Interdisciplinary Systems Development Projects: Change Management across Disciplines and Tools

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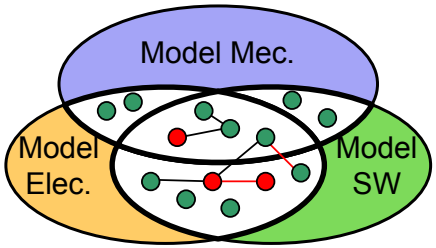
Context and Motivation

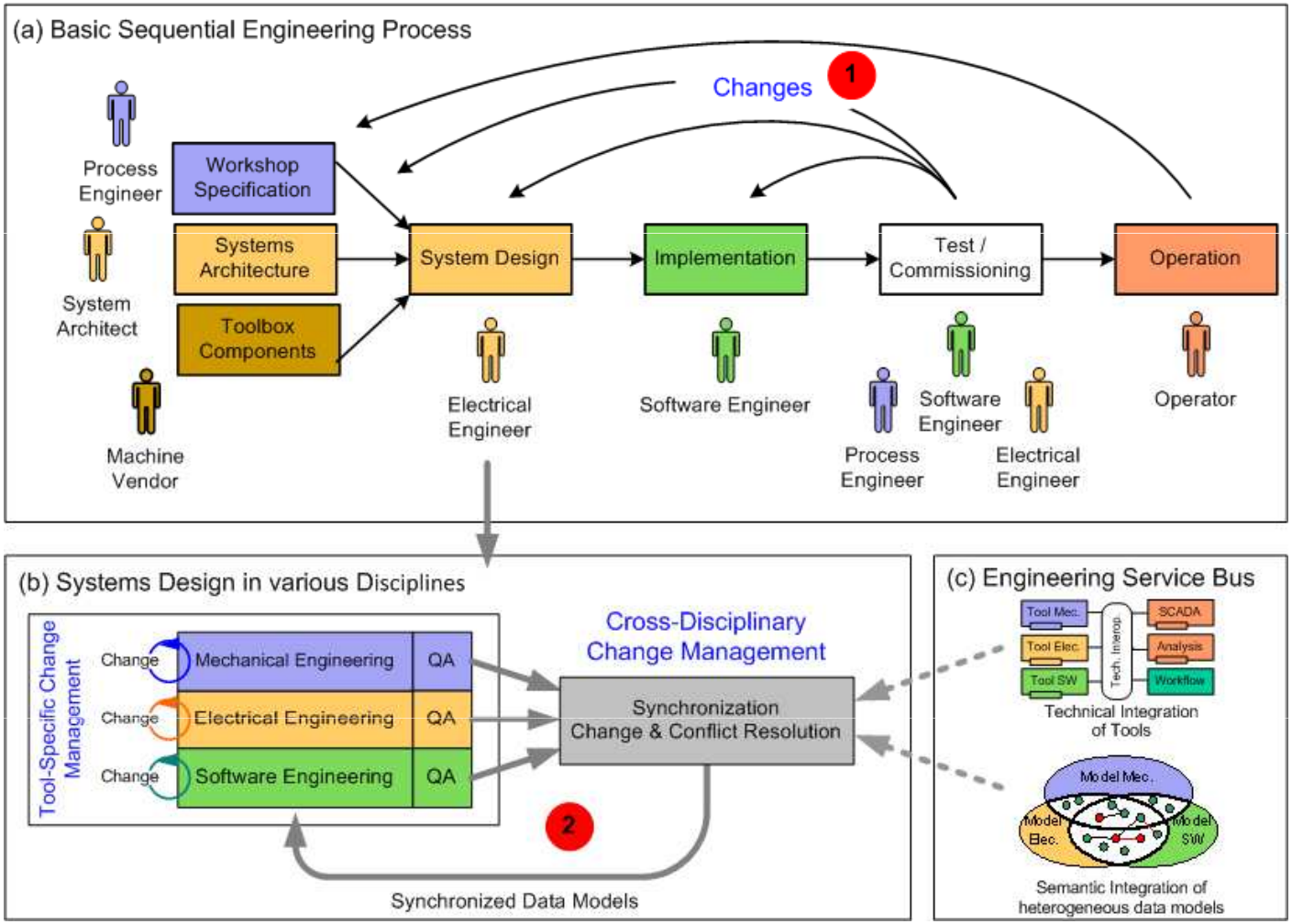
- Automation systems engineering projects
  - Contributions from several engineering disciplines.
  - Distributed development projects.
  - Complex artifacts like mechanical, electrical, and software components and plans, which get updated concurrently.



- Change and Version Management
  - Available for each individual engineering discipline.
  - Very little work on change and management across semantically heterogeneous data models in engineering tools and projects.

- Challenge
  - Efficient change management activities embedded within an engineering process across disciplines, data models, and tools.

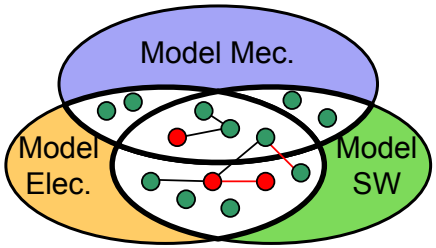
Engineering Object Change Management



- Concurrently changes in distributed environments require efficient change management approaches (1).
- Efficient synchronization mechanisms (2) enable cross-disciplinary change management based the Engineering Service Bus Platform.

Agenda

- **Efficient change management process** across disciplines, data models, and tools:
  - Identification of common concepts in individual disciplines to link domain-specific data models.
  - Establishing a virtual common data model for efficient and effective data exchange approaches.
  - Establishing a change management process approach across disciplines and tool borders.



- **Prototype implementation**
  - Feasibility study of the integrated change management approach at a hydro power plant systems integrator.
  - Measurement of processes for verification and validation.

- **Added value component**
  - Engineering cockpit for project monitoring and control.

