISRA-C++:2008 rule number followed by the rule classification in parentheses (**req**) for required rule and (**adv**) for advisory rule.
2. **PC-Lint** column lists whether a rule is checked by PC-Lint/`au-misra-cpp.lnt`. The checked rules are marked with a check-mark (☑). Empty status (☐), also clearly marked by the yellow background, means that the rule is **not** checked by PC-Lint and requires a **manual review**.

> **NOTE:** The ability of PC-Lint to check a MISRA-C++:2008 rule is determined by means of two sources (1) the Gimpel Software matrix [PC-Lint-MISRA-C++:2008] and (2) the test against the actual code. When in doubt, the rules are marked as **not-checked** by PC-Lint.

3. **QP/C++** column lists the compliance status of the QP/C++ source code. Letters **A** or **M** in this column mean that the QP/C++ framework source code complies with the rule, whereas A means that the rule has been checked automatically (via PC-Lint), and M means that the rule has been verified manually. A number in this column (clearly marked by the orange background) indicates a **deviation** from the rule. The number is the subsection number within the section Deviation Procedures for QP/C++ Source Code, which describes in detail the nature and particular circumstances of the deviation.
4. **QP/C++ app.** column lists the deviations of the QP/C++ **application-level** code imposed by the QP/C++ framework. No entry in this column indicates that QP/C++ imposes or no deviations, meaning that the application-level code can be made compliant with the rule. However, for some rules (clearly marked by the red background in this column) the design and/or the implementation of the QP/C++ framework imposes a deviation from the rule, in which case the column lists the subsection number within the section Deviation Procedures for Application-Level Code. Finally, cases that the QP/C++ **might** impose a deviation, but a **workaround** exists, are clearly marked with the blue background in this column.
5. **Description** column contains a short description of the rule, as published in Appendix A of the [MISRA-C++:2008] guidelines.

3.1 Unnecessary constructs

Rule No.	PC-Lint	QP/C++	QP app.	Description
0-1-1(req)	☑	5.1[1]	5.1[1]	A project shall not contain unreachable code.
0-1-2(req)	☑	5.1[1]	5.1[1]	A project shall not contain infeasible paths.
0-1-3(req)	☑	A		A project shall not contain unused variables.
0-1-4(req)	☑	A		A project shall not contain non-volatile POD variables having only one use
0-1-5(req)	☑	A		A project shall not contain unused type declarations
0-1-6(req)	☑	A		A project shall not contain instances of non-volatile variables being given values that are never subsequently used.
0-1-7(req)	☑	A		The value returned by a function having a non-`void` return type that is not an overloaded operator shall always be used
0-1-8(req)	☑	A		All functions with `void` return type shall have external side-effects
0-1-9(req)	☑	A		There shall be no dead code
0-1-10(req)	☑	A		Every defined function shall be called at least once
0-1-11(req)	☑	5.2		There shall be no unused parameters (named or unnamed) in non-virtual functions.
0-1-12(req)	☑	A		There shall be no unused parameters (named or unnamed) in a virtual function and all the functions that override it.

[1] QP/C++ deviates from this rule only in the QS macros in the `Q_SPY` configuration

3.2 Storage

Rule No.	PC-Lint	QP/C++	QP app.	Description
0-2-1(req)	☑	A		An object shall not be assigned to an overlapping object

3.3 Runtime failures

Rule No.	PC-Lint	QP/C++	QP app.	Description
0-3-1(doc)	☑	**A**(1)	(1)	Minimization of run-time failures shall be ensured by the use of at least one of: (a) static analysis tools/techniques; (b) dynamic analysis tools/techniques; (c) explicit coding of checks to handle run-time faults.
0-3-2(req)	☑	**A**(2)	(2)	If a function generates error information, then that error information shall be tested.

(1) The QP/C++ framework uses static analysis tool (PC-Lint) and explicit coding of checks (assertions). For compliance with this rule, application-level code needs to use static analysis tool as well.
(2) The QP/C++ framework uses assertions except of error returns.

3.4 Arithmetic

Rule No.	PC-Lint	QP/C++	QP app.	Description
0-4-1(doc)	☐	**M**(1)		Use of scaled-integer of fixed-point arithmetic shall be documented.
0-4-2(doc)	☐	**M**(1)		Use of floating-point arithmetic shall be documented.
0-4-3(doc)	☐	**M**(1)		Floating-point implementations shall comply with a defined floating-point standard.

(1) QP/C++ does not use scaled-integers or floating-point arithmetic

3.5 Language

Rule No.	PC-Lint	QP/C++	QP app.	Description
1-0-1(req)	☑	**A**		All code shall confirm to ISO/IEC 14882:2003 “The C++ Standard Incorporating Technical Corrigendum 1”.
1-0-2(doc)	☐	**M**(1)		Multiple compilers shall only be used if they have a common, defined interface.
1-0-3(doc)	☐	**M**(2)		The implementation of integer division in the chosen compiler shall be determined and documented.

(1) Selected QP/C++ ports might require assembly modules. In all such cases a documented interface standard, such as APCS (ARM Procedure Calling Standard) are observed.
(2) QP/C++ does not use integer division or modulo operation anywhere in the code. (QP/C++ does not use even integer multiplication.)

3.6 Character sets

Rule No.	PC-Lint	QP/C++	QP app.	Description
2-2-1(doc)	☐	M(1)		The character set and the corresponding encoding shall be documented.

(1) QP/C++ source code uses only ASCII character set

3.7 Trigraph sequence

Rule No.	PC-Lint	QP/C++	QP app.	Description
2-3-1(req)	☑	A		Trigraphs shall not be used.

3.8 Alternative tokens

Rule No.	PC-Lint	QP/C++	QP app.	Description
2-5-1(adv)	☑	A		Digraphs should not be used.

3.9 Comments

Rule No.	PC-Lint	QP/C++	QP app.	Description
2-7-1(req)	☑	A(1)		The character sequence `/*` shall not be used within a C-style comment
2-7-2(req)	☐	M		Sections of code shall not be “commented out” using C-style comments
2-7-3(adv)	☐	M		Sections of code shall not be “commented out” using C++ comments.

(1) QP/C++ source code does not use the C-style comments, except in a few comments for multi-line assertions, where some compilers generated errors when C++ comments were used.

3.10 Identifiers

Rule No.	PC-Lint	QP/C++	QP app.	Description
2-10-1(req)	☐(1)	A		Different identifiers shall be typographically unambiguous.
2-10-2(req)	☑	A		Identifiers declared in an inner scope shall not hide an identifier declared in an outer scope.
2-10-3(req)	☐	M		A `typdef` name (including qualification, if any) shall be a unique identifier.
2-10-4(req)	☐	M		A class, union, or `enum` name (including qualification, if any) shall be unique identifier.
2-10-5(adv)	☐	M		The identifier name of a non-member object or function with static storage duration should not be reused.
2-10-6(req)	☑	A		If an identifier refers to a type, it shall not also refer to an object or a function in the same scope.

