

Proposal for PLCopen Working Group

# Metrics for Quality Assessment of PLC Software in Machine and Plant Manufacturing

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High control software quality that can optimally meet the challenges of complex, long-living, and evolving machines and plants has since long been one of the key enablers on the road to Industry 4.0. Software metrics are a proven means in computer science to objectively assess software quality. Recently, numerous approaches have emerged in research to transfer established metrics for PLC software in automated manufacturing systems, which are partly also implemented by PLC platform suppliers to enable an automated quality assessment. However, up to now, these approaches have barely made their way into industrial development practice in machine and plant manufacturing.

Therefore, this working group aims to develop **guidelines** on how a **metric-based quality assessment of PLC software** can be integrated into the daily industrial routine for different stakeholders in the **software engineering workflow in machine and plant engineering**. Existing approaches from research and tool support from platform suppliers will be used and enlarged to be applicable for various use cases and company-specific boundary conditions – with little effort in daily practice and at the same time greatest possible benefit.

We expect the guidelines to provide the **following benefits** for PLCopen members and their customers:

- Enable **customers of PLCopen members** to use available code analysis solutions **in daily practice**
- Increase of the satisfaction of customers of PLCopen members by an intuitive, **low-effort integration** of metrics-based code analysis into company-specific software engineering workflows for gut-level support
- **Increase of the target group** of available metrics and code analysis approaches provided by PLCopen members through workflow integration and use of the results for different stakeholders
- Support customers in **saving time** during development by systematic identification of **target conflicts** between software quality characteristics in early design phases

#### References:

- 1) B. Vogel-Heuser, E. Neumann and J. Fischer. "MICOSE4aPS: Industrially Applicable Maturity Metric to Improve Systematic Reuse of Control Software," *ACM Transactions on Software Engineering and Methodology (TOSEM)*, vol. 31, no. 1, pp. 1-24, Jan. 2022.
- 2) E. Neumann, B. Vogel-Heuser, M. Gnadlinger, J. Fischer, L. Reimoser, S. Diehm, T. Englert and M. Schwarz. "Metric-based Identification of Target Conflicts in the Development of Industrial Automation Software Libraries ," in *IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, IEEE, Dec. 2022. [submitted]
- 3) J. Fischer, B. Vogel-Heuser, H. Schneider, N. Langer, M. Felger and M. Bengel. "Measuring the Overall Complexity of Graphical and Textual IEC 61131-3 Control Software," *Robotics and Automation Letters*, vol. 6, no. 3, pp. 5784-5791, May. 2021.
- 4) B. Vogel-Heuser, J. Reif, J. Passoth, C. Huber, F. Brodbeck, S. Maasen, U. Lindemann and D. Hujo. "BPMN++ to Support Managing Organizational, Multiteam and Systems Engineering Aspects in Cyber Physical Production Systems Design and Operation," *Design Science*, vol. 8, no. 8, pp. 1-30, Jan. 2022.

**Motivation:** Platform suppliers offer **comprehensive tool support** to measure code quality, but **barely used by customers in daily practice**

**Goal:** Guidelines to **support customers of PLCopen members** to optimally integrate existing metrics for code quality into the software engineering workflow to achieve the **greatest possible benefit with little effort**

Time scope: 6 months

### Phase I: Preparation with platform suppliers

- Expected result: Overview of what is **already enabled by industrial tools** and can be used as **input for the guidelines**
- Participants: **Industrial platform suppliers** (ABB, Beckhoff, CODESYS, Phoenix Contact, Schneider Electric, Siemens, ...)

