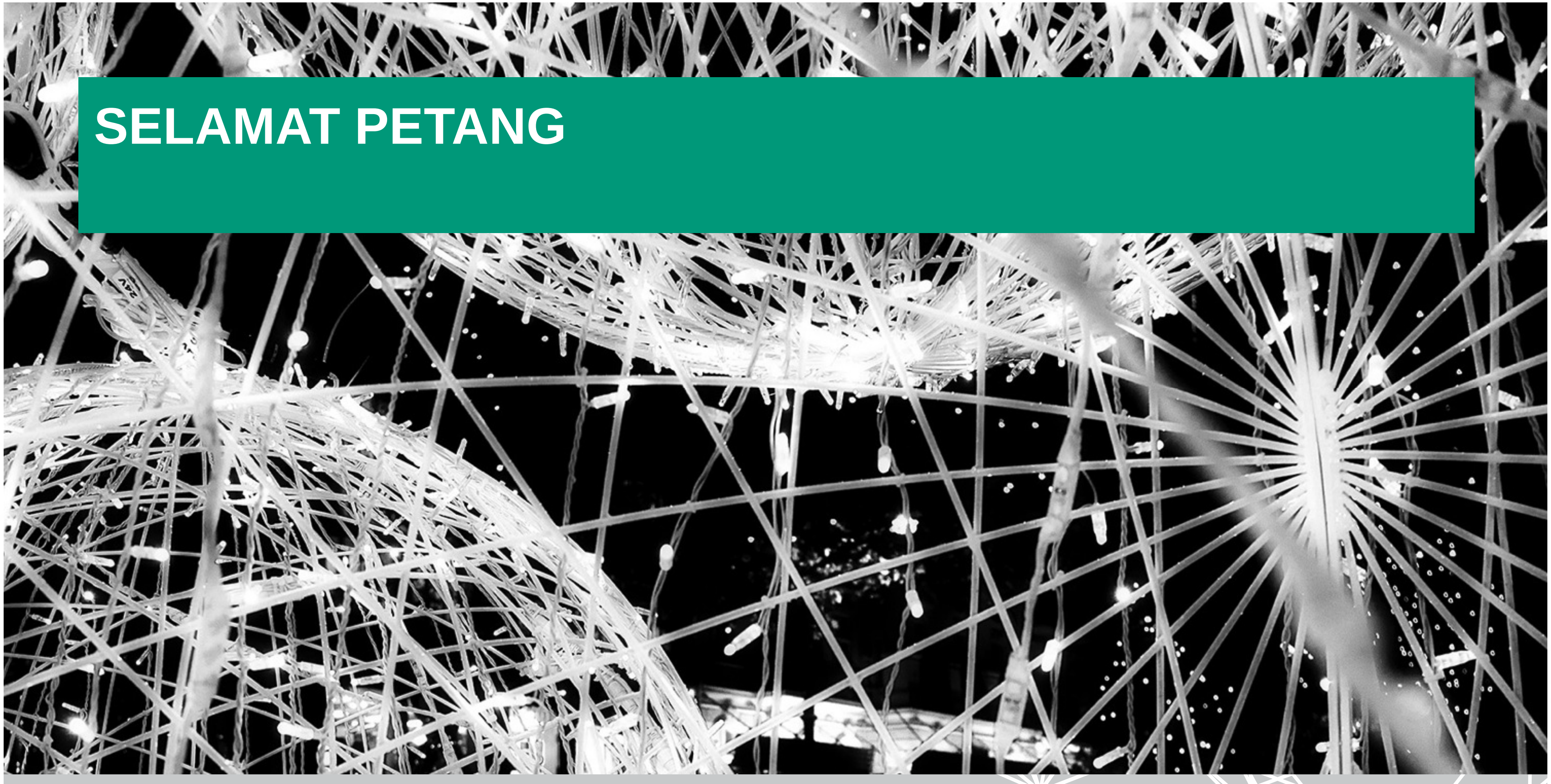
SELAMAT PETANG



Engineering a Connected World

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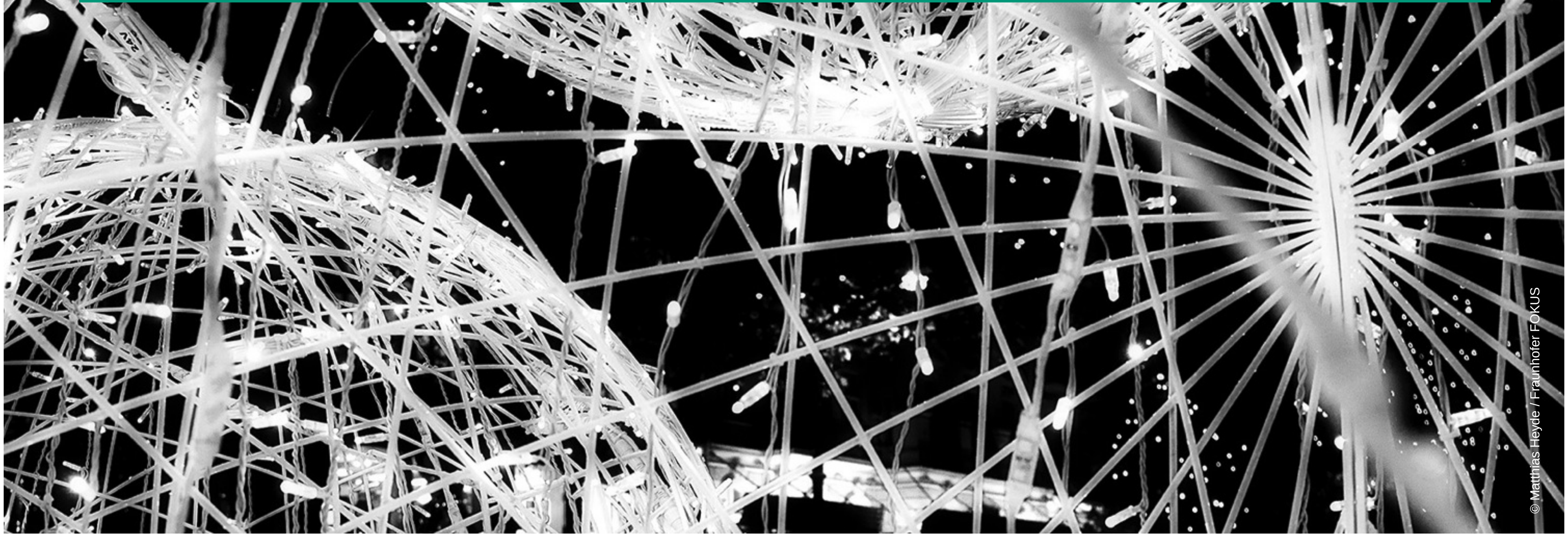
HISTORY AND PROSPECTIVE FUTURE OF TEST AUTOMATION



Ina Schieferdecker

SOFTEC 2016, Kuala Lumpur, Malaysia

Engineering a Connected World

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SOFTWARE OUTAGES ARE COSTLY AND DANGEROUS

1. 1996: European Ariane 5 rocket; over $370 million loss

2. 1985-1987: Therac-25 medical radiation therapy; patients received up to 100 times the intended dose, and at least three of them died

3. 2010: Virgin Blue's Reservation Desk outage; $20 million loss

4. 2012: Wrong orders for Knight Capital Group's funds; $440 million loss

5. …

6. Jan. 2016: IHS study; **costs to North American companies of $700 billion a year for ICT outages**. This includes lost employee productivity (78%), lost revenue (17%), and actual costs to fix the downtime issues (5%).

OTHER'S VIEWS

Grand Challenges

Digitale Kultur
Wie bewahren wir digitale Informationen für unsere Nachwelt auf? Bücher, Bilder und Tonträger lassen sich ins M
sich sogar digitalisieren und digitalisiert für lan
aber bewahrt man einen Video-Clip, der digita
Internet veröffentlicht wird, für die nachfolgen
weiterlesen ...

