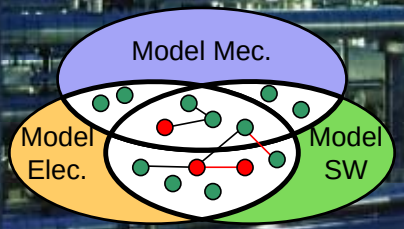
Process Automation and Quality Management in Multi-Disciplinary Engineering Environments

Stefan Biffl **Dietmar Winkler**
Christian Doppler Laboratory SE-Flex-AS
Institute of Software Technology and Interactive Systems (ISIS)
Vienna University of Technology
http://cdl.ifs.tuwien.ac.at



Motivation

Background

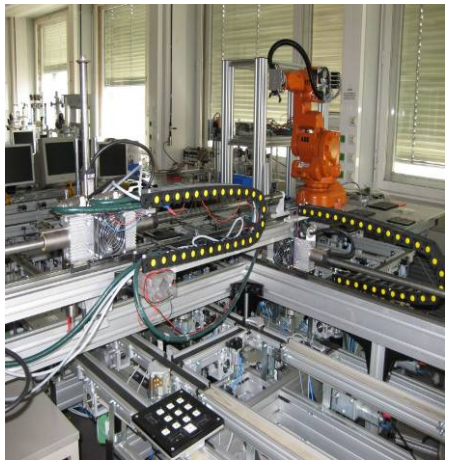
- Software+ Engineering Process Analysis and Improvement.

Challenges in Multi-Disciplinary Engineering Team Processes

- Change Management in concurrent engineering processes across disciplines.
- **Risk-based process analysis** as foundation for quality management and process automation
- **Measurement** required to assess project and product characteristics and initiate project and product improvement.
- **Comprehensive project and process** view across disciplines
- Standardization and benchmarking.

Engineering Process Automation & Quality Management

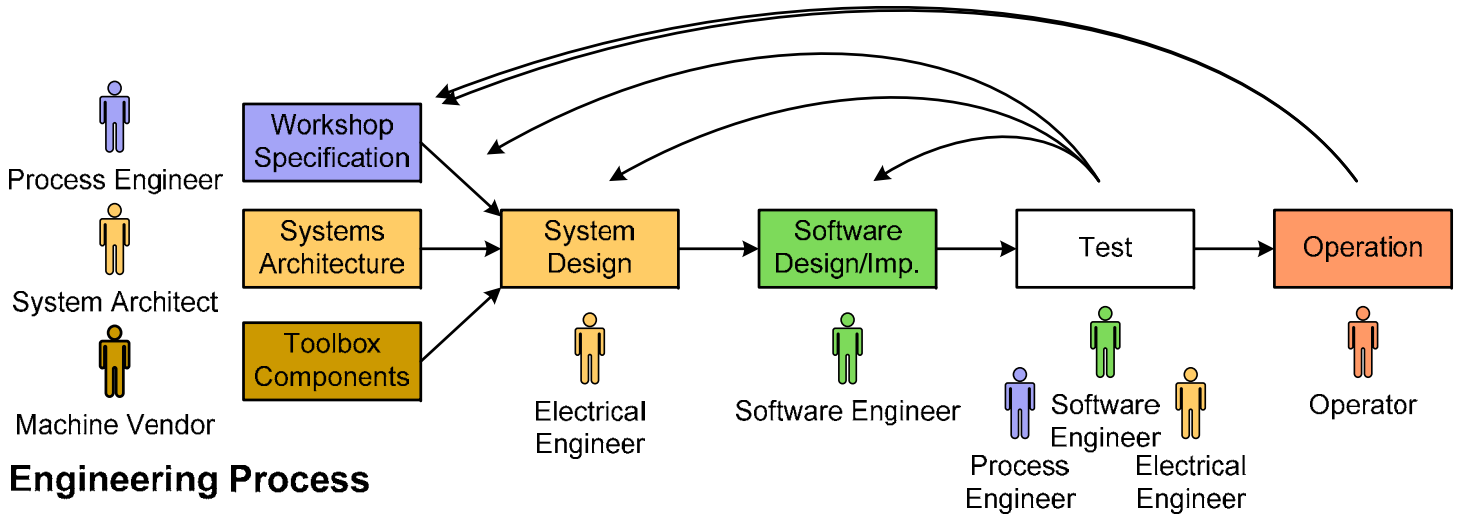
- Builds up on technical and semantic integration platforms.
- Supports process automation on **Engineering Team Level**.
- Supports quality measurement and analysis as foundation for (a) **engineering process improvement** and (b) **project monitoring and control**.



Scope of Research

Software Engineering Integration for Flexible Automation Systems





Basic research challenges

- Early defect detection across engineering discipline and tool boundaries.
- Engineering process analysis using design- and run-time data sources.