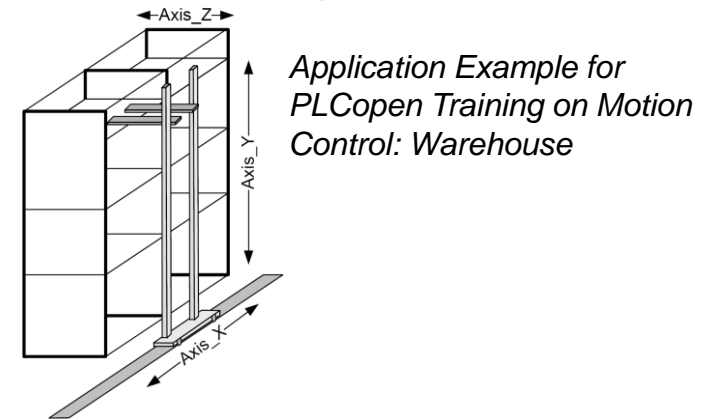
### Phase II: Guideline development with supplier feedback

- Expected result: Guidelines on how to use **available metrics** in the industrial **software development workflow** for concrete use cases (implemented as small example projects)
- Participants: Industrial platform suppliers

### Optional: Feedback on the of guidelines from practitioners

- Participants: **Industrial practitioners from machine and plant manufacturing**

### One coherent application example to explain the guidelines



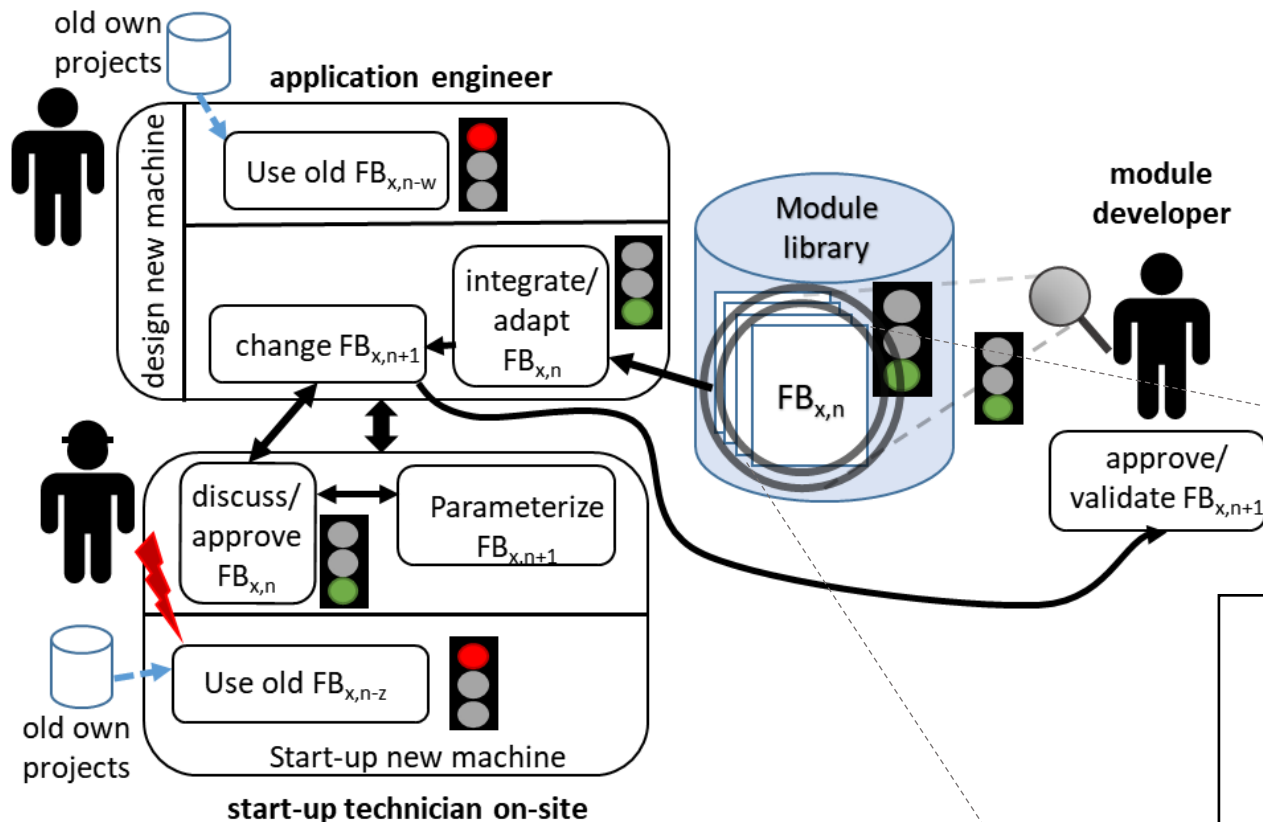
- Aspects included in the guidelines (to be discussed):**
- Workflow for quality assessment
  - Selection of metrics and reference values
  - Interfaces to existing tools
  - Reporting format
- 

