



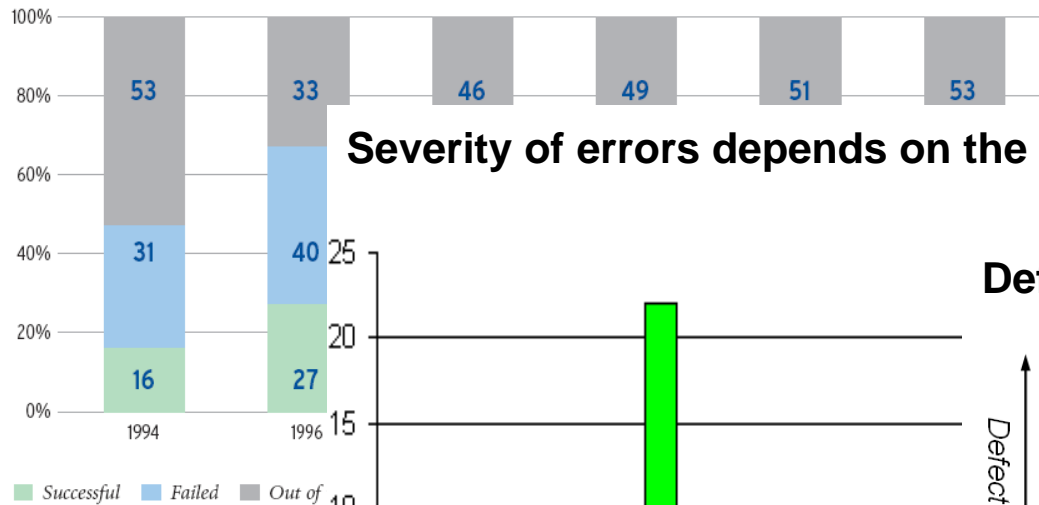
Test the test

A review and outlook of quality assurance techniques for software-intense communication-based systems

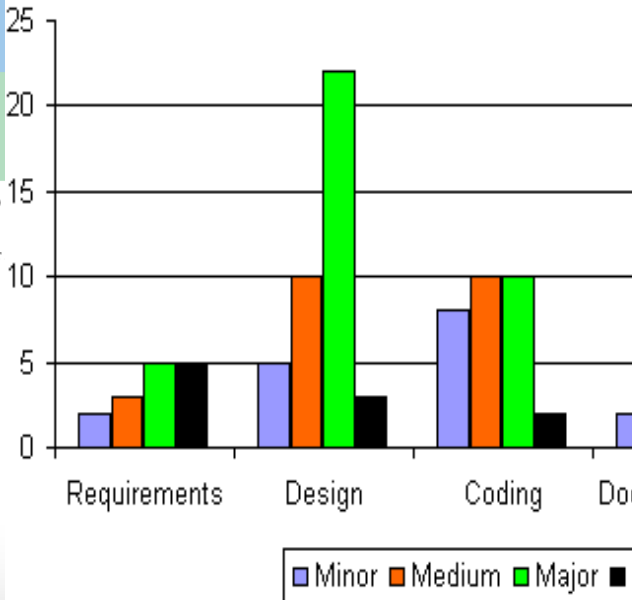
Ina Schieferdecker
TU Berlin/Fraunhofer FOKUS, Berlin, Germany

Development of Software-Intense Systems: Current Situation

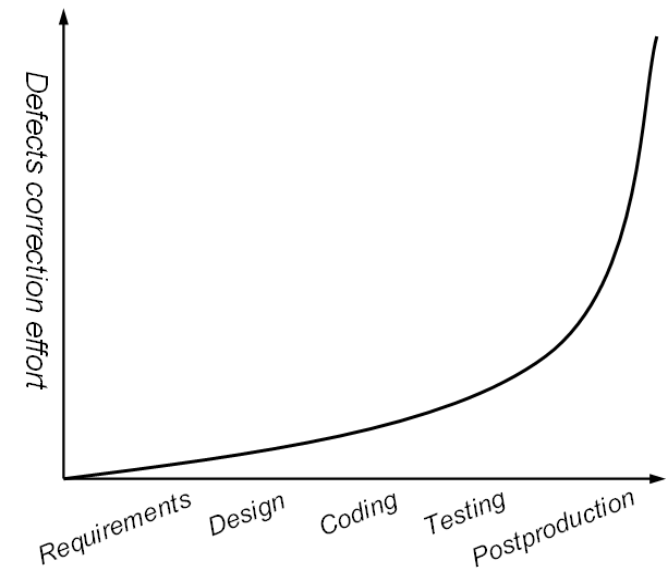
The percentage of successful IT projects is again dropping:



Severity of errors depends on the phase where they're made



Defect correction effort



System and Test system

**Although programmers, testers and program managers know
that code must be designed and tested,
many appear to be unaware
that tests themselves must be designed and tested –
by a process no less rigorous and no less controlled
than that used for code.**