Internet der Zukunft
Wie erkennen wir beim Versenden einer digita
auf dem Weg zum Empfänger unbemerkt geles
versiegelten Briefumschlag sah man, ob das S
digitale Information kann unbemerkt kopiert, a
manipuliert worden sein. Wie sichern wir dann
Vertraulichkeit im Netz? **weiterlesen ...**

Systemische Risiken

3 of 5 grand computer science challenges relate to software quality

Software bildet den Kern der Innovationen

Ob soziale Netze, Apps, intelligente Energienetze, Websho
mobility oder Industrie 4.0 und vieles mehr – Software ist
Produkt- und von Dienstleistungsinnovationen. Software-
erschaffen Werte, Software-Entwicklung steht im Zentrum
Innovationsprozesse.

Es gilt, die Ke ... weiter auszubauen.

Software engineering central to Germany

Neue IT-Trends wie Industrie 4.0/Internet of Things (48%), BigData (50%) oder auch Mobile (71%) sind aus Sicht des Managements zukunftsrelevant und werden in den Unterneh-

Software quality research needed

Herausforderungen des IoT-Testings

IoT poses new challenges

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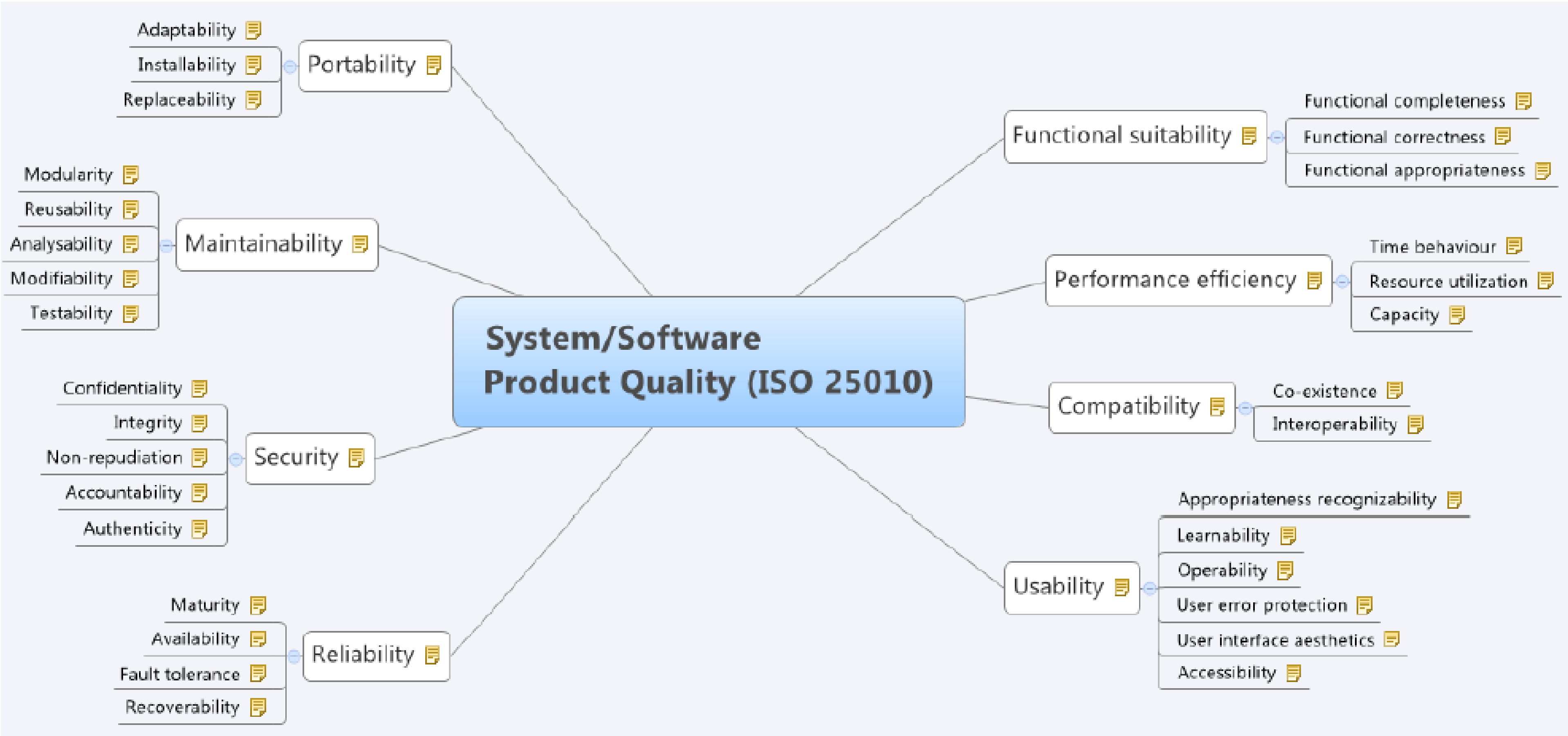
OUTLINE

1. Status software quality
2. Some history
3. Some future perspectives

WHAT IS SOFTWARE QUALITY



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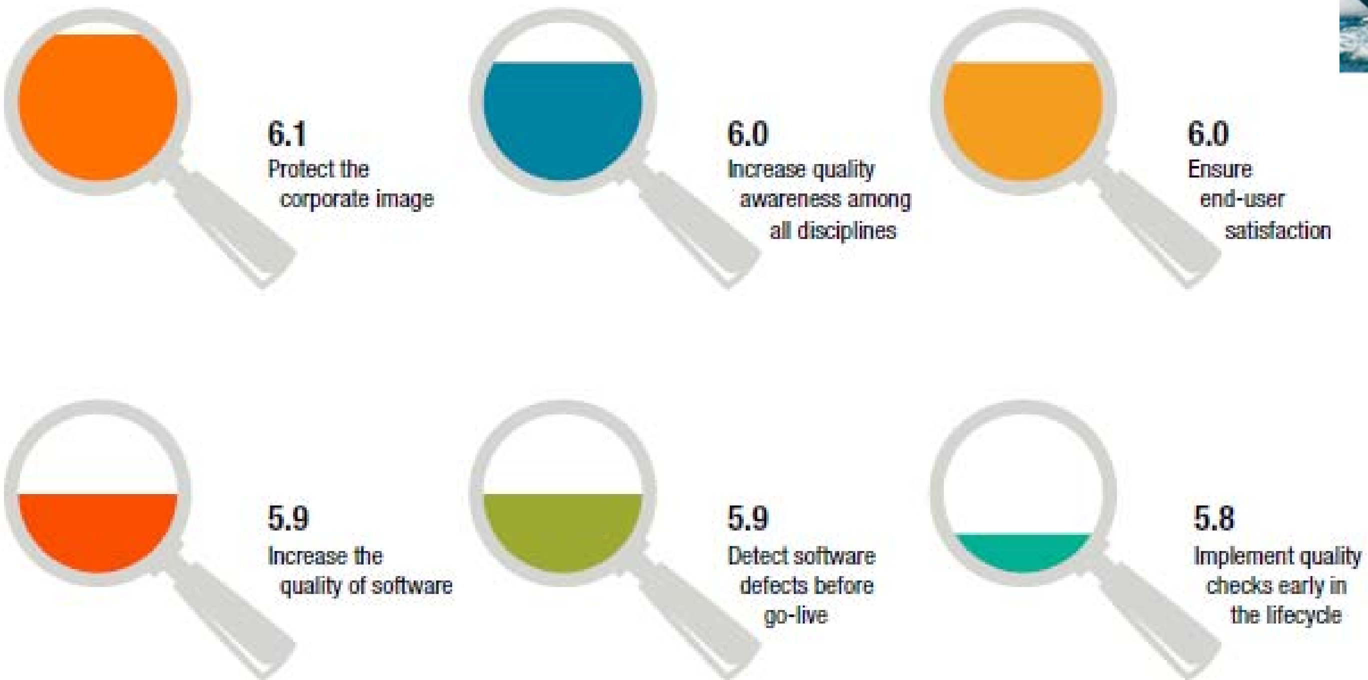
WHY IS IT IMPORTANT

