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SQMB '11

Automated Model Quality Rating of Embedded Systems

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Agenda

Challenge

Approach

Further Evaluation

Summary and Outlook

Challenge (1/2)

Current Situation

- Model-based software development increasingly becoming standard in automotive industry.
 - Size and complexity of models becoming ever larger:
 - Example of a large Matlab Simulink model from passenger vehicle domain:
 - approx. 15,000 blocks
 - 700 subsystems
 - Subsystem hierarchy with 16 levels
 - Considerable time pressure in development.
 - Despite high abstraction level, developers have much freedom.
- Lots of possibilities for potential errors.

Challenge (2/2)

Goals

- Rating of model quality in an automatic and comprehensible manner.
 - Reduce costs and effort.
- Use of existing information to as high a degree as possible.
- Provide a compact overview of model quality.
- Visualization of current status and progress of model quality.

Agenda

Challenge

Approach

- Model Quality

- Quality Model in the Development Process

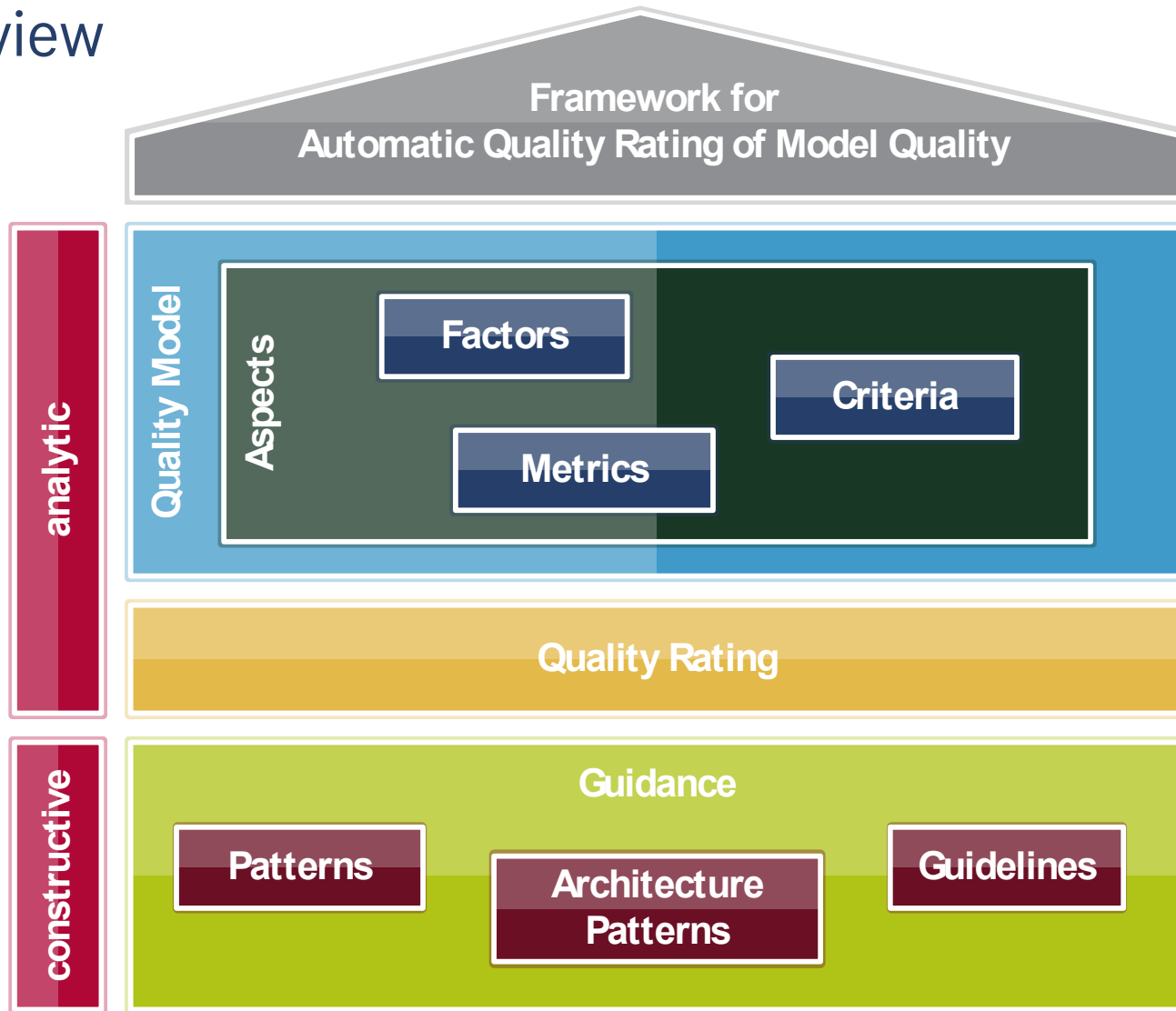
- Evaluation of Measured Values

- Aggregation of Evaluations

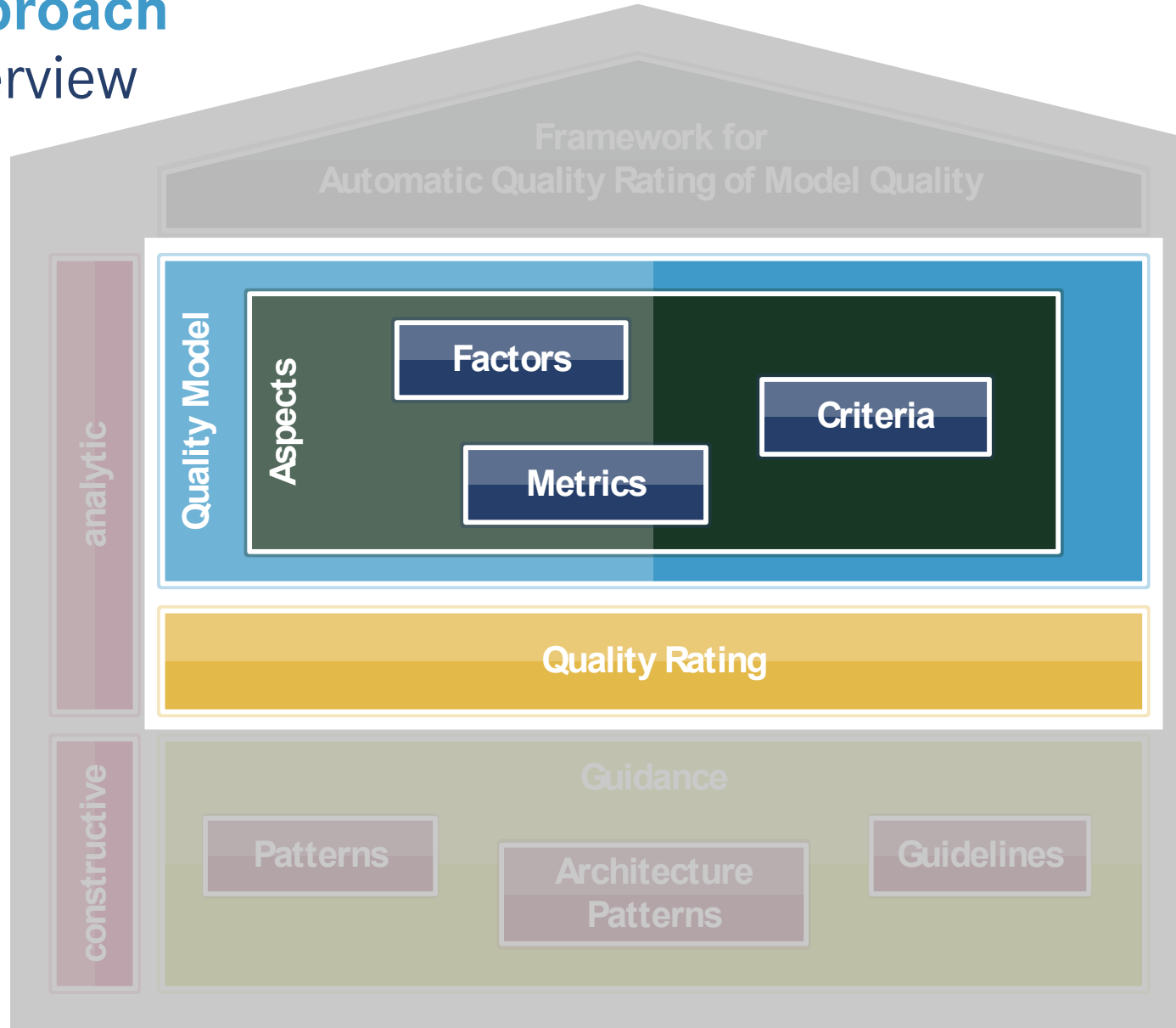
Further Evaluation

Summary and Outlook

Approach Overview



Approach Overview



Model Quality (1/2)