(1) The PC-Lint matrix indicates “partial” checking of this rule

3.11 Literals

Rule No.	PC-Lint	QP/C++	QP app.	Description
2-13-1(req)	☑	A		Only those escape sequences that are defined in ISO/IEC 14882:2003 shall be used.
2-13-2(req)	☑	A		Octal constants (other than zero) and octal escape sequences (other than `'\0'`) shall not be used.
2-13-3(req)	☑	A		A “`U`” suffix shall be applied to all octal or hexadecimal integer literals of unsigned type.
2-13-4(req)	☑	A		Literal suffixes shall be upper case.
2-13-5(req)	☑	A		Narrow and wide string literals shall not be concatenated.

3.12 Declarations and Definitions

Rule No.	PC-Lint	QP/C++	QP app.	Description
3-1-1(req)	☑	A		It shall be possible to include any header file in multiple translation units without violating the One Definition Rule.
3-1-2(req)	☑	A		Functions shall not be declared at block scope.
3-1-3(req)	☑	A		When an array is declared, its size shall either be stated explicitly or defined implicitly by initialization.

3.13 One Definition Rule

Rule No.	PC-Lint	QP/C++	QP app.	Description
3-2-1(req)	☑	A		All declarations of an object or function shall have compatible types
3-2-2(req)	☑	A		The One Definition Rule shall not be violated
3-2-3(req)	☑	A		A type, object or function that is used in multiple translation units shall be declared in one and only one file.
3-2-4(req)	☑	A		An identifier with external linkage shall have exactly one definition.

3.14 Declarative regions and scope

Rule No.	PC-Lint	QP/C++	QP app.	Description
3-3-1(req)	☑	A		Objects and functions with external linkage shall be declared in a header file
3-3-2(req)	☑	A		If a function has internal linkage then all re-declarations shall include the static storage class specifier.

3.15 Name lookup

Rule No.	PC-Lint	QP/C++	QP app.	Description
3-4-1(req)	☐	M		An identifier declared to be an object or type shall be defined in a block that minimizes its visibility.

3.16 Types

Rule No.	PC-Lint	QP/C++	QP app.	Description
3-9-1(req)	☐	M		The types used for an object, a function return type, or a function parameter shall be token-for-token identical in all declarations and re-declarations.
3-9-2(adv)	☑	A[(1)]		`typedef`s that indicate size and signedness should be used in place of the basic numerical types.
3-9-3(req)	☑	5.3[(2)]		The underlying bit representations of floating-point values shall not be used.

[(1)] QP/C++ uses the standard exact-with integer types `stdint.h` (WG14/N843 C99, Section 7.18.1.1)
[(2)] QP/C++ deviates from this rule only in QS software tracing implementation for binary output of floating-point values.

3.17 Integer promotions

Rule No.	PC-Lint	QP/C++	QP app.	Description
4-5-1(req)	☑	A		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.
4-5-2(req)	☐	M		Expressions with type `enum` shall not be used as operands to built-in operators other than the subscript operator `[ ]`, the assignment operator =, the equality operators `==` and `!=`, the unary `&` operator, and the relational operators `<, <=, >, >=`.
4-5-3(req)	☑	A		Expressions with type (plain) char and `wchar_t` shall not be used as operands to built-in operators other than the assignment operator `=`, the equality operators `==` and `!=`, and the unary `&` operator.

3.18 Pointer conversions

Rule No.	PC-Lint	QP/C++	QP app.	Description
4-10-1(req)	☐	M[(1)]		`NULL` shall not be used as an integer value.
4-10-2(req)	☑	A		Literal zero (0) shall not be used as the null-pointer-constant.

[(1)] QP/C++ source code does not use the NULL literal anywhere in the code
[(1)] QP/C++ source code uses the strongly-typed, specifically cast pointer literals, e.g., `static_cast<QEvt const *>(0);`

3.19 Expressions

Rule No.	PC-Lint	QP/C++	QP app.	Description
5-0-1(req)	☑	A		The value of an expression shall be the same under any order of evaluation that the standard permits.
5-0-2(adv)	☑	A		Limited dependence should be placed on C++ operator precedence rules in expressions.
5-0-3(req)	☑	A		A *cvalue* expression shall not be implicitly converted to a different underlying type.
5-0-4(req)	☑	A		An implicit integral conversion shall not change the signedness of the underlying type.
5-0-5(req)	☑	A		There shall be no implicit floating-integral conversions.
5-0-6(req)	☑	A		An implicit integral or floating-point conversion shall not reduce the size of the underlying type.
5-0-7(req)	☑	A		There shall be no explicit floating-integral conversions of a *cvalue* expression.
5-0-8(req)	☑	A		An explicit integral or floating-point conversion shall not increase the

Rule No.	PC-Lint	QP/C++	QP app.	Description
				size of the underlying type of a *cvalue* expression.
5-0-9(req)	☑	**A**		An explicit integral conversion shall not change the signedness of the underlying type of a *cvalue* expression.
5-0-10(req)	☑	**A**		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.
5-0-11(req)	☑	**A**		The plain `char` type shall only be used for the storage and use of character values.
5-0-12(req)	☑	**A**(1)		`signed char` and `unsigned char` type shall only be used for the storage and use of numeric values.
5-0-13(req)	☑	**A**		The condition of an `if`-statement and the condition of an iteration-statement shall have type `bool`.
5-0-14(req)	☑	**A**		The first operand of a conditional-operator shall have type `bool`.
5-0-15(req)	☑	**5.4**		Array indexing shall be the only form of pointer arithmetic.
5-0-16(req)	☑	**A**		A pointer operand and any pointer resulting from pointer arithmetic using that operand shall both address elements of the same array.
5-0-17(req)	☑	**A**		Subtraction between pointers shall only be applied to pointers that address elements of the same array.
5-0-18(req)	☑	**5.5**		`>`, `>=`, `<`, `<=` shall not be applied to objects of pointer type, except where they point to the same array.
5-0-19(req)	☑	**A**		The declaration of objects shall contain no more than two levels of pointer indirection.
5-0-20(req)	☐	**M**		Non-constant operands to a binary bitwise operator shall have the same underlying type.
5-0-21(req)	☑	**A**		Bitwise operators shall only be applied to operands of unsigned underlying type.

(1) QP/C++ source code uses special type `char_t` for all (single-byte) strings and string constants.

3.20 Postfix expressions

Rule No.	PC-Lint	QP/C++	QP app.	Description
5-2-1(req)	☑	A		Each operand of a logical `&&` or `||` shall be a postfix-expressoin.
5-2-2(req)	☑(1)	A	(1)	A pointer to a virtual base class shall only be cast to a pointer to a derived class by means of `dynamic_cast`.
5-2-3(adv)	☐	M		Casts from a base class to a derived class should not be performed on polymorphic types.
5-2-4(req)	☑	5.6(2)		C-style casts (other than void casts) and functional notation casts (other than explicit constructor calls) shall not be used.
5-2-5(req)	☑	5.7		A cast shall not remove any `const` or **`volatile`** qualification from the type of a pointer or reference.
5-2-6(req)	☑	A	6.1	A cast shall not convert a pointer to a function to any other pointer type, including a pointer to function type.
5-2-7(req)	☑	5.8	6.2	An object with pointer type shall not be converted to an unrelated pointer type, either directly or indirectly.
5-2-8(adv)	☑	A	5.6(2)	An object with integer type or pointer to `void` type shall not be converted to an object with pointer type.
5-2-9(adv)	☑	5.9		A cast should not convert a pointer type to an integral type.
5-2-10(adv)	☑	5.10		The increment (`++`) and decrement (`--`) operators should not be mixed with other operators in an expression.
5-2-11(req)	☑	A		The comma operator, `&&` operator and the `||` operator shall not be overloaded.
5-2-12(req)	☑	A		An identifier with array type passed as a function argument shall not decay to a pointer.