Research applications in the industry partners' domains

- Platform to build integrated tools for automation systems development & QA.
- SCADA systems with data analysis for monitoring automation systems.

State of the Art

Defect Detection and Quality Assurance in the Engineering Process

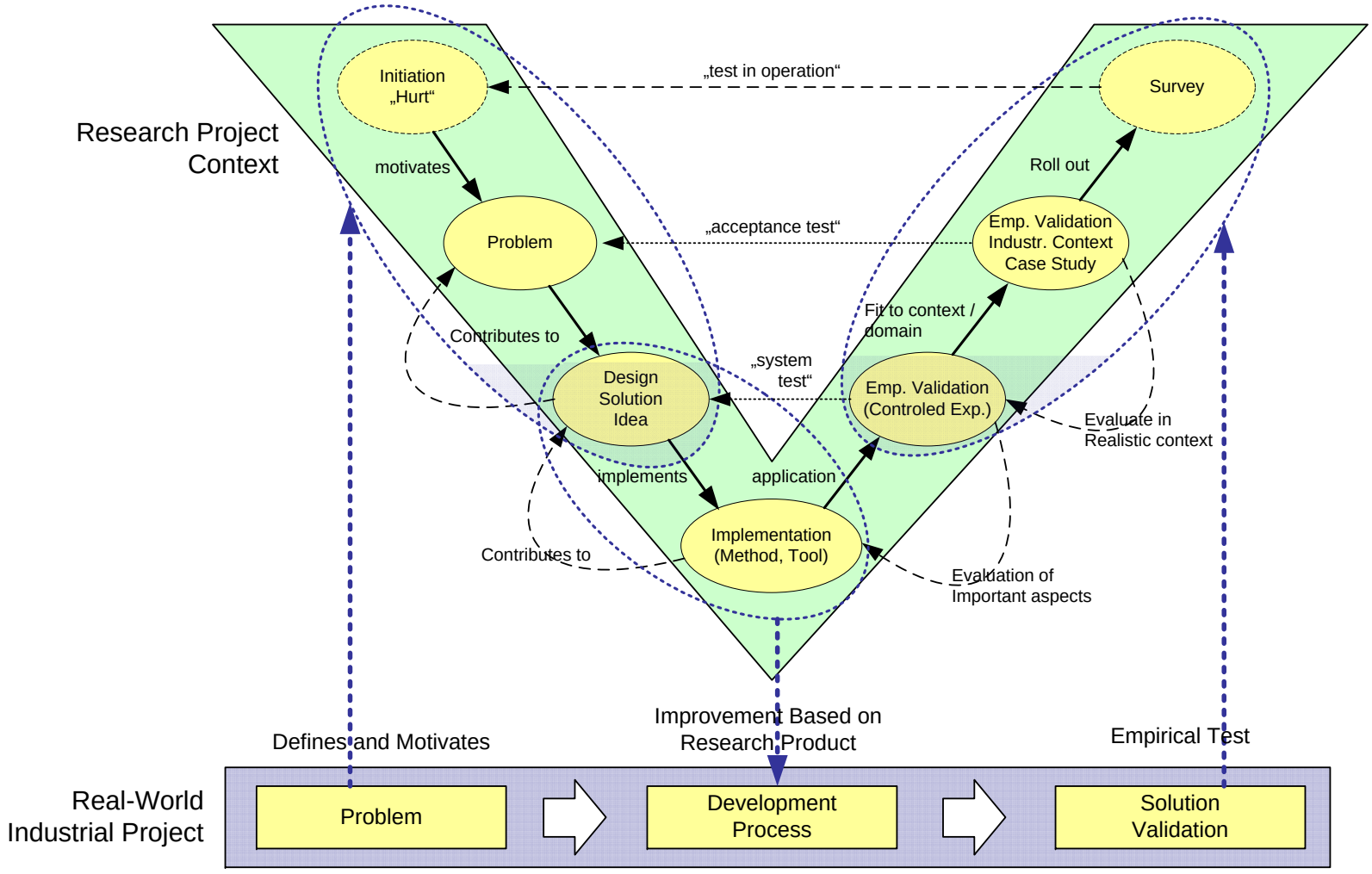
- Methods for defect detection in software engineering:
  Artifacts inspection, model checking, testing, test-first development.
- In automation systems engineering: focus on integration and acceptance testing
- Verification of system behavior, e.g., state charts.
- Automated test case generation, execution and reporting based on models.

Our previous work

- Software defect detection and prediction methods and models
- Value- and risk-based software test planning
- Test-first software development for automation systems
- Test management & simulation for production automation system
- Integrating constructive and analytical software engineering approaches, i.e., Pair programming and best-practice inspection
- Various empirical studies on software inspection, architecture evaluation, and agile development practices.