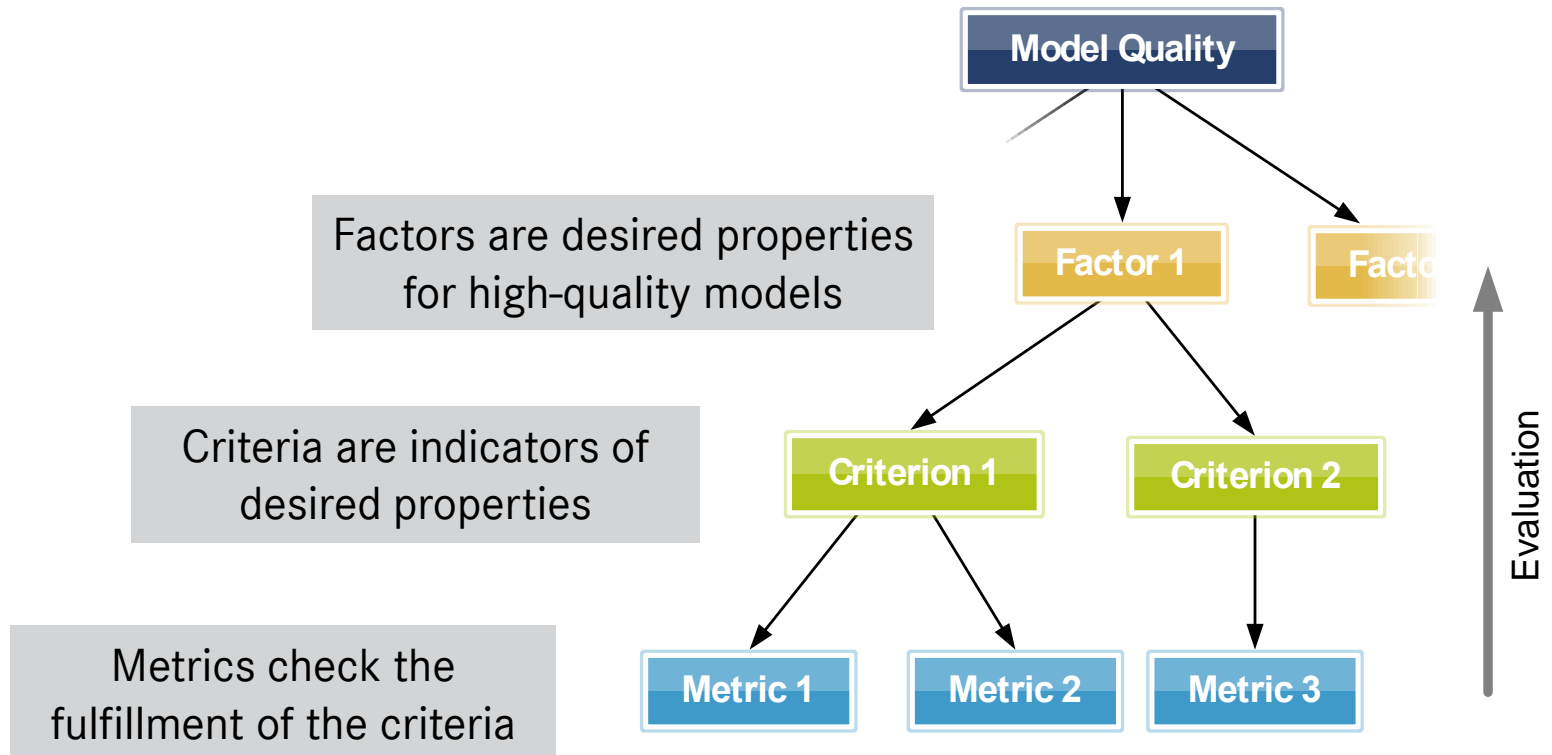
High-Quality Simulink Models

- A model may fulfill criteria with a positive influence on desired factors (e.g. **Maintainability**, **Comprehensibility** or **Reliability**).
- The more criteria a Simulink model fulfills, the higher its quality.
- All criteria that allow inference about desired factors are of interest.

Model Quality (2/2)

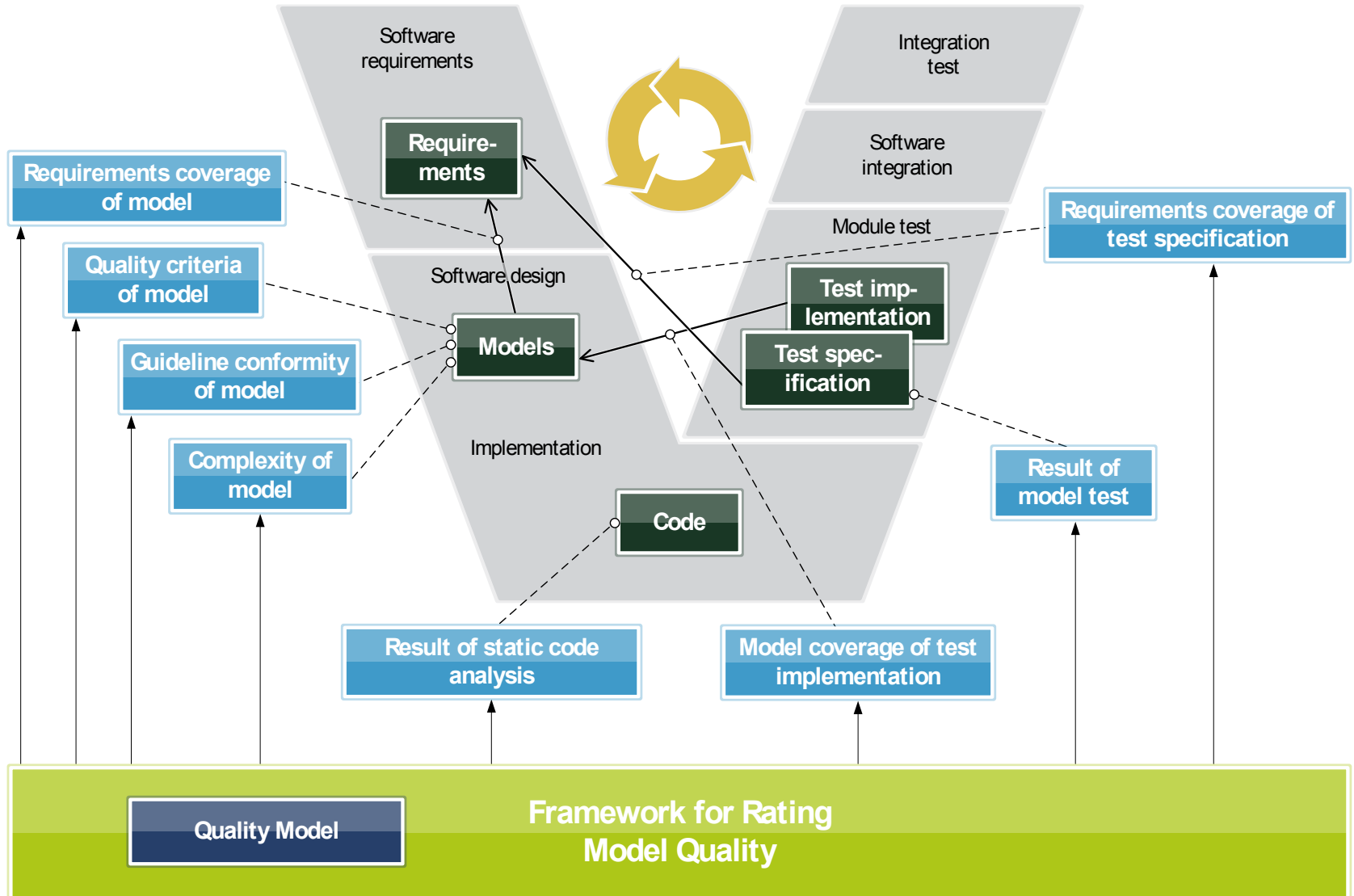
Objective Rating

- An objective rating is possible with the help of a quality model.



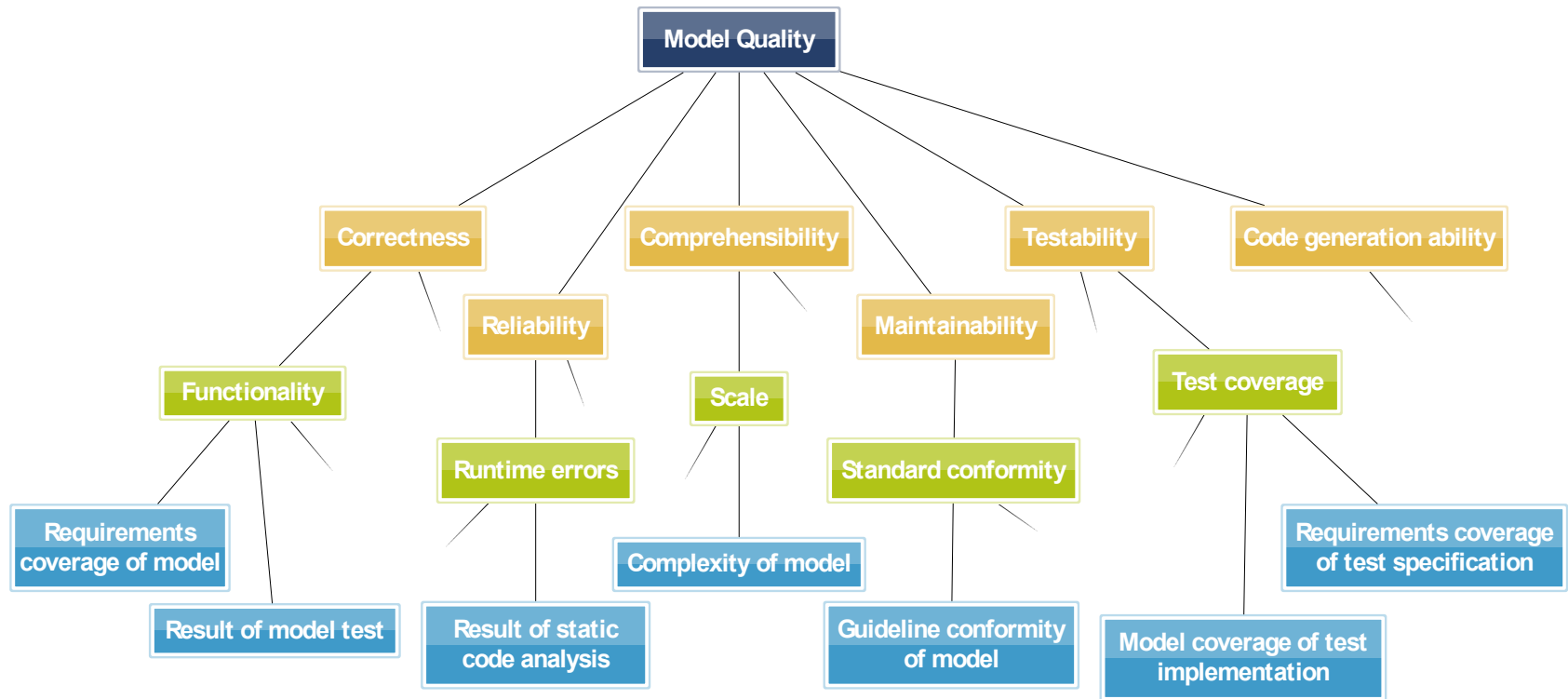
- The quality model currently consists of 6 factors, 18 criteria and 46 metrics.