(1) PC-Lint reports any down-cast as violation of the rule 5-2-2. The QP/C++ source code provides macro `Q_EVENT_CAST()` for performing downcasting of events from the `QEvt` base class to the specific user-defined derived class.
(2) QP/C++ source code uses predominantly C++ style casts. The C-style casts are used only in code that is likely to be used in C modules, such as QP/C++ assertions (`qassert.h` header file).
(3) QP/C++ provides macro `Q_UNIT2PTR_CAST()`, which could be used in the QP/C++ **applications** to access specific hardware registers.

3.21 Unary expressions

Rule No.	PC-Lint	QP/C++	QP app.	Description
5-3-1(req)	☑	A		Each operand of the ! operator, the logical `&&` or the logical `||` operators shall have type `bool`.
5-3-2(req)	☑	A		The unary minus operator shall not be applied to an expression whose underlying type is unsigned.
5-3-3(req)	☑	A		The unary `&` operator shall not be overloaded.
5-3-4(req)	☑	A		Evaluation of the operand to the `sizeof` operator shall not contain side effects.

3.22 Shift operators

Rule No.	PC-Lint	QP/C++	QP app.	Description
5-8-1(req)	☑	A		The right hand operand of a shift operator shall lie between zero and one less than the width in bits of the underlying type of the left hand operand.

3.23 Logical AND operator

Rule No.	PC-Lint	QP/C++	QP app.	Description
5-14-1(req)	☑	A		The right hand operand of a logical `&&` or `||` operator shall not contain side effects.

3.24 Assignment operators

Rule No.	PC-Lint	QP/C++	QP app.	Description
5-17-1(req)	☐	M[1]		The semantic equivalence between a binary operator and its assignment operator form shall be preserved.

[2] QP/C++ does not overload any operators.

3.25 Comma operator

Rule No.	PC-Lint	QP/C++	QP app.	Description
5-18-1(req)	☑	A		The comma operator shall not be used.

3.26 Constant expressions

Rule No.	PC-Lint	QP/C++	QP app.	Description
5-19-1(adv)	☑	A		Evaluation of constant unsigned integer expressions should not lead to wrap-around.

3.27 Expression statement

Rule No.	PC-Lint	QP/C++	QP app.	Description
6-2-1(req)	☑	A		Assignment operators shall not be used in sub-expressions.
6-2-2(req)	☑	A		Floating-point expressions shall not be directly or indirectly tested for equality or inequality.
6-2-3(req)	☑	A		Before preprocessing, a null statement shall only occur on a line by itself; it may be followed by a comment, provided that the first character following the null statement is a white-space character.

3.28 Compound statement

Rule No.	PC-Lint	QP/C++	QP app.	Description
6-3-1(req)	☑	A		The statement forming the body of a `switch`, `while`, `do ... while` or `for` statement shall be a compound statement.

3.29 Selection statements

Rule No.	PC-Lint	QP/C++	QP app.	Description
6-4-1(req)	☑	A		An `if ( condition )` construct shall be followed by a compound statement. The else keyword shall be followed by either a compound statement, or another `if` statement.
6-4-2(req)	☑	A		All `if … else if` constructs shall be terminated with an `else` clause.
6-4-3(req)	☐	M	6.4(1)	A `switch` statement shall be a well-formed `switch` statement.
6-4-4(req)	☐	M		A `switch`-label shall only be used when the most closely-enclosing compound statement is the body of a `switch` statement.
6-4-5(req)	☑	A	6.4(1)	An unconditional throw or `break` statement shall terminate every non-empty `switch`-clause.
6-4-6(req)	☑	A	6.4(1)	The final clause of a `switch` statement shall be the `default`-clause.
6-4-7(req)	☑	A		The condition of a `switch` statement shall not have `bool` type.
6-4-8(req)	☑	A		Every `switch` statement shall have at least one `case`-clause.

(1) The published examples of state machine implementations with QP/C++ deviate from MISRA-C++ rules 6-4-3, 6-4-5, and 6-4-6. However, a fully compliant implementation is also possible and is described in Section 6.4.

3.30 Iteration statements

Rule No.	PC-Lint	QP/C++	QP app.	Description
6-5-1(req)	☐	M		A `for` loop shall contain a single loop-counter which shall not have floating type.
6-5-2(req)	☐	M		If loop-counter is not modified by `--` or `++`, then, within condition, the loop-counter shall only be used as an operand to `<=, <, > or >=`.
6-5-3(req)	☑	A		The loop-counter shall be modified within condition statement.
6-5-4(req)	☐	M		The loop-counter shall be modified by one of: `-, ++, -=n, or +=n`; where `n` remains constant for the duration of the loop.
6-5-5(req)	☐	M		A loop-control-variable other than the loop-counter shall not be modified within condition or expression.
6-5-6(req)	☐	M		A loop-control-variable other than the loop-counter which is modified in statement shall have type `bool`.

3.31 Jump statements

Rule No.	PC-Lint	QP/C++	QP app.	Description
6-6-1(req)	☐	M(1)		Any label referenced by a `goto` statement shall be declared in the same block, or in a block enclosing the `goto` statement.
6-6-2(req)	☑	A(1)		The `goto` statement shall jump to a label declared later in the same function body.
6-6-3(req)	☑	A(2)		The `continue` statement shall only be used within a well-formed `for` loop.
6-6-4(req)	☑	A(3)		For any iteration statement there shall be no more than one `break` or `goto` statement used for loop termination.
6-6-5(req)	☑	A	(4)	A function shall have a single point of exit at the end of the function.

(1) QP/C++ source code does not use `goto`.
(2) QP/C++ source code does not use `continue`.
(3) QP/C++ source code does not use `break` for loop termination.
(4) The published examples of state handler function with QP/C++ deviate from MISRA-C++ rule 6-6-5. However, a fully compliant implementation is also possible and is described in Section 6.4.

3.32 Specifiers

Rule No.	PC-Lint	QP/C++	QP app.	Description
7-1-1(req)	☑	5.11		A variable which is not modified shall be `const` qualified.
7-1-2(req)	☑	A		A pointer or reference parameter in a function shall be declared as pointer to `const` or reference to `const` if the corresponding object is not modified.

3.33 Enumeration declarations

Rule No.	PC-Lint	QP/C++	QP app.	Description
7-2-1(req)	☑	A		An expression with `enum` underlying type shall only have values corresponding to the enumerators of the enumeration.