Research Methods

- V-Model of Empirical Research

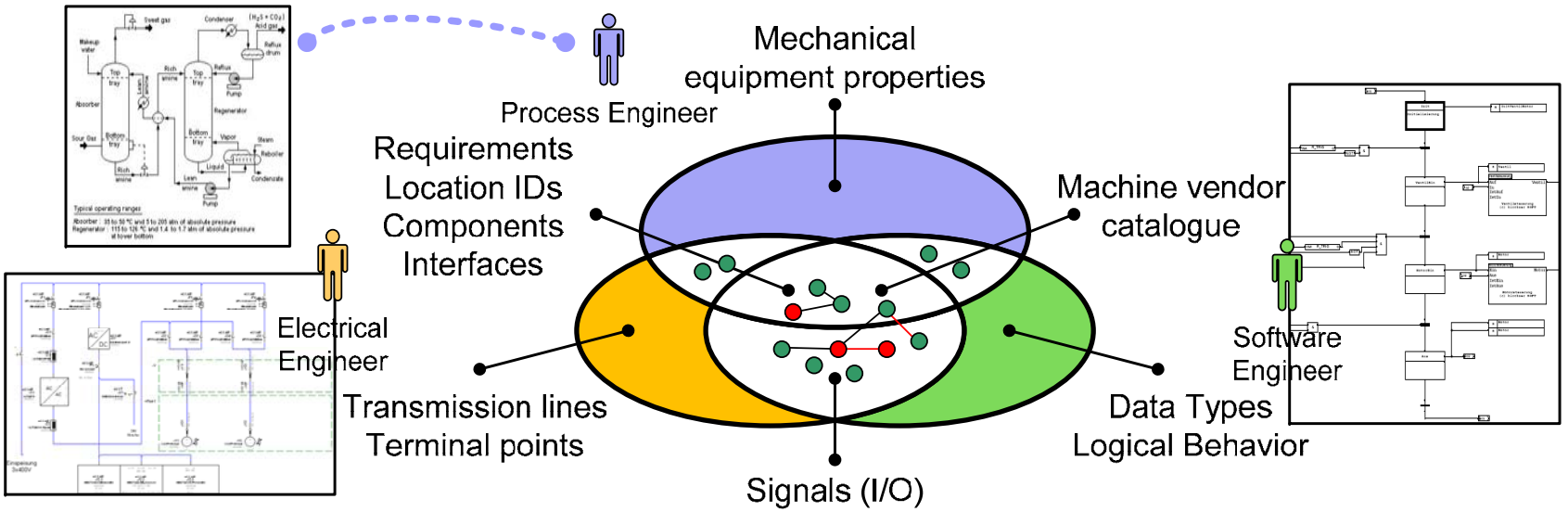


IESE; "V-Model of Empirical Research", In: Tutorial of Empirical Software Engineering, Fraunhofer IESE, Kaiserslautern, Germany, 2002.

Planned Research Work

Defect Detection in Engineering Models across Tools

Use of common concepts in models across engineering disciplines



Defect type examples

- Missing, wrong, inconsistent model elements or relationships
- Conflicts from changes of overlapping model elements
- Run-time violation of model constraints

Defect detection approaches

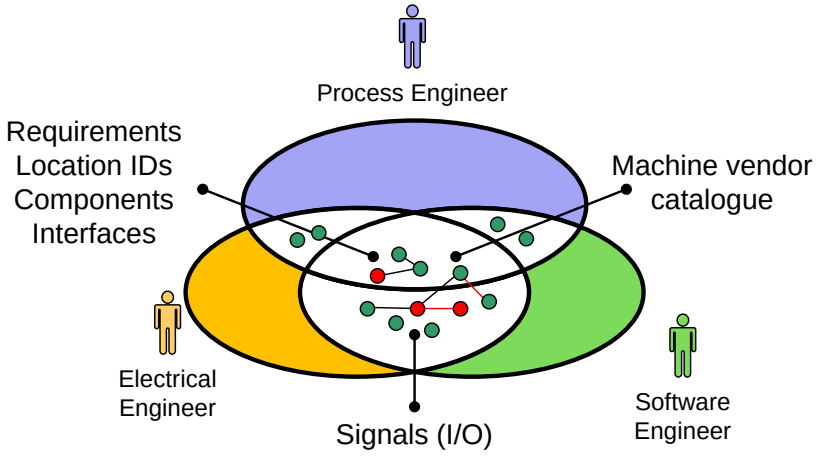
- Review of overlapping model parts
- Automated check of model assertions (syntactic and semantic)
- Change conflict detection and resolution
- Derivation of run-time assertions