1560 CIOs and IT and testing leaders
From 32 countries across the globe
Scale of 1-7 with 7 highest

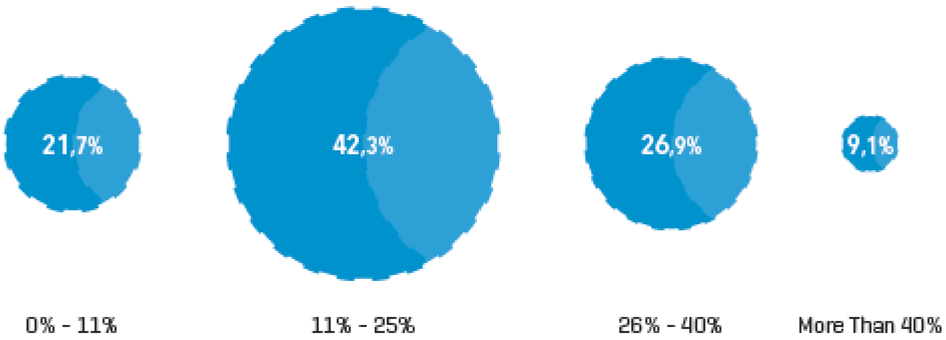
Management objectives with QA & Testing



WHY IS IT IMPORTANT

About 3,200 respondents from 89 countries

What percent of a typical IT/ R&D project budget is allocated to software testing?



The large majority of respondents indicate budgets between 11% and 40%.
This is in line with World Quality Report 2015-16 that indicates an average expenditure of 26% for 2014 and 35% for 2015.

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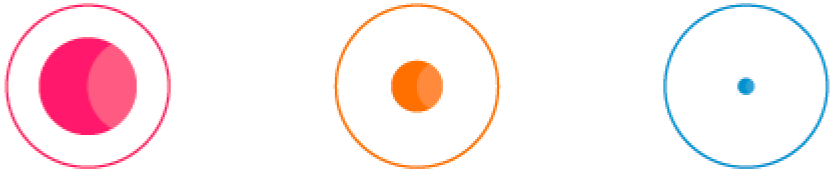
WHY IS IT IMPORTANT

About 3,200 respondents from 89 countries

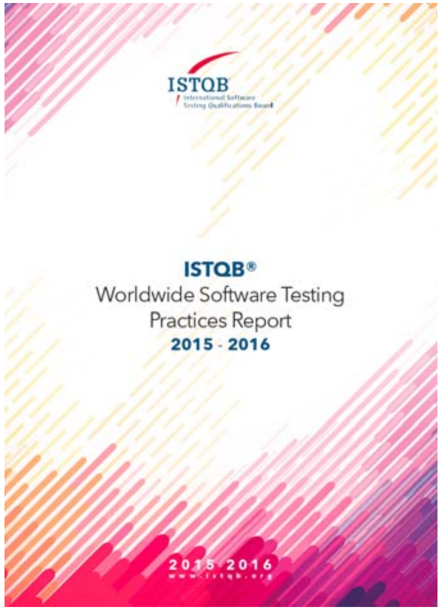
What is your expectation for your organization’s software testing budget in the next 12 months?



59,2%	31%	9,8%
Growth	Stable	Decrease

16,6% 1%-10% Growth
14,7% 11%-20% Growth
11,9% 21%-30% Growth
6,2% 31%-40% Growth
4,1% 41%-50% Growth
5,7% More Than 50% Growth

6,5% Slight Decrease
3,3% Signification Decrease



About 60% of the respondents expect an increase of the budgets allocated to testing; this confirms the growing trend exhibited in the World Quality Report 2015-16, which forecasts that by 2018 the IT budget allocated to QA & testing will rise to 40%.

Average expected growth is 14% which is in line with the forecasted CAGR of the Global Testing Market in 2015-2019 in the Technavio Report (www.technavio.com)

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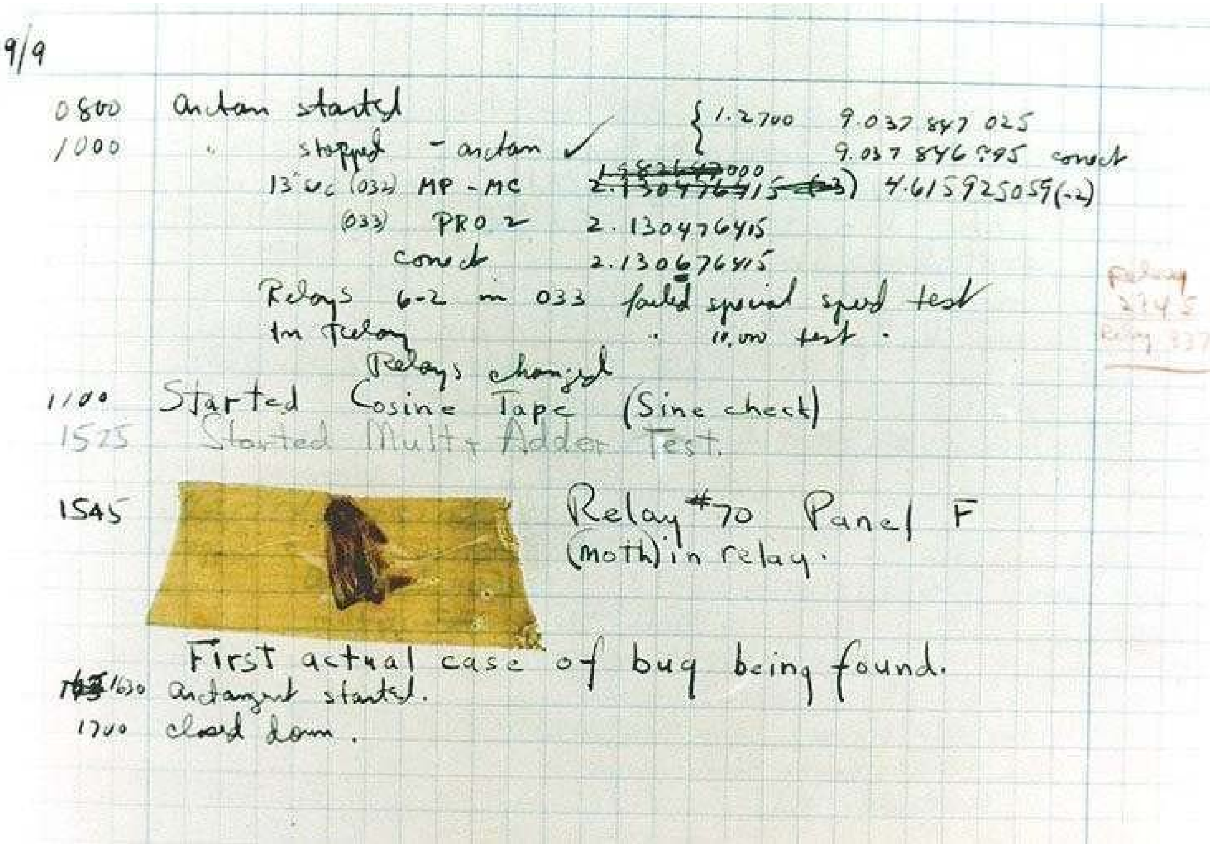
9.9.1945 15:45

The first „software bug“

- A moth in the computer Mark II causes a defect in Relay No. 70, Panel F.
- Mrs. Grace Murray Hopper removes the defect and records it in the log book.