Quality Model in the Development Process (1/2)



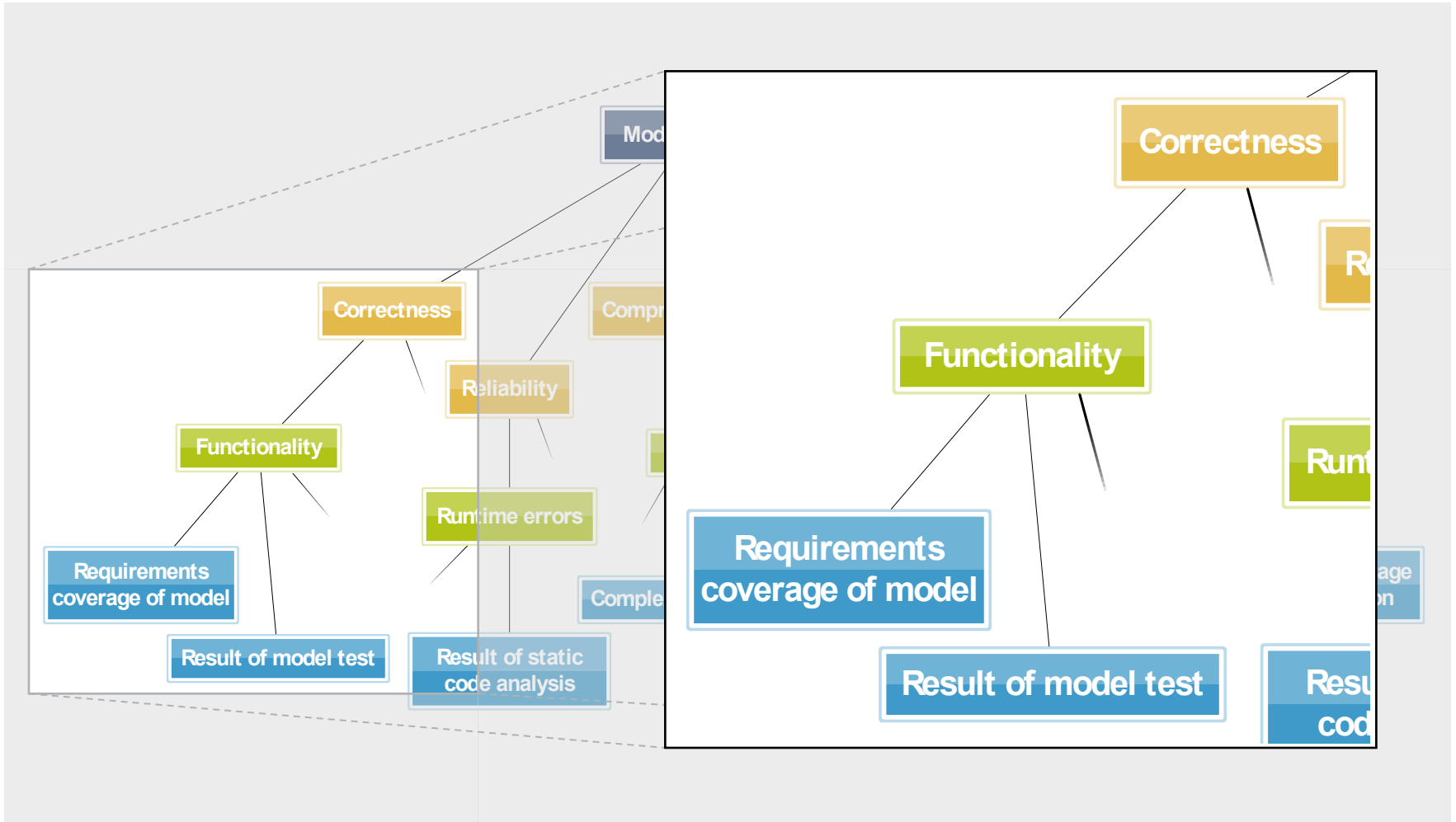
Quality Model in the Development Process (2/2)

Classification



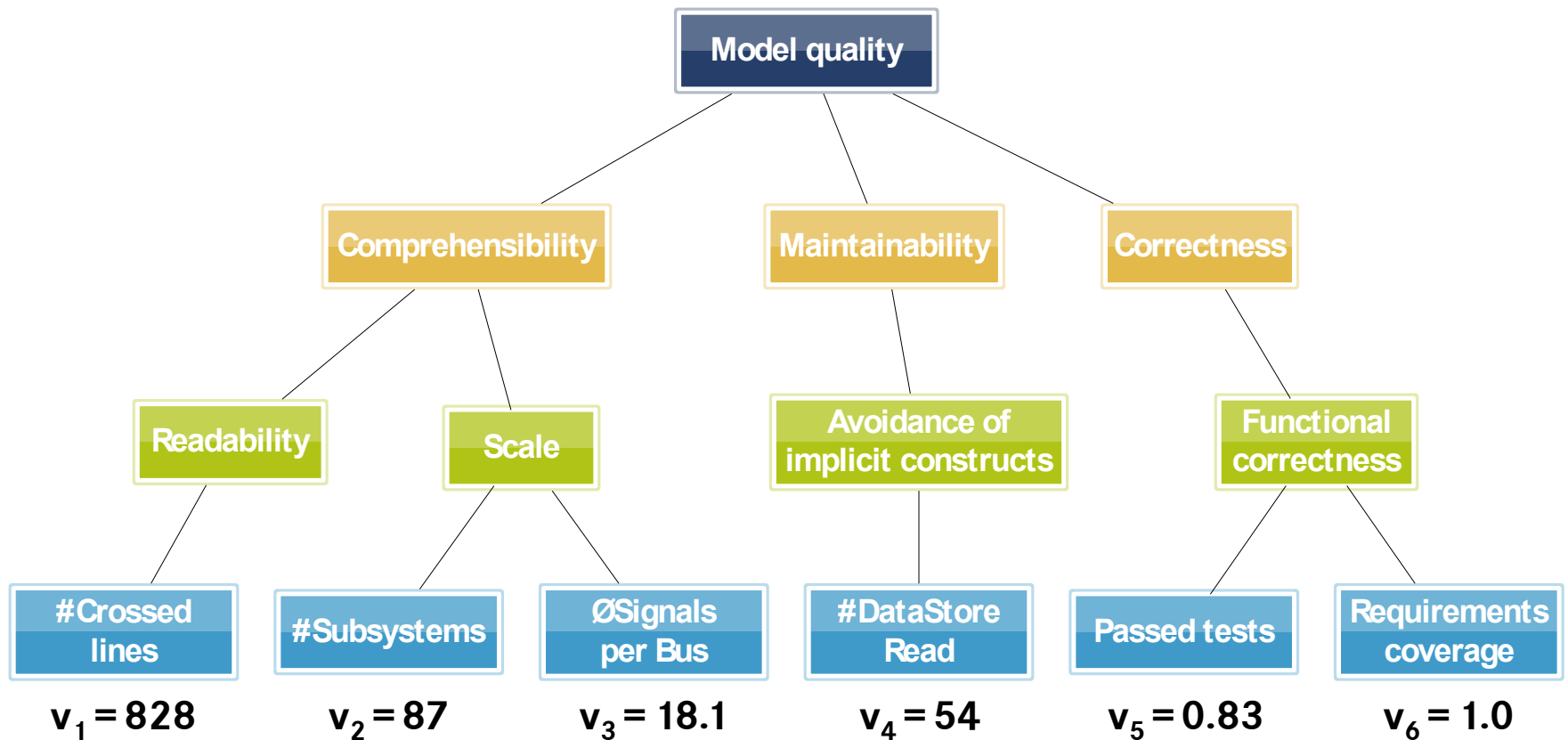
Quality Model in the Development Process (2/2)

Classification



Evaluation of Measured Values (1/5)

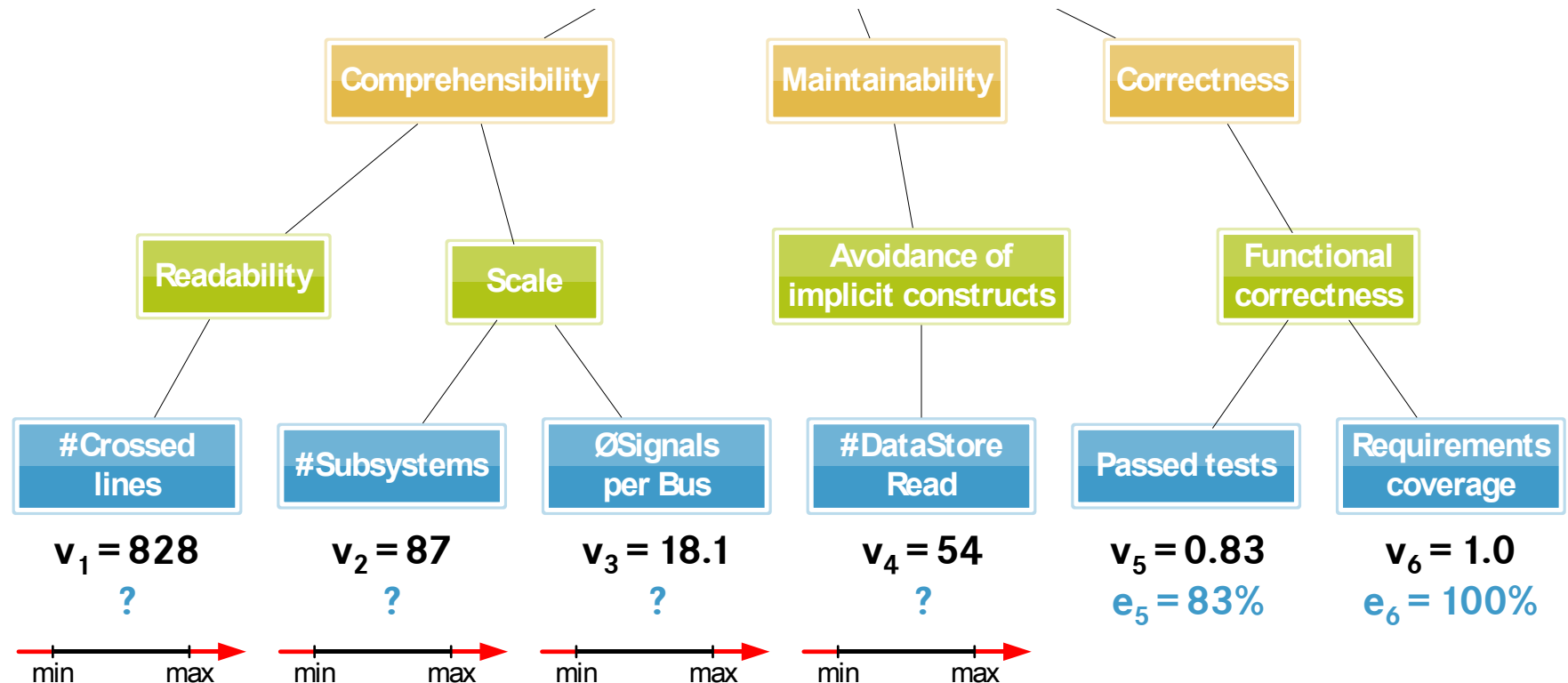
Measurements



Evaluation of Measured Values (2/5)