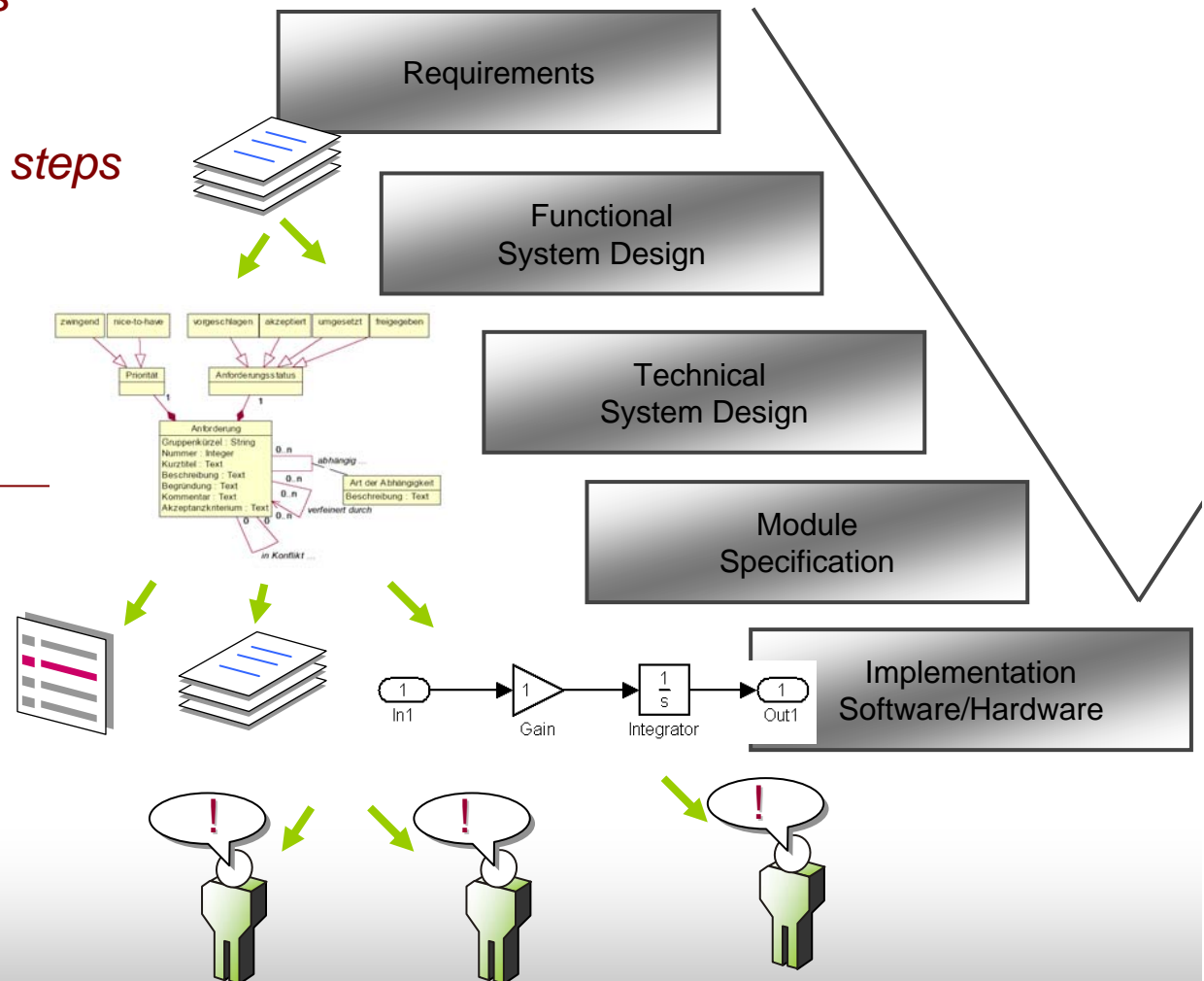
Boris Beizer

Model-Driven Engineering

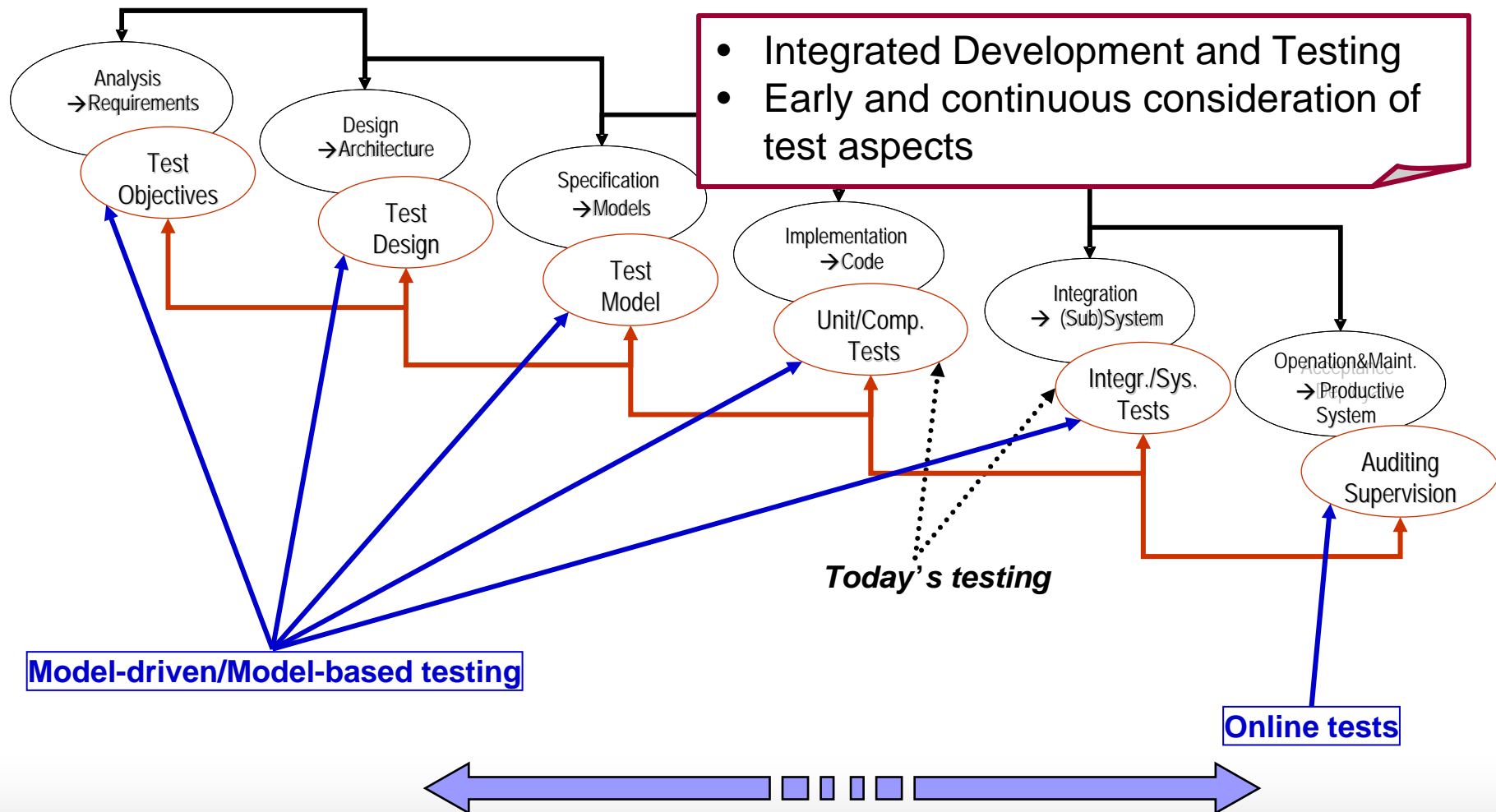
- *Models as central artefacts*
- *Precise meaning*
- *Automation of engineering steps*

Open Issues

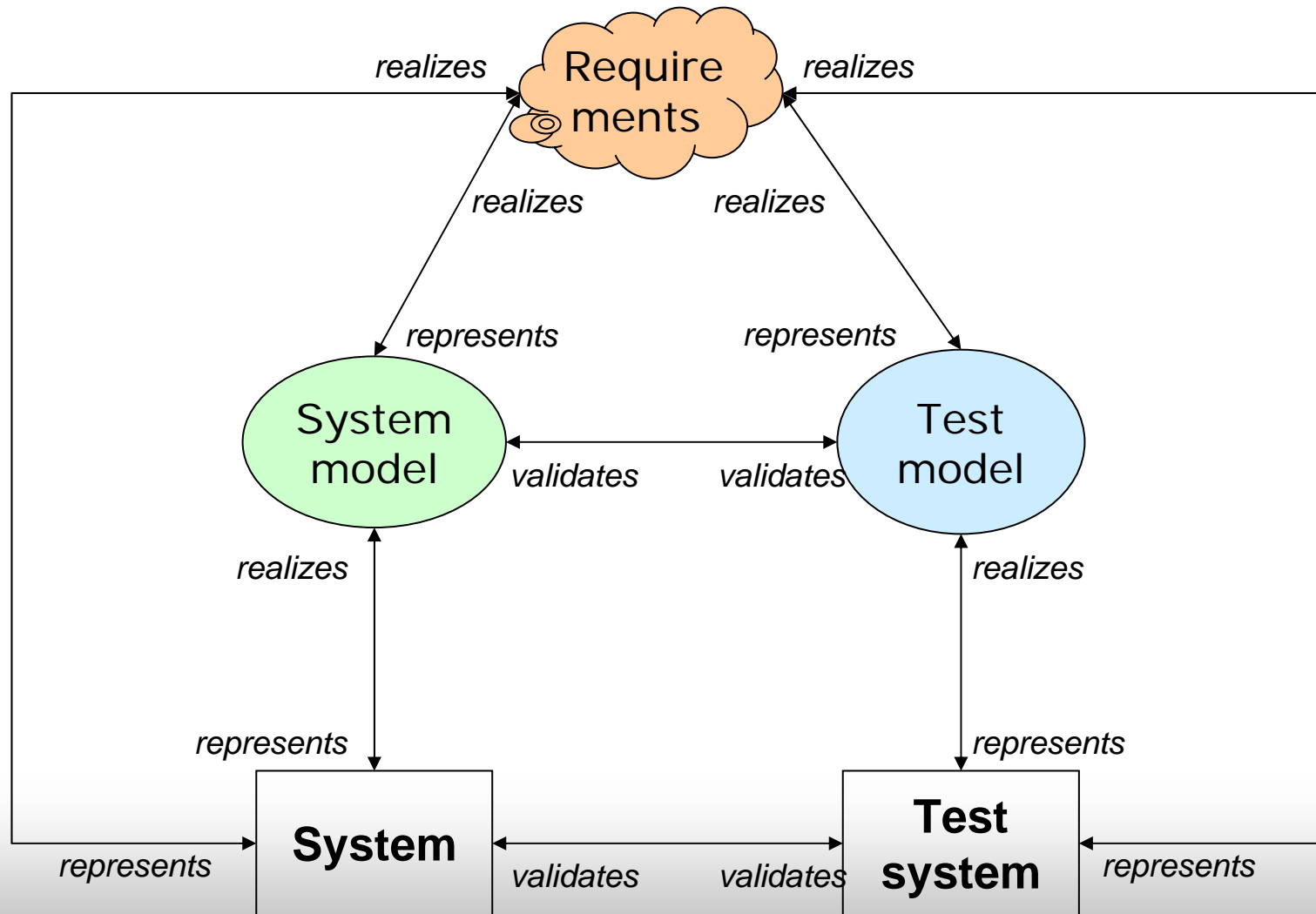
- Heterogeneity of models
- Model management
- Models at runtime
- Model-based testing
- Model quality
- ...



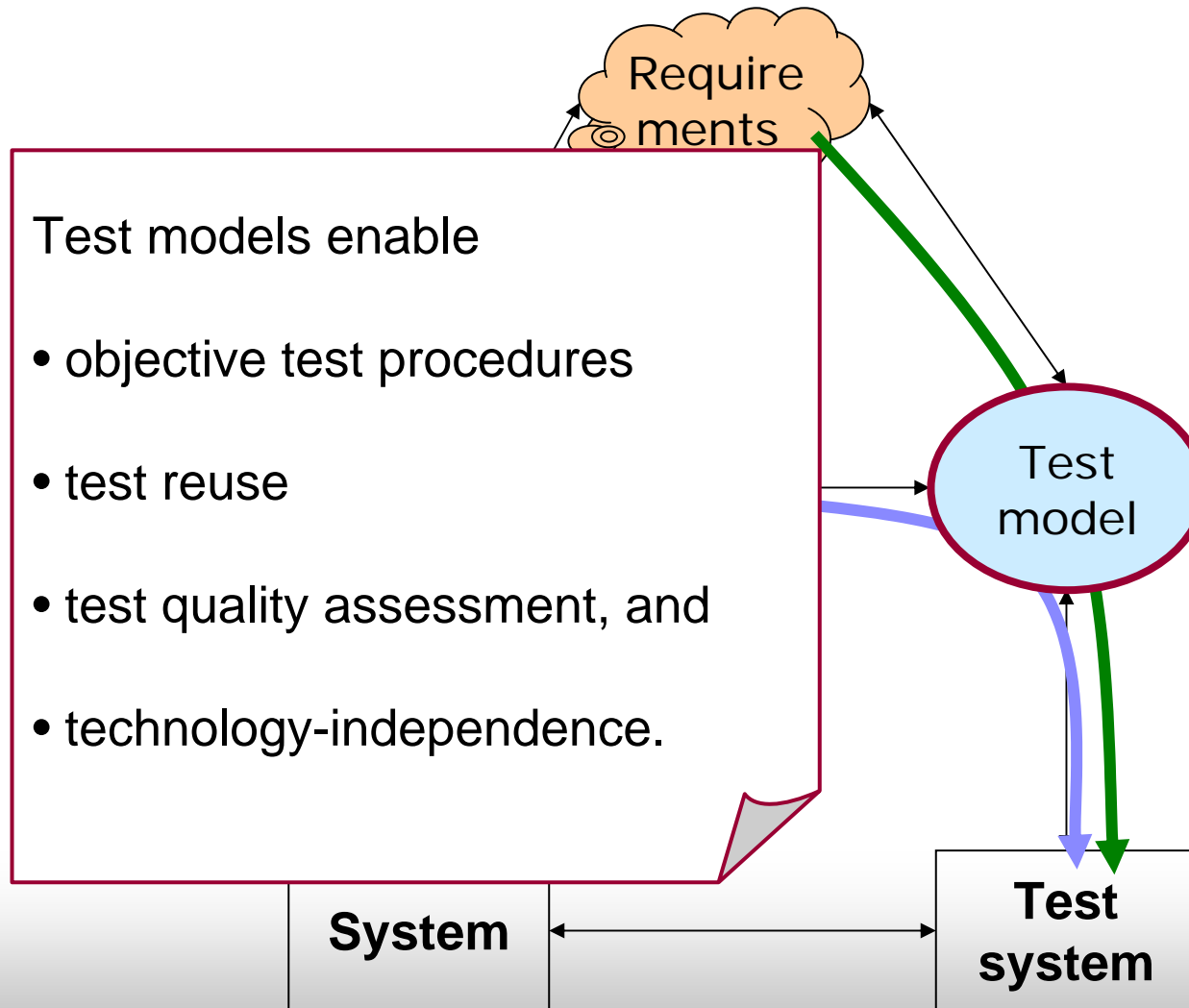
Placement of My Work



The role of test models



Model-Based Test Generation



Issues – the full spectrum of system engineering

- Model the tests
 - Concepts
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 - Distribution
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 - Performance
- Manage the tests
 - Processes
 - Variants
- ...