»First actual case of bug being found.«



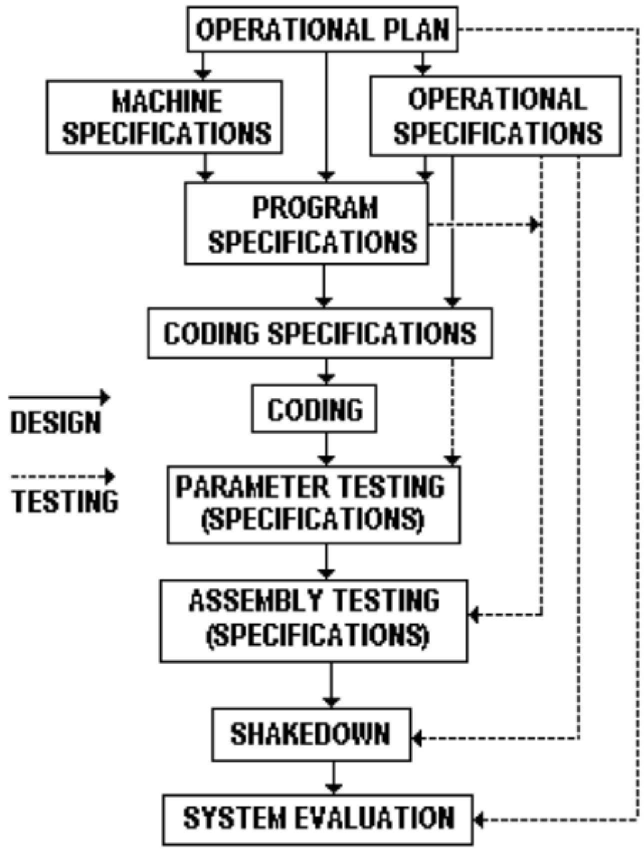
Source:
http://www.history.navy.mil/photos/pers-us/uspers-h/g-hoppr.htm

1956

H. D. Benington: Production of Large Computer Programs. Proceedings of Symposium On Advanced Computer Programs for Digital Computers, June 1956

»The paper is adapted from a presentation at a symposium on advanced programming methods for digital computers sponsored by the Navy Mathematical Computing Advisory Panel and the Office of Naval Research in June 1956. The author describes the techniques used to produce the programs for the Semi-Automatic Ground Environment (SAGE) system.«

»We find that large programs can now be produced; unfortunately, they are difficult to test and document.«



TESTING PRINCIPLES – INTEGRATION AND SYSTEM TEST

Stepwise integration test

»As parameter testing of component subprograms is completed, the system program is gradually assembled and tested using first simulated inputs and then live data.«

System tests in target environment

»When the completed program has been assembled, it is tested in its operational environment during shakedown.«

Acceptance test as final step

»At the completion of this phase, the program is ready for operation and evaluation.«

TESTING PRINCIPLES – CRITICALITY AND EFFORTS

Software as system part

»When the program is delivered for operation, its performance must be highly reliable because the control system is a critical part of a much larger environment of men and machines.«

Test efforts ~38% (without system test!)

No “complete tests” – testing is sampling

»It is debatable whether a program of 100,000 instructions can ever be thoroughly tested - that is, whether the program can be shown to satisfy its specifications under all operating conditions. Considering the size and complexity of a system program, it is certain that the program will never be subjected to all possible input conditions during its lifetime.«

»For this reason, one must accept the fact that testing will be sampling only.«

Testing to be improved

»On the other hand, many sad experiences have shown that the program-testing effort is seldom adequate.«

SELECTED HISTORICAL RESULTS BY JORIS MEERTS

1949	**On Checking a Large Routine (Turing)**	In the conference paper On Checking a Large Routine Alan M. Turing proposes an answer to the question how one can check a routine in the sense of making sure that it is right.
1951	**Total Quality Control (Feigenbaum)**	In his famous book 'Total Quality Control' Armand Vallin Feigenbaum defines quality as a customer determination. Quality depends on the perspective of the customer. The product should satisfy the customer in both actual and expected needs. There is a company-wide responsibility for quality.
1957	**Program testing vs debugging (Baker)**	Charles L. Baker (RAND Corporation) distinguishes program testing from debugging in his review of the book Digital Computer Programming by Dan McCracken. The review is published in the journal Mathematical Tables and Other Aids to Computation.
1958	**First software test team (Weinberg)**	The first test team is formed by Gerald M. Weinberg, working as manager of Operating Systems Development for the Project Mercury. Project Mercury is the first human spaceflight program of the United States.
1967	**Evaluation of the Functional Testing of Control Programs**	In the IBM white paper Evaluation of the Functional Testing of Control Programs William Elmendorf calls for a disciplined approach to software testing.
1968	**NATO report mentions Software Quality Assurance**	During the Software Engineering conference sponsored by the NATO Science Committee (7th to 11th October 1968) among other things quality assurance for software production is one of the topics. The report of the conference includes the working paper Checklist for planning software system production by Robert W. Bemer. This paper contains a chapter on quality assurance. One of the questions in the checklist is 'Is the product tested to ensure that it is the most useful for the customer in addition to matching functional specifications?'.

http://www.testingreferences.com/testinghistory.php

SELECTED HISTORICAL RESULTS BY JORIS MEERTS

1969	**Testing shows the presence, not the absence of bugs**	Edsger Dijkstra's famous quote was reportedly first spoken on a conference by the NATO Science Committee, Rome, Italy, 27–31 October 1969.
1971	**Mutation testing (Lipton)**	In a class term paper titled Fault Diagnosis of Computer Programs Richard Lipton proposed the initial concepts of mutation. Mutation testing is a methodology for unit testing in which small parts of the code are changed. This is done, for example, in order to test the quality of the unit tests.
1973	**Program Test Methods (Hetzel)**	The Chapel Hill Symposium, organized by the University of North Carolina and held on June 21-23 1972, leads to publication of the book Program Test Methods edited by William Hetzel. The book contains the edited papers of the symposium as well as a large annotated bibliography. The book focuses on the problems in testing and validation.
1975	**Toward a Theory of Test Data Selection (Goodenough, Gerhart)**	The paper by John B. Goodenough and Susan L. Gerhart discusses formal proof methods and the limitations of structure-based testing. It also outlines the use of decision tables.
1976	**Cyclomatic Complexity (McCabe)**	Thomas J. McCabe introduces cyclomatic complexity as a software metric for the complexity of a program in his IEEE paper A Complexity Measure. McCabe also introduces basic path testing as a white box test technique.
1976	**Software Reliability: Principles and Practices (Myers)**	In his book Software Reliability: Principles and Practices Glenford Myers discusses software testing among other things. He mentions, for example, that 'The goal of the testers is to make the program fail'.

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SELECTED HISTORICAL RESULTS BY JORIS MEERTS

1976	**Cost-of-change curve (Boehm)**	In his paper Software Engineering, published in the December 1976 issue of IEEE Transactions , Barry Boehm publishes his cost-of-change curve. The curve essentially shows that the cost of changing the software (fixing a software defect) rises exponentially in time. Boehm uses data from his work at TRW and other sources such as GTE, IBM and Bell Laboratories.
1982	**SQS founded in Germany**	The German company Software Quality Systems (SQS) is founded Heinz Bons and Rudolf van Megen. It is one of the leading software testing organisations in Europe.
1983	**IEEE 829 published**	The first version of the IEEE 829 Standard for Software Test Documentation is published in 1983. The standard specifies the form of a set of documents for use in eight defined stages of software testing.
1984	**SEI founded**	The Carnegie Mellon Software Engineering Institute (SEI) is established by the U.S. Department of Defense. In its own words "the SEI advances software engineering and related disciplines to ensure the development and operation of systems with predictable and improved cost, schedule, and quality."
1986	**V-model published (Rook)**	In the article Controlling Software Projects, published in the IEEE Software Engineering Journal, Paul E. Rook introduces the V-model. Rook works for GEC Software Ltd. in London at that time. The model demonstrates the relationships between each phase of the development life cycle and its associated phase of testing.
1987	**Test, then code**	Motto on the lapel pin of SQE as worn during the Fourth International Conference on Software Testing, Washington DC.