3.34 Namespaces

Rule No.	PC-Lint	QP/C++	QP app.	Description
7-3-1(req)	☑	A[1]		The global namespace shall only contain `main`, namespace declarations and `extern "C"` declarations.
7-3-2(req)	☑	A		The identifier `main` shall not be used for a function other than the global function `main`.
7-3-3(req)	☑	A		There shall be no unnamed namespaces in header files.
7-3-4(req)	☑	A		`using`-directives shall not be used.
7-3-5(req)	☐	M		Multiple declarations for an identifier in the same namespace shall not straddle a `using`-declaration for that identifier.
7-3-6(req)	☑	A		`using`-directives and `using`-declarations (excluding class scope or function scope using-declarations) shall not be used in header files.

[1] QP/C++ source code can be configured to place all declarations and definitions in the `QP::` namespace. This is the recommended setting for MIRSA-C++:2008 compliance.

3.35 The asm declaration

Rule No.	PC-Lint	QP/C++	QP app.	Description
7-4-1(doc)	☐	M[1]		All usage of assembler shall be documented.
7-4-2(req)	☑	A		Assembler instructions shall only be introduced using the `asm` declaration.
7-4-3(req)	☐	M[1]		Assembly language shall be encapsulated and isolated.

[1] QP/C++ encapsulates and isolates potential use of assembler language in the macros `QF_INT_ENABLE()`, `QF_INT_DISABLE()`, `QF_CRIT_ENTRY()`, `QF_CRIT_EXIT()`, `QK_ISR_ENTRY()`, and `QK_ISR_EXIT()`

3.36 Linkage specifications

Rule No.	PC-Lint	QP/C++	QP app.	Description
7-5-1(req)	☑	A		A function shall not return a reference or a pointer to an automatic variable (including parameters), defined within the function.
7-5-2(req)	☑	A		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.
7-5-3(req)	☑	A		A function shall not return a reference or a pointer to a parameter that is passed by reference or `const` reference.
7-5-4(adv)	☑	A		Functions should not call themselves, either directly or indirectly.

3.37 Declarations — General

Rule No.	PC-Lint	QP/C++	QP app.	Description
8-0-1(req)	☑	A		An *init-declarator-list* or a *member-declarator-list* shall consist of a single *init-declarator* or *member-declarator* respectively.

3.38 Meaning of declarations

Rule No.	PC-Lint	QP/C++	QP app.	Description
8-3-1(req)	☑	A		Parameters in an overriding virtual function shall either use the same default arguments as the function they override, or else shall not specify any default arguments.

3.39 Function definitions

Rule No.	PC-Lint	QP/C++	QP app.	Description
8-4-1(req)	☑	A		Functions shall not be defined using the ellipsis notation.
8-4-2(req)	☑	A		The identifiers used for the parameters in a re-declaration of a function shall be identical to those in the declaration.
8-4-3(req)	☑	M		All exit paths from a function with non-void return type shall have an explicit return statement with an expression.
8-4-4(req)	☑(1)	M		A function identifier shall either be used to call a function or it shall be preceded by `&`.

(1) PC-Lint reports the recommended use of the `&` operator on function names as the error 546 (suspicious use of `&`). This is actually contrary to the MISRA-C++:2008 guidelines, so the error 546 is suppressed in the `lib-qpcpp.lnt` option file.

3.40 Declarators — Initializers

Rule No.	PC-Lint	QP/C++	QP app.	Description
8-5-1(req)	☑	5.12		All variables shall have a defined value before they are used.
8-5-2(req)	☑	A		Braces shall be used to indicate and match the structure in the non-zero initialization of arrays and structures.
8-5-3(req)	☑	M		In an enumerator list, the = construct shall not be used to explicitly initialize members others than the first, unless all items are explicitly initialized.

(1) PC-Lint includes in this rule also checks of the constructor initializer lists. QP/C++ deviates from this rule only in the constructor initializer lists for `QEvt` and `QActive`.

3.41 Member functions

Rule No.	PC-Lint	QP/C++	QP app.	Description
9-3-1(req)	☑	A		`const` member functions shall not return non-`const` pointers or references to class-data.
9-3-2(req)	☑	A		Member functions shall not return non-`const` handles to class-data.
9-3-3(req)	☑	A		If a member function can be made `static` then it shall be made `static`, otherwise if it can be made `const` then it shall be made `const`.

3.42 Unions

Rule No.	PC-Lint	QP/C++	QP app.	Description
9-5-1(req)	☑	5.13(1)		Unions shall not be used.

(1) QP/C++ deviates from this rule only in QS functions `QS::f32` and `QS::f64` in the `Q_SPY` configuration

3.43 Bit-fields(1)

Rule No.	PC-Lint	QP/C++	QP app.	Description
9-6-1(doc)	☐	M		When the absolute positioning of bits representing a bit-field is required, then the behavior and packing of bit-fields shall be documented.
9-6-2(req)	☑	A		Bit-fields shall be either `bool` type or an explicitly unsigned or signed integral type.
9-6-3(req)	☑	A		Bit-fields shall not have `enum` type.
9-6-4(req)	☑	A		Named bit-fields with signed integer type shall have a length of more than one bit.

(1) QP/C++ does not use bit fields at all.

3.44 Multiple base classes(1)

Rule No.	PC-Lint	QP/C++	QP app.	Description
10-1-1(adv)	☑	A		Classes should not be derived from virtual bases.
10-1-2(req)	☐	M		A base class shall only be declared virtual if it is used in a diamond hierarchy.
10-1-3(req)	☑	A		An accessible base class shall not be both virtual and non-virtual in the same hierarchy.

(1) QP/C++ does not use virtual base classes at all.

3.45 Member name lookup

Rule No.	PC-Lint	QP/C++	QP app.	Description
10-2-1(adv)	☐	M(1)		All accessible entity names within a multiple inheritance hierarchy should be unique.

(1) QP/C++ does not use multiple inheritance at all.

3.46 Virtual Functions(1)

Rule No.	PC-Lint	QP/C++	QP app.	Description
10-3-1(req)	☐	M		There shall be no more than one definition of each virtual function on each path through the inheritance hierarchy.
10-3-2(req)	☑	A		Each overriding virtual function shall be declared with the `virtual` keyword.
10-3-3(req)	☐	M		A virtual function shall only be overridden by a pure virtual function if it is itself declared as pure virtual.

(1) Except for virtual destructors in `QFsm` and `QHsm` base classes, QP/C++ does not use virtual functions.

3.47 Constructors

Rule No.	PC-Lint	QP/C++	QP app.	Description
12-1-1(req)	☑	A		An object's dynamic type shall not be used from the body of its constructor or destructor.
12-1-2(adv)	☑	A		All constructors of a class should explicitly call a constructor for all of its immediate base classes and all virtual base classes.
12-1-3(req)	☐	M(1)		All constructors that are callable with a single argument of fundamental type shall be declared explicit.

(1) The QP/C++ code does not contain any constructors with single argument of fundamental type.

3.48 Copying class objects

Rule No.	PC-Lint	QP/C++	QP app.	Description
12-8-1(req)	☑	A		A copy constructor shall only initialize its base classes and the non-static members of the class of which it is a member.
12-8-2(req)	☑	A		The copy assignment operator shall be declared protected or private in an abstract class.