Determination of Permissible Values

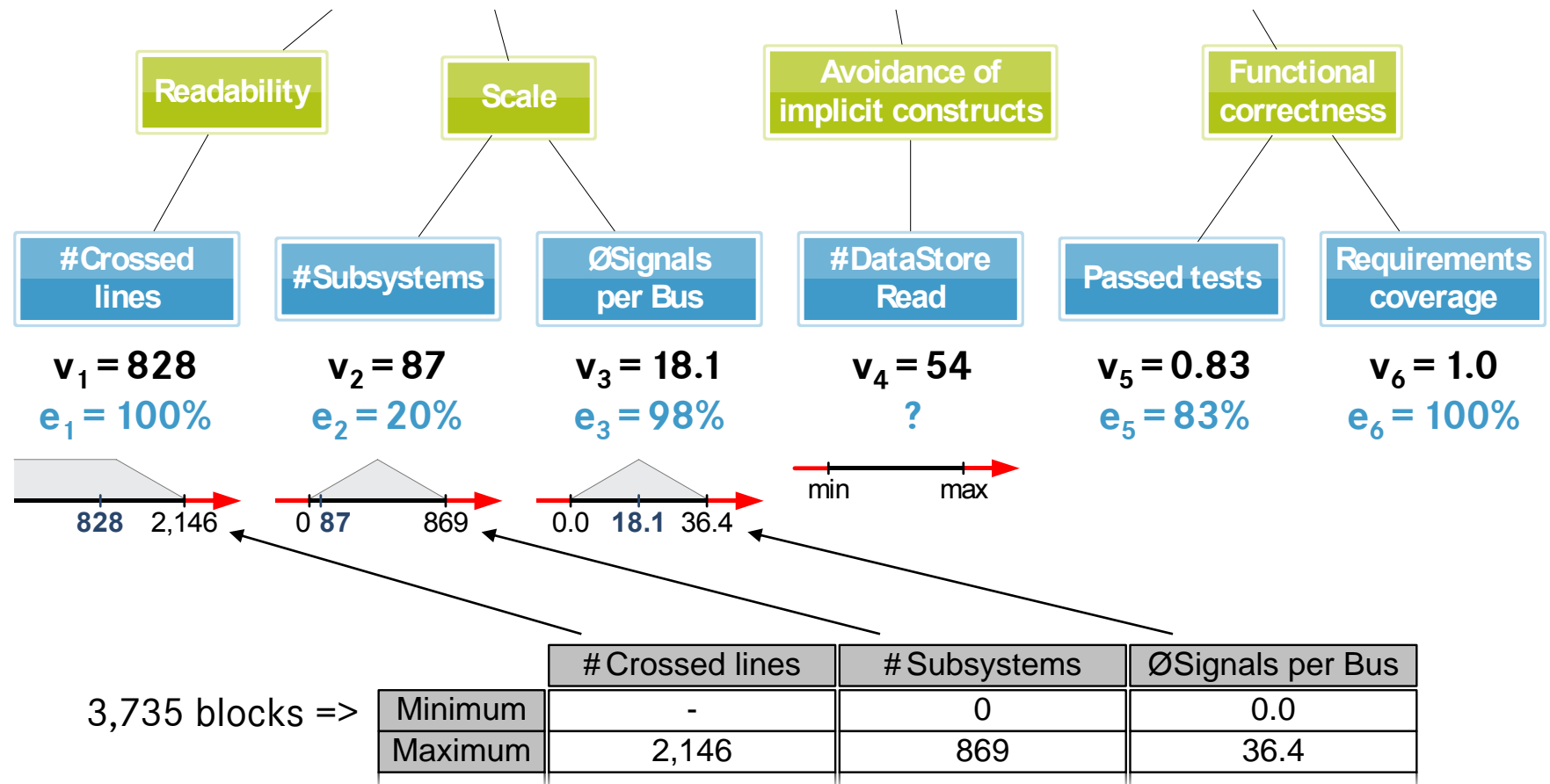
- Define limits for each metric in order to check their permissible values.



Evaluation of Measured Values (3/5)

Reference Model

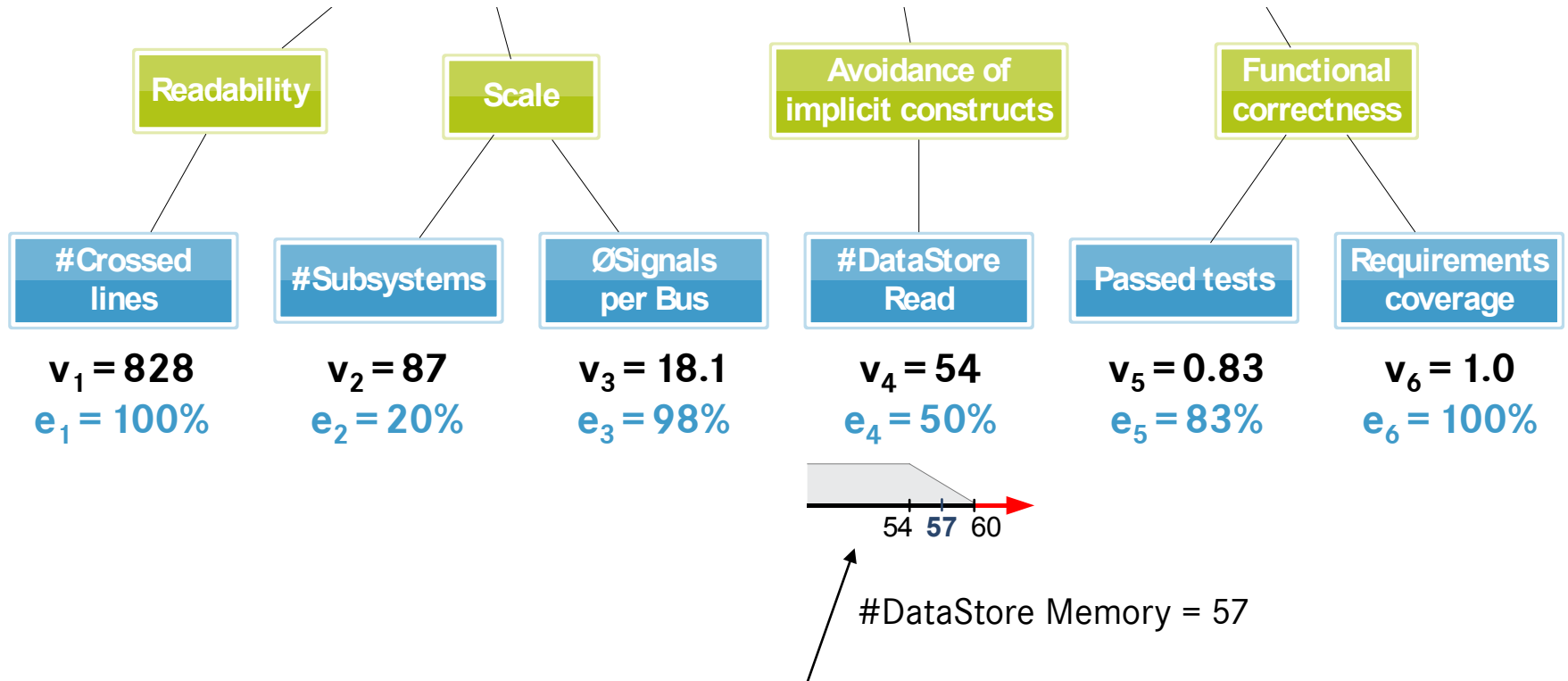
- A reference model describes how an average Simulink model should look.



Evaluation of Measured Values (4/5)