Benefits for PLCopen Members:

- **Increasing customer satisfaction** by maximizing the applicability of existing solutions of PLCopen members
- **Increase the target group** of existing solutions through **workflow integration** and use of the results for **different stakeholders**

- Initiator: TUM, Chair AIS
- Start: **October 1<sup>st</sup>, 2022**
- **Bi-weekly meetings** of the contributors to the guideline
- Request **feedback** from platform suppliers and practitioners on the interim status and finalized guidelines

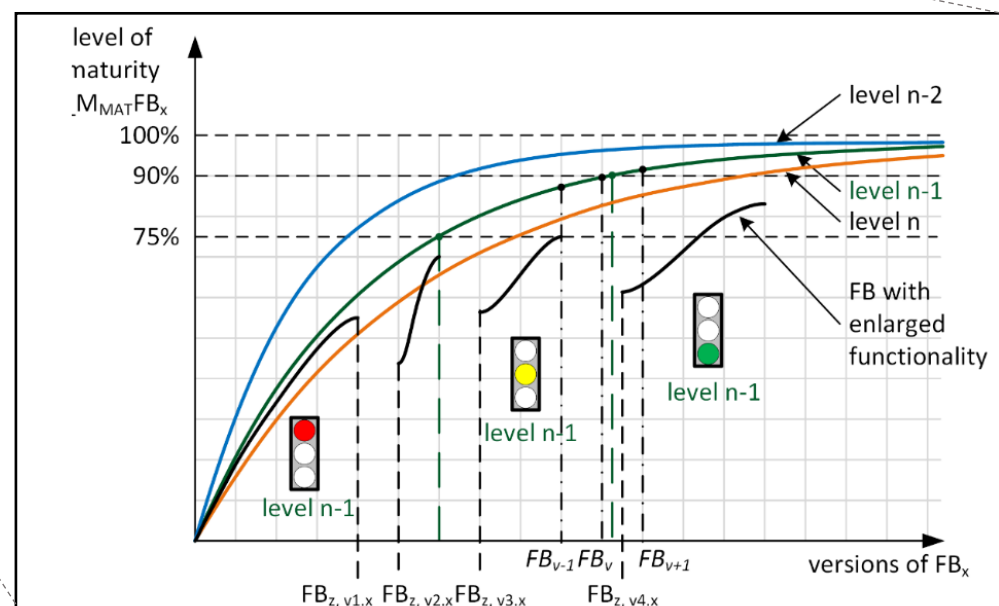
## Maturity measurement of evolving library elements and modules



