THE CHALLENGE OF ISO 26262 FOR COMPLEX SOFTWARE MODELS

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QUALITY IN THE DRIVER'S SEAT

SOLUTIONS FOR INTEGRATED QUALITY ASSURANCE OF EMBEDDED AUTOMOTIVE SOFTWARE

OUR COMPANY

MODEL ENGINEERING SOLUTIONS

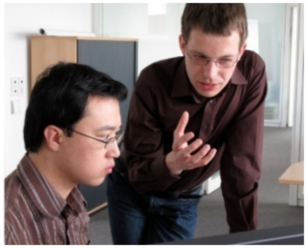
WHO WE ARE

- Founded in 2006 in Berlin out of Mercedes-Benz Research
- A staff of 50+ experts in the field of engineering, testing and functional safety
- Clear focus on model-based engineering and quality assurance for MBD

WHAT WE DO

- Integrated process support for all stages of model-based software development
- We develop software tools for quality assurance of model-based software

INTEGRATED PROCESS SUPPORT FOR MBD



MANAGEMENT SUPPORT

QUALITY ENGINEERING

INTEGRATED APPROACH FOR MBD

QUALITY TOOLS

TRAINING WORKSHOPS

KEY CUSTOMERS

MES MODEL ENGINEERING SOLUTIONS

EvoBus
RENAULT
faurecia
TAKATA
NISSAN
THALES
PORSCHE
T - - Systems - - -
Audi
CARMEQ
MAGNA
NSK
DENSO
Continental
Johnson Controls
SIEMENS
BOSCH
SAIC
DFM
ZF
LG Chem
WABCO
HELLA

AGENDA

MES MODEL ENGINEERING SOLUTIONS

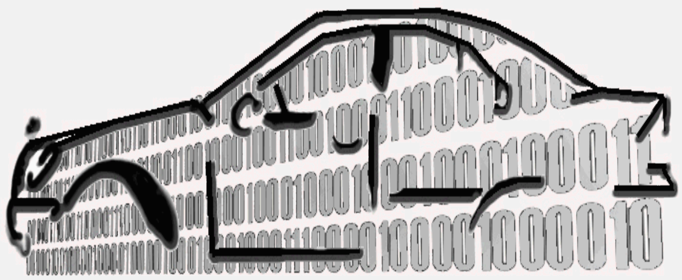
- **ISO 26262 and model-based development**
- Model testing as dedicated process steps
- Architectural complexity
- Handling of model quality
- Summary and conclusion

Disclaimer: Examples are using the Simulink / Stateflow approach to model-based SW development in the Automotive domain. Results can be transferred to other modelling languages and paradigms.

MODEL-BASED DEVELOPMENT

Model-based development dominates SW development in Automotive

- Functionality is realized as a **model**
- **Generation of production code** from the model
- Enabler for early-stage **quality assurance**
- Makes **distributed engineering** more efficient