Myself



Ina Schieferdecker

1. Diploma, Mathematical Computer Science
Humboldt University
2. PhD on Performance Enhanced
Formal Specifications
Technical University
3. Work at GMD FOKUS → Fraunhofer FOKUS
4. Research Stays at ICSI, CRIM, Uni Oslo

Prof. on Design and Testing of
Communication- Based Systems
Technical University Berlin

<http://www.ets.tu-berlin.de>

Head of Competence Centre
Modelling and Testing
Fraunhofer FOKUS

<http://www.fokus.fraunhofer.de/motion>

Co-Founder of Testing Technologies, Berlin

<http://www.testingtech.de>

Board Member of ASQF

<http://www.asqf.de>

Member of German Testing Board

<http://www.german-testing-board.de>

Lead of TTCN-3 Maintenance Team

<http://www.ttcn-3.org>

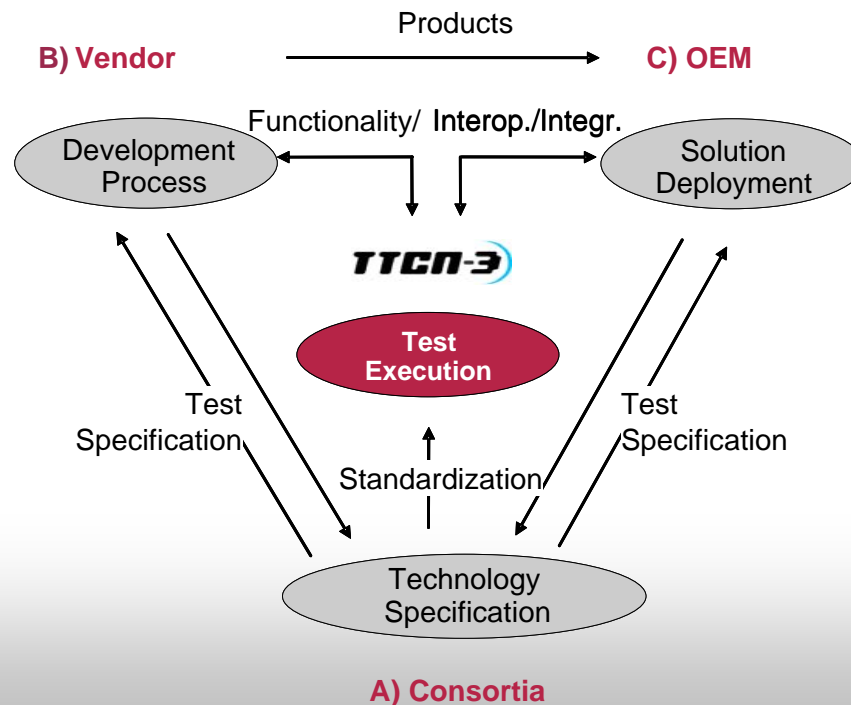
Issues – the full spectrum of system engineering

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- ...

TTCN-3 - The Testing and Test Control Notation



- **Test specification and execution technology for different tests**
 - Distributed, platform-independent testing
 - Integrated graphical test development, documentation and analysis
 - Adaptable, open test environment
- Adopted by ETSI and ITU since 2000



- **The testing middleware**

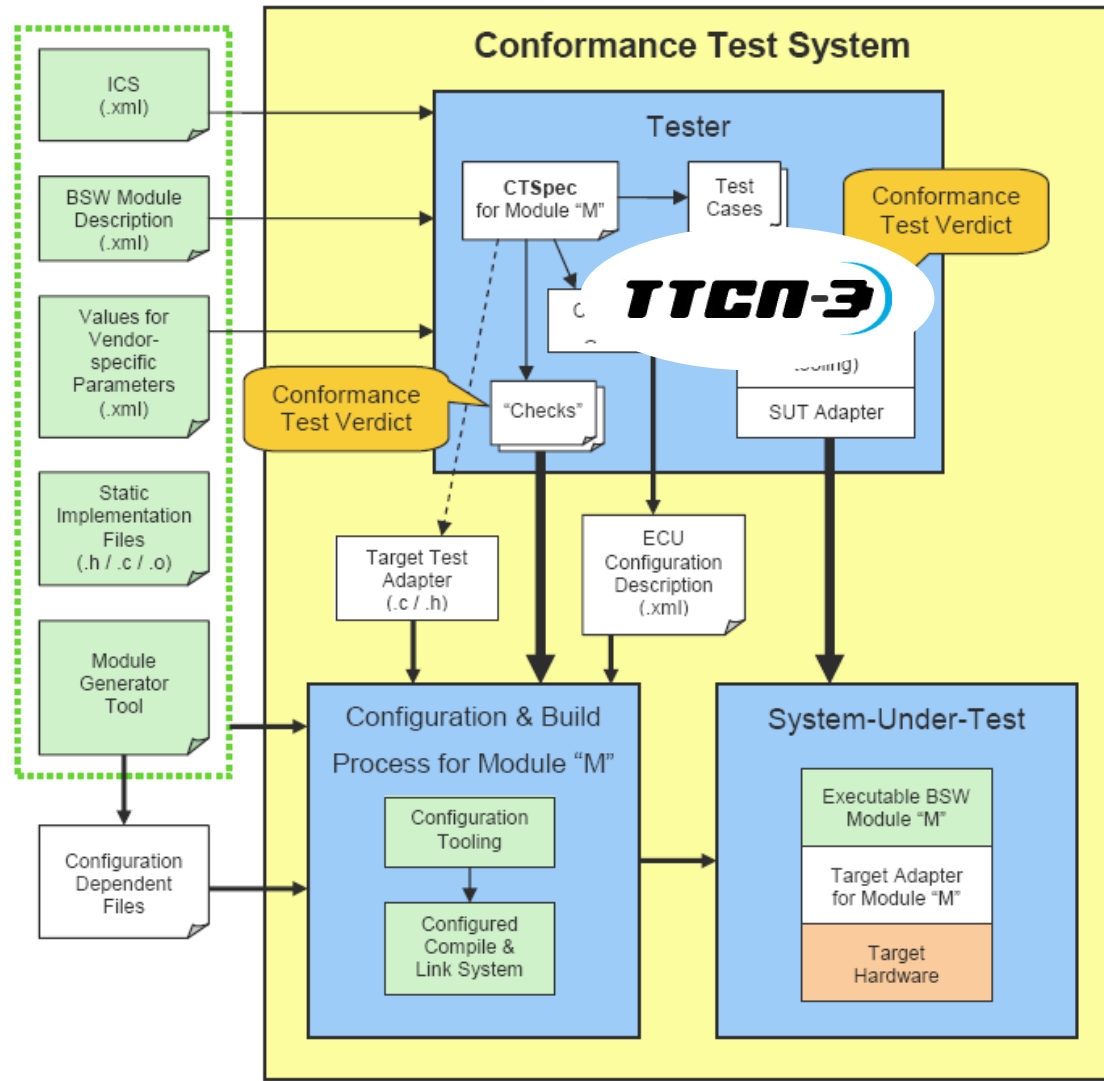
- Unifying the definition and documentation of tests in different development phases
- unifying the tests for various systems (cockpit, powertrain, cabin, etc.)
- unifying the test infrastructure

- **Areas of Testing**

- Regression Testing
- Conformance/Functionality Testing
- Interoperability/Integration Testing
- Load/ Stress Testing