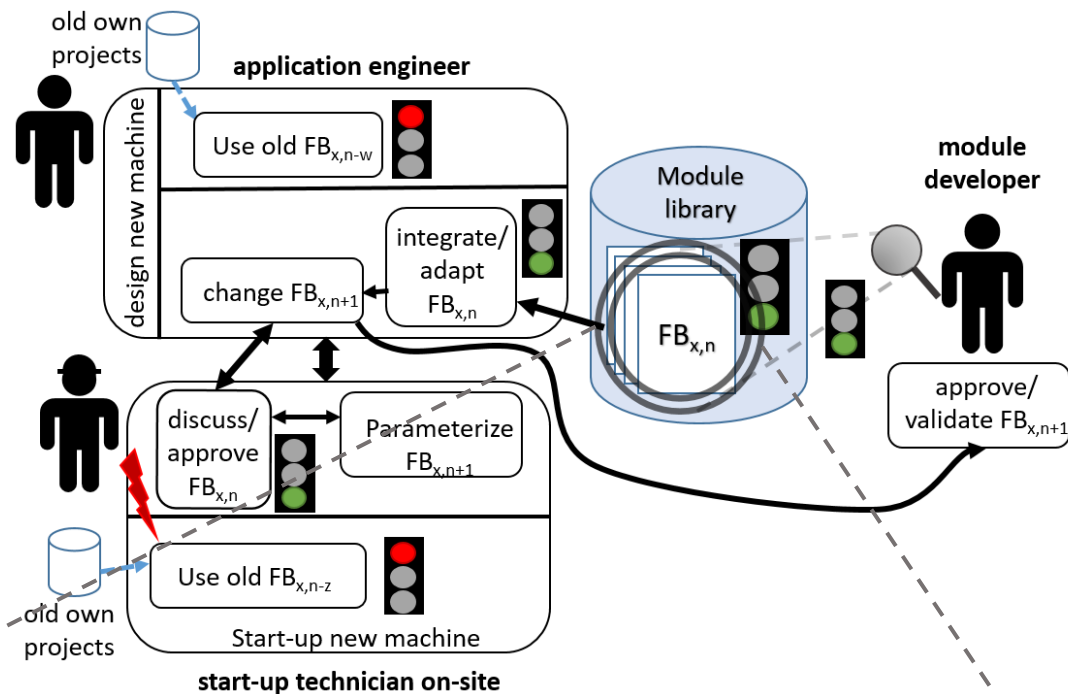
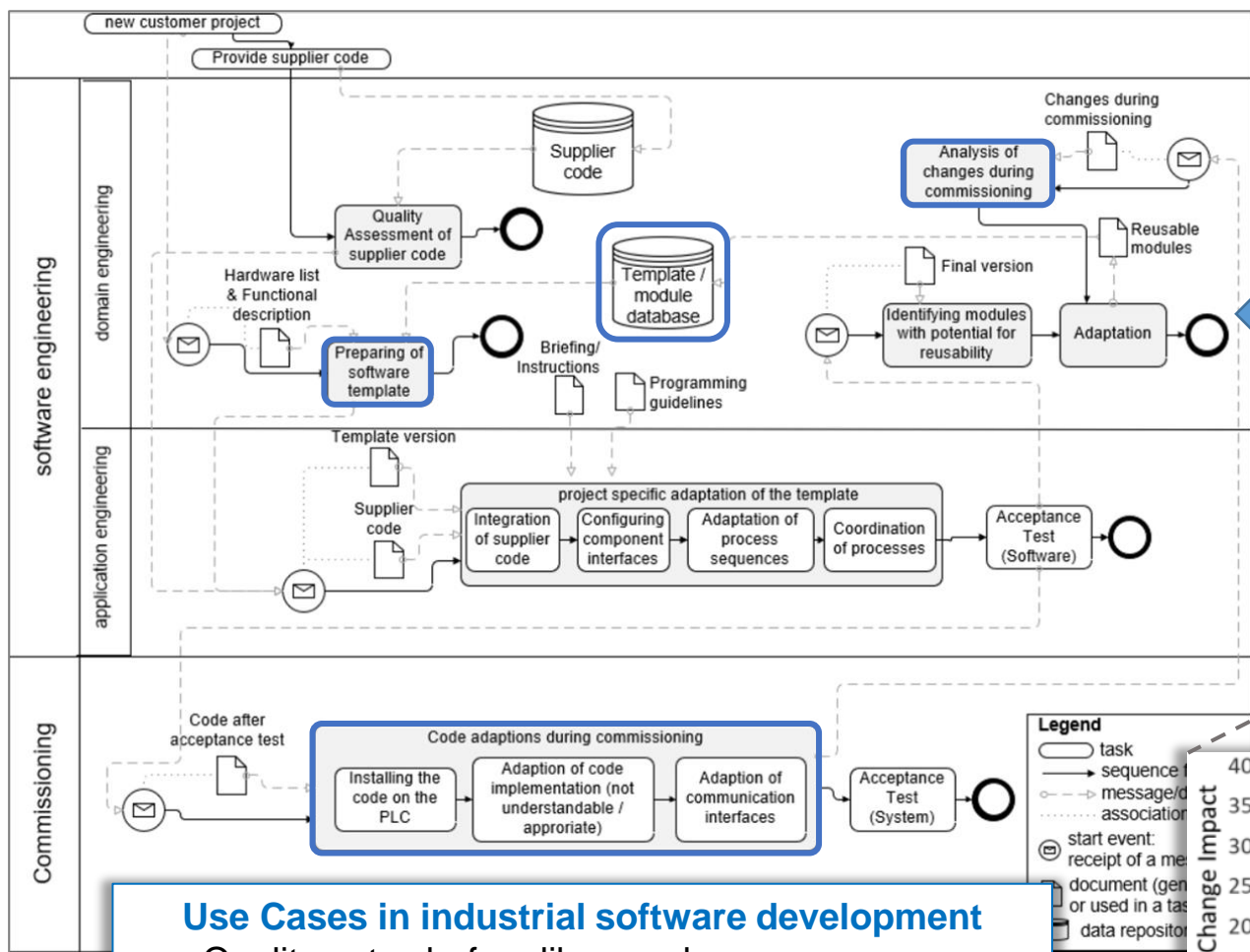
**Challenge:** Application engineers and start-up technicians often hesitate to **reuse mature modules from the library** and rely on their **own old projects**