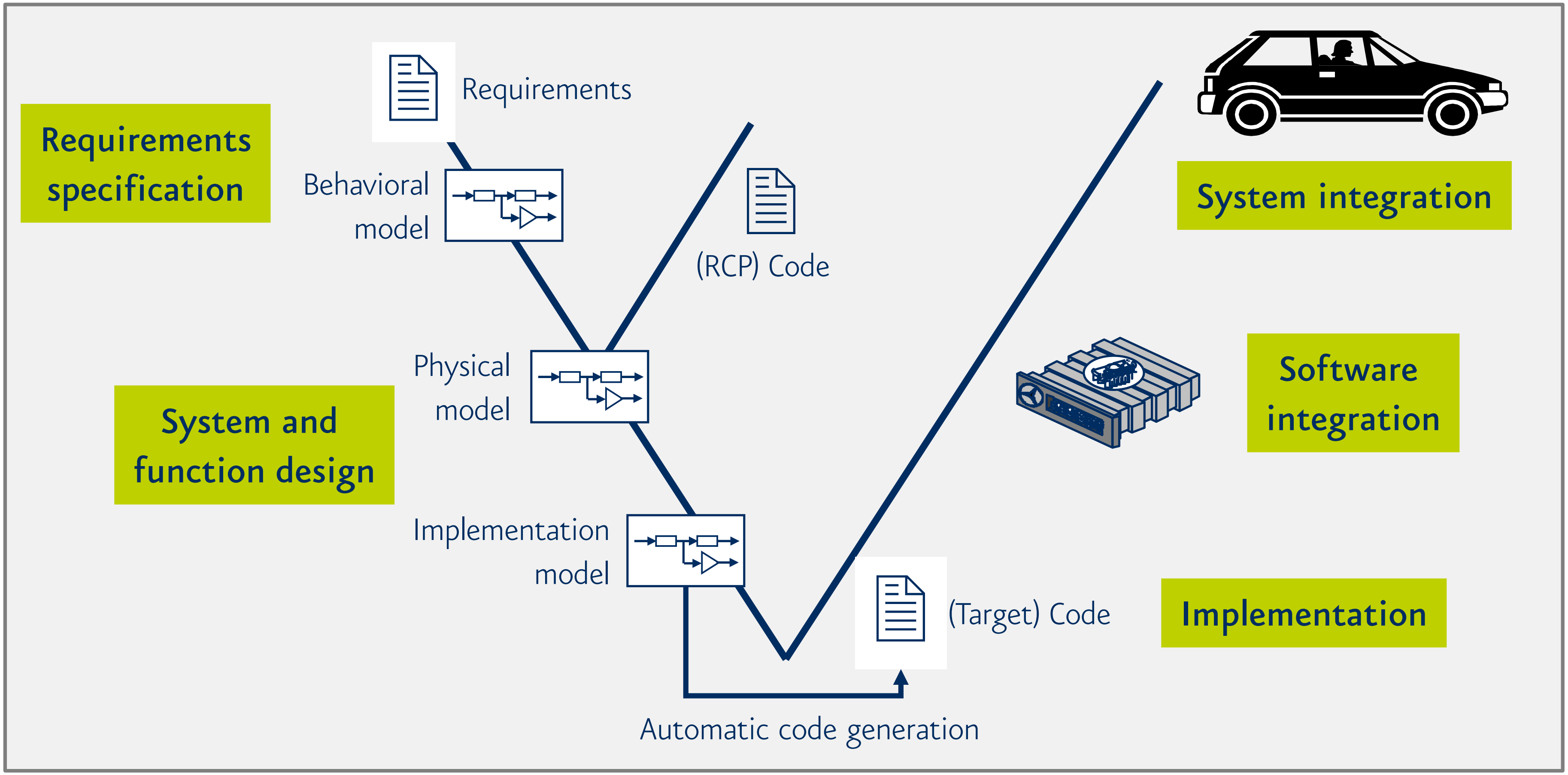


Traditional software development

Model-based software development

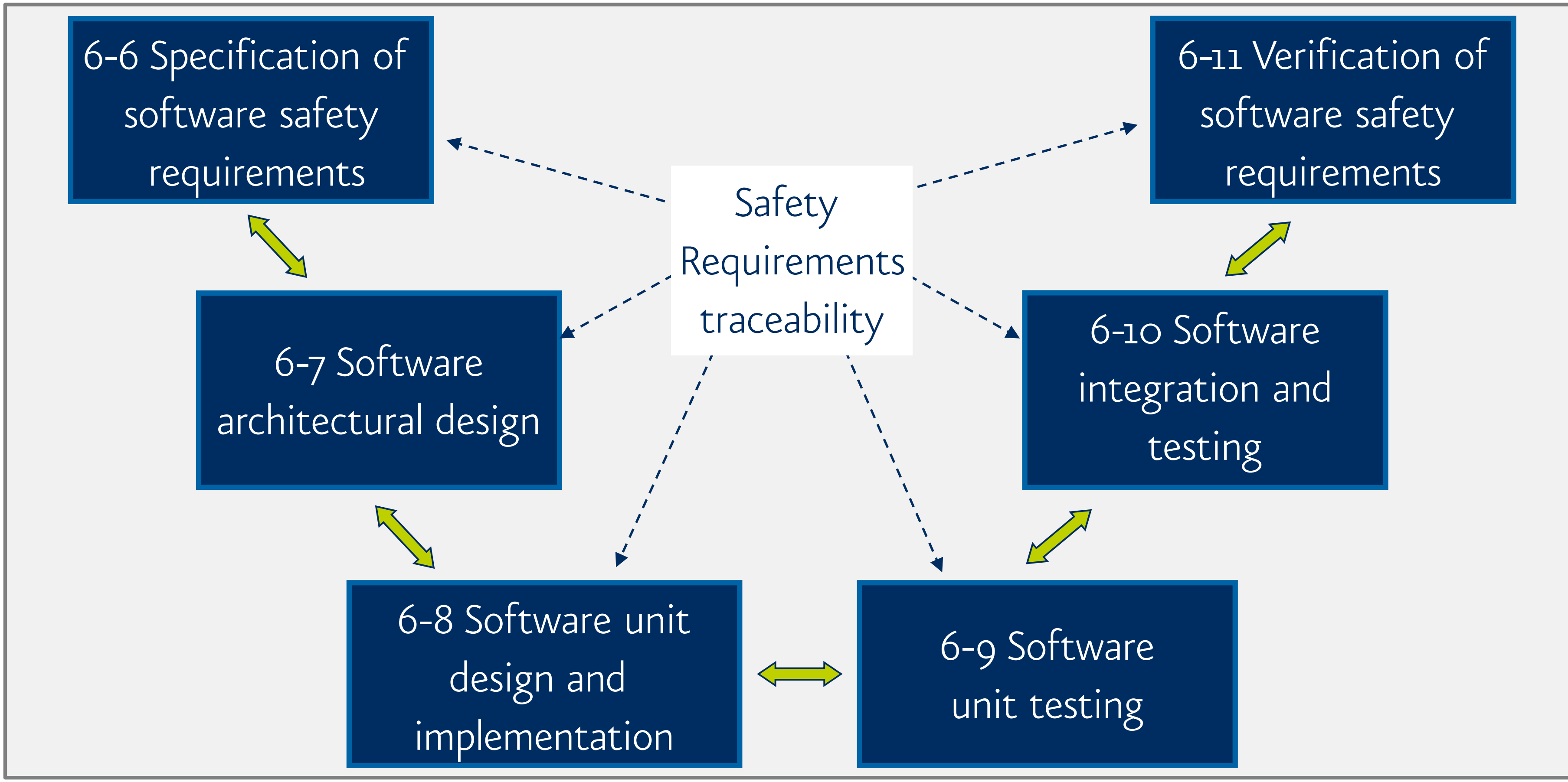
Models contribute to various tasks during development.