Rules

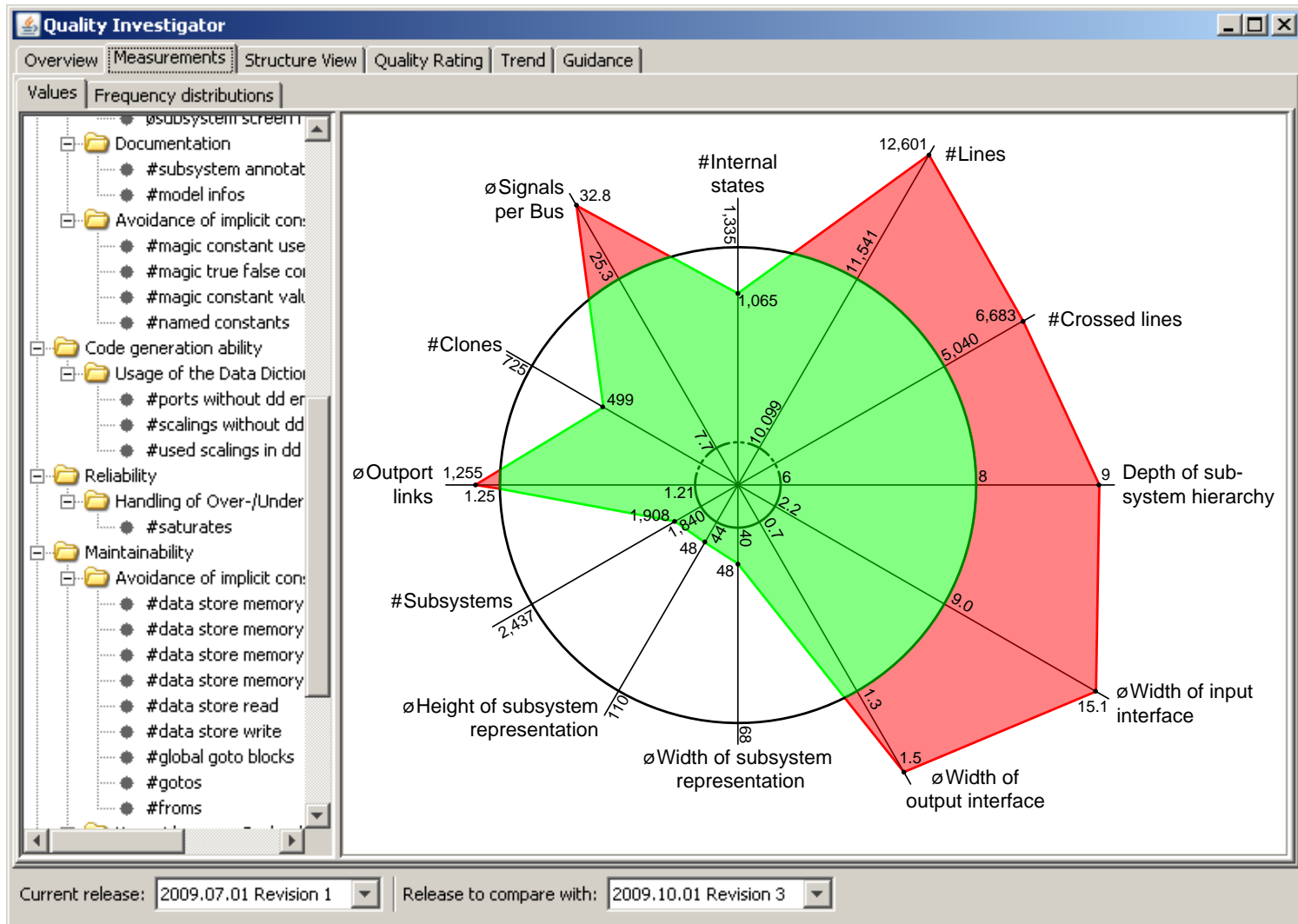
- Rules specifying relations between measured values.



#DataStore Read \geq #DataStore Memory

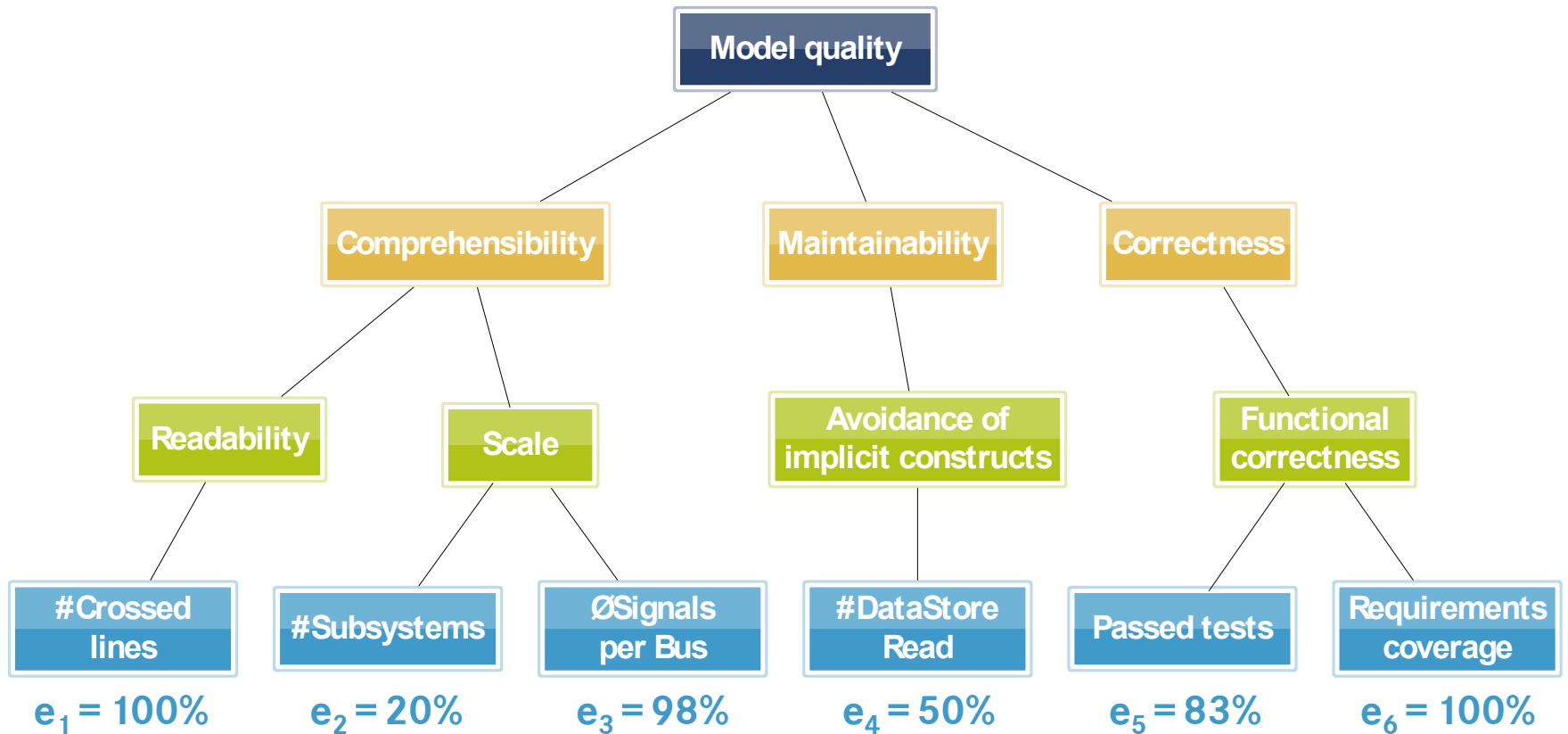
Evaluation of Measured Values (5/5)

Visualization



Aggregation of Evaluations (1/5)

Evaluated Metrics



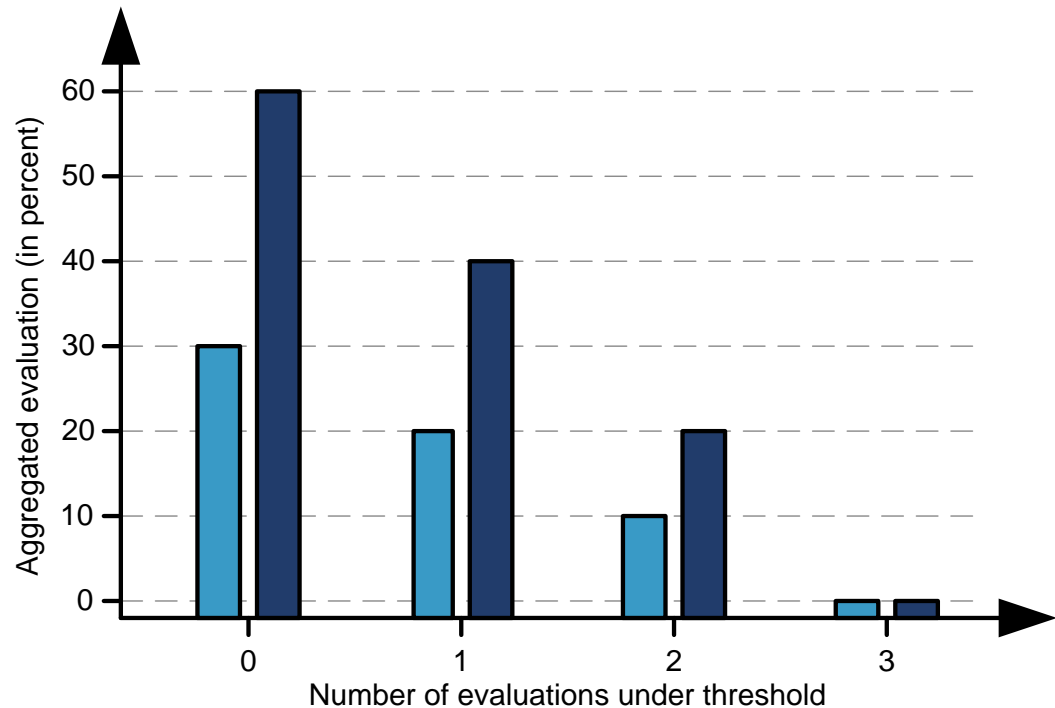
Aggregation of Evaluations (2/5) Algorithm

- Aggregated values provide a quick overview of a model's quality.
- An arithmetic mean is not suitable: If one or more metrics are not fulfilled to a sufficient extent, this must lead to a devaluation.