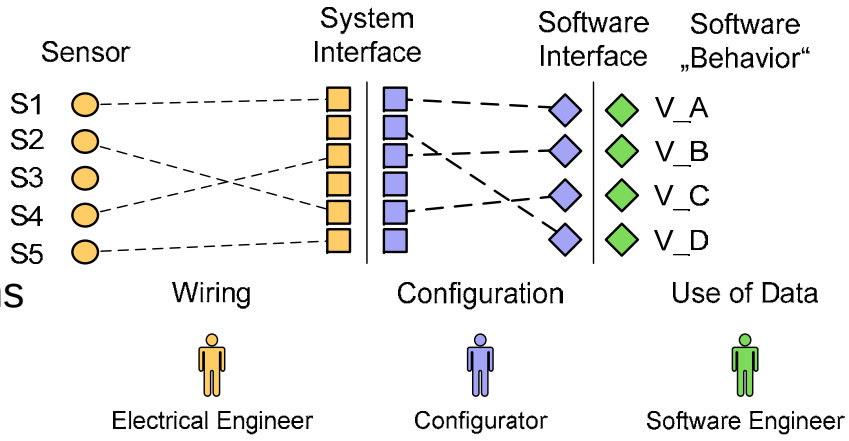
UC: End-to-End Quality Assurance

- Challenge: Defect Detection across engineering disciplines

- **Identification of various defect types:**
  - Missing, wrong, inconsistent model elements or relationships.
  - Conflicts from changes to overlapping model elements.
  - Run-time violation of model constraints.

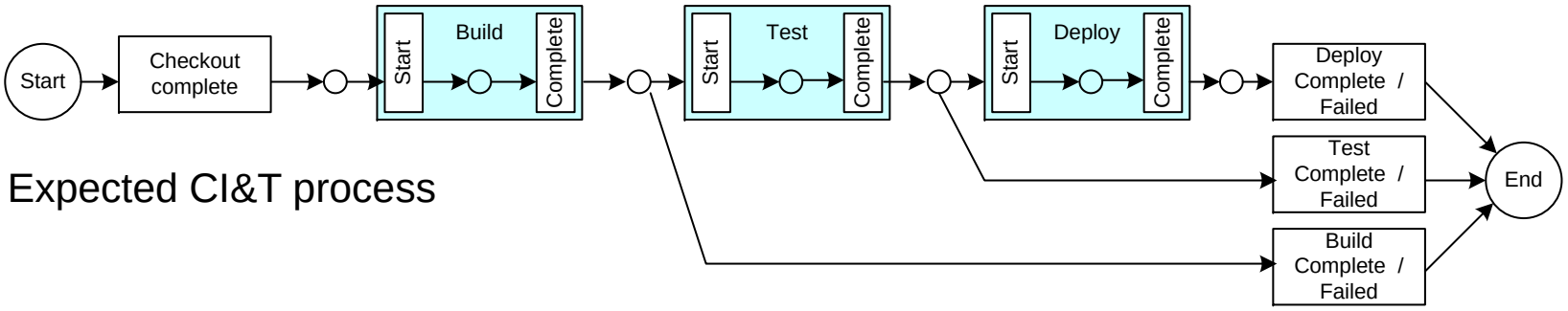
- **Quality Assurance approaches**
  - Review of overlapping model parts, e.g., with inspections.
  - Automated check of model assertions (syntactic and semantic).
  - Change conflict detection and resolution.





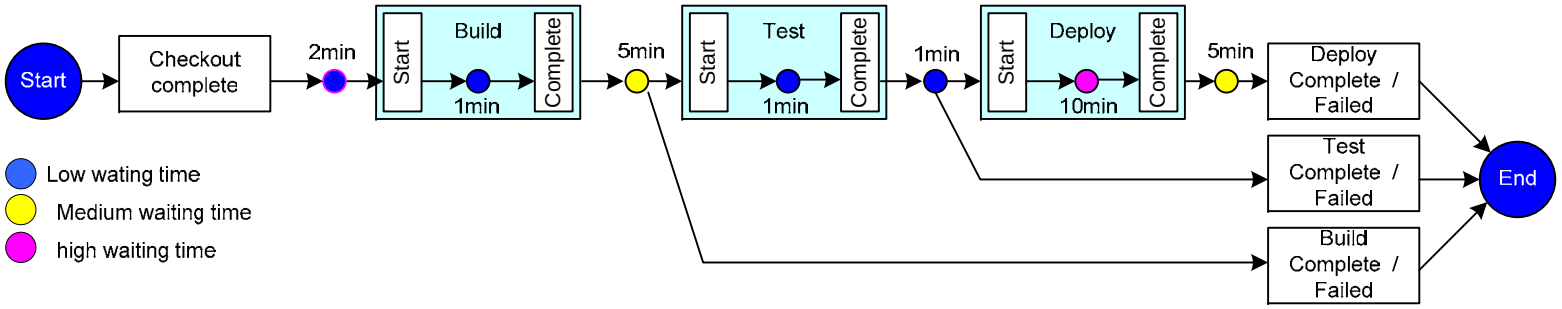
UC: Engineering Process Analysis (CI&T)

- **Process automation, analysis and assessment** based on (EngSB) event logs
  - Visualization of the expected engineering process.
  - Comparison of expected with traces of actual engineering processes.
  - Analysis of actual engineering process variants (frequency of paths taken).
  - Measurement of engineering process duration, waiting and execution times.
- Example: Continuous Integration and Test (CI&T).