SELECTED HISTORICAL RESULTS BY JORIS MEERTS

1987	**Software reliability (Musa)**	The seminal work Software Reliability: Measurement, Prediction, Application is published by John D. Musa, Anthony Iannino, and Kazuhira Okumoto. Software reliability has become a key part in software quality.
1989	**SIGIST founded**	The British Specialist Interest Group in Software Testing (SIGIST) is founded in 1989 by Geoff Quentin. Its first meeting is held at Imperial College in London. The meeting, during which four presentations (on risks, standards and reliability) are given, is attended by 29 people. The aim of the group is to share problems, successes and failures in testing, share techniques and share ideas of tools to support testing.
1991	**ISO 9126 published**	ISO/IEC 9126 Software engineering — Product quality is an international standard for the evaluation of software quality. Its quality model splits up quality into six characteristics.
1992	**First version of TTCN**	The first version of the Testing and Test Control Notation (TTCN) - originally meaning Tree and Tabular Combined Notation - is published by the ETSI Centre for Testing and Interoperability. The language is launched as a specification of abstract test suites for conformance testing of International Telecommunications Union protocols. It is now promoted as a general purpose test language for distributed communicating systems.
1993	**W-model introduced (Herzlich)**	In his presentation The Politics of Testing Paul Herzlich introduces the W-model. The model attempts to address shortcomings in the V-Model. Herzlich holds the presentation during the first EuroSTAR conference in London.

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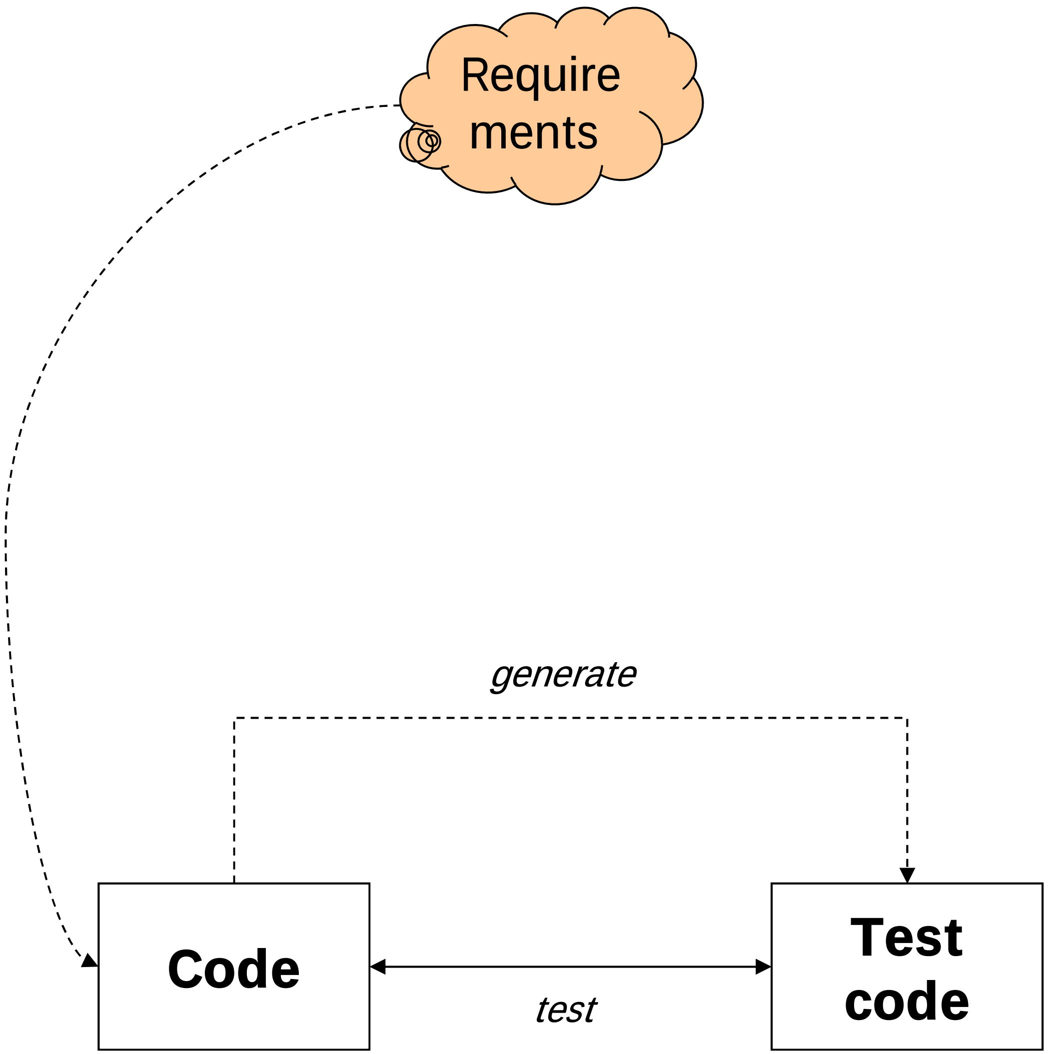
SELECTED HISTORICAL RESULTS BY JORIS MEERTS

1994	**First Chaos report (Standish Group)**	The Standish Group starts the Chaos report, a continuing study to identify the scope of software project successes and failures, the major factors that cause software projects to fail, and the key ingredients that can reduce software project failures.
1996	**TMM developed**	The Testing Maturity Model is developed at the Illinois Institute of Technology.
2000	***TTCN-3 developed***	*The Testing and Test Control Notation is published by ETSI*
2004	***UTP developed***	*The UML Testing Profile is published by OMG*
2010	***TTCN-3 embedded developed***	*Real-time and performance extensions for TTCN-3 published by ETSI*
2013	***TTCN-3 fuzzing developed***	*Fuzzing extensions for TTCN-3 published by ETSI*

TESTING TECHNIQUES – STRUCTURAL TESTING



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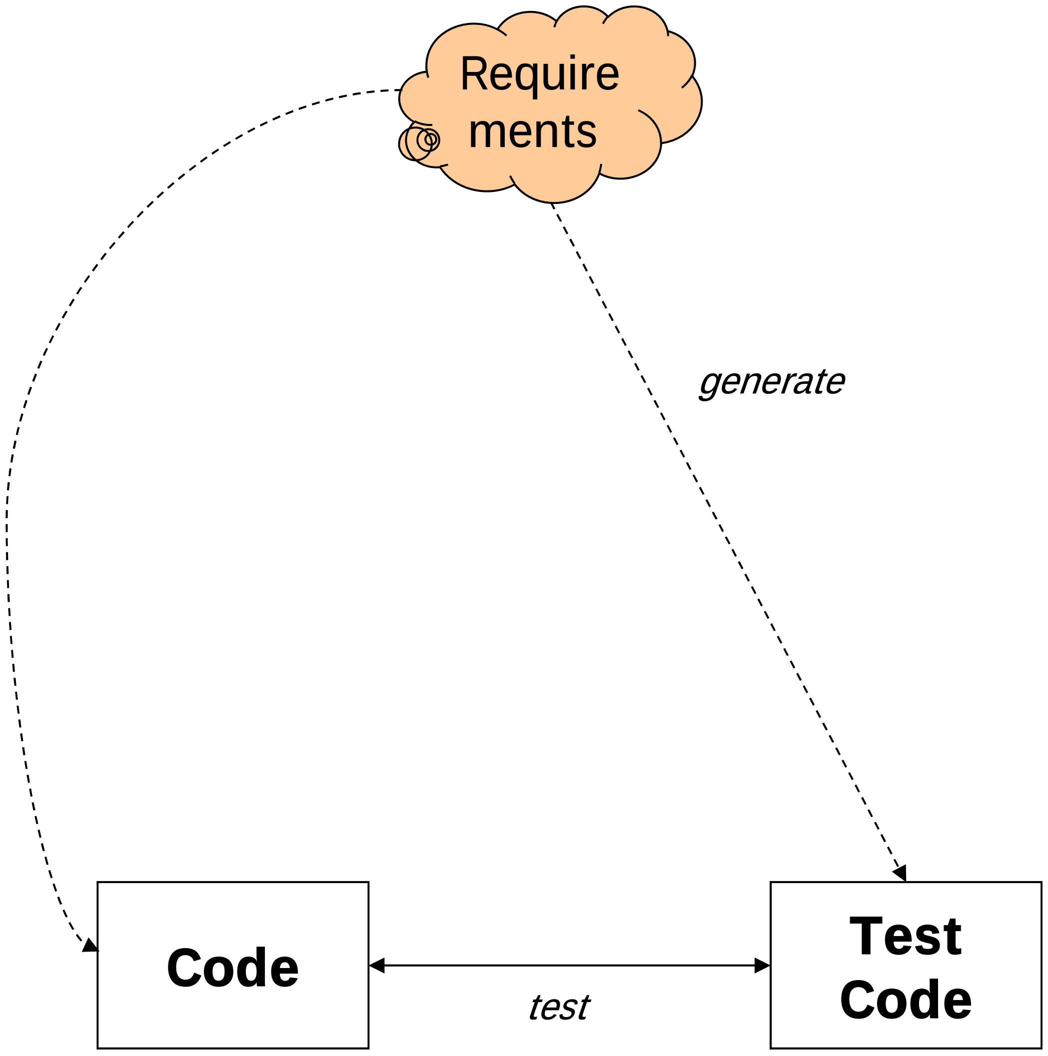
TESTING TECHNIQUES – FUNCTIONAL TESTING