3.49 Template declarations[1]

Rule No.	PC-Lint	QP/C++	QP app.	Description
14-5-1(req)	☑	A		A non-member generic function shall only be declared in a namespace that is not an associated namespace.
14-5-2(req)	☑	A		A copy constructor shall be declared when there is a template constructor with a single parameter that is a generic parameter.
14-5-3(req)	☑	A		A copy assignment operator shall be declared when there is a template assignment operator with a parameter that is a generic parameter.

[1] QP/C++ code does not use templates anywhere in the code.

3.50 Name resolution[1]

Rule No.	PC-Lint	QP/C++	QP app.	Description
14-6-1(req)	☑	A		In a class template with a dependent base, any name that may be found in that dependent base shall be referred to using a qualified-id or `this->`
14-6-2(req)	☑	A		The function chosen by overload resolution shall resolve to a function declared previously in the translation unit.

[1] QP/C++ code does not use templates anywhere in the code.

3.51 Template instantiation and specialization[1]

Rule No.	PC-Lint	QP/C++	QP app.	Description
14-7-1(req)	☑	A		All class templates, function templates, class template member functions and class template static members shall be instantiated at least once.
14-7-2(req)	☐	M		For any given template specialization, an explicit instantiation of the template with the template-arguments used in the specialization shall not render the program ill-formed.
14-7-3(req)	☑	A		All partial and explicit specializations for a template shall be declared in the same file as the declaration of their primary template.

[1] QP/C++ code does not use templates anywhere in the code.

3.52 Function template specialization[1]

Rule No.	PC-Lint	QP/C++	QP app.	Description
14-8-1(req)	☑	A		Overloaded function templates shall not be explicitly specialized.
14-8-2(adv)	☑	A		The viable function set for a function call should either contain no function specializations, or only contain function specializations.

[1] QP/C++ code does not use templates anywhere in the code.

3.53 Exception handling — General[1]

Rule No.	PC-Lint	QP/C++	QP app.	Description
15-0-1(doc)	☐	M		Exceptions shall only be used for error handling.
15-0-2(adv)	☑	A		An exception object should not have pointer type.
15-0-3(req)	☑	A		Control shall not be transferred into a `try` or `catch` block using a `goto` or a `switch` statement.

[1] QP/C++ code does not throw or catch exceptions anywhere in the code.

3.54 Throwing an exception

Rule No.	PC-Lint	QP/C++	QP app.	Description
15-1-1(req)	☐	M		The assignment-expression of a throw statement shall not itself cause an exception to be thrown.
15-1-2(req)	☑	A		`NULL` shall not be thrown explicitly.
15-1-3(req)	☑	A		An empty throw (`throw;`) shall only be used in the compound-statement of a catch handler.

3.55 Handling an exception

Rule No.	PC-Lint	QP/C++	QP app.	Description
15-3-1(req)	☑	A		Exceptions shall be raised only after start-up and before termination of the program.
15-3-2(adv)	☐	A		There should be at least one exception handler to catch all otherwise unhandled exceptions
15-3-3(req)	☐	M		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.
15-3-4(req)	☑			Each exception explicitly thrown in the code shall have a handler of a compatible type in all call paths that could lead to that point.
15-3-5(req)	☑			A class type exception shall always be caught by reference.
15-3-6(req)	☐			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.
15-3-7(req)	☑			Where multiple handlers are provided in a single try-catch statement or function-try-block, any ellipsis (catch-all) handler shall occur last.

3.56 Exception specification

Rule No.	PC-Lint	QP/C++	QP app.	Description
15-4-1(req)	☑	**A**		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.

3.57 Exception handling — Special functions

Rule No.	PC-Lint	QP/C++	QP app.	Description
15-5-1(req)	☑	**A**		A class destructor shall not exit with an exception.
15-5-2(req)	☑	**A**		Where a function's declaration includes an exception-specification, the function shall only be capable of throwing exceptions of the indicated type(s).
15-5-3(req)	☑	**M**		The `terminate()` function shall not be called implicitly.

3.58 Processing directives — General

Rule No.	PC-Lint	QP/C++	QP app.	Description
16-0-1(req)	☑	**A**		`#include` directives in a file shall only be preceeded by other preprocessor directives or comments.
16-0-2(adv)	☑	**A**		Macros shall only be `#define`'d or #`undef`'d in the global namespace.
16-0-3(req)	☑	**M**		`#undef` shall not be used.
16-0-4(req)	☑	**5.14**		Function-like macros shall not be defined.
16-0-5(req)	☑	**A**		Arguments to a function-like macro shall not contain tokens that look like preprocessing directives.
16-0-6(req)	☑	**A**		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 ##`.
16-0-7(req)	☑	**A**		Undefined macro identifiers shall not be used in `#if and #elif` preprocessor directives, except as operands to the `defined` operator.
16-0-8(req)	☑	**A**		If the `#` token appears as the first token on aline, then it shall be immediately followed by a preprocessing token.

3.59 Conditional inclusion

Rule No.	PC-Lint	QP/C++	QP app.	Description
16-1-1(req)	☑	A		The `defined` preprocessor operator shall only be used in one of the two standard forms.
16-1-2(req)	☑	A		All #else, `#elif` and `#endif` preprocessor directives shall reside in the same file as `#if` or `#ifdef` directive to which they are related.

3.60 Source file inclusion

Rule No.	PC-Lint	QP/C++	QP app.	Description
16-2-1(req)	☐	5.15		Preprocessor shall only be used for file inclusion and include guards.
16-2-2(req)	☑	5.15		C++ macros shall only be used for: include guards, type qualifiers, or storage class specifiers.
16-2-3(req)	☑	A		Include guards shall be provided.
16-2-4(req)	☑	A		The `', ", /* or //` characters shall not occur in a header file name.
16-2-5(adv)	☑	A		The `\` character should not occur in a header file name.
16-2-6(req)	☑	A		The `#include` directive shall be followed by either a `<filename>` or `"filename"` sequence.

3.61 Macro replacement

Rule No.	PC-Lint	QP/C++	QP app.	Description
16-3-1(req)	☑	A		There shall be at most one occurrence of the `# or ##` operators in a single macro definition.
16-3-2(adv)	☑	5.16[1]	.[1]	The `# and ##` operators should not be used.

[1] QP/C++ code uses a single `##` operator in the `Q_NEW()` macro and only when constructors for `QEvt`s are allowed (`Q_EVT_CTR` macro is defined). Additionally, the “dictionary” QS macros use a single `#` operator.

3.62 Pragma directive

Rule No.	PC-Lint	QP/C++	QP app.	Description
16-6-1(doc)	☐	M		All uses of the `#pragma` directive shall be documented.

3.63 Library introduction — General

Rule No.	PC-Lint	QP/C++	QP app.	Description
17-0-1(req)	☑	A	(1)	Reserved identifiers, macros and functions in the standard library shall not be defined, redefined or undefined.
17-0-2(req)	☑	A	(1)	The names of standard library macros and objects shall not be reused.
17-0-3(req)	☐	M	(1)	The names of standard library functions shall not be overridden.
17-0-4(doc)	☑	A	(1)	All library code shall conform to MISRA C++.
17-0-5(req)	☑	A	(1)	The `setjmp` macro and the `longjmp` function shall not be used.