Model-based SW development focusses on the generation of code.



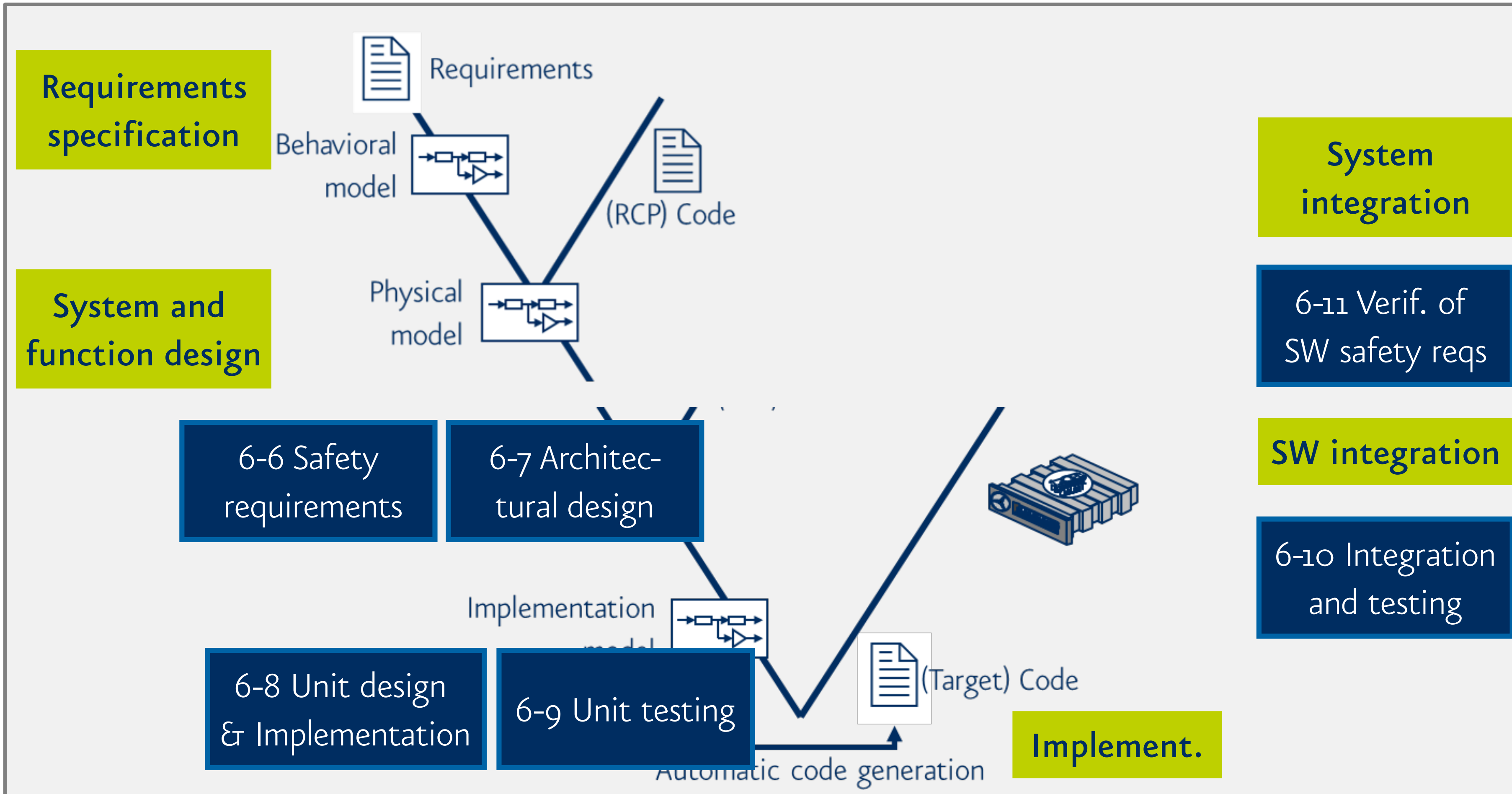
ISO 26262 DEVELOPMENT PROCESS

The ISO 26262 reference model schedules validation at several phases. Model-based development offers frontloading and reuse of test artifacts.



ALLOCATION OF ISO-26262-6 PHASES

SW-safety activities are covered by model-based development process.



AUTOMOTIVE SOFTWARE MODELS

- Automotive software models are often very complex
  - Many levels 7 +
  - Many blocks 8000 +
  - Complex signalling
- Too complex to test or walk through manually
- Example MES “Huge Model”

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The standard highly recommends requirement-based tests. Automated random generation of test cases is not sufficient.