Expected CI&T process

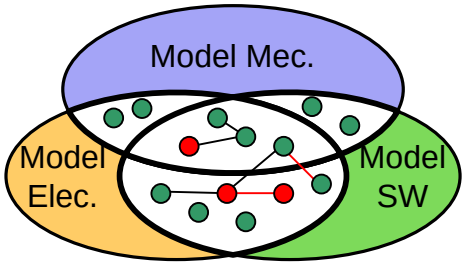
Process analysis based on sample engineering logs..



Planned Research

- **Process and project management in heterogeneous engineering environments**
  - Process automation and analysis based on event data and measurement.
  - Systems Testing for EngSB Applications
    - Support of OpenEngSB development
      (code coverage, unit- integration and systems test level)
    - Runtime-test coverage.

- **Quality Assurance and Quality Management**
  - Process, project and product improvement
  - Static and dynamic QA approaches,
    e.g., inspection and testing
  - Defect detection across disciplines



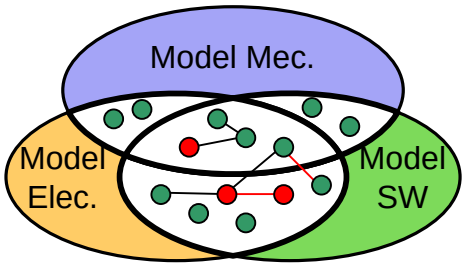
Summary

- Multi-disciplinary engineering projects are prone to risks from defects and delays due to technical gaps between tools and semantic gaps between data models.
- Technical and semantic integration provide the foundation for engineering process automation and quality management to lower these project risks.

- **The Engineering Service Bus (EngSB) environment provides:**
  - Technical Integration: Workflow-Rules and Events.
  - Semantic Integration: Data Models across disciplines.
  - Defect Detection & Process Automation: Engineering rules and process analysis.

- **End-to-End Quality Assurance examples:**
  - Difference analysis between signal versions
  - Defect detection in data models across tools and engineering disciplines

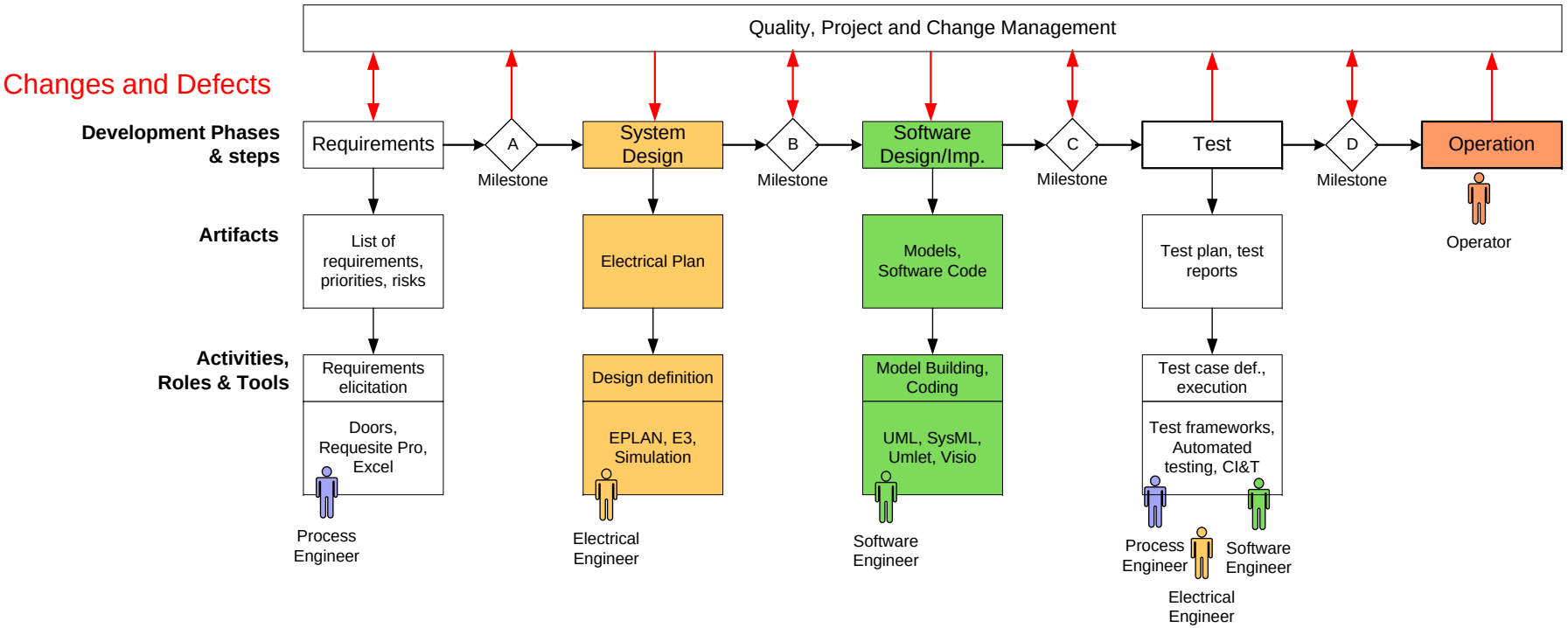
- **Process automation examples**
  - Change management with tickets and notification.
  - Continuous integration and test (CI&T)
  - Engineering process design and analysis.