Evaluations:

$e_1 = [25\%, 30\%, 35\%]$

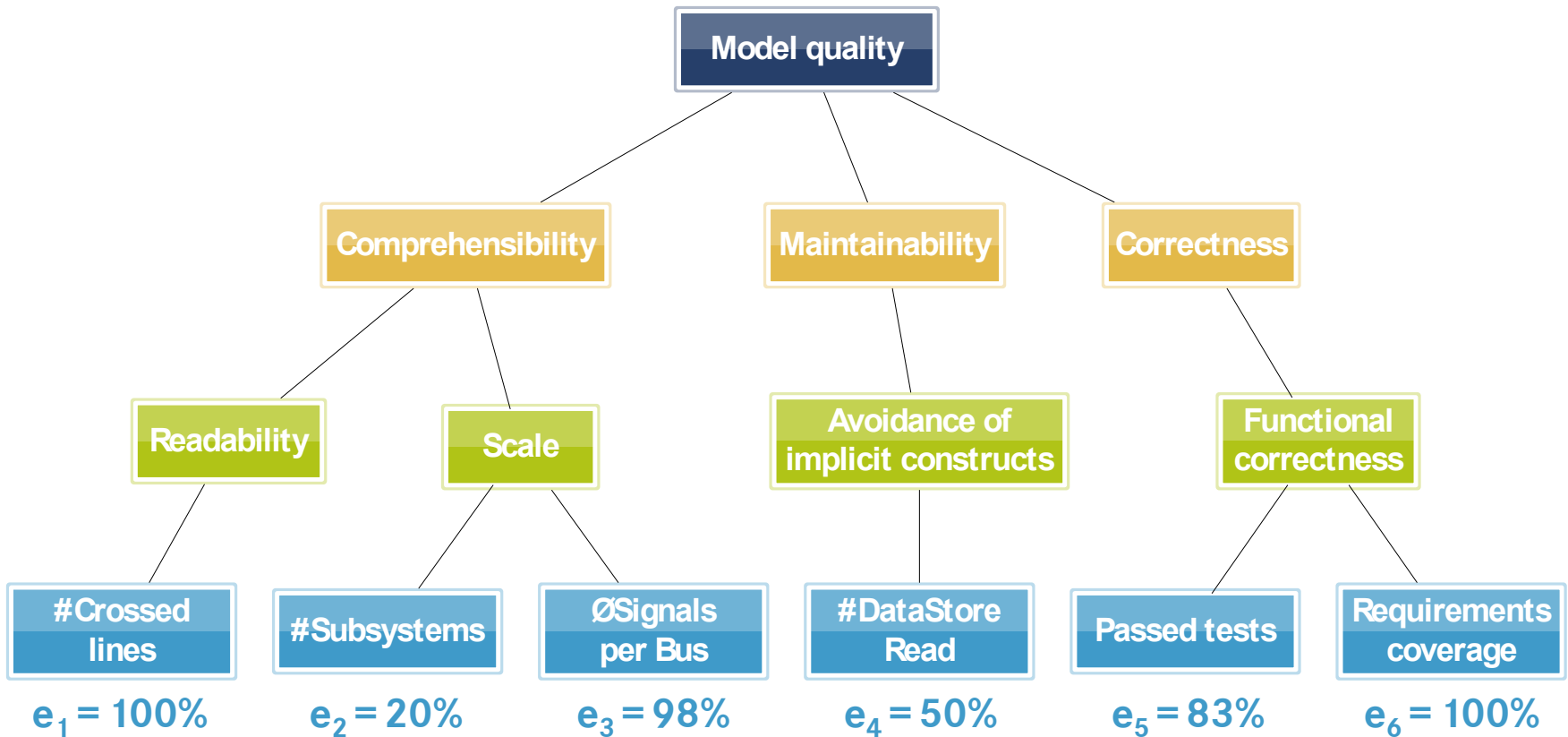
$e_2 = [10\%, 80\%, 90\%]$



Aggregation of Evaluations (3/5)

Aggregation in the Quality Model

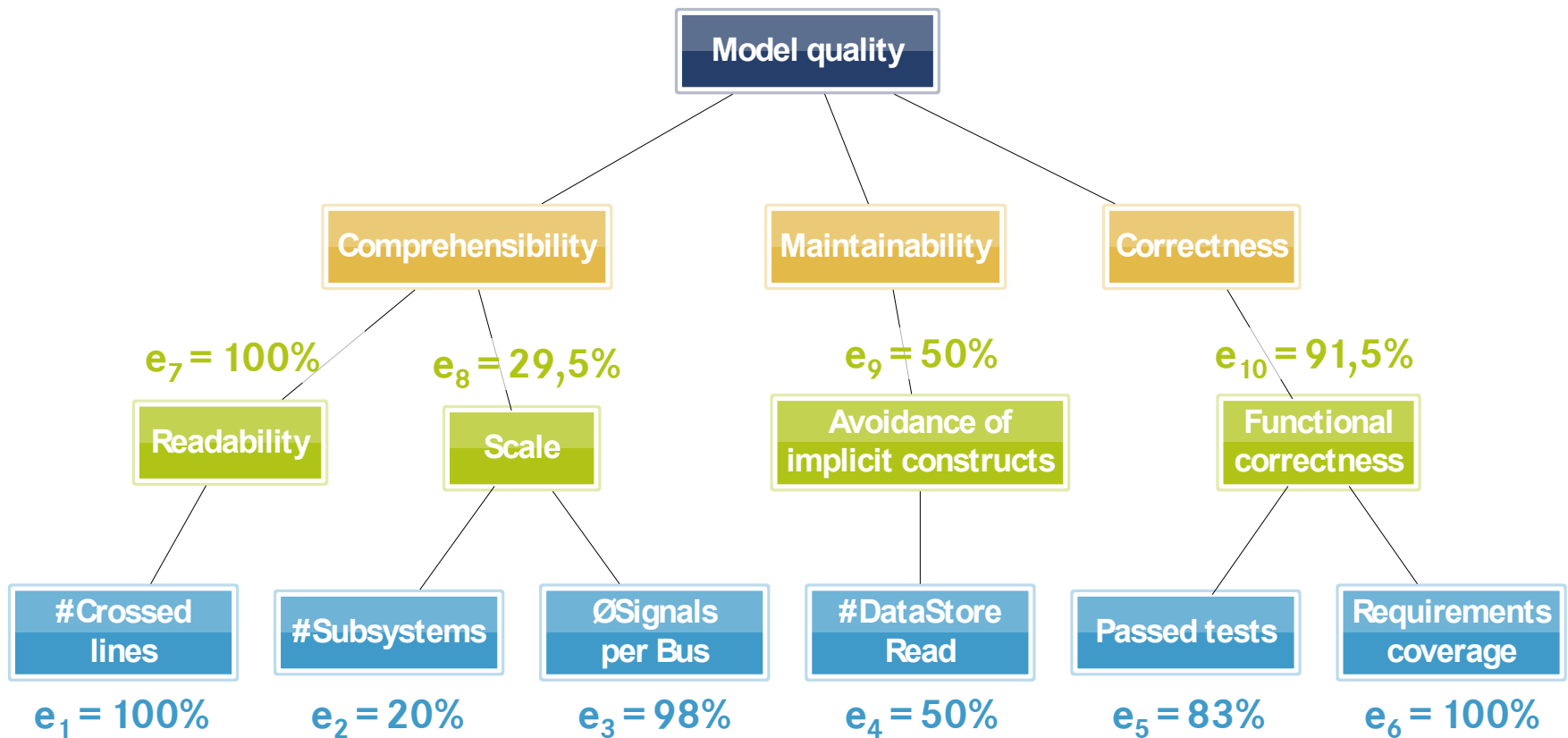
Threshold = 30%



Aggregation of Evaluations (3/5)

Aggregation in the Quality Model

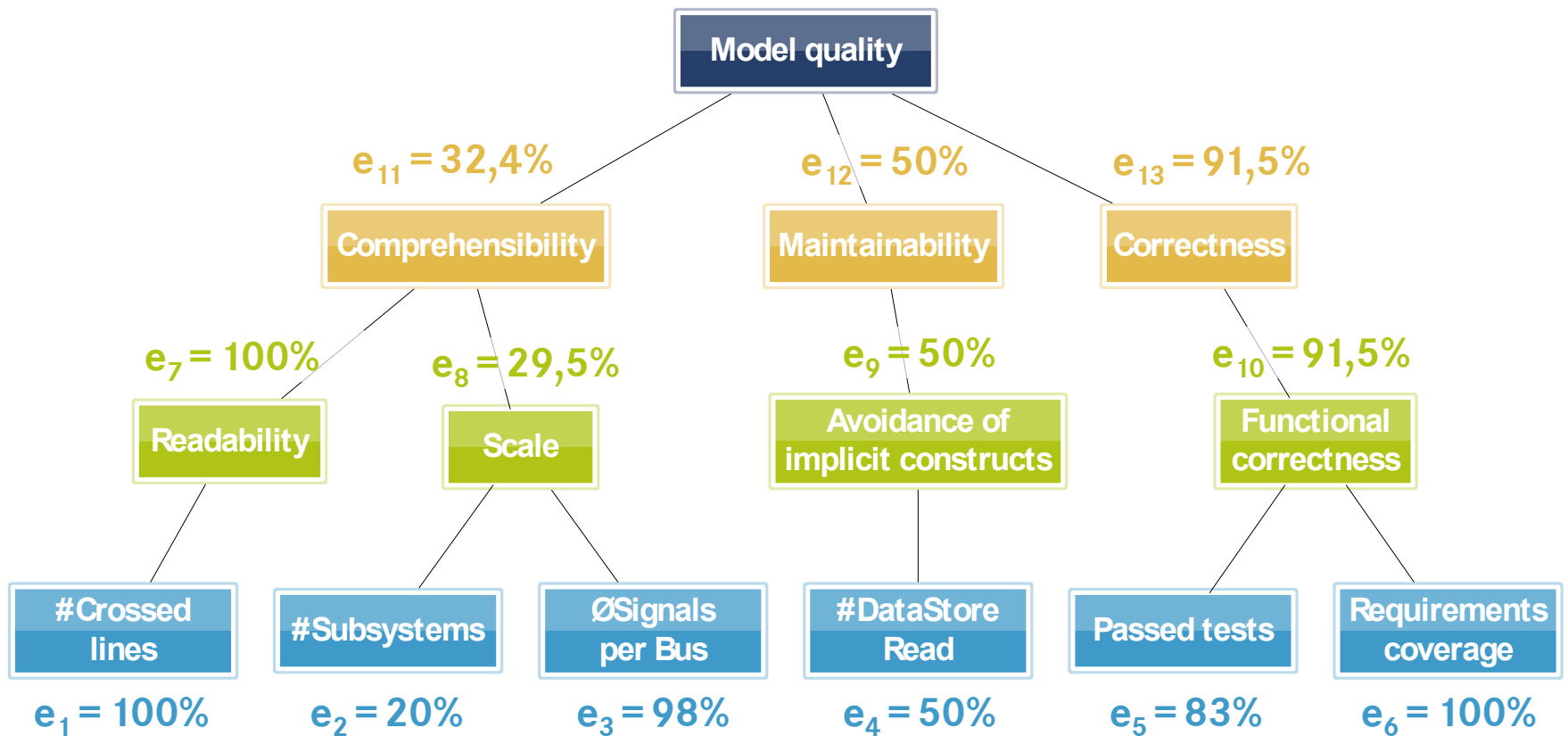
Threshold = 30%



Aggregation of Evaluations (3/5)