(1) Requires analysis of the complete application source code, including all libraries

3.64 Language support library — General(1)

Rule No.	PC-Lint	QP/C++	QP app.	Description
18-0-1(req)	☑	A		The C library shall not be used.
18-0-2(req)	☑	A		The library functions `atof, atoi and atol` from library `<cstdlib>` shall not be used.
18-0-3(req)	☑	A		The library functions `abort, exit, getenv` and system from library `<cstdlib>` shall not be used.
18-0-4(req)	☑	A		The time handling functions of library `<ctime>` shall not be used.
18-0-5(req)	☑	A		The unbounded functions of library `<cstring>` shall not be used.

(1) QP/C++ code does not rely in any way on any standard C or C++ libraries. The `stdint.h` header file used in QP/C++ does not require any code to be pulled from the standard libraries.

3.65 Language support library — Implementation properties

Rule No.	PC-Lint	QP/C++	QP app.	Description
18-2-1(req)	☑	A		The macro `offsetof` shall not be used.

3.66 Language support library — Dynamic memory management

Rule No.	PC-Lint	QP/C++	QP app.	Description
18-4-1(req)	☑	A		Dynamic heap memory allocation shall not be used.

3.67 Language support library — Other runtime support

Rule No.	PC-Lint	QP/C++	QP app.	Description
18-7-1(req)	☑	A		The signal handling facilities of `<csignal>` shall not be used.

3.68 Diagnostics library — Error numbers

Rule No.	PC-Lint	QP/C++	QP app.	Description
19-3-1(req)	☑	A		The error indicator `errno` shall not be used.

3.69 Input/Output library — General

Rule No.	PC-Lint	QP/C++	QP app.	Description
27-0-1(req)	☑	A		The stream input/output library `<cstdio>` shall not be used.

4 Beyond MISRA: Compliance with Additional Rules and Standards

4.1 Strong Type Checking

The philosophy of the C++ language is to assume that the programmers know what they are doing, which can mean that if errors are made they are allowed to pass unnoticed by the language. An area in which C++ is particularly weak in this respect is that of "type checking". C++ compilers will not object, for example, if the programmer tries to store a floating point number in an integer that they are using to represent a true/false value. Most such mismatches are simply forced to become compatible. If C++ is presented with a square peg and a round hole it doesn't complain, but makes them fit!

PC-Lint has an advanced **strong type checking** capabilities (see Chapter 9 in the PC-Lint Manual [PC-Lint 08]), which includes sophisticated dimensional analysis of the types resulting from **combining** other types (e.g., *velocity_miles_per_hour* = *distance_miles* / *time_hours*). The strong type checking is activated in PC-Lint with the `-strong(AJX)` option.

> **NOTE:** The strong type checking of PC-Lint takes the static analysis to the next level beyond MISRA-C++, because it can turn C++ into a truly **strongly-typed language**.

However, a software system can become "strongly-typed" only if it is built from components that are also "strongly-typed". Fortunately, the **QP/C++ framework is "strongly typed"**, meaning that is passes cleanly the PC-Lint analysis with the `-strong(AJX)` option activated. This is an immense benefit for QP/C++ users, because it allows the application-level code to take advantage of the strong type checking.

4.2 Quantum Leaps C/C++ Coding Standard

Although intentionally not addressed by the MISRA-C++:2008 guidelines, the use of a consistent coding style is a very important aspect of developing safety-related code. The QP/C++ code strictly follows to the Quantum Leaps C/C++ Coding Standard [QL-Code 11].

5 Deviation Procedures for QP/C++ Source Code

This section documents deviations from MISRA-C++:2008 rules in the **QP/C++ source code**.

5.1 Rule 0-1-1(req) and 0-1-2(req)

A project shall not contain unreachable code.

A project shall not contain infeasible paths.

Deviation from these rules occurs only in the QS software tracing instrumentation and is related to QS filters. When QS tracing is disabled, certain QS trace records might look like unreachable code or infeasible paths (e.g., `if (false) ...`).

5.2 Rule 0-1-11(req)

There shall be no unused parameters (named or unnamed) in non-virtual functions.

Deviation from this rule occurs in the standard "vanilla" and QK ports of QP/C++ (and perhaps in other ports that do not use the per-task stacks). For the sake of wide-range portability, the signature of the functions `QActive::start()` must include the stack memory and stack size, but these parameters might not be actually used in all QP/C++ ports.

5.3 Rule 3-9-3(req)

The underlying bit representations of floating-point values shall not be used.

Deviation from this rule occurs only in the QS software tracing instrumentation (**not** in production code) and is related to serialization of floating point numbers. The deviation is allowed only in the context of the functions `QS::f32()` and `QS::f64()`.

5.4 Rule 5-0-15(req)

Array indexing shall be the only allowed form of pointer arithmetic.

Deviation from this rule is related to the general policy of the QP/C++ framework with respect to memory allocation. In QP/C++, all memory (e.g., memory pools or event queue buffers) is pre-allocated by the application code and then passed as pointer and size of the memory to the framework. Subsequently, the memory is accessed using array indexing, but from the original base pointer, not from a true array—hence the deviation from rule 5-0-15.

The deviation form rule 5-0-15 is encapsulated in the QP/C++ internal macro `QF_PTR_AT_()`, and this is the only context allowed to deviate per this procedure.

5.5 Rule 5-0-18(req)

>, >=, <, <= shall not be applied to pointers, except where they point to the same array.

Deviation from this rule occurs in only one assertion in the QP/C++ code (file `qmp_put.cpp`). The precondition assertion checks that the returned pointer to memory block indeed comes from the memory pool to which it is being returned. If the block belongs to the pool, the pointer comparison is made within the same array, so the rule is actually **not** violated. The transgression occurs only if the block pointer is not in range.

The assertion of pointer range is encapsulated in the internal macro `QF_PTR_RANGE_` and has proved to be very valuable in ensuring the system integrity and in this particular context the benefits outweigh the risk of deviating from the MISRA rule.

5.6 Rule 5-2-4(req)

C-style casts (other than void casts) and functional notation casts (other than explicit constructor calls) shall not be used.

Deviation from this rule occurs only in the QP assertions. For practical reasons, the `qassert.h` header file is designed to be useful both in C++ and C modules, as many embedded projects use both languages. The strict use of C++ style casts would preclude using assertions in C modules, which could discourage programmers from using QP assertions everywhere in the code. The deviation from rule 5-2-4 should be limited to QP assertions.

5.7 Rule 5-2-5(req)

A cast shall not remove any const or volatile qualification from the type of a pointer or reference.

QP/C++ code deviates from this rule only in the internal macros `QF_EVT_REF_CTR_INC_`, `QF_EVT_REF_CTR_DEC_`, and `QF_EPOOL_PUT_`, where the `const` qualification needs to be occasionally discarded. The discarding of `const` is always preceded by a check that a given event is indeed dynamic (by testing the `QEvt.poolId_` member). Deviation from this rule is considered a better tradeoff for safety and design correctness than not using the `const` qualification for events at all.

5.8 Rule 5-2-7(req)

An object with integer type or pointer to void type shall not be converted to an object with pointer type.