Backup Slides

Product Development Processes on Team Level

- Process approaches have been proven in Business IT Software development, e.g., V-Modell XT, RUP, Scrum.
- Challenges for Systems Engineering Processes
  - Various disciplines, e.g., mechanical, electrical, and software engineering.
  - Heterogeneous software tools for individual engineering disciplines.
  - Wide range of stakeholder roles in multi-disciplinary engineering teams.
  - Focus on risks in overlaps between engineering disciplines (common concepts).



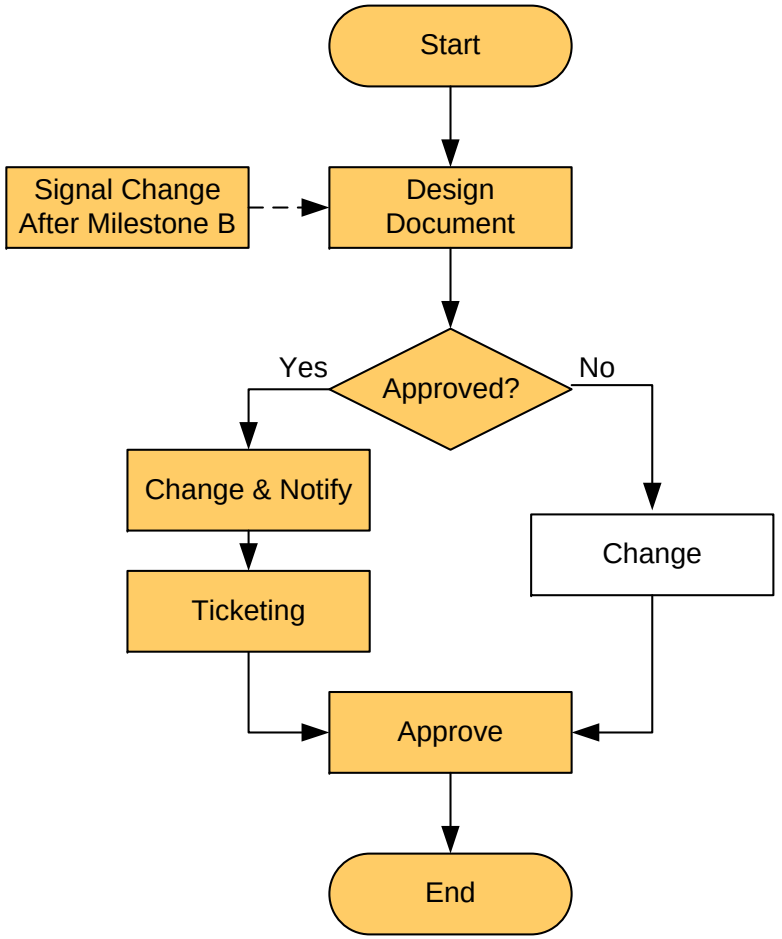
UC: Change Management for Signal Engineering

- Basic workflow for Change Management (research prototype at Andritz Hydro).
- Works with EPlan, OPM, and customer-specific signal lists.