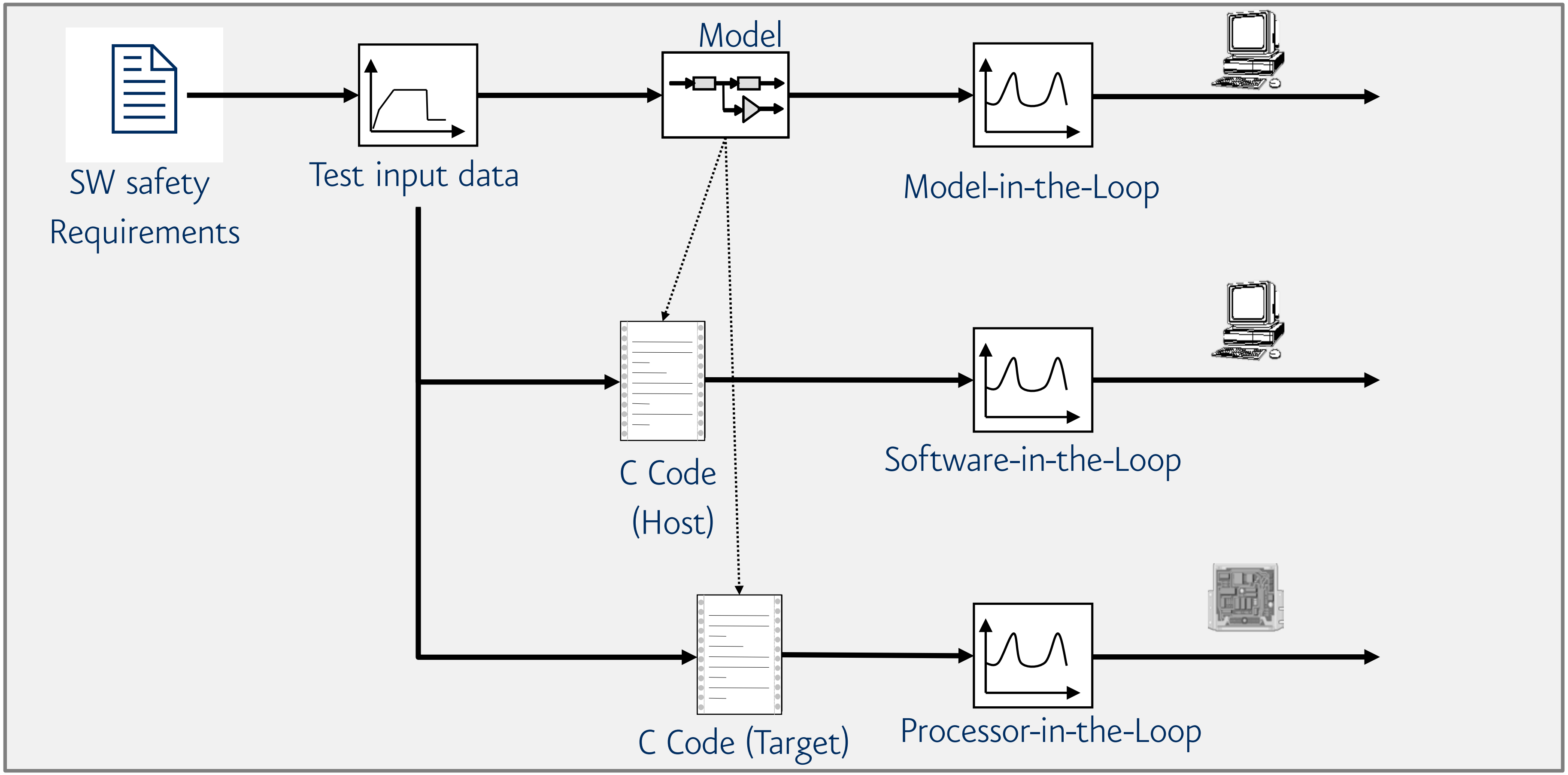
Table 10 — Methods for software unit testing

Methods		ASIL A	ASIL B	ASIL C	ASIL D
1a	Requirements-based test[a]	++	++	++	++
1b	Interface test	++	++	++	++
1c	Fault injection test[b]	+	+	+	++
1d	Resource usage test[c]	+	+	+	++
1e	Back-to-back comparison test between model and code, if applicable[d]	+	+	++	++

Table 11 — Methods for deriving test cases for software unit testing

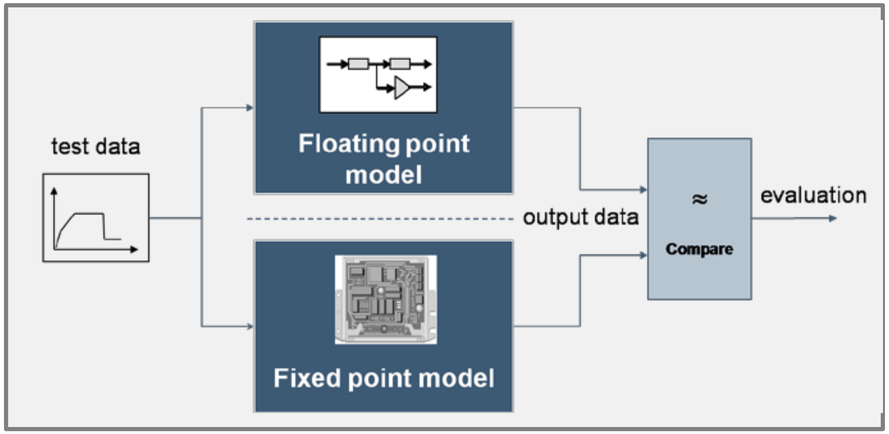
Methods		ASIL A	ASIL B	ASIL C	ASIL D
1a	Analysis of requirements	++	++	++	++
1b	Generation and analysis of equivalence classes[a]	+	++	++	++
1c	Analysis of boundary values[b]	+	++	++	++
1d	Error guessing[c]	+	+	+	+