TTCN-3 Adoption

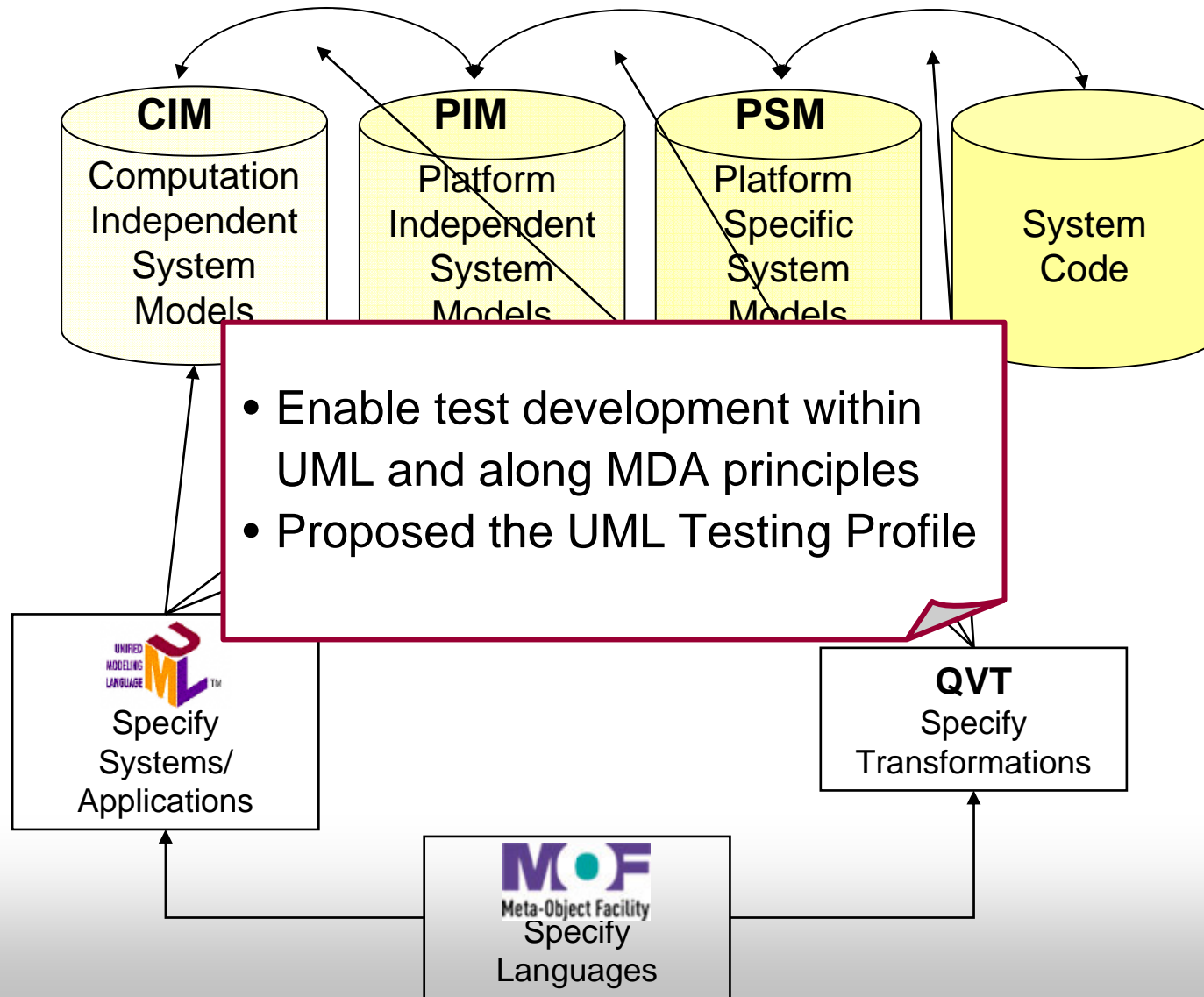
AUTOSAR



■ Usages

- Telecommunication
 - VoIP
 - IMS
 - WIMAX
 - LTE
 - ...
- Automotive
 - Autosar
 - cockpit applications – MOST Forum
- Avionics systems – ESA
- Medical devices – HL7
- Power transmission systems
- Smart cards
- Transport
- ...

MDA: A Model-Centric System Development





The UML Testing Profile

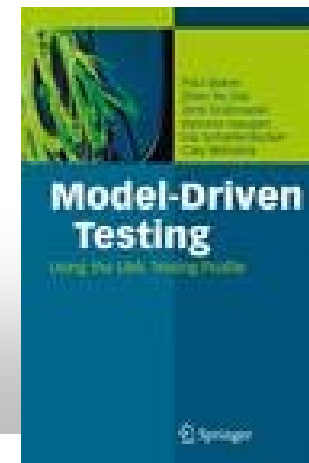
- Definition of a testing profile to capture all information that would be needed by different test processes
 - To allow **black-box testing** (i.e. at UML interfaces) of computational models in UML
- A testing profile based upon UML 2.0
 - That enables the **test definition and test generation** based on **structural** (static) and **behavioral** (dynamic) **aspects** of UML models, and
 - That is capable of **inter-operation with existing test technologies** for black-box testing
- Define
 - **Test architecture**: Test structure, test components and test configuration
 - **Test data**: Test data and templates used in test procedures
 - **Test behavior**: Dynamic aspects of test procedures
 - **Time**: Time quantified definition of test procedures
- OMG standard since 2005

Selected Publications

- Schieferdecker, I.; Stepien, B.; Rennoch, A.: *PerfTTCN, a TTCN Language Extension for Performance Testing*, in: Kim, M.; Kang, S.; Hong, K. (eds.), Testing of Communication Systems, Vol. 10, 10th International IFIP TC6/WG6.1 Workshop on Testing of Communication Systems, Cheju Island (Korea), Sept. 1997, London (UK): Chapman & Hall, 1997.
- P. Baker, E. Rudolph, I. Schieferdecker. *Graphical Test Specification - The Graphical Format of TTCN-3*. Proc. of the 10th SDL Forum 2001, Copenhagen, June 2001.
- Jens Grabowski, Dieter Hogrefe, György Réthy, Ina Schieferdecker, Anthony Wiles, Colin Willcock. *An introduction into the testing and test control notation (TTCN-3)*. Computer Networks, Volume 42, Issue 3, Elsevier, Amsterdam, June 2003, 375-403.
- I. Schieferdecker, A. Rennoch, E. Höfig: *TTCN-3 – A Test Technology for the Automotive Domain*, Gühmann, u.a., Simulation und Test in der Funktions- und Softwareentwicklung für die Automobilelektronik, Berlin, March 2005.
- J. Großmann and I. Schieferdecker: *Testing Embedded Control Systems with TTCN-3*, Enhancing TTCN-3 with Concepts for Continuous Streams. STTT Special Issue on Advances in Test Automation, 2008.
- I. Schieferdecker, J. Grabowski, T. Vassiliou-Gioles, G.Din: *TTCN-3 – Systematic Testing for Reactive Systems*, Accepted to appear in “Formal Methods and Testing” by J. Bowen, M. Harman, and R. Hierons, Springer 2008.

Selected Publications

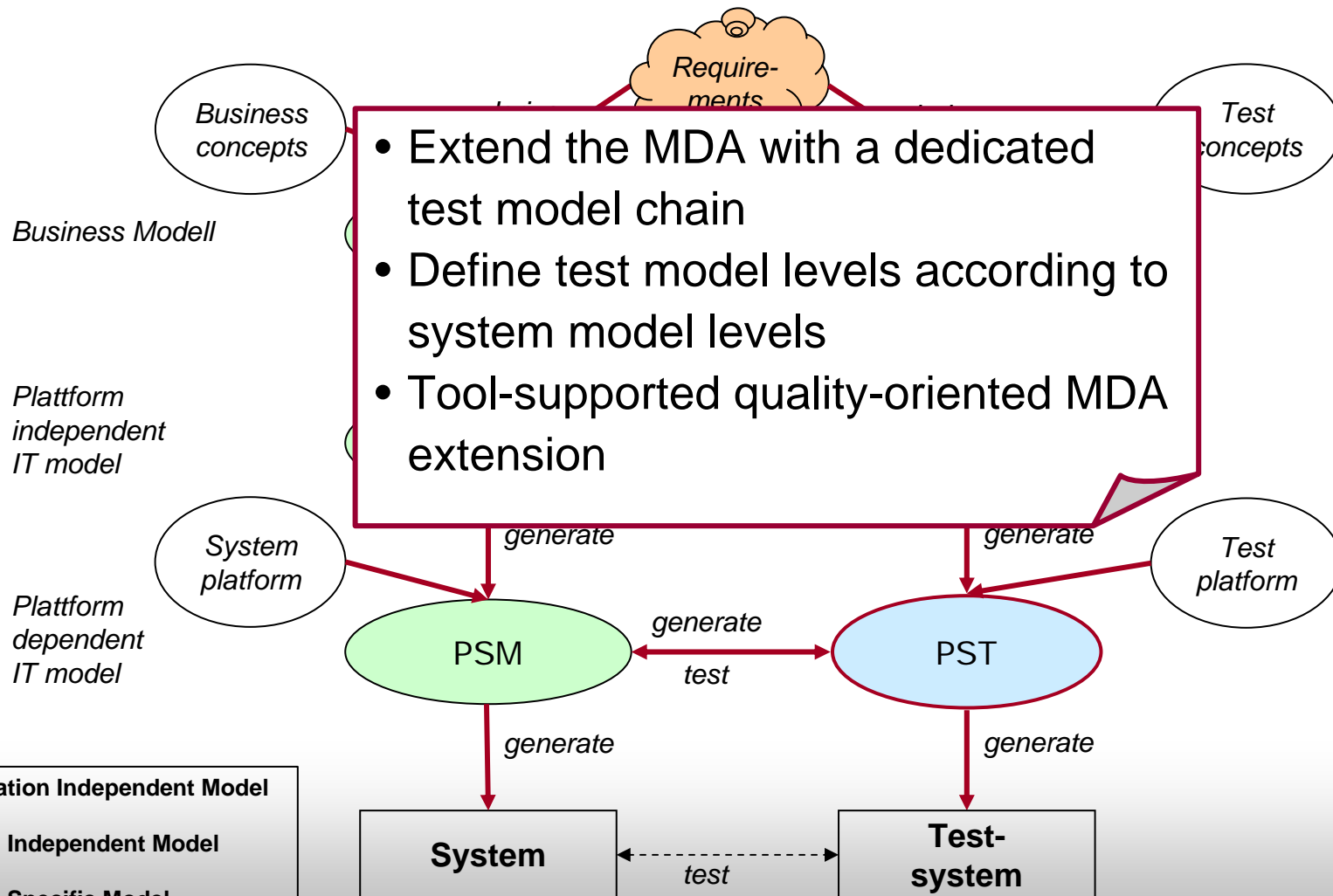
- P. Baker, Z. R. Dai, J. Grabowski, Ø. Haugen, S. Lucio, E. Samuelsson, I. Schieferdecker, and C. Williams: *The UML 2.0 Testing Profile*, Conquest 2004, ASQF Press, September 2004, Nuremberg, Germany.
- H.-G. Gross, I. Schieferdecker, G. Din: *Specification and Implementation of Built-in Contract Tests*, in *Testing COTS Components and COTS-based Systems*, Springer 2004
- I. Schieferdecker: *The UML 2.0 Test Profile as a Basis for Integrated System and Test Development*. GI Jahrestagung, Informatik 2005, Bonn, Sept. 2005
- P. Baker, Z. R. Dai, J. Grabowski, O. Haugen, I. Schieferdecker, C. Williams: *Model-Driven Testing*, Springer, 2007.