Example:

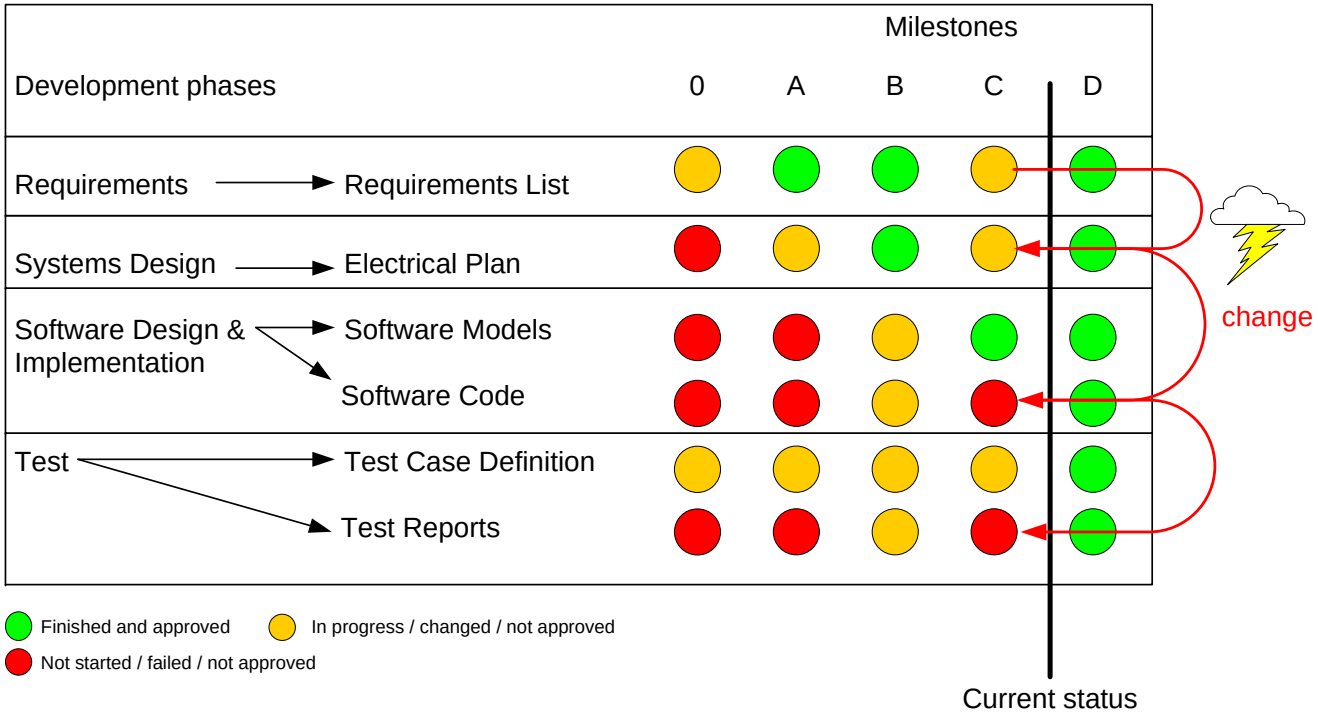
- Change management has to address signal changes with overlapping attributes between tools from several engineering disciplines.

- Electrical engineer needs to change a signal (after Milestone B = status approved)
- Change reason: sensors of alternative types require modified signal attributes:
  - Changes are driven by engineering rules.
  - Ticketing and notification in engineering team if process automation is incomplete.



UC: Engineering Process Monitoring and Analysis

- Project monitoring, analysis, and improvement based on quantitative data.
- Process-driven approach enables traceability, repeatability, measurement, and improvement of processes and products.
- Engineering process status reporting:
  - Identification and inspection of all deliverables at a defined milestone for approval.
  - Traceability of project progress.
  - Quantitative data, e.g., sequence of steps for process assessment, duration, and number of iterations.



Dipl.-Ing. Dietmar Winkler

- Institute of Software Technology and Interactive Systems
  - E-Mail: dietmar.winkler@tuwien.ac.at
  - Web: http://qse.ifs.tuwien.ac.at/~winkler
- Research Interests and Application Areas
  - Software Engineering and Project Management
  - Software Product and Process Improvement
  - Software Quality Assurance and Quality Management
  - Empirical Software Engineering
  - Software Processes
  - Scenario-based Software Architecture Evaluation
- Selected Past & Present Cooperations:
  - Continental Automotive Switzerland AG (Quality Management Consulting)
  - Austrian Computer Society (OCG Arbeitsgruppe “Software Prozesse”)
  - Bundesrechenzentrum GmbH (Quality Assurance and Knowledge Management)
  - Continental Automotive Switzerland AG (Process and QM Consulting)
  - Czech Technical University (SE and QA Consulting)
  - Fraunhofer Institute for Experimental SE (Strategic Quality Planning)

Selected Projects and Publications (1/3)

General Software Engineering

- Schatten A., Biffl S., Demolsky M., Gostischa-Franta E., Östreicher T., Winkler D.: „Best-Practice Software-Engineering“, Spektrum Akademischer Verlag, 1. Auflage, March 2010.
- Biffl S., Winkler D., Höhn R., Wetzel H.: "Software Process Improvement in Europe: Potential of the new V-Model XT and Research Issues", SPIP Journal, 2006.