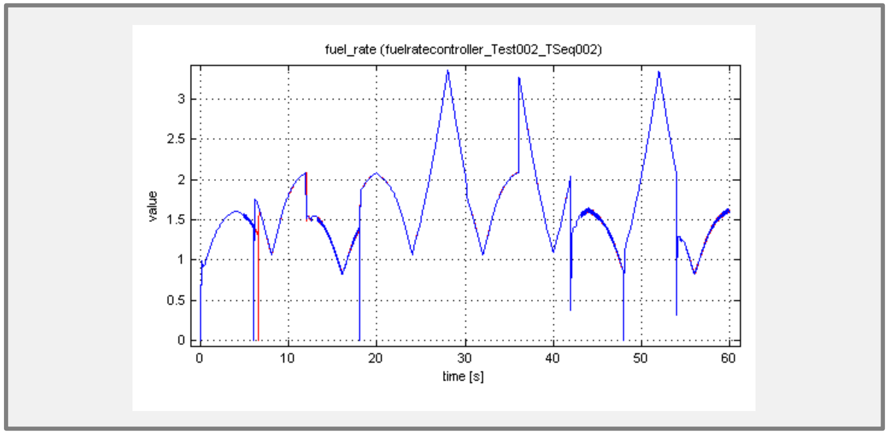
Requirements driven tests continuously assure safety requirements.
Comprehensive model testing reduces overall efforts by frontloading.



Model testing requires a high degree of automation to cope with large models.

- Test execution platform: reduce manual tasks to set-up, test case specification
- Back-to-back test to maintain safety requirements
- Automated assessments to validate test results





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MES MODEL ENGINEERING SOLUTIONS

ENFORCEMENT OF LOW COMPLEXITY "STRONGLY RECOMMENDED".

Table 3 — Principles for software architectural design

Methods		ASIL A	ASIL B	ASIL C	ASIL D
1a	Hierarchical structure of software components	++	++	++	++
1b	Restricted size of software components[a]	++	++	++	++
1c	Restricted size of interfaces[a]	+	+	+	+
1d	High cohesion within each software component[b]	+	++	++	++
1e	Restricted coupling between software components[a, b, c]	+	++	++	++
1f	Appropriate scheduling properties	++	++	++	++
1g	Restricted use of interrupts[a, d]	+	+	+	++

[a] In methods 1b, 1c, 1e and 1g "restricted" means to minimize in balance with other design considerations.

[b] Methods 1d and 1e can, for example, be achieved by separation of concerns which refers to the ability to identify, encapsulate, and manipulate those parts of software that are relevant to a particular concept, goal, task, or purpose.

[c] Method 1e addresses the limitation of the external coupling of software components.

[d] Any interrupts used have to be priority-based.