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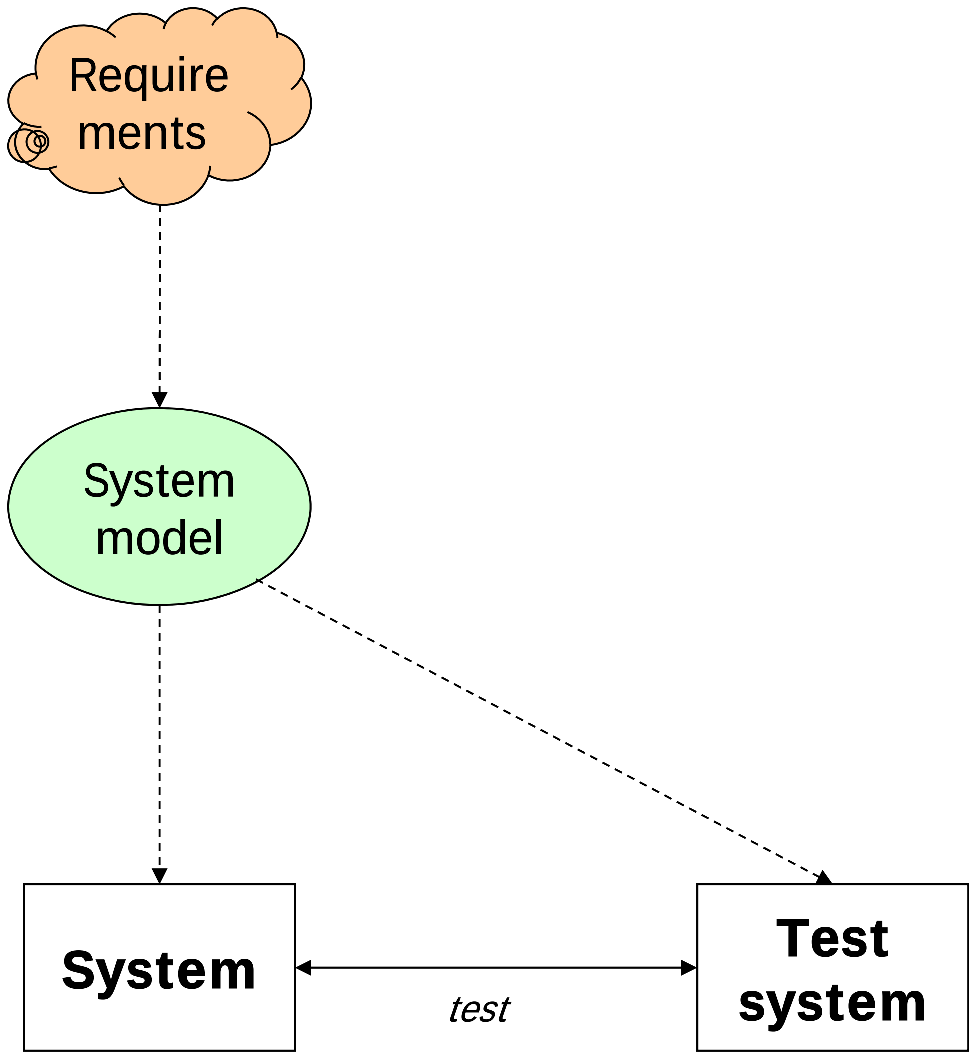
TESTING TECHNIQUES – MODEL-BASED TESTING 1.0