Issues – the full spectrum of system engineering

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 - Processes
 - Variants
 - ...
-
- Huge test suites (>60000 LOC), e.g. for:
 - Session Initiation Protocol (SIP)
 - Internet Protocol Version 6 (IPv6)
 - **Suffer from quality problems like any larger software!**

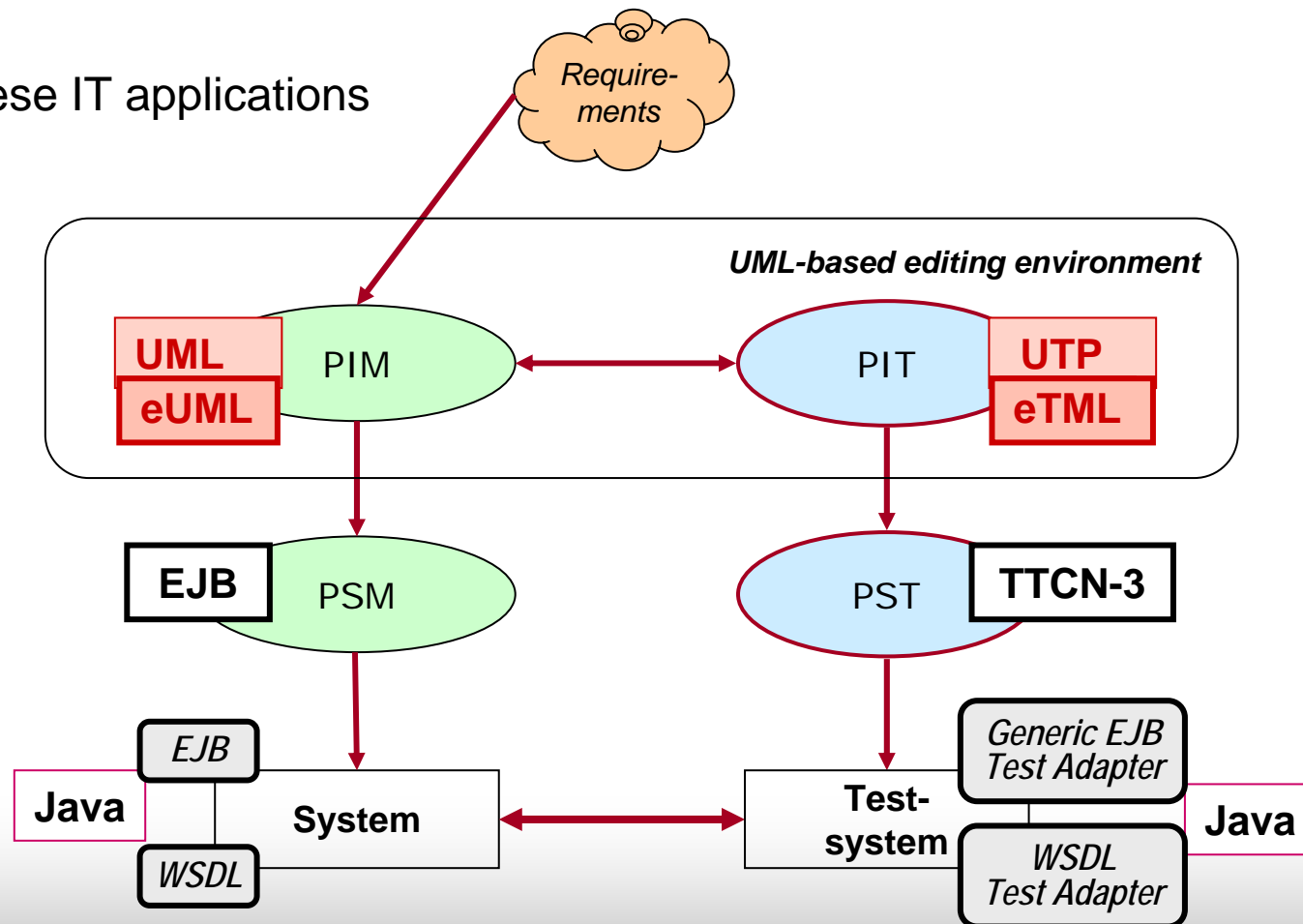
MDA Extended: Integrated Modelling and Testing



CIM	Computation Independent Model
CIT	... Test
PIM	Platform Independent Model
PIT	... Test
PSM	Platform Specific Model
PST	... Test

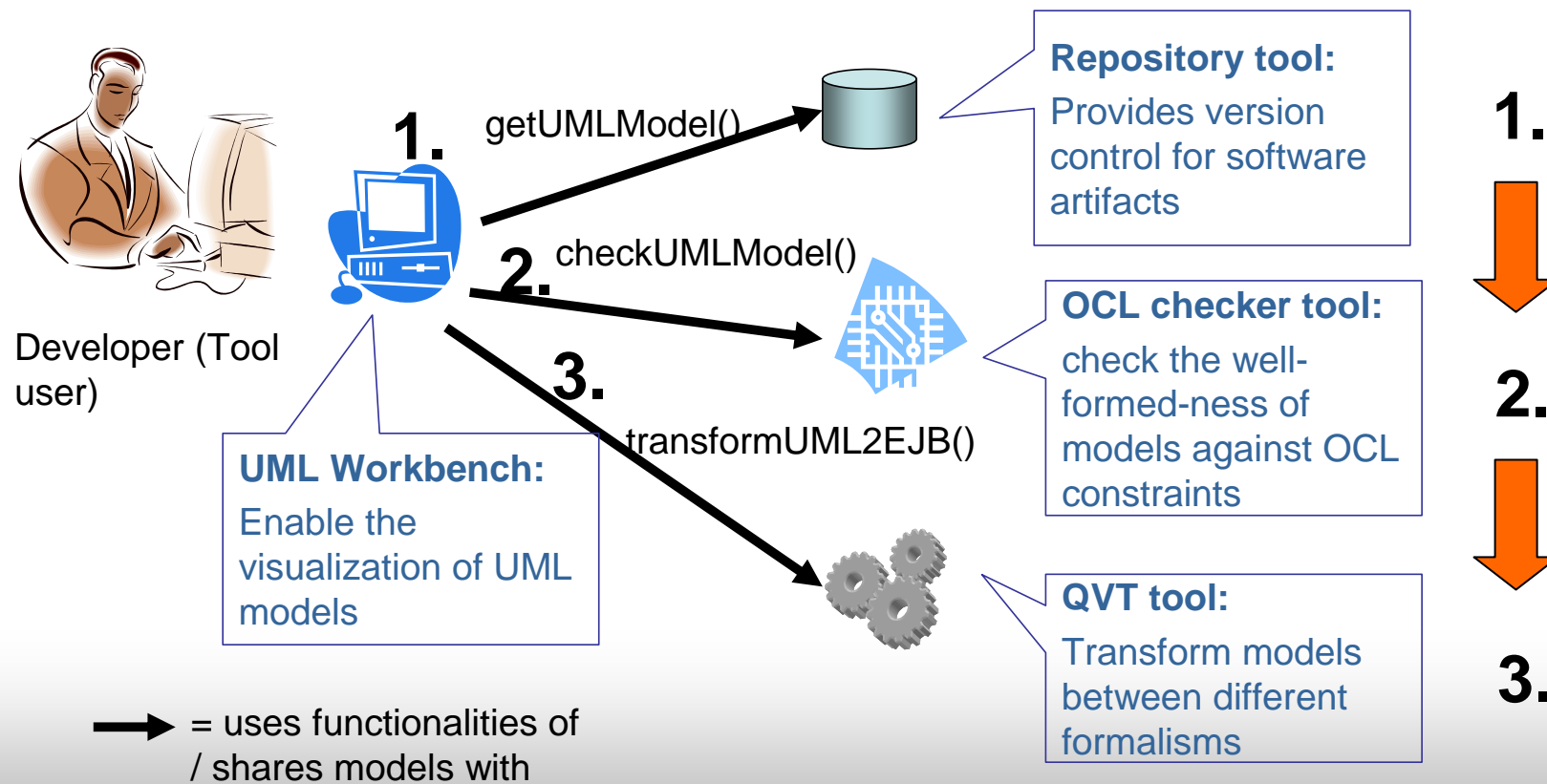
Detailed MDA Extended

Used for Japanese IT applications

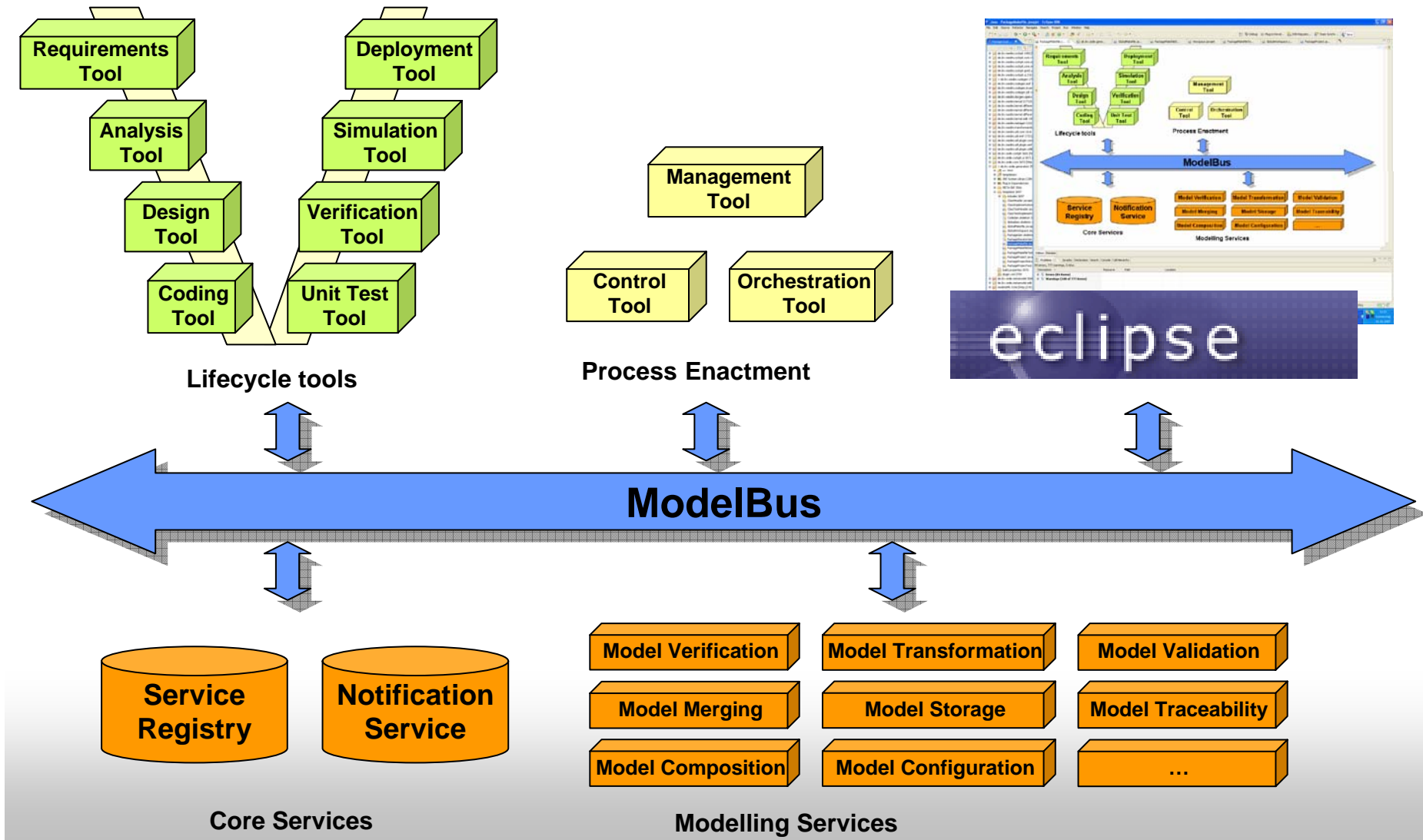


Integrated Modelling Infrastructure: Concept and Design

- Model-Driven Development is “orchestration” of **modelling services**
- Goal of ModelBus = **Infrastructure** for modelling service **integration** and **interoperability**