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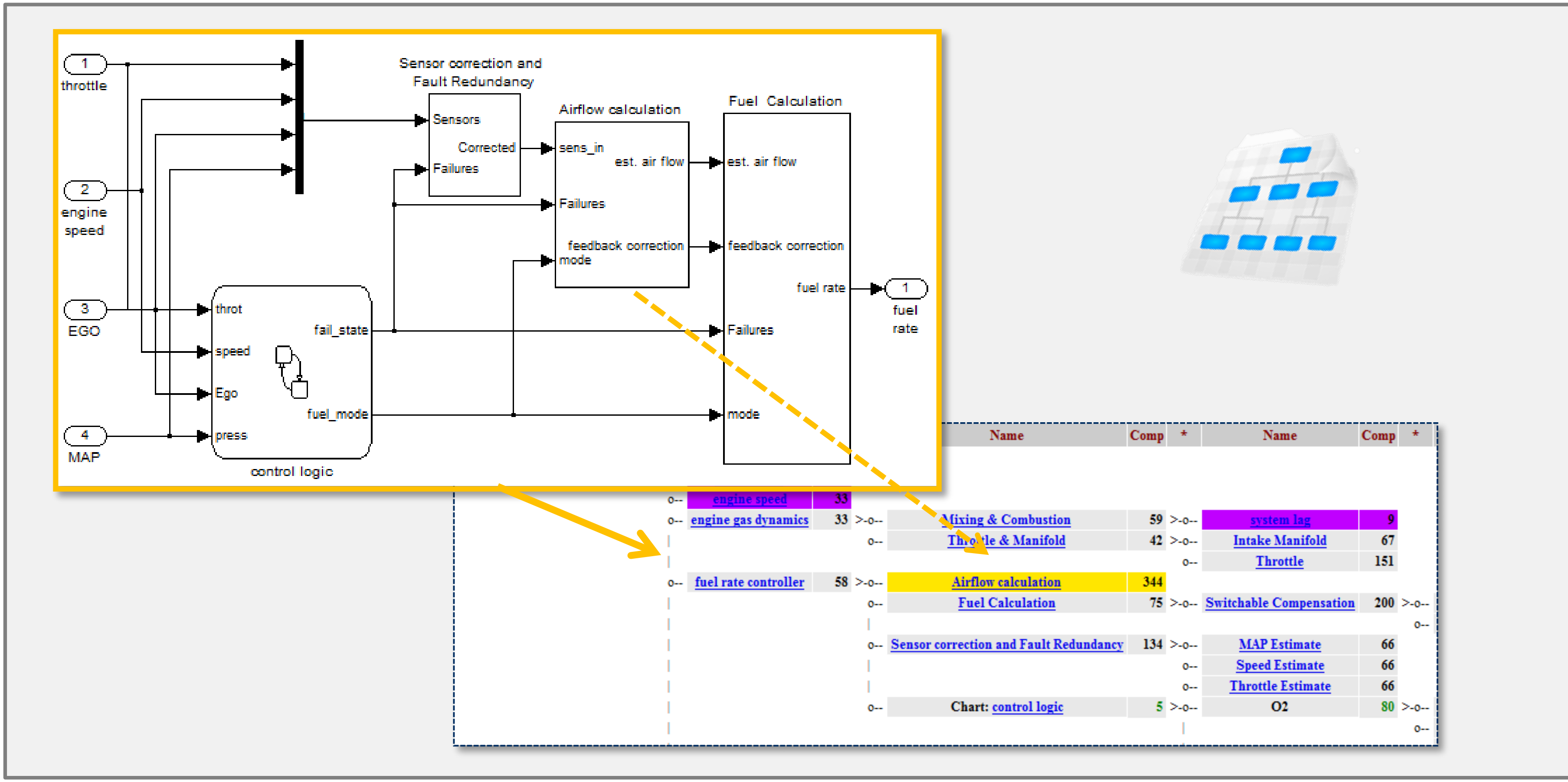
Model architecture analysis identifies complex model parts easily.



ARCHITECTURE ANALYSIS FOR LARGE MODELS

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Architecture analysis is essential to control complexity in large models.

- Clear visualization of model architecture and complexity
- Realistic indicators on model and component size
- Better allocation of resources for development, testing, and review of models
- Detection of clones and unbalanced functionality
- Guidance to refactoring and creation of libraries

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- ISO 262626 and model-based development
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- Architectural complexity
- **Modelling guidelines**
- Summary and conclusion

Browse through modeling guidelines

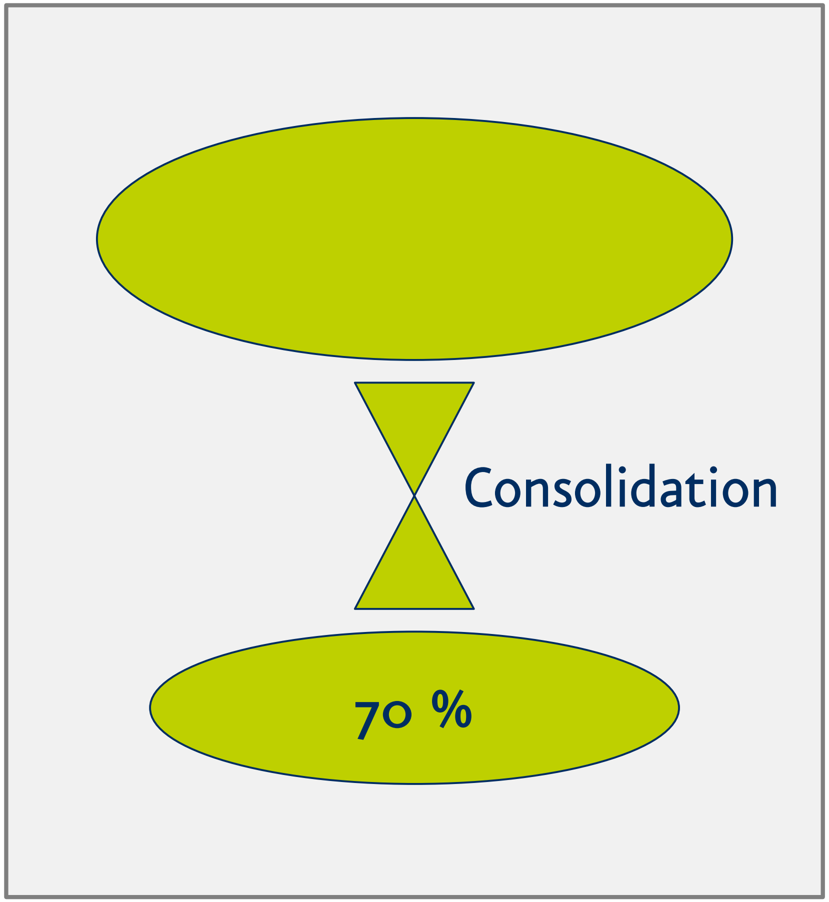
State-of-the-art is defined by approx. 700+ individual guidelines

- Mathworks Automotive Advisory Board
- MISRA Autocode TargetLink
- MISRA Autocode Simulink / Stateflow
- dSPACE TargetLink guidelines
- MES Functional Safety Guidelines

STAGED DETERMINATION OF GUIDELINES

Reduce redundancy and resolve inconsistencies by expert assessment.