Aggregation in the Quality Model

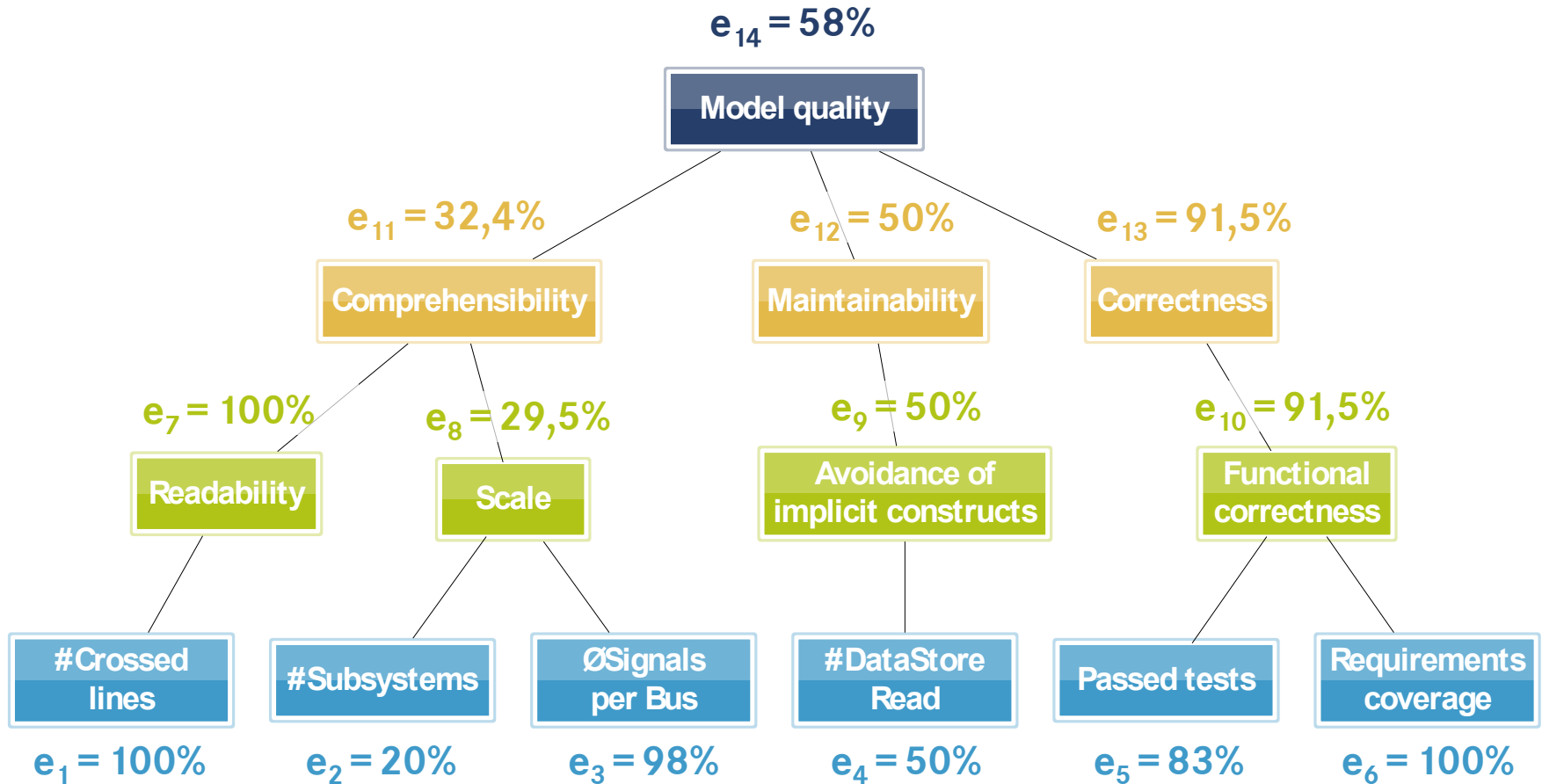
Threshold = 30%



Aggregation of Evaluations (3/5)

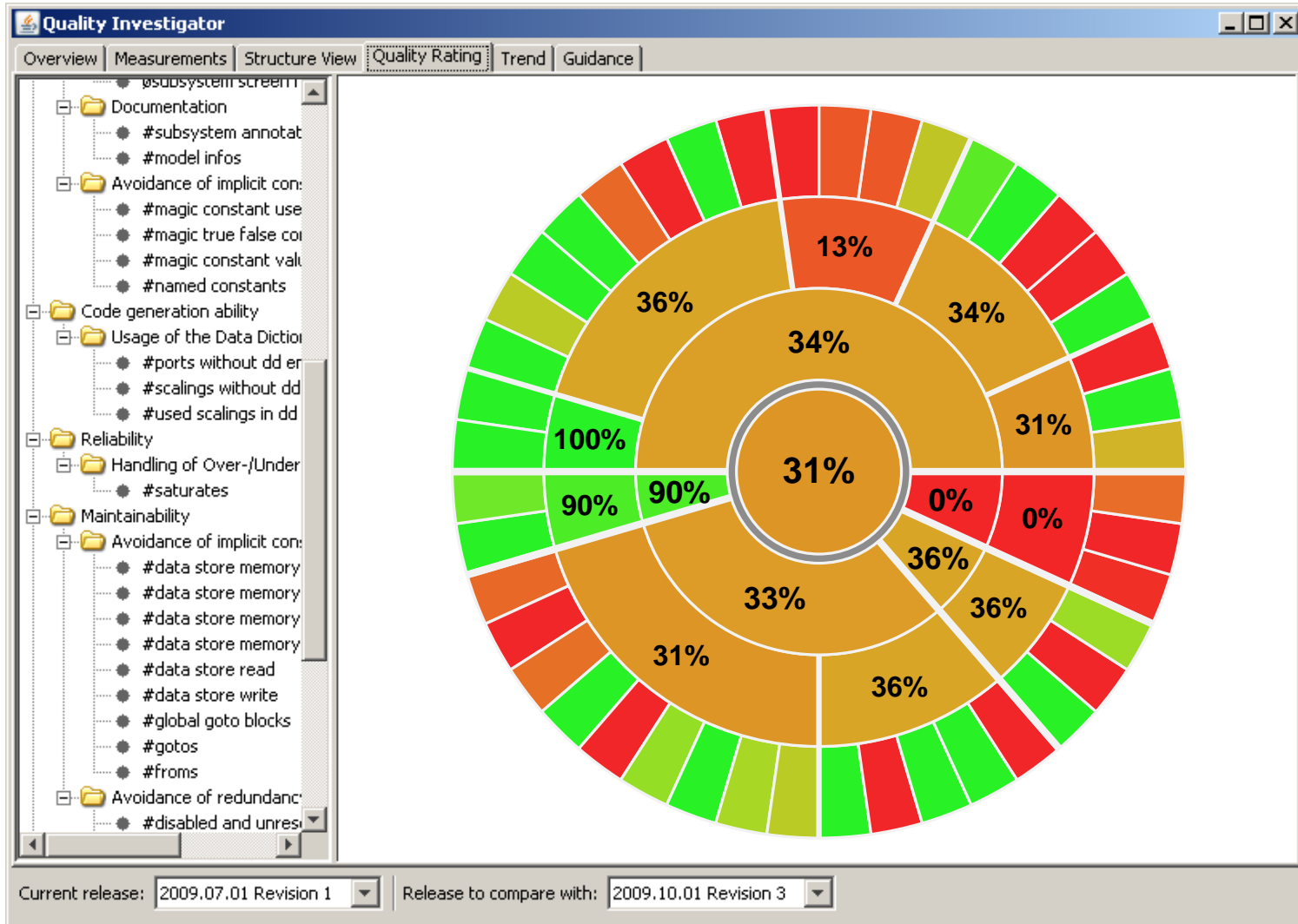
Aggregation in the Quality Model

Threshold = 30%



Aggregation of Evaluations (4/5)

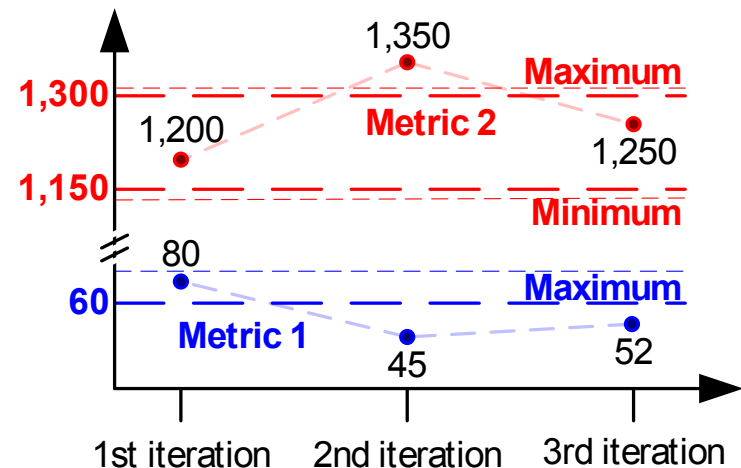
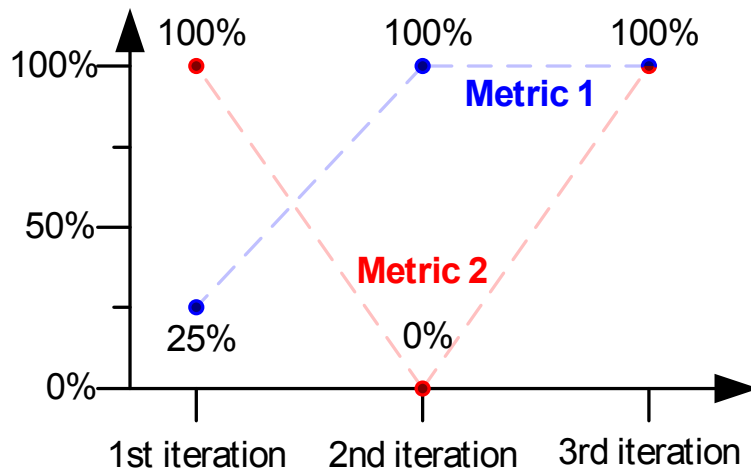
Visualization



Aggregation of Evaluations (5/5)

Retracing Quality Rating over Time

- Model quality rating provides a snapshot of a model's evaluations at a specific time.
- Trend analysis is used to retrace the evolution and evaluation of measured values over time.
- Shows how the metrics' measured values lie in relation to their limits.



