

AUTOCODING WORKING GROUP Automatic Code Generation for AOCS Flight SW

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- Background Extended Working Group (EWG) on Autocoding
- Technology: Modelling Guidelines outcome of EWG
- Process: Autocoding generation process outcome of EWG
- Planning / Conclusions





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SAVOIR Autocoding Working Group





A. Modelling guidelines (AOCS modelling):

- Define modelling guidelines
- Configuration of code generation toolboxes
- Classification of guidelines

B. Model/Code development process guidelines:

- Verification & Validation process review wrt manual coding
- Automatic steps and available tools (possible improvements, customization) guidelines
- Test reporting guidelines (templates, content description)

C. Compliance with existing standards:

- Cross check/mapping of ECSS requirements to the Autocoding V&V process
- Comparison with Autocoding processes as proposed/implemented on different projects



SAVOIR Autocoding handbook draft





SAVOIR Autocoding Extended Working Group





Collection of comments and observations to the HB draft TAS, ADS, OHB, GMV, CNES, DLR

Mathworks has been also involved focused on details about the toolboxes



The purpose of this Extended Working Group (EWG) is to **review the ESA Modelling guidelines for Autocoding Handbook** to be used as reference when creating models and generating flight code.

The Handbook shall be used as reference with the objective of ensuring generated code is **correct**, **reliable**, readable, sharable/reusable and maintainable.

The intended use of the guidelines are the following ones:

- Use in **support to projects** providing an harmonized ESA position across the Agency.
- Use in **R&D technology** activities.
- Promotion of the use of this type of methodology across the phases of a development.
- Contribution to the assessment of the quality of the final software product

The scope of the Handbook includes

- The technology (modelling guidelines, impact of the code generator, etc...)
- The process (GNC algorithm development process and application software process covering all the lifecycle up to V&V)

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Technology: modelling guidelines, code generation



Modelling guidelines have the objective to ensure generated code is:

CORRECT

• The code generation process shall work properly and free from errors, generated code shall correspond to the model.

RELIABLE

STRONGLY RECOMMENDED

• The generated code shall be fully equivalent to the model to ensure verification is valid

READABLE, REUSABLE, SHARABLE

- Despite no manual changes to the generated code are foreseen, the readability shall be kept for code inspection, debugging, etc...
- The possibility to reuse or share generated code (industrial organizations) shall be foreseen by code readability

MANTEINABILITY

RECOMMENDED

RECOMMENDED

MANDATORY

• The maintenance of auto-generated code is meant to be achieved without manual intervention, but acting on the model and re-generating the code. This possibility shall be maximized by modular architecture and traceability

Guidelines review



A. Modelling guidelines scope

- Review the guidelines category, mandatory only when no alternative exists
- Express guidelines in terms of objectives, without providing implementation details
- Identify guidelines linked to toolbox and those independent

B. Use of referenced model

- The use of referenced model is allowed to improve readability and possibility to reuse part of model
- Alternative solutions exists

C. Configuration settings

• The code configuration settings shall be defined and applied at each generation to avoid differences

D. Configuration control

• The model versioning shall be kept in configuration control. Several methods exist to trace changes into the model (model block, each subsystem, etc..)

E. Model coverage and code coverage

• It is understood that model coverage does not always corresponds to same code coverage, due to code generation process. As per ECSS E40 clause 5.8.3.5, if it can be justified that the required percentage cannot be achieved by test execution, then analysis, inspection or review of design shall be applied to the non covered code.

F. Mapping of Reviews/timeline

• The correspondence between AOCS reviews and SW reviews will be updated





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11

Process: Code generation development & Verification





Autocoding Process





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Requirements definition





A. From system level to AOCS Subsystem:

- Derivation of requirements: functional, performance, FDIR
- Justification of AOCS design architecture

B. From system level to SW Subsystem:

- Derivation of SW requirements (non AOCS)
- Definition of AOCS SW Interface Requirements
 Document
- → AOCS team shall start modelling following AOCS SW IRD

AOCS Performance Verification MIL vs SIL (1/2)





A. AOCS performance verification MIL

- AOCS model developed following Autocoding HB guidelines
- AOCS performance (pointing, stability, sensitivity..) verified on MIL wrt AOCS requirements baseline
- Justification of AOCS design

B. Code generation:

- Code generation process configured as per HB
- Definition of AOCS Performance verification reference test cases (subset from MC campaign)
- Comparison of results MIL vs SIL → equivalence expected at last digital bit
- → The Proof of Equivalence (PoE) is mandatory to confirm performance verification on Model covers the verification of Code
- → The PoE can be achieved with accurate modelling and use of mathematical library
- → If PoE at last digit is not achieved, option 2 (see next slide shall be used)

AOCS Performance Verification MIL vs SIL (1/2)





A. AOCS development MIL

- AOCS model developed following Autocoding HB guidelines
- Justification of AOCS design

B. Code generation:

• Code generation process configured as per HB

C. AOCS Performance verification SIL:

- Verification of AOCS performance (pointing, stability, etc..) running full MC campaign
- → The Code (final product) is used to verify AOCS Performance, no need of equivalence vs Model
- → Any iteration shall not allow Code modifications (changes through Model and Code generation)
- → Synchronization with reviews to be considered

Unit testing MIL vs SIL





A. Unit testing MIL

- Units available and testable, modularity is ensured
- Equivalence between Model coding and Software coding to be demonstrated

B. Unit Testing SIL/SVF:

- Process equivalent to the manual coding, SW units to be defined and ensured by appropriate code generation setup
- → The developer shall demonstrate compliance with ECSS E-40 Clause 5.5.3 Software Unit testing
- → The HB defines the request of unit testing with the scope reported in ECSS. In case UT are performed at Model level it shall be demonstrated the equivalence



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18

Planning



VIJOB DON ESA Working group to prepare and release draft issue of Handbook Issue 1 draft release VIJOB DON Collection of comments and observations to the HB draft • TAS, ADS, OHB, GMV, CNES, DLR • Mathworks has been also involved and iteration of comments is on-going, more focused on details about the toolboxes and their use **Replies to comments** Final feedback from external members • Following first iteration with MTW \rightarrow trace update draft HB including major findings JOB DONI **Meetings Session: discussions and reviews** Comments received and assessed. Meeting with external members held in October. HB draft update and release \rightarrow Q4 2020 Autocoding HB issue 1 to be released by end of the year



- The Autocoding HB is not intended to be applicable document: defines the modelling guidelines and the development and verification process objectives to ensure the generated code is correct and reliable ensuring good readability, reusability and maintainability
- The defined Autocoding process does not differ from existing processes, considering several possible implementations to achieve the same objective
- The Autocoding Handbook covers only the AOCS flight SW in this first release. Possible extensions to be implemented in future issues.
- The Autocoding HB does not cover the development process from delivery of verified code to SW team and system verification up to SW qualification and implementation on target HW. These steps are not affected by the automatic generation of code

Time for questions