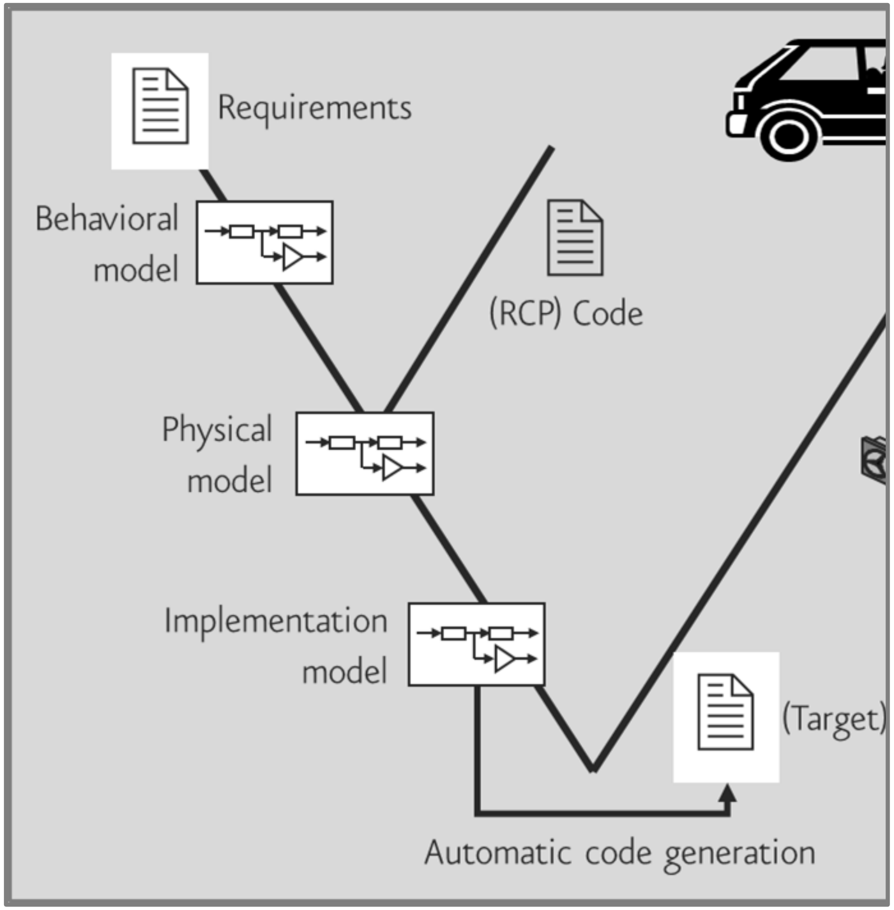
- Assessment of guidelines to filter out redundancy and inconsistencies
- Impact of the individual guidelines must be fully understood before removing a specific guideline
- Consolidation revealed that nearly 35% of the guidelines are overlapping