Agenda

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Summary and Outlook

Further Evaluation

1. Comparison of a model's quality rating with perceived model quality by the developers.
 2. Verify whether the number of findings in model reviews correlates with the quality rating.
 3. Verify whether the appearance of actual bugs correlates with the quality rating.
- Rate as many models as possible.

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Summary and Outlook

Summary

- A quality model is used for defining our notion of model quality.
- Most important artifacts of the model-based development process are taken into account.
- Metrics check the fulfillment of desired quality criteria.
- The measured values of the metrics are evaluated.
- Evaluations are aggregated in the quality model to provide a quick overview.
- Retracing quality rating over time.

Outlook

Evaluation

- Verify normalization by block count in the reference model **[in progress]**.
- Check if the approach is only applicable to models in the same project **[in progress]**.

Quality model

- Potentially the expressive power of the quality model must be enhanced (e.g. handling of conflicting measurements).

Metrics

- Integration of more Simulink-specific metrics **[in progress]**.
- Identification of the metrics with the highest relevance **[in progress]**.
- Add more interfaces to tools for automatic rating **[in progress]**.
- Compare the frequency distribution of the per subsystem measurements.

Thank you for your attention!

Backup

Reference Model

- Average values of arbitrary models normed against the model's reference (#blocks)

• Measurements database

	Modell 1	Modell 2	Modell 3	Modell 4	Modell 5	Average	Variance
# Gotos	44	9	0	32	47	0.01318	0.01551
# Subsystems	340	677	231	150	1,083	0.17428	0.12372
# Crossed lines	299	931	6,683	828	2,581	0.45065	0.20779
# Blocks	1,120	2,924	9,017	2,526	4,309	1.0	0.0

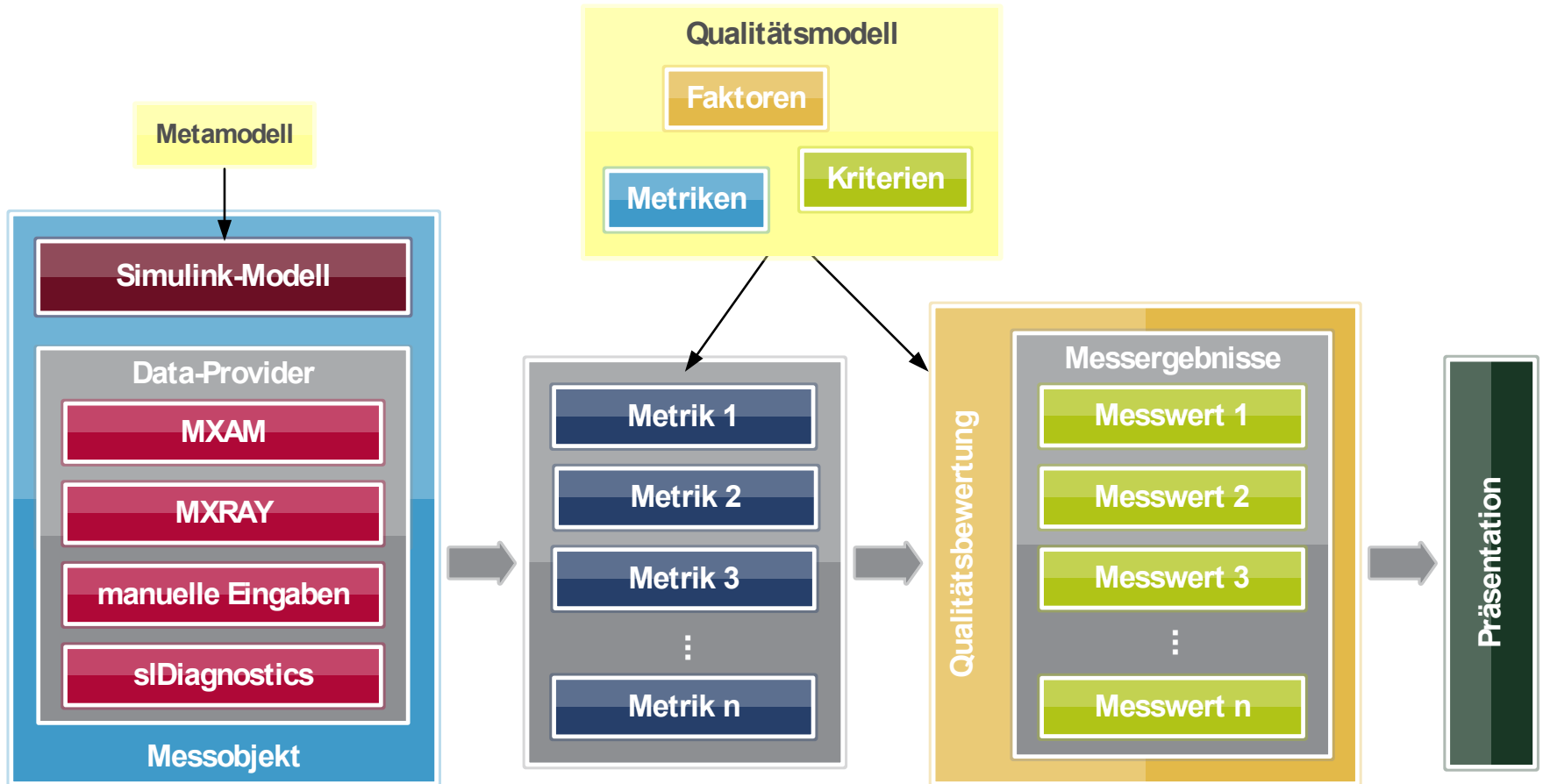
• Instantiated reference model

	200 blocks		1,000 blocks		5,000 blocks	
	Min.	Max.	Min.	Max.	Min.	Max.
#Subsystems	14	46	70	230	348	1,149
#Lines	224	256	1,120	1,280	5,600	6,400
#Crossed lines	-	96	-	480	-	2,400

- Average values multiplied by reference (#blocks)

- Min and max result from variance of averages.

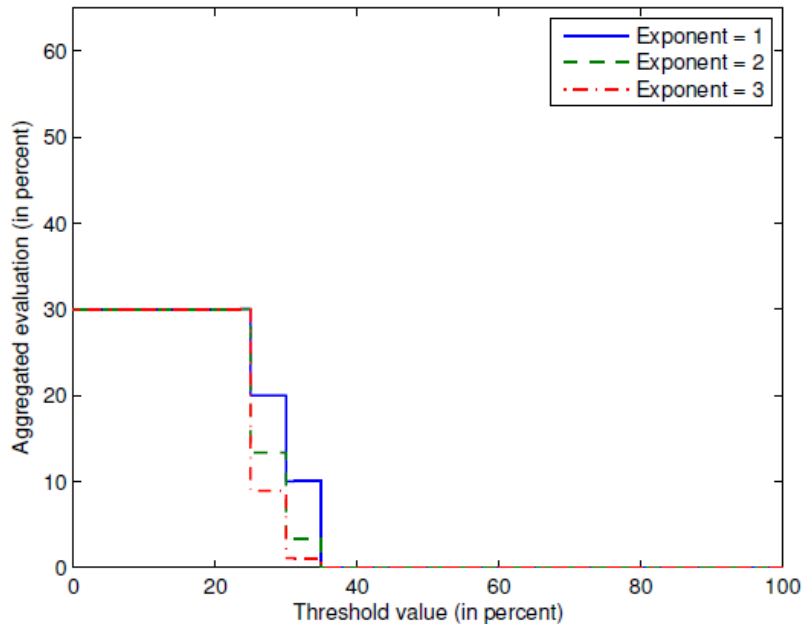
Prototype Infrastructure



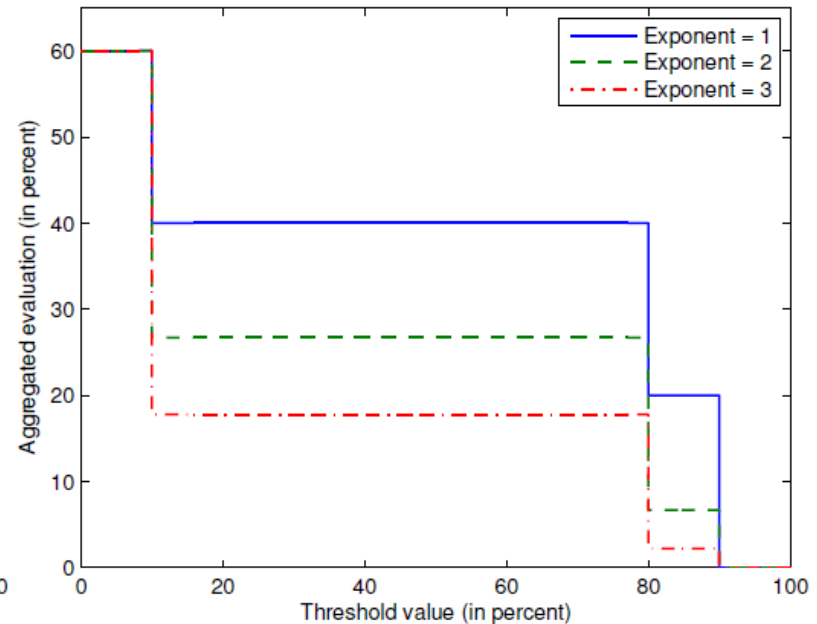
Aggregation of Evaluations (?/?)

Algorithm and Formula

$$\text{aggregatedEvaluation} = \underbrace{\frac{\sum_i \text{evaluation}_i}{\# \text{evaluations}}}_{\text{Arithmetic mean}} \cdot \underbrace{\left(\frac{\# \text{evaluationsOverThreshold}}{\# \text{evaluations}} \right)^{\text{exponent}}}_{\text{Damping factor}}$$



$e_1 = [25\%, 30\%, 35\%]$



$e_2 = [10\%, 80\%, 90\%]$

Evaluation of Measured Values (?/?)

Limits