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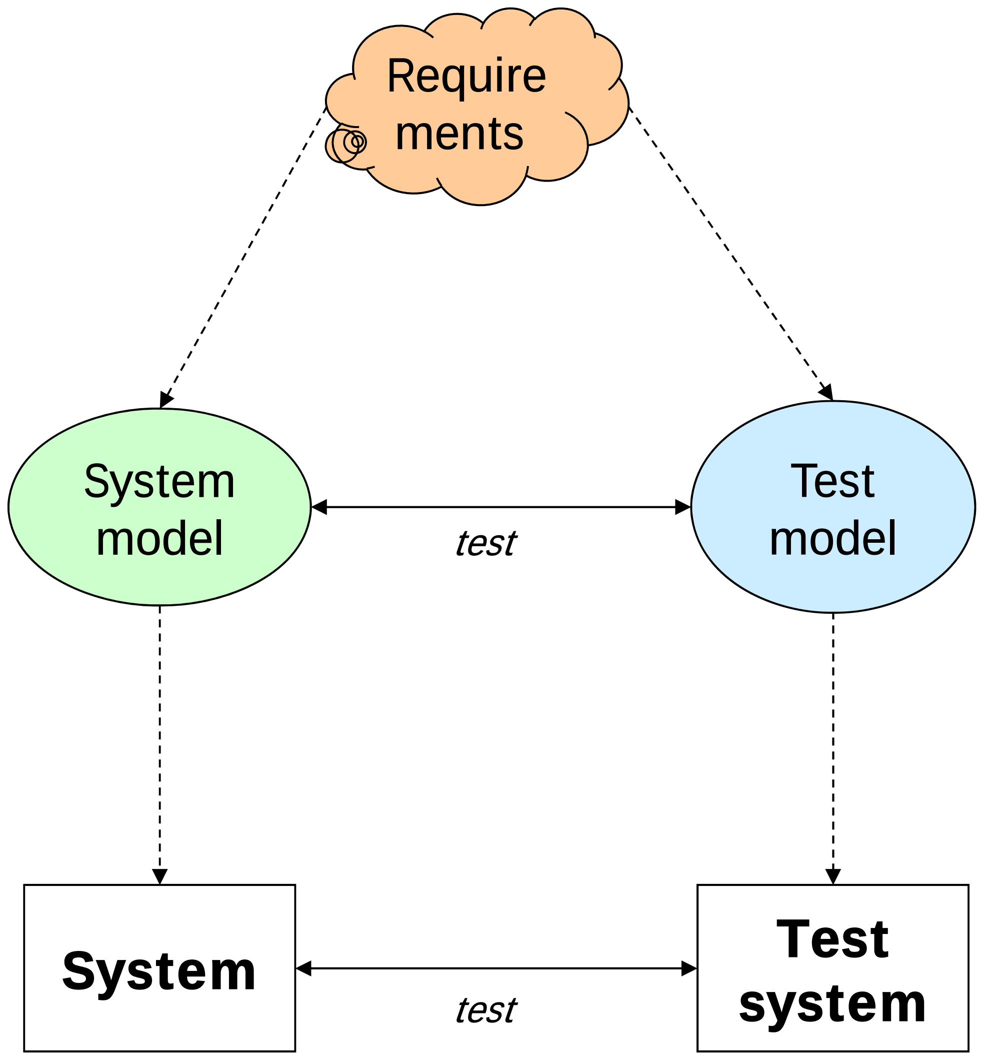
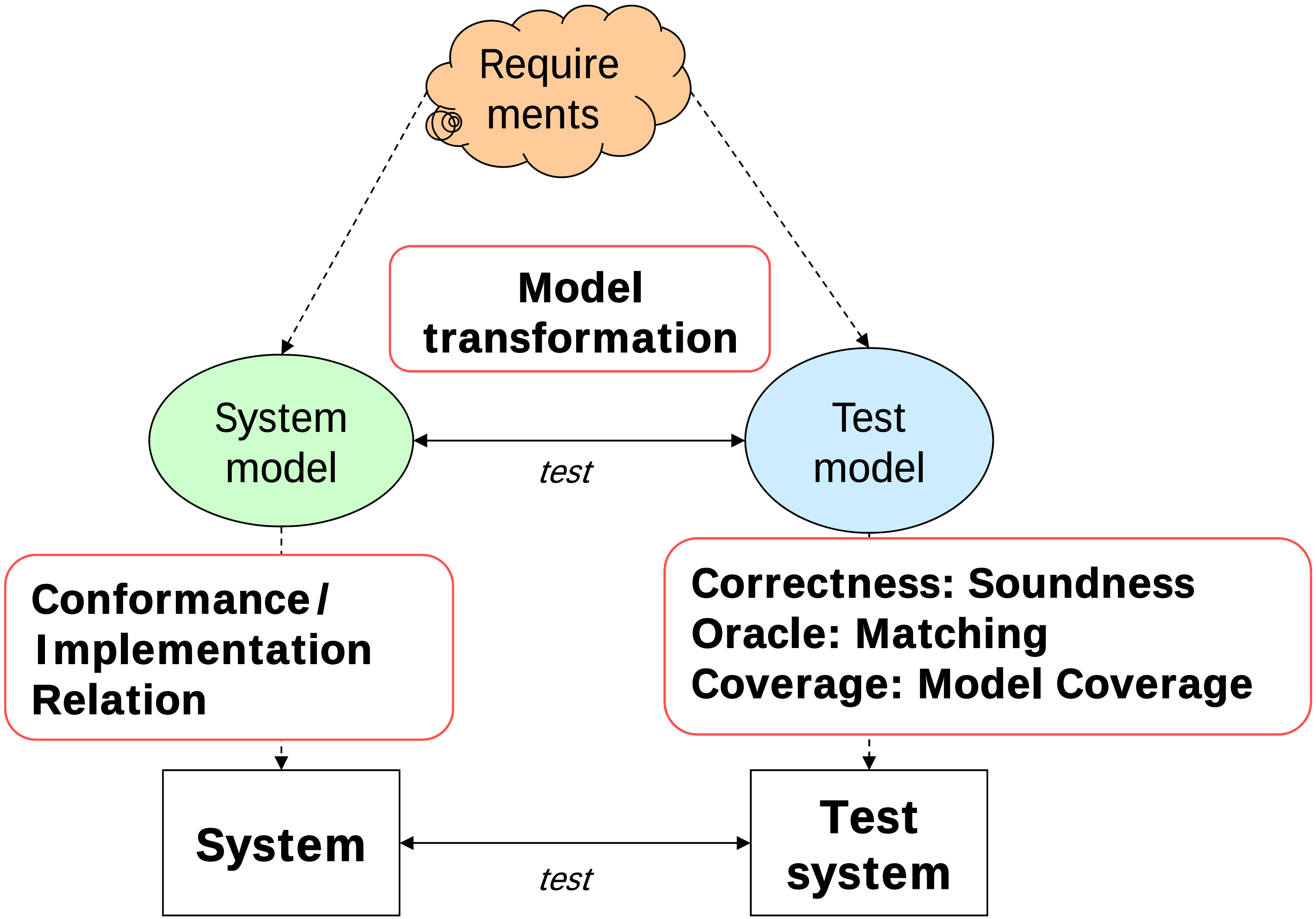
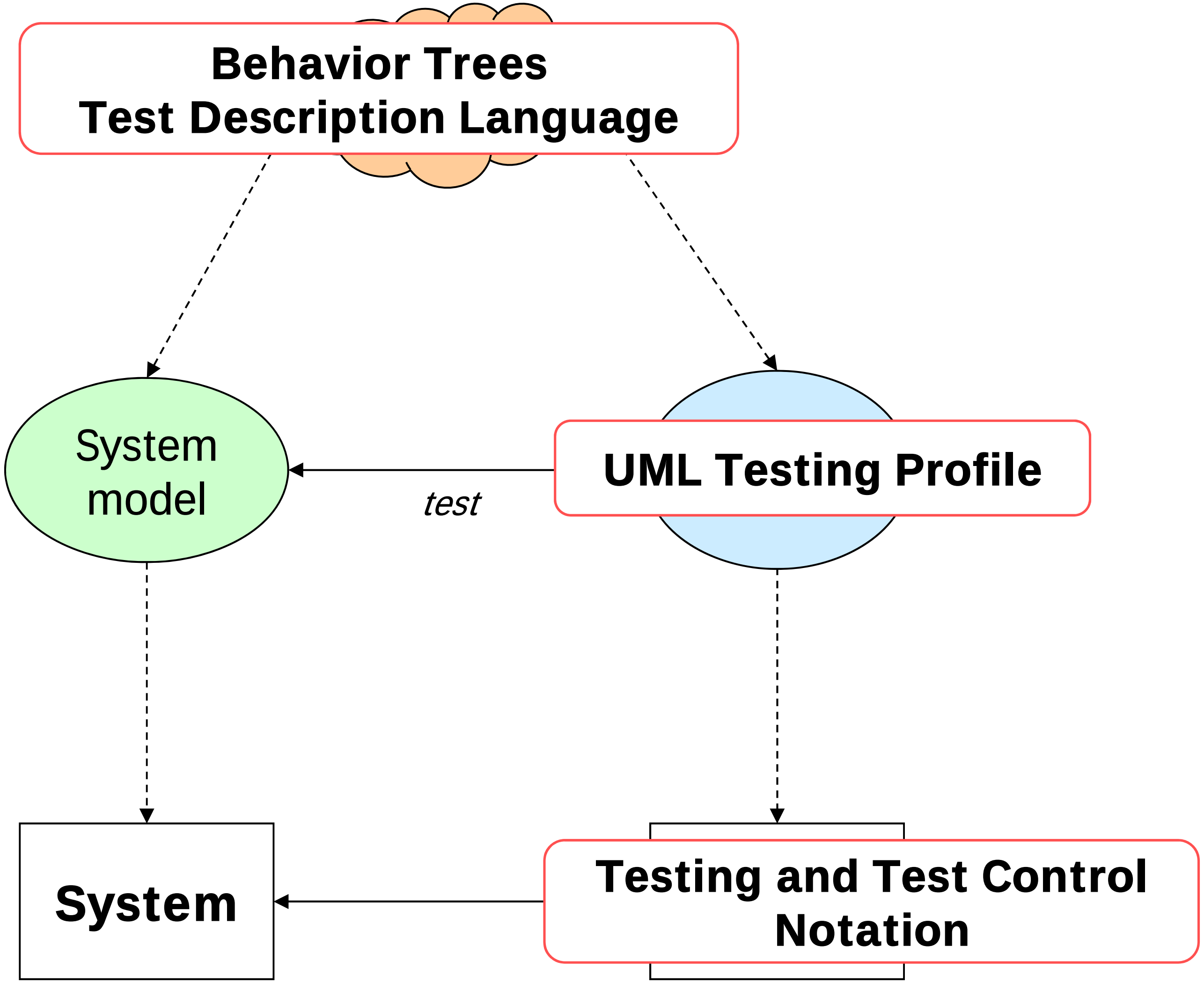
TESTING TECHNIQUES – MODEL-BASED TESTING 2.0