Integrated Modelling Infrastructure: ModelBus



Quantitative and qualitative assessment

- Quantitative:
 - Metrics
 - Value ranges

- Qualitative:
 - Rules
 - Guidelines
 - Patterns
 - Anti-patterns

- Quantitative and qualitative assessment not disjoint:
 - Pattern/anti-pattern → Metric: count occurrences
 - Metric → rules: metric violates threshold

Test Model Quality Improvement

■ Approach:

■ Assess test suites,

■ Detect issues,

■ Restructure test suites.

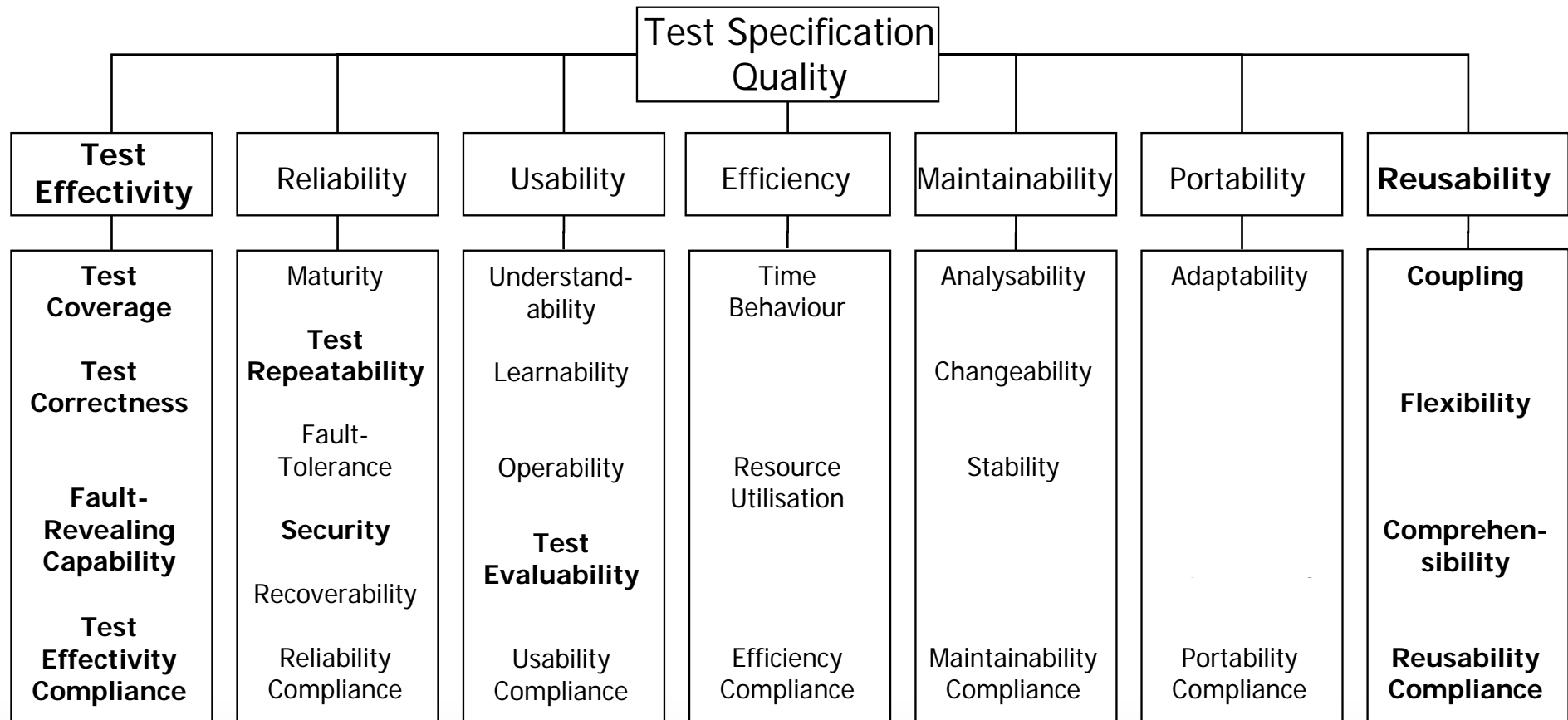


**Metrics,
Patterns/Anti-Patterns**



Refactoring

Instantiation of ISO quality model: quality of test specifications



TTCN-3 Anti-Pattern

■ TTCN-3 “code smells”

- Duplicated Code, e.g. *Duplicate Alt Branches*
- References, e.g. *Singular Component Variable/Const./Timer*
- Parameters, e.g. *Constant Actual Parameter Value*
- Complexity, e.g. *Complex Conditional*
- Default Anomalies, e.g. *Activation Asymmetry*
- Test Behaviour, e.g. *Missing Verdict*
- Test Configuration, e.g. *Idle Parallel Test Component*
- Coding Standards, e.g. *Magic Values*
- Data Flow Anomalies, e.g. *Unused Variable Definition*
- Miscellaneous, e.g. *Over-specific Runs On*

TTCN-3 Metrics

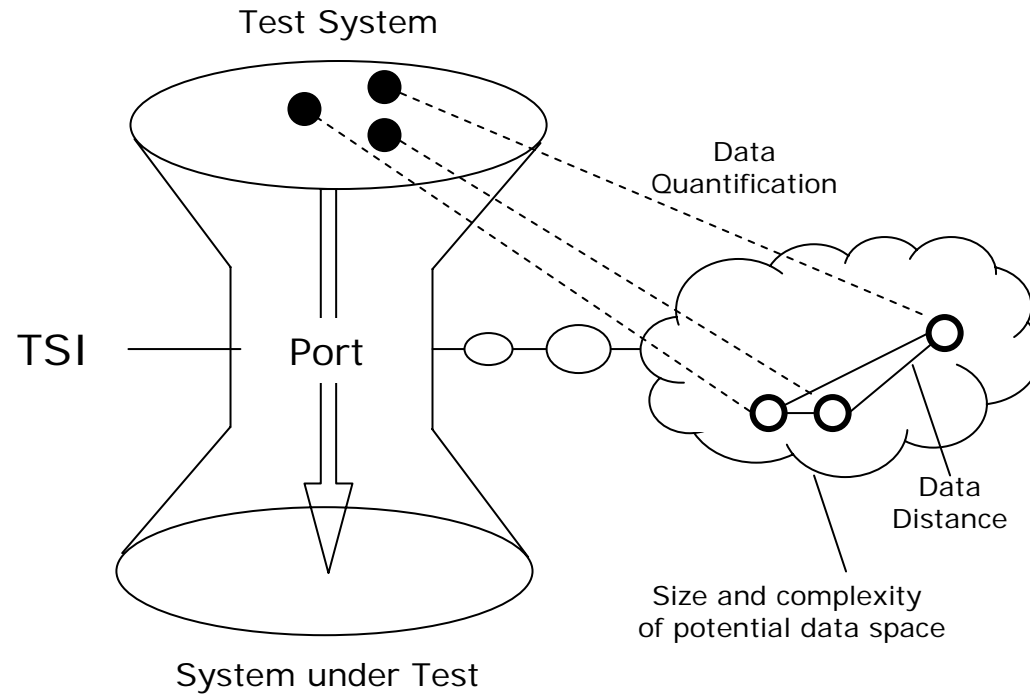
■ Generic metrics

- lines of code
- min, max, average lines of code for a function
- min, max, average number of parameters for a function
- number of unused variables
- min, max, average cyclomatic complexity for a function
- min, max, average function fan-in for a test suite
- min, max, average function fan-out for a test suite
- ...

■ TTCN-3 specific metrics

- number of verdict assignments
- min, max, average execution time for a test case
- min, max, average number of parallel test components employed for the execution of a test case
- fan-in/fan-out for test control, test cases, altsteps
- min, max, average number of parameters for a module, test case, altstep, template
- ...