STAGED DETERMINATION OF GUIDELINES

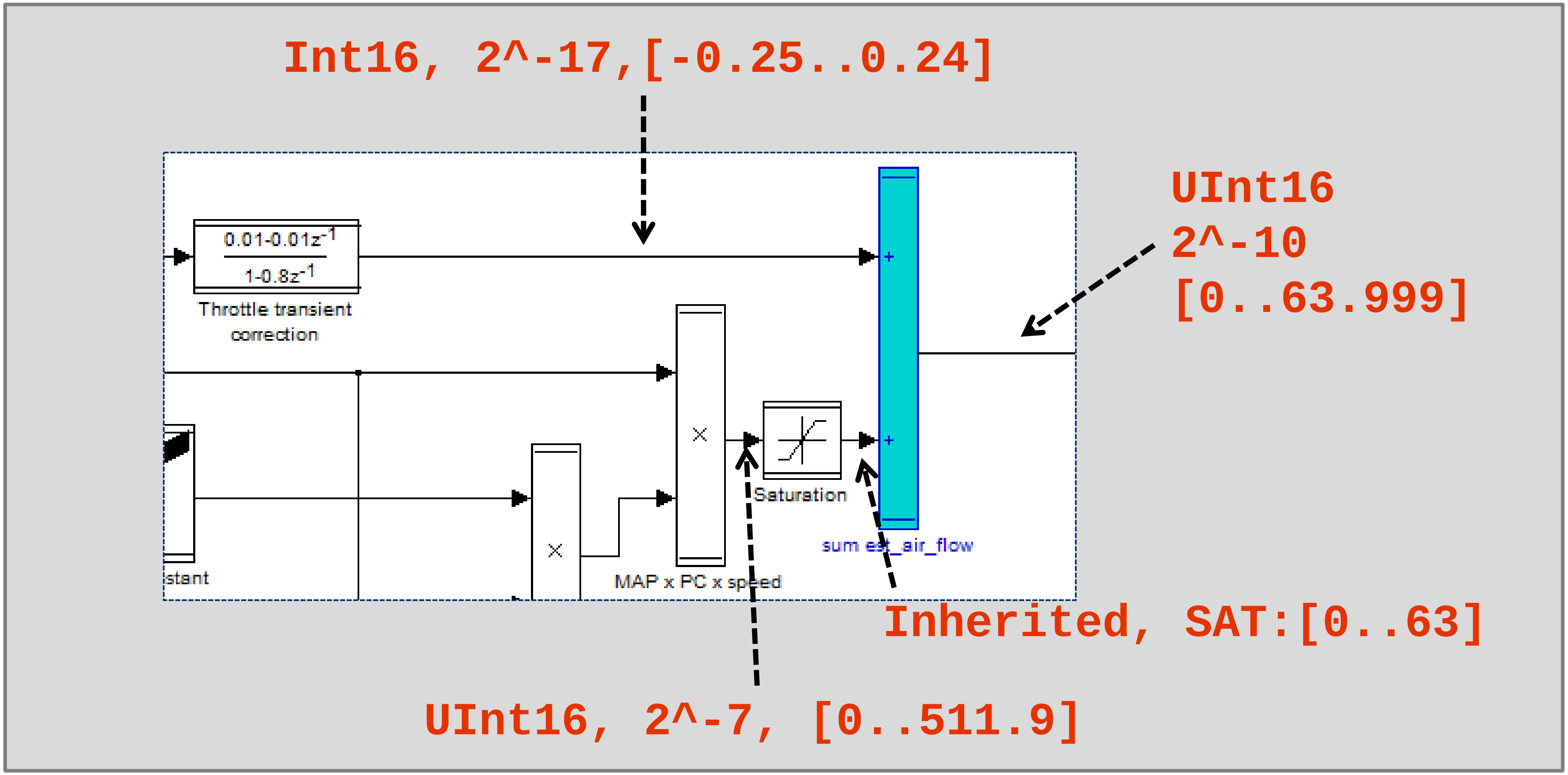
Identify the most appropriate phase for application of guideline.

- ISO 26262-6 generally requests application to “Software unit design and implementation”
- Model-based software development allows frontloading and early application of guidelines
- Each guideline is scheduled to the appropriate phase of development



SPECIFIC EXAMPLE OF A ISO 26262 GUIDELINE

Strong data typing is by intention not supported by Simulink/Stateflow.
Specific checks are required to assure the requested property.



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MES MODEL ENGINEERING SOLUTIONS

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- Architectural complexity
- Model Quality and modelling guidelines
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BEST PRACTICE FOR ISO - WITH LARGE MODELS

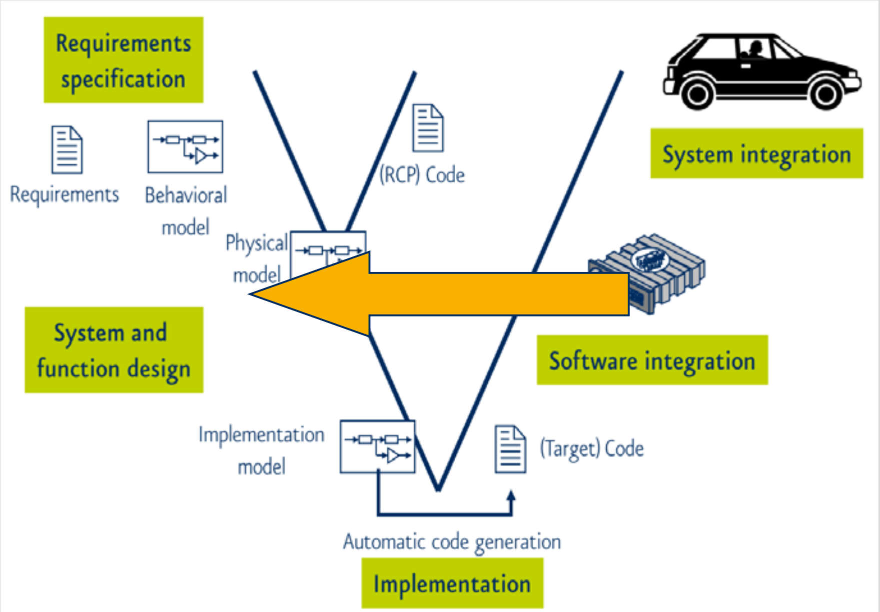
MES
MODEL ENGINEERING SOLUTIONS

- Automate testing and test evaluation
- Automate static review and guideline management
- Manage model complexity and redundancy
- Refine architecture and restructure model into coherent components
- Use library and model references in a consistent way

MES MODEL ENGINEERING SOLUTIONS

MBD helps to meet safety requirements.

- Increase of productivity via code generation
  - Safe up to 50% of implementation time
- Significant improvement of software quality
  - Up to 40% less software errors
- Reduction of development time and costs



FRONTLOADING OF QUALITY ASSURANCE CONTRIBUTES TO SAFETY

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