QP/C++ code deviates from this rule in the internal macro `QF_EPOOL_GET_`, where a generic pointer to a memory block is cast to a specific object type. This sort of cast is inevitable in any memory allocator, but is strictly encapsulated inside the `QF_EPOOL_GET_` macro.

5.9 Rule 5-2-9(adv)

A cast should not convert a pointer type to an integral type.

Deviation from this rule occurs only in the QS software tracing instrumentation (**not** in production code). The QS code needs to output pointers to functions and pointers to objects by means of the macros `QS_FUN_`, `QS_OBJ_`, respectively. The deviation is allowed only in the context of these macros.

5.10 Rule 5-2-10(adv)

The increment (++) and decrement (--) operators should not be mixed with other operators in an expression

Deviation from this rule occurs only in the QS software tracing macro `QS_TEC_` (**not** in production code).

5.11 Rule 7-1-1(req)

A variable which is not modified shall be const qualified.

Deviation from this rule might occur in some QP/C++ ports, which don't use all the parameters of the `QActive::start()` method. For example, QP/C++ ports to the built-in “Vanilla” and QK kernels don't need the per-task stack and re-use the stack and stack-size parameters for different purposes. In these cases the stack and/or the stack-size is not modified and could be const-qualified, but this would interfere with the portability of the QP/C++ framework.

5.12 Rule 8-5-1(req)

All variables shall have a defined value before they are used.

The QP/C++ code complies with this rule everywhere, except the compiler-initialization lists for `QActive` and `QEvt` classes, which PC-Lint includes in checking this rule.

The constructor of `QActive` intentionally does not initialize the `m_prio`, `m_eQueue`, `m_thread`, and `m_osObject` members, because in QP/C++ the initialization of active objects is a two-stage process (with the second stage of initialization happening in the top-most initial transition) to give the application designer the necessary control over the timeline of initialization. Also, some members of the `QActive` base class exist only in the certain QP/C++ ports and don't exist in others.

5.13 Rule 9-5-1(req)

Unions shall not be used.

Deviation from these rules occurs only in the QS software tracing instrumentation (**not** in production code) and is related to serialization of floating point numbers. The deviation is allowed only in the context of the functions `QS::f32()` and `QS::f64()`.

5.14 Rule 16-0-4(req), 16-2-1(req), and 16-2-2(req)

Function-like macros shall not be defined.

QP/C++ uses function-like macros in situations that an (inline) function cannot handle. For example, the QS software tracing or assertions need to be configurable to be activated or deactivated at compile-time (without actually changing the source code). Finally, function-like macros are used to encapsulate the very specific contexts of deviations from the MISRA rules, such as specific type casts. All function-like macros deviating from the rule 16-0-4 are listed explicitly in the option files, so any other macros violating the rule will be reported.

5.15 Rule 16-2-1(req) and 16-2-2(req)

16-2-1: Preprocessor shall only be used for file inclusion and include guards.

16-2-2: C++ macros shall only be used for: include guards, type qualifiers, or storage class specifiers.

A framework has much stronger requirements for configurability and portability than a specific application. The QP/C++ achieves the high degree and ease of configurability through the concept of the Platform Abstraction Layer (PAL). The PAL, however, derives its portability from the use of preprocessor macros. For example, the QP/C++ ports must be able to configure the desired size of the event signal or the maximum number of active objects in the system. This information then determines the most optimal data structures and algorithms to use. This is not achievable through inline functions. Also, preprocessor macros are used to encapsulate the very specific contexts of deviations from the MISRA rules, such as specific type casts. All macros deviating from the rules 16-2-1 and 16-2-2 are listed explicitly in the option files, so any other macros violating the rule will be reported.

5.16 Rule 16-3-2(adv)

The # and ## operators should not be used.

The QP/C++ source code uses the `##` operator in the `Q_NEW()` macro, in which case, the `Q_NEW()` macro must take the variable number of arguments for the specific `QEvt`-subclass constructor (variadic macro).

In the QS software tracing configuration, the QS “dictionary” records use a single `#` operator.

6 Deviation Procedures for Application-Level Code

This section documents deviations from MISRA-C++:2008 rules in the **application-level** code, which are caused by the QP/C++ framework design or implementation. This section also describes workarounds to avoid some deviations.

6.1 Rule 5-2-6(req)

A cast shall not convert a pointer to a function to any other pointer type, including a pointer to function type.

The QP/C++ applications deviate from rule 5-2-6, because the state-handler functions signatures in the derived subclasses of `QHsm` or `QFsm` are not exactly identical with the state-handler pointer-to-function `StateHandler`. The deviation from rule 5-2-6 is encapsulated in the macro `Q_STATE_CAST()`, which is defined as follows (file `qep.h`):

```
#define Q_STATE_CAST(handler_) (reinterpret_cast<QP::QStateHandler>(handler_))
```

In the QP/C++ applications, the macro `Q_STATE_CAST()` is used to cast the initial pseudo-state-handler in the constructor, like this:

```
Philo::Philo()
  : QP::QActive(Q_STATE_CAST(&Philo::initial)),
    m_timeEvt(TIMEOUT_SIG)
{}
```

The need to deviate from the rule 5-2-6 is a consequence of using function pointers in conjunction with class inheritance, which are both fundamental to the QP/C++ framework. This, very particular, deviation from rule 5-2-6 is safe and is allowed only in the context of state-handler functions, which are related.

Additionally, macros `Q_TRAN()` and `Q_SUPER()` also use the macro `Q_STATE_CAST()`, so they too indirectly deviate from the rule 5-2-6.

6.2 Rule 5-2-7(req)

An object with pointer type shall not be converted to an unrelated pointer type, either directly or indirectly.

The QP/C++ applications deviate from rule 5-2-7 because of downcasting the generic event pointer (`QEvt const *`) to the specific event in the state machine code. The QP/C++ framework encapsulates this deviation in the macro `Q_EVENT_CAST()`. The code snippet below shows a use case. Please note that the macro `Q_EVENT_CAST()` does not cast the `const` away, so writing to the event pointer is not allowed.

```
case EAT_SIG: {
    if (Q_EVENT_CAST(TableEvt)->philoNum == PHILO_ID(me)) . . .
```

6.3 Rule 5-2-8(req)

An object with integer type or pointer to void type shall not be converted to an object with pointer type.

The QP/C++ applications might deviate from rule 5-2-8 when they need to access specific hard-coded hardware addresses directly. The QP/C++ framework encapsulates this deviation in the macro `Q_UINT2PTR_CAST()`. The following code snippet provides a use case of this macro:

```
#define QK_ISR_EXIT()  . . . \
    *Q_UINT2PTR_CAST(uint32_t, 0xE000ED04U) = \
        static_cast<uint32_t>(0x10000000U); \
```

6.4 Rule 6-4-3(req), 6-4-5(req), and 6-4-6(req)

6-4-3(req): A switch statement shall be a well-formed switch statement.

6-4-5(req): An unconditional throw or break statement shall terminate every non-empty switch-clause.

6-4-6(req): The final clause of a switch statement shall be the default clause.