Test Variance Metrics



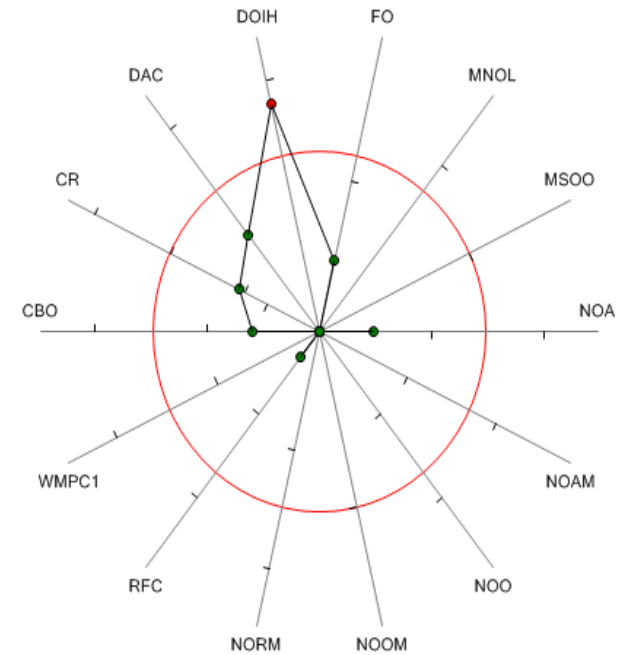
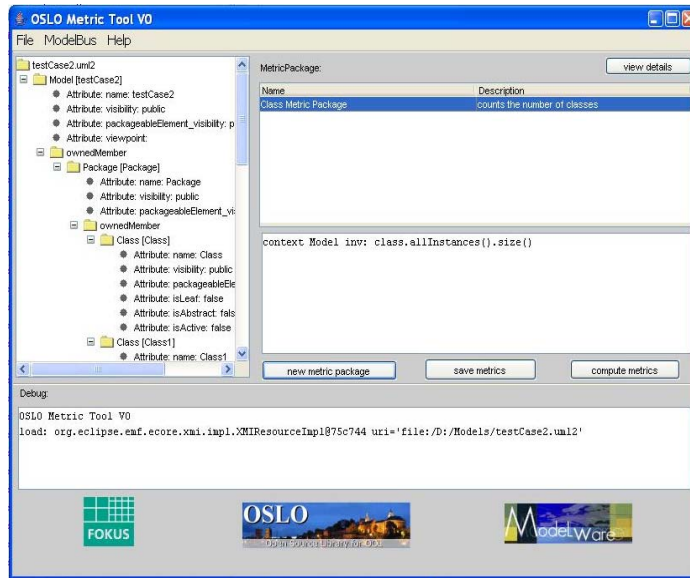
Test data variance in TTCN-3

- 1. SUT is represented by TSI
 - set of ports of different port types allowing various data types
 - **“system”** clause in test case definition

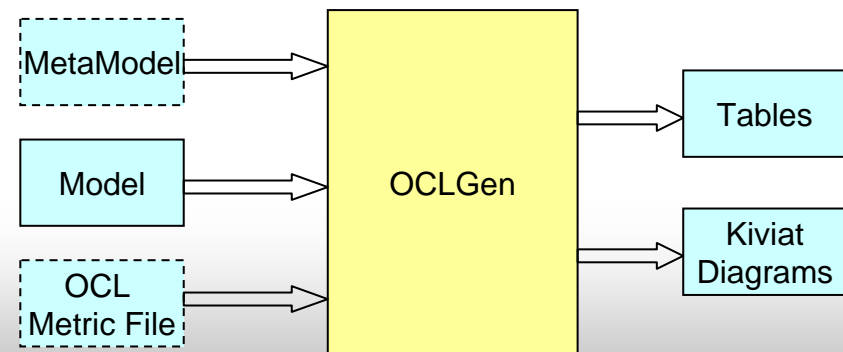
- 2. TSI coverage – data input space
 - Quantitative similarity
 - distance measures
 - Qualitative similarity
 - partitioning method

- 3. Assumptions
 - all TSI ports are **message-based port**

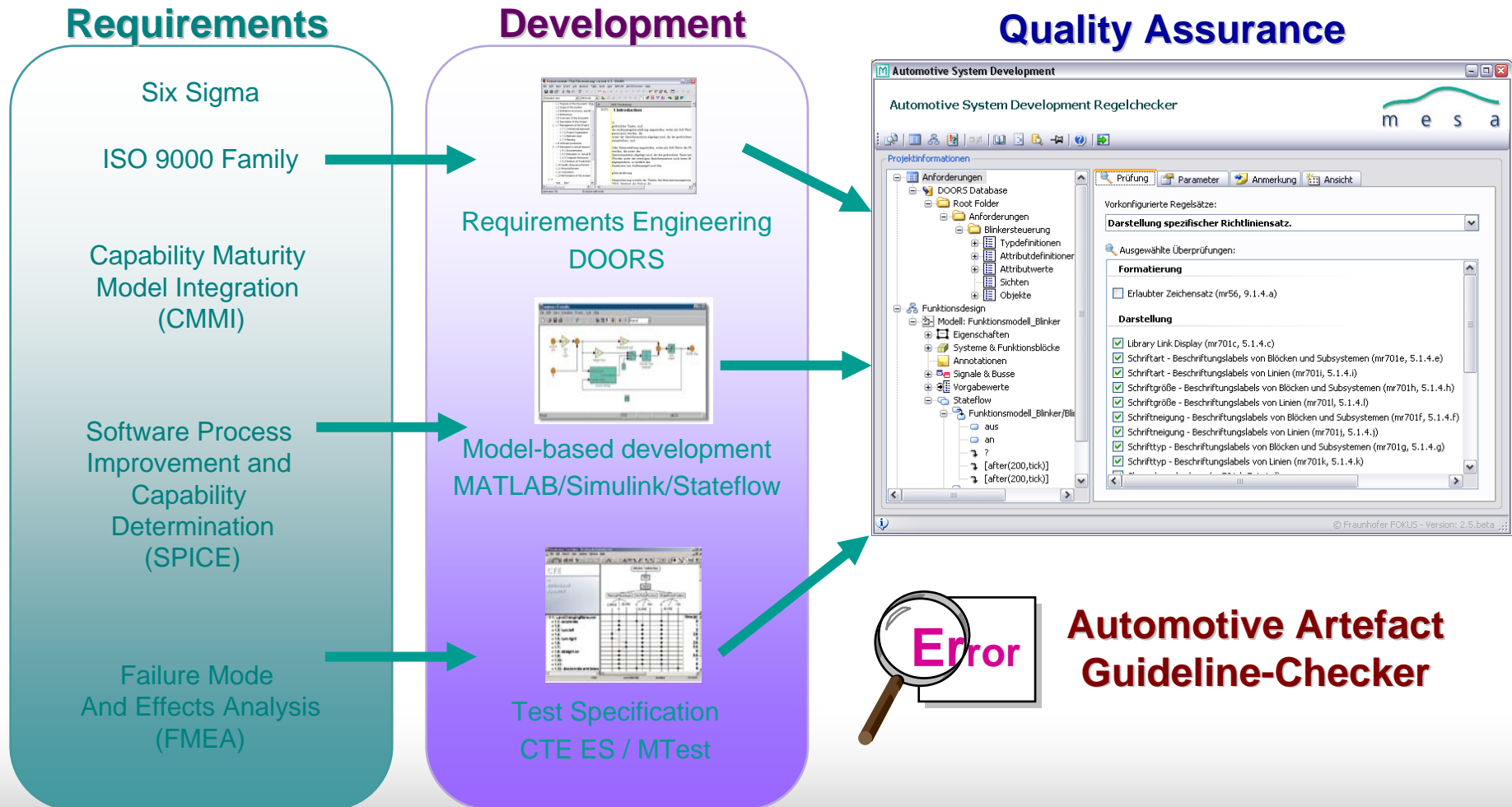
Quantitative Assessment: Model Metrics



- Metrics computation
 - Compute metrics with OCL, also with metric packages
 - Based on meta models
 - Generic metrics for different models
- Results presentation
 - Numerical reports
 - Graphical presentation
 - Trigger warnings to project manager



Quality Assessment: Guideline Checks



Selected Publications

- M. Born, I. Schieferdecker, M. Li: *UML Framework for Automated Generation of Component-Based Test Systems*. - Intern. Conf. on Software Engineering Applied to Networking and Parallel/ Distributed Computing (SNPD'00), Reims, France, 2000
- I. Schieferdecker, G. Din: *A Metamodel for TTCN-3*, 1st International Workshop on Integration of Testing Methodologies ITM 2004, October 2004, Toledo, Spain, Springer, Lecture Notes in Computer Science 3236.
- D. Vega, I. Schieferdecker, G. Din: *Towards Quality of TTCN-3 Tests*, SAM 2006, May 2006, Kaiserslautern, Germany, Workshop Proceedings, 2006.
- M. Busch, R. Chaparadza, Z.R. Dai, A. Hoffmann, L. Lacmene, T. Ngwangwen, G.C. Ndem, H. Ogawa, D. Serbanescu, I. Schieferdecker, J. Zander-Nowicka: *Model Transformers for Test Generation from System Models*, Conquest 2006, Hanser Verlag, September 2006, Berlin, Germany.

Selected Publications

- B. Zeiß, D. Vega, I. Schieferdecker, H. Neukirchen, J. Grabowski: *Applying the ISO 9126 Quality Model to Test Specifications — Exemplified for TTCN-3 Test Specifications*. Software Engineering 2007 (SE 2007). Lecture Notes in Informatics (LNI) 105. Copyright Gesellschaft für Informatik, Köllen Verlag, Bonn, Febr. 2007
- I. Schieferdecker: *Quality Assurance for Autonomous Systems – A Review of Model-Based Methods*. 8th Intern. Symposium on Autonomous Decentralized Systems (ISADS 2007), Keynote, Sedona, Arizona, March 2007, Keynote.
- D. Vega, I. Schieferdecker and G. Din: *Test Data Variance as a Test Quality Measure - Exemplified for TTCN-3*, 19th IFIP International Conference on Testing of Communicating Systems and 7th International Workshop on Formal Approaches to Testing of Software, TestCom/FATES 2007, Springer LNCS, Tallinn, Estonia, June 2007.
- D. Vega, I. Schieferdecker and G. Din: *TTCN-3 Test Data Analyser using Constraint Programming*, submitted to TestCom 2008, Tokyo, Japan, June 2008.

Issues – the full spectrum of system engineering

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Selected Publications

- A. Vouffo-Feudjio and I. Schieferdecker. *Test Pattern with TTCN-3*, FATES 2004, 4th International Workshop on Formal Approaches to Testing of Software, Linz, Austria, Sept. 2004, Springer.
- J. Zander-Nowicka, I. Schieferdecker, A. Marrero Pérez: *Automotive Validation Functions for on-line test evaluation of hybrid real-time systems*, IEEE AutoTestCon 2006, Anaheim California, USA, Sept, 2006
- S. Wappler, I. Schieferdecker: *Automatic Test Case Generation for Object-Oriented Unit Testing Using Genetic Programming*, 22nd IEEE/ACM International Conference on Automated Software Engineering, ASE'07, Atlanta, Georgia, USA, Nov. 2007.
- S. Alekseev, P. Tollkühn, Z.R. Dai, A. Hoffmann, A. Rennoch, I. Schieferdecker: *Testing Customizable Software for Telecommunication Services*, ICIN 2007: Emerging Web and Telecom Services, Bordeaux, France, Oct. 2007
- F. Belli, M. Linschulte, I. Schieferdecker: *Ereignisorientiertes Testen Web-basierter Systeme - Verfeinerung des holistischen Ansatzes und eine Fallstudie*, ARCS'07, Workshop on 'Dependability and Fault Tolerance', Zurich, Suisse, March 2007
- J. Zander-Nowicka, A. Marrero Perez, I. Schieferdecker: *From Functional Requirements through Test Evaluation Design to Automatic Test Data Templates Retrieval – a Concept for Testing of Software Dedicated for Hybrid Embedded Systems*, International Conference on Software Engineering Research and Practice (SERP'07), Las Vegas, Nevada, USA, June 2007.