TESTING TECHNIQUES – MODEL-BASED TESTING 2.0



TESTING TECHNIQUES – TEST TECHNOLOGIES



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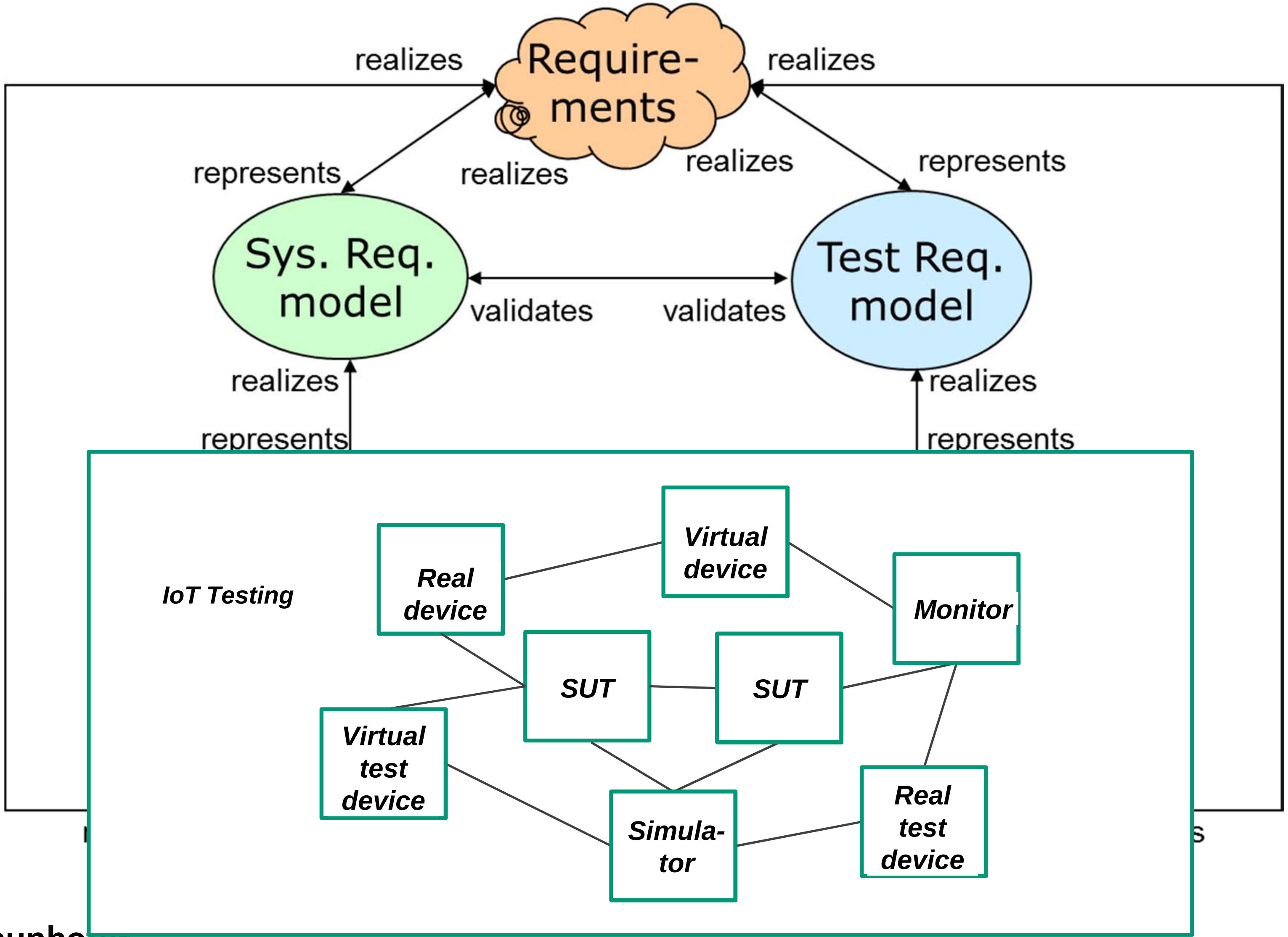
TESTING INTERNET OF THINGS SOLUTIONS



PROFESSIONAL TESTING

	Main modules	Supplementary modules
CTEL	EL-ITP EL-TM	
CTAL	AL-TM AL-TA AL-TTA	Security, Test Autom, **Industrial IoT ?!**, **Consumer IoT ?!**, **Public IoT ?!**
CTFL	Software Foundation **Embedded Systems Foundation ?!**	Agile, Auto motive, MBT, Usability, Mobile, **IoT ?!**

10 YEARS AGO: SELECTED PREDICTIONS – 2010

First time, someone is in jail due to bad quality software.

Prof. Dr. Jochen Ludewig, Uni Stuttgart

People deaths due to bad software will become normal to us.

Prof. Dr. Martin Glinz, Uni Zürich, Schweiz

10 YEARS AGO: SELECTED PREDICTIONS – 2020

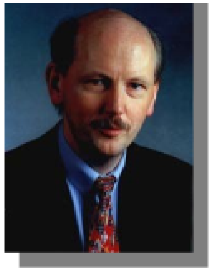
Up to 50% of people working in software engineering will have a real computer science education. We will have strict liabilities and strict assurance processes. We will use strong tools in automation.

Prof. Dr. Jochen Ludewig, Uni Stuttgart

There will be a worldwide accepted curriculum on software quality engineering.

Prof. Dr. Mario Winter, FH Köln

10 YEARS AGO: SELECTED PREDICTIONS – 2035



Software is that complex and critical that everyone is working on avoiding faults in first place and trying to seek the remaining ones.

Rudolf van Megen, SQS AG

There is only self-healing software. Allianz will be the market leader in software assurances.

Prof. Dr. Bernd Hindel, ASQF, method park Software AG

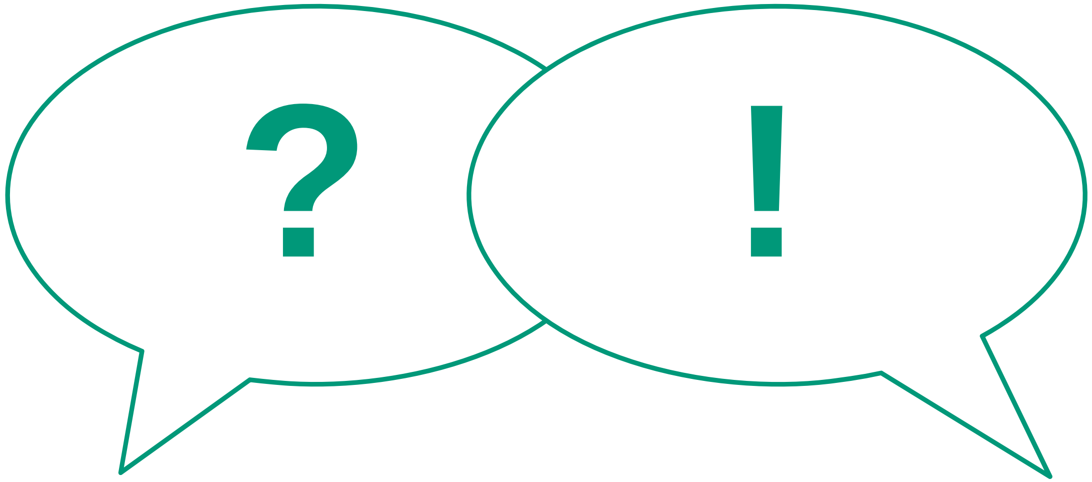
The Software TÜV will enforce quality standards and offer software certificates.

Prof. Dr. Ina Schieferdecker, Fraunhofer, Fokus

MY CONJECTURES

- Testing – both static and dynamic – continues to be the most important instrument in assuring quality of software-based critical systems as approaches like correctness by construction, security by design, etc. have their limits
- Testing needs to be extended into the production environment with models at runtime, online testing methods, and alike
- Along digitized networking, Industry 4.0, Smart Cities, etc., the SSTV (Software und System Test Verein) is more and more needed and hopefully established before 2035
- In future, software and test software may be merged into self-testing software, which can sanity check itself and check its environment

TERIMA KASIH KERANA MEMBERI PERHATIAN



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