The traditional way of implementing state-handler functions in QP/C++, as described in the book "Practical UML Statecharts" [PSiCC2 08] deviates from the rules 6-4-3, 6-4-5, and 6-4-6. However, it is also possible to avoid all these deviations, in exchange for a slight change in the UML semantics of guard processing, which will become clearer after describing the implementation.

The MISRA-compliant state handler implementation is used in the DPP examples with lint described in Section 8. The following Listing 4 shows an example of MISRA-compliant state handler function. The explanation section immediately following the listing highlights the important points.

> **NOTE:** Starting from the QM version **2.2.00**, the QM modeling tool generates MSRA-C++ compliant code structure shown in Listing 4.

Listing 4: MISRA-C++ compliant state handler implementation

```
    QP::QState Philo::hungry(Philo * const me, QP::QEvt const * const e) {
(1)     QP::QState status;
        switch (e->sig) {
            case Q_ENTRY_SIG: {
                AO_Table->POST(pe, Q_NEW(TableEvt, HUNGRY_SIG, PHILO_ID(me)));
(2)             status = Q_HANDLED();
(3)             break;
            }
            case EAT_SIG: {
(4)             if (Q_EVENT_CAST(TableEvt)->philoNum == PHILO_ID(me)) {
(5)                 status = Q_TRAN(&Philo::eating);
                }
(6)             else {
(7)                 status = Q_UNHANDLED();
                }
(8)             break;
            }
(9)         default: {
```

```
(10)              status = Q_SUPER(&QHsm::top);
(11)              break;
                }
            }
(12)        return status;
        }
```

(1) The automatic variable `status` will store the status of the processing to return. Please note that the `status` variable is not initialized.

NOTE: The `status` variable is not initialized intentionally, to catch any path through the code that would not set the value explicitly. The vast majority of compilers (including, of course PC-Lint) raise a warning about an uninitialized variable to alert of the problem. However, it is highly recommended to test each particular compiler for the ability to report this problem.

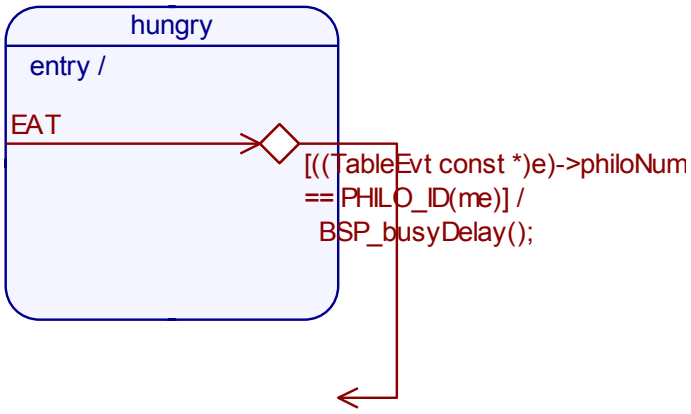
(2) The return value is set to `Q_HANDLED()` macro. This tells the QEP event processor that the entry action has been handled.

(3) According to the recommended MISRA-C `switch` statement structure, the case is terminated with a `break`

(4) The guard condition is coded as usual with an `if`-statement. Please note the use of the `Q_EVENT_CAST()` macro to downcast the generic event pointer to `TableEvt` class.

(5) When the guard condition in the `if`-statement evaluates to TRUE, the return value is set to `Q_TRAN()` macro. This macro tells the QEP event processor that the event has been handled and that the transition to state `Philo::eating` needs to be taken.

Figure 1: A choice point without an explicit [else] branch



(6,7) When the guard condition evaluates to FALSE, and the state model does not explicitly prescribe how to handle this situation (see Figure 1), the code should have an implicit `else` branch, in which the return value is set from the macro **`Q_UNHANDLED()`**. This specific return value will cause the QEP event processor to propagate the event to the superstate, which is exactly what the UML specification prescribes in this case.

NOTE: The `Q_UNHANDLED()` macro has been introduced in QP version **4.5.01** exactly for MISRA compliance. The QM graphical modeling tool generates MISRA-compliant code described in this section starting from the version **2.2.00**.

(8) According to the recommended MISRA-C++ `switch` statement structure, the `case` is terminated with a `break`
(9) According to the recommended `switch` structure, the `default`-clause is the final clause.
(10) Inside the `default`-clause, the return value is set to `Q_SUPER()` macro. This tells the QEP event processor that `QHsm::top` is the superstate of this state.
(11) According to the recommended MISRA-C `switch` statement structure, the `default`-clause is terminated with a `break`
(12) In compliance with MISRA-C rules 14.7 and 16.8, the function terminates with the single `return` statement.

7 Summary

The QP/C++ framework complies with most of the MISRA-C++:2008 rules and all remaining deviations are carefully insulated and encapsulated into very specific contexts. The framework goes even beyond MISRA, by complying with string type checking and a consistent, documented coding standard.

QP/C++ comes with extensive support for automatic rule checking by means of PC-Lint, which is designed not just for proving compliance of the QP/C++ framework code, but more importantly, to aid in checking compliance of the application-level code. Any organization engaged in designing safety-related embedded software could benefit from the unprecedented quality infrastructure built around the QP/C++ framework.

8 Related Documents and References

Document	Location
[MISRA-C++:2008] MISRA-C++:2008 Guidelines for the Use of the C++ language in Critical Systems, MISRA, June 2008, ISBN: 978-1-906400-03-3 paperback ISBN: 978-1-906400-04-0 PDF	Available for purchase from MISRA website http://www.misra.org.uk
[ISO C++ 03] ISO/IEC 14882:2003, The C++ Standard Incorporating Technical Corrogendum 1, International Organization for Standardization, 2003.	www.**iso**.org/**iso**/catalogue_detail.htm?csnumber=38110
[PC-Lint 08] "Reference Manual for PC-lint/FlexeLint: A Diagnostic Facility for C and C++", Software Version 9.00 and Later, Gimpel Software, September, 2008	Bundled with PC-Lint from Gimpel http://www.gimpel.com
[PC-Lint-MISRA-C++:2008] PC-Lint/FlexeLint Support for MISRA C++,	Available from Gimpel after request
[QL-Code 11] "Application Note: C/C++ Coding Standard", Quantum Leaps, LLC, 2011	http://www.state-machine.com/resources/AN_QL_Coding_Standard.pdf
[QL AN-DPP 08] "Application Note: Dining Philosopher Problem Application", Quantum Leaps, LLC, 2008	http://www.state-machine.com/resources/AN_DPP.pdf

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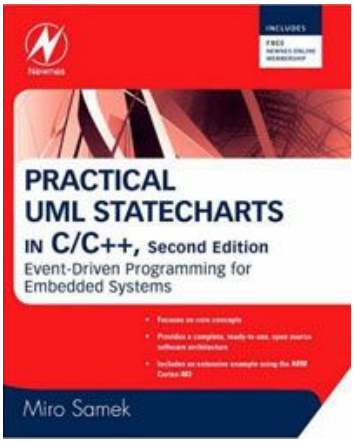

"*Practical UML Statecharts in C/C++, Second Edition: Event Driven Programming for Embedded Systems*", by Miro Samek, Newnes, 2008