Source: Vogel-Heuser et al. "Key maturity indicators for module libraries for PLC-based control software in the domain of automated Production Systems," in *INCOM*, 2018.

**Solution:** **Change-based metric** to calculate the maturity of control software library modules  
 → **Objective maturity indicator to supplement the „gut feeling“ of software developers**

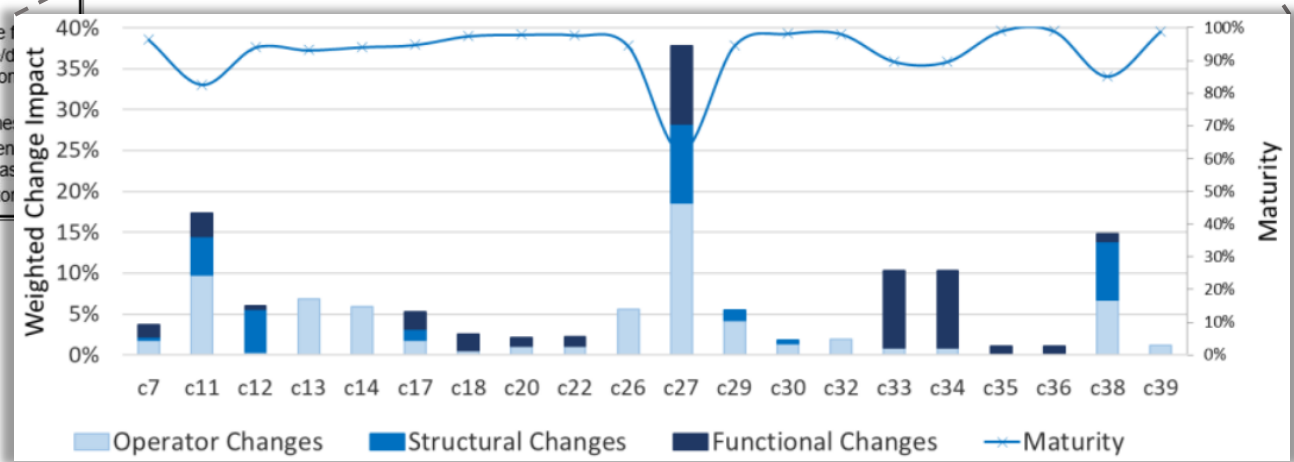


## Integration of maturity measurement into industrial software development workflow



**Use Cases in industrial software development**

- Quality gates before library release
- Quality monitoring of library POU's across versions
- Evaluation of change scope before unit testing to estimate testing efforts



Vogel-Heuser et al. "MICOSE4aPS: Industrially Applicable Maturity Metric to Improve Systematic Reuse of Control Software," *TOSEM*, vol. 31, no. 1, 2022.