Complex and heterogeneous systems

- Biffl S., Moser T., Winkler D.: “Risk assessment in multi-disciplinary (Software+) Engineering Projects, Submitted to IJSEKE 2010.
- Moser T., Biffl S., Sunindyo W.D., Winkler D.: “Integrating Production Automation Expert Knowledge Across Engineering Stakeholder Domains”, CISIS, 2010.
- Moser T., Biffl S., Winkler D.: “Process-Driven Feature Modelling for Variability Management of Technical Project Environment Configurations”, Submitted to Profes 2010.
- Winkler D., Matousek K., Kubalik, J., Biffl S.: “Software Engineering Practices in Multi-Agent Software Development based on the V-Modell XT”, TU Prague, TechReport 2007.

Test-Driven Automation

- Hametner R., Winkler D., Östreicher T., Biffl S.: “The Adapation of Test-Driven Software Processes to Industrial Automation Engineering”, Submitted to INDIN 2010.
- Winkler D., Hametner R., Biffl S.: „Automation Component Aspects for Efficient Unit Testing“, ETFA, 2009.
- Winkler D., Biffl S., Östreicher T.: „Test-Driven Automation – Adopting Test-First Development to Improve Automation Systems Engineering Processes“, EuroSPI 2009.

Selected Projects and Publications (2/3)

Quality Assurance

- Winkler D., Elberzhager F., Biffl S., Eschbach R.: „Software Process Improvement Initiatives based on Quality Assurance Strategies: A QATAM pilot application“, Submitted to EuroSPI 2010
- Winkler D.: “Improvement of Defect Detection with Software Inspection Variants”, VDM Verlag, ISBN: 978-3-8364-7013-1, 2008.
- Winkler D., Elberzhager F., Eschbach R., Biffl S.: “QATAM – A Method to Assess Quality Assurance Strategies”, IESE-Report No 092.08/E. 2008.
- Biffl S., Denger C., Elberzberger F., Winkler D.: „A Quality Assurance Strategy Tradeoff Analysis Method”, Euromicro SEAA, Work in Progress, Lübeck, Germany, 2007.

Architecture Evaluation

- Winkler D., Ali Babar M., Biffl S., Ilic B.: „Optimizing the Scenario Elicitation Process in Scenario-based software architecture evaluations“, Submitted to ESEM 2010.
- Winkler D., Biffl S., Seemann C.: “A Controlled Experiment on Team Meeting Style in Software Architecture Evaluation”, EASE 2010. (upcoming).
- Biffl S., Ali Babar M., Winkler D..: “Impact of Experience and Team Size on the Quality of Scenarios for Architecture Evaluation”, EASE 2008 (Selected as Best Paper).
- Winkler D., Biffl S., Ali Babar M.: “An Empirical Investigation of Scenarios Gained and Lost in Architecture Evaluation Meetings”, ESEM, 2008.
- Ali Babar M., Winkler D., Biffl S.: „Evaluating the Usefulness and Ease of Use of a Groupware Tool fort the Software Architecture Evaluation Process”, ESEM 2007.

Selected Projects and Publications (3/3)

Agile Software Development and Quality Assurance

- Winkler D., Biffl S., Faderl K.: “Investigating the Temporal Behavior of Defect Detection in Software Inspection and Inspection Based Testing”, submitted to PROFES 2010.
- Winkler D., Biffl S., Kaltenbach A.: “Evaluating Tools that Support Pair Programming in a Distributed Engineering Environment”, Conference on Evaluation and Assessment in Software Engineering (EASE), Keele, Great Britain, 12.-13.04.2010. (upcoming).
- Winkler D., Biffl S.: "An Empirical Study on Design Quality Improvement from Best-Practice Inspection and Pair Programming", 7th Int. Conf. on Product Focused Software Process Improvement (Profes), Amsterdam, Netherlands, 2006.
- Winkler D.: "Integration of Analytical Quality Assurance Methods into Agile Software Construction Practice: Research Proposal for a Family of Controlled Experiments", 1st Int. Doctoral Symp. on Empirical Software Engineering, IDoESE, Rio de Janairo, Brazil, 2006
- Winkler D., Varvaroi R., Goluch G., Biffl S.: "An Empirical Study On Integrating Analytical Quality Assurance Into Pair Programming", ISESE, Rio de Janairo, Brazil, 2006.
- Winkler D., Riedl B., Biffl S.: "Improvement of Design Inspections with Inspection and Testing", Proceeding 31st IEEE Euromicro Conference, Porto, Portugal, September 2005.
- Biffl S., Winkler D., Thelin T., Höst M., Russo B., Succi G.: "Investigating the Effect of V&V and Modern Construction Techniques on Improving Software Quality", Poster Proc. of ACM/IEEE Int. Symp. on Empirical Software Engineering (ISESE), Los Angeles, 2004