MISRA Compliance for XEN project

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November 2020

Agenda

- Brief history of MISRA C
- What does it mean to “comply” with MISRA C?
- Compliance to language subsets – MISRA Compliance:2016 and :2020

A brief history of MISRA C

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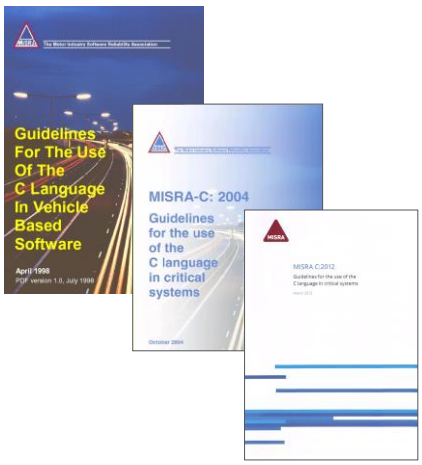
A brief history of MISRA C

- MISRA C:1998
  - Developed by Ford and Land Rover pooling effort from their own in-house C guidelines
  - Targeting automotive need for “a restricted subset of a standardized structured language” in MISRA 1994 “Development guidelines for vehicle based software”
- MISRA C:2004
  - Reworked based on user experiences including wider industry use
  - Exemplar Suite
- MISRA C:2012



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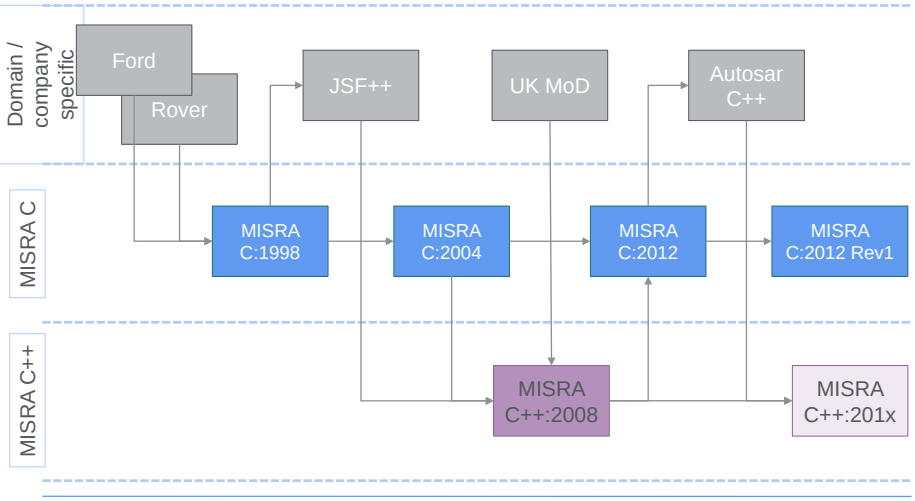
History of MISRA C/C++ guidelines



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Guideline types in MISRA C:2012

- Rules
  - Provide a clear and unambiguous specification
  - Compliance can be checked by performing static analysis on the code
  - Deal with issues related to C code
- Directives
  - Specification may be open to different interpretations
  - Static analysis may be of some assistance when checking compliance but other checks are likely to be required
  - May deal with non-code issues such as
    - Software development process requirements
    - Software design guidance

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Guideline types: examples

Directives	
Dir 4.2:	All usage of assembly language should be documented
Dir 4.11:	The validity of values passed to library functions shall be checked

Rules	
Rule 8.2:	Function types shall be in prototype form with named parameters
Rule 11.1:	Conversions shall not be performed between a pointer to a function and any other type

Guideline categories in MISRA C:2012

- Mandatory
  - Must always be followed and may never be deviated
- Required
  - Must be followed unless a formal deviation is in place
- Advisory
  - An organization, project or user may choose not to comply
  - No formal deviation is required although documentation is recommended nonetheless
- Readability
  - Applicable only to automatically-generated code
  - Compliance only required if code is to be read by humans

Guideline categories: examples

Mandatory	
Rule 9.1:	The value of an object with automatic storage duration shall not be read before it has been set

Required	
Rule 14.1:	A loop counter shall not have essentially floating type

Advisory	
Rule 12.3:	The comma operator should not be used

Readability (classification applicable to auto-generated code)	
Rule 7.3:	The lowercase character “l” shall not be used in a literal suffix

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Rule decidability in MISRA C:2012

- A rule is “decidable” if it is theoretically possible for a static analysis tool to identify **every** non-compliance in **every** program; otherwise it is “undecidable”

Decidable	
Rule 8.6:	An identifier with external linkage shall have exactly one external definition
Rule 20.8:	The controlling expression of a *#if* or *#elif* preprocessing directive shall evaluate to 0 or 1

Undecidable	
Rule 2.1:	A project shall not contain *unreachable* code
Rule 14.3:	Controlling expressions shall not be invariant

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Rule analysis scopes in MISRA C:2012

- A rule has “Single Translation Unit” scope if it is possible to check the entire program for compliance one unit at a time; otherwise it has “System” scope

Single Translation Unit	
Rule 9.2:	The initializer for an aggregate or union shall be enclosed in braces
Rule 20.4:	A macro shall not be defined with the same name as a keyword

System	
Rule 8.5:	An external object or function shall be declared once in one and only one file
Rule 17.2:	Functions shall not call themselves, either directly or indirectly

- ISO 26262 context: changes in Edition 2 to software verification activities

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What does it mean to “comply” with MISRA C?

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What does it mean to comply with MISRA C?

- Frequently as an assessor my experience is
  - "We've selected a tool that claims to check MISRA C"
  - "We've not got any unresolved tool messages"
  - So we comply … don't we??

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What does it mean to comply with MISRA C?

- The reality is
  - Not all guidelines are enforceable through static analysis
    - MISRA C contains 17 directives and 156 rules
      - Of those rules only 119 are "decidable"
  - Not all tools enforce all guidelines
  - It is necessary to understand how well tools enforce guidelines – vendor claims e.g. "we enforce 143 rules" need to be verified – "how good" is the checking? Remember not all of those 143 rules are "decidable"
    - Code examples are available that can be used to evaluate a tool but do not represent a conformance suite
    - The tool configuration is also significant
  - MISRA C does not have any sensitivity to e.g. ASIL in ISO 26262
  - Some guidelines may not be achievable in a particular project or context
  - Tools can be configured to suppress messages in various ways

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What does it mean to comply with MISRA C?

- As a minimum an assessor should expect to see …
  - That there is a plan for which guidelines are enforced and how
  - That tools have been selected considering their capability to enforce decidable rules (and support evaluation of other guidelines)
  - That any deviations are documented and formally approved
    - Including that any use of message suppression in tools is linked to a documented deviation

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The role of deviations

- There are cases where it is necessary to deviate from MISRA C requirements for example in I/O code
- A formalized deviation process is required to capture and approve necessary deviations
  - At a project level – where a deviation is required for a specific class of circumstances
  - As a specific deviation – for a single instance in a single source file, where a deviation is unavoidable, for example for a specific timing reason
- However deviations should not be an excuse for avoiding writing compliant code

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MISRA Compliance:2016
A more rigorous approach to deviations

- A framework for claiming compliance with MISRA coding guidelines
- Includes guidance on a robust and structured process for the use of deviations
- Includes a mechanism for establishing pre-approved "permits" to help streamline the deviation process
- Supersedes the compliance, deviation and process requirements previously published in various MISRA coding guidelines (e.g. Section 5 of MISRA C)
- MISRA Compliance:2020 makes its application mandatory
- MISRA C:2004 permits
  - Contains a number of deviation permits covering commonly-encountered use cases for use with the MISRA C:2004 guidelines
  - Intended for use alongside MISRA Compliance:2016
  - These are **not** "carte blanche" deviations …

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MISRA Compliance:2016
The context

- The development contract
  - Decision to apply MISRA Guidelines should be applied at the start of the project
  - ISO 26262 context: Development Interface Agreement (DIA)
- The software development process
  - Mature and effective software development process assumed e.g. according to ISO 26262
- New guideline classifications in MISRA C:2012 may impact approach to deviations
  - Directives vs Rules
  - Analysis scope
  - Decidability (this is a particularly important area)

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MISRA Compliance:2016
Key work products

- Inputs
  - MISRA C:2012 (or …)
  - Guideline enforcement plan
    - Including information associated with tool use (⇒ ISO 26262 Part 8 Clause 11) and any manual processes
  - Guideline re-categorization plan
  - Permits
- Outputs
  - Guideline compliance summary
  - Approved deviations
  - Permits

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Guideline enforcement plan (sample excerpt)

Guideline	Compilers		Analysis tools		Manual review
	A	B	C	D	
Dir 1.1					Procedure x
Dir 2.1	No errors	No errors			
…					
Rule 4.1			Message 42		
Rule 4.2				Warning 178	
Rule 5.1	Warning 123				
…					
Rule 12.1				Message 26	
Rule 12.2			Message 262		Procedure y
Rule 12.3			Message 508		
Rule 12.4				Message 61	

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Guideline re-categorization plan

- The organizations involved in the development can re-categorize MISRA Guidelines depending on project and context needs
  - Some *Required* Guidelines could be made *Mandatory*
  - Some *Advisory* Guidelines could be made *Mandatory*, *Required* or *Disapplied*
- However
  - *Mandatory* Guidelines cannot be re-categorized
  - A *Required* Guideline cannot be downgraded to *Advisory* or *Disapplied*
- ISO 26262 Part 6 context
  - See Note to clause 5.4.3 “Existing coding guidelines and modelling guidelines can be modified for a specific item development”
    - ASIL dependency and rationale for methods could be an input to decisions
  - See also work product 5.5.1 “Documentation of the software development environment”

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Example re-categorization plan

Guideline	MISRA category	Revised* category
Dir 1.1	Required	Mandatory
Dir 2.1	Required	Required
…		
Rule 4.1	Required	Required
Rule 4.2	Advisory	Disapplied
Rule 5.1	Required	Mandatory
…		
Rule 12.1	Advisory	Mandatory
Rule 12.2	Required	Required
Rule 12.3	Advisory	Advisory
Rule 12.4	Advisory	Required

* Could be company-wide or project specific e.g. specified in a DIA

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Investigating tool messages

- General principle is that all messages reported by tools must be addressed
- Messages reported by tools or compilers could be
  - Correct diagnosis of a violation
    - Correction (ideally) or deviation needed
  - Diagnosis of a possible violation
    - Investigate and document why the code is correct despite the diagnosis
  - False diagnosis of a violation
    - Investigate and explain why diagnosis is incorrect
    - Ideally with support of tool developer ⇒ ISO 26262 context: Confidence in the use of software tools
  - Diagnosis of another issue that is not a violation
    - Rationale needed for why the message can be ignored

The (correct) role of deviations

- Claims of compliance with MISRA C in the presence of unavoidable rule violations must be authorized through a defined process and supported by deviation records
- Deviation record contains
  - The guideline(s) being violated
  - Description of circumstances where violation is acceptable
  - The reason why the deviation is required
  - Background information to explain context and language issues
  - Requirements to include risk assessment procedures and precautions to be observed
- Context of deviation – single instance or common use case
- The role of deviation permits (see later)

When is a deviation not permitted?

- When it is simply for the convenience of the developer
- Where there is a reasonable alternative coding strategy that would remove the violation
- When impact on other Guidelines has not been considered
- When there is not a suitable process in place for managing deviations
  - Including sign-off by a designated technical authority

Use cases for deviations

- Deviations should only be approved if justified on the basis of one or more of
  - Code quality
  - Access to hardware
  - Integration of adopted code
  - Non-compliant adopted code

Adopted code

- Term used to refer to code that has not been developed within the scope of the current project
  - ISO 26262 context: a software component that is “reused”, see Part 6 Clause 7.4.7
- Sources of adopted code include
  - The Standard Library
  - Device drivers
  - Middleware
  - Third party libraries
  - Automatically generated code
  - Legacy code

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Adopted code

- Key questions associated with adopted code (and that must both be addressed)
  - Has the code been developed to an adequate level of safety and security?
    - ISO 26262: Part 8 Clause 12 “Qualification of software components”
  - Has the code been developed to be compliant with MISRA Guidelines?
- Particular procedures may need to be applied concerning
  - Guidelines with system-wide analysis scope
  - Adopted binary (object) code
  - Adopted source code
    - Specific Guideline Re-categorization Plans may be needed (remember a Mandatory guideline cannot be re-categorized)
  - Adopted header files
  - The Standard Library

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Claiming compliance

- Process aspects
  - Staff competence
  - Management process
- Evidence of compliance
  - Guideline compliance summary
- Permitted levels of claimed compliance

MISRA category	Compliance levels that may be claimed			
Mandatory	Compliant			
Required	Compliant	Deviations		
Advisory	Compliant	Deviations	Violations	Disapplied

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Example Guideline Compliance Summary