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Selected Publications

- T. Li, A. Hoffmann, M. Born and I. Schieferdecker: *A Platform Architecture to Support the Deployment of Distributed Applications*, IEEE International Conference on Communications. IEEE ICC2002 in New York, NY, USA, Apr.-May 2002.
- I. Schieferdecker, T. Vassiliou-Gioles: *Realizing distributed TTCN-3 test systems with TCI*, IFIP 15th Intern. Conf. on Testing Communicating Systems - TestCom 2003, Sophia-Antipolis, France, May 2003, Springer, Lecture Notes in Computer Science 2644, Best Paper.
- P. H. Deussen, G. Din, I. Schieferdecker: *A TTCN-3 Based Online Test and Validation Platform for Internet Services*, Sixth International Symposium on Autonomous Decentralized Systems - Advanced Distributed Transportation Systems, ISADS 2003, Pisa, Italy, IEEE Press, April 2003.
- J. Zander, Z.R. Dai, I. Schieferdecker, G. Din: *From U2TP Models to Executable Tests with TTCN-3 - An Approach to Model Driven Testing*, IFIP 17th Intern. Conf. on Testing Communicating Systems - TestCom 2005, Montreal, Canada, March 2005.
- J. Zander-Nowicka, I. Schieferdecker, T. Farkas: *Derivation of Executable Test Models From Embedded System Models using Model Driven Architecture Artefacts*, Dagstuhl-Workshop Modellbasierte Entwicklung eingebetteter Systeme (MBEES 2006), Jan. 2006, Germany
- R.Chaparadza, M. Busch, Z.R. Dai, A. Hoffman, L. Lacmene, T. Ngwangwen, G. C. Ndem, D. Serbanescu, I. Schieferdecker, J. Zander-Nowicka: *Transformations: UML2 System Models to U2TP models, U2TP models to TTCN-3 models and, TTCN-3 Code Generation and Execution*, ECMDA Workshop, Bilbao, Spain, July 2006.

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Selected Publications

- T. Vassiliou-Gioles, G. Din, I. Schieferdecker: *Execution of External Applications using TTCN-3*. IFIP 16th Intern. Conf. on Testing Communicating Systems - TestCom 2004, St Anne's College, Oxford, United Kingdom, March 2004, Springer, Lecture Notes in Computer Science 2978.
- I. Schieferdecker, G. Din, D. Apostolidis: *Distributed Functional and Load tests for Web services*, International Journal on Software Tools for Technology Transfer (STTT), Springer 2005.
- G. Din, S. Tolea, I. Schieferdecker: *Distributed Load Tests with TTCN-3*, IFIP Intern. Conf. on Testing Communication-Based Systems, TestCom 2006, May 2006, New York, USA.
- G. Din, R. Petre, I. Schieferdecker: *A Workload Model for Benchmarking IMS Core Networks*, IEEE Global Communications Conference, GLOBECOM 2007, Washington, DC, USA, Nov. 2007.
- D. Serbanescu, V. Molovata, G. Din, I. Schieferdecker, I. Radusch: *Real-Time Testing With TTCN-3*, submitted to TestCom 2008, Tokyo, Japan, June 2008.

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Selected Publications

- M. Born, I. Schieferdecker, O. Kath and C. Hirai: *Combining System Development and System Test in a Model-centric Approach*, RISE 2004 International Workshop on Rapid Integration of Software Engineering techniques, November 26, 2004, Luxembourg, Luxembourg, Springer, Invited.
- I. Schieferdecker: *The UML 2.0 Test Profile as a Basis for Integrated System and Test Development*. GI Jahrestagung, Informatik 2005, Bonn, Sept. 2005
- T. Deiß, A. Rennoch, I. Schieferdecker and T. Vassiliou-Gioles: *Advanced Test Processes using TTCN-3*, ITEA Publications, March 2006.

Summary

- Goal
 - Test model/test system as integral part of system engineering
 - For early and continuous quality considerations
- Test modelling techniques
- Test the test
 - Generate correct tests
 - Verify test correctness
 - Assess test quality
- Other aspects of quality engineering

MOTION's Technologies

- Modeling plugins (UML, U2TP, ...)
- Metamodeling infrastructure (MOF)
 - medini via
- Testing infrastructure (TTCN-3)
 - TTworkbench via
- Invariant checking (OCL)
 - OSLO via
- QoS enabled Middleware (CCM)
 - Qedo via
- Tool coupling
 - ModelBus via
- ... and various concrete solutions



ikv++ technologies ag

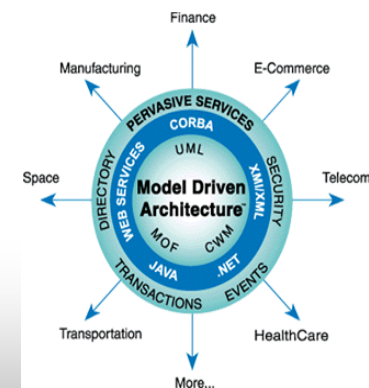


MOF
Meta-Object Facility

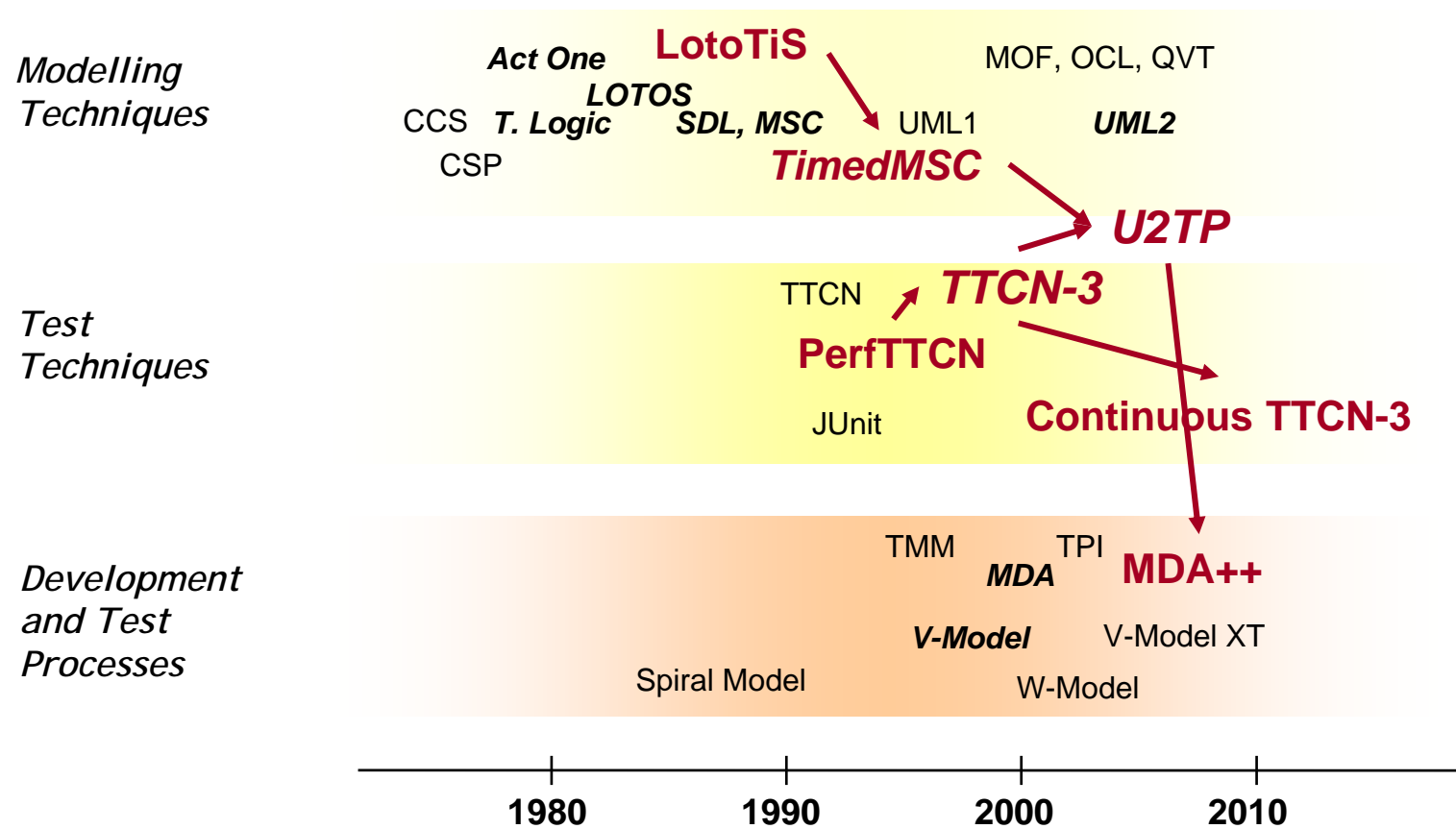


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Summary of Developments



Legend

- MDA** - usage
- PerfTTCN** - own development
- TTCN-3** - own development in standards

Outlook

- Model quality is generic
 - Approach should be extended to various kinds of models
 - Generic quality aspects vs. specific quality aspects
 - Appropriateness of metrics and of rules

- Need for a model-oriented quality engineering approach
 - Model-based system management
 - Model metrics, patterns and anti-patterns
 - Model-based process integration
 - ...

Thank You for Your Attention!

Any Questions?