Guideline	MISRA category	Compliance
Dir 1.1	Required	Compliant
Dir 2.1	Required	Deviations
…		
Rule 4.1	Required	Deviations
Rule 4.2	Advisory	Disapplied
Rule 5.1	Required	Compliant
…		
Rule 12.1	Advisory	Compliant
Rule 12.2	Required	Deviations
Rule 12.3	Advisory	Violations
Rule 12.4	Advisory	Deviations

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Project delivery

- Supporting information for a claim of compliance
  - Guideline enforcement plan; the following may be requested by the acquirer (“customer” in ISO 26262 DIA)
    - Supporting information on tools and processes
    - Evidence of tool checks
    - Evidence of detected violations
  - Guideline compliance summary
  - Details of any approved deviation permits that have been used
  - Deviation records for all *Required* guidelines
    - Whether *Required* in MISRA C itself or re-categorized

Example deviation record

Project	F10_BCM		
Deviation ID	D_00102	Status	Approved
Permit	Permit / Example / C:2012 / R.10.6.A.1		
Rule 10.6	The value of a composite expression shall not be assigned to an object with wider essential type		
Use-case	The value of a composite expression is assigned to an object of wider essential type to avoid sub-optimal compiler code generation		
Reason	Code Quality (Time behaviour)	Scope	Project
Tracing tags	D_00102_1 to D_00102_10		

Raised by	E C Unwin	Approved by	D B Stevens
	Signature		*Signature*
Position	Software Team Leader	Position	Engineering Director
Date	14-Mar-2015	Date	12-Apr-2015

See Appendix A of MISRA Compliance:2016 for full details including supporting rationales

Deviation permits

- A deviation permit defines a use case under which a violation may be justified and specifies the documentation and process requirements which must be supplied in the deviation record
- The motivation for permits is to capture common use cases and provide common information that can be the basis of a deviation record
- **Note: a deviation record is still required, a permit is not a pre-defined deviation!**

MISRA C:2004 Permits

- A set of pre-written Permits (which can form the basis of Deviations) for certain MISRA C:**2004** rules
  - Rule 1.1 – code compliance with ISO/IEC C90 (mostly around language extensions in later language versions)
  - Rule 5.1 – length of external identifiers
  - Rule 6.4 – bit-fields of type other than *unsigned int* or *signed int*
  - Rule 8.5 – in-line function defined in header file
  - Rule 12.7 – bitwise operators applied to signed operands
  - Rule 13.7 – Boolean operations with invariant results
  - Rule 14.1 – unreachable code
  - Rule 17.1 – pointer operations performed on a memory region that is not an array object
  - Rule 17.4 – array indexing applied to a pointer addressing a specific hardware memory space

Mapping MISRA Compliance ↔ ISO 26262

MISRA Compliance topic	ISO 26262
The development contract	Part 8 Clause 5 “Interfaces in distributed development”
The software development process	Part 6 plus supporting and management processes
Guideline enforcement plan Guideline reclassification plan	Safety plan (software specific content) Part 6 requirements for coding guidelines (including adaptation for specific item / element development) Part 8 Clause 11 “Confidence in the use of software tools”
Guideline compliance summary Deviations	Part 6 requirements for coding guidelines (including adaptation for specific item / element development) Safety case
Adopted code	Part 8 Clause 12 “Qualification of software components”
Competence and management process	ISO 26262 Part 2 Clauses 5 and 6

Future directions

- MISRA Compliance:2016 provides an essential rigorous framework for managing deviations from coding guidelines
  - But can be aligned to and implemented within the framework of a standard such as ISO 26262
- MISRA Compliance:2020 makes it application mandatory
  - Effectively replaces the existing guidelines on deviations and claiming compliance (e.g. MISRA C:2012 Sections 5.4 and 5.5)
- Under discussion: whether approach to MISRA compliance in automatically-generated code becomes a set of “permits”
  - MISRA C:2004 – separate document provided: MISRA AC AGC
  - MISRA C:2012 – reclassification provided in Appendix E
- Permits also under development for MISRA C:2012

Conclusions and recommendations for XEN

- Establish a guideline enforcement plan
  - Carefully consider tool capability and coverage of rules
- Establish a guideline recategorization plan
- Developed permits for identified XEN use cases
- Ensure all deviations have an approved deviation record
  - “Permits” are not an automatic approval of deviations but streamline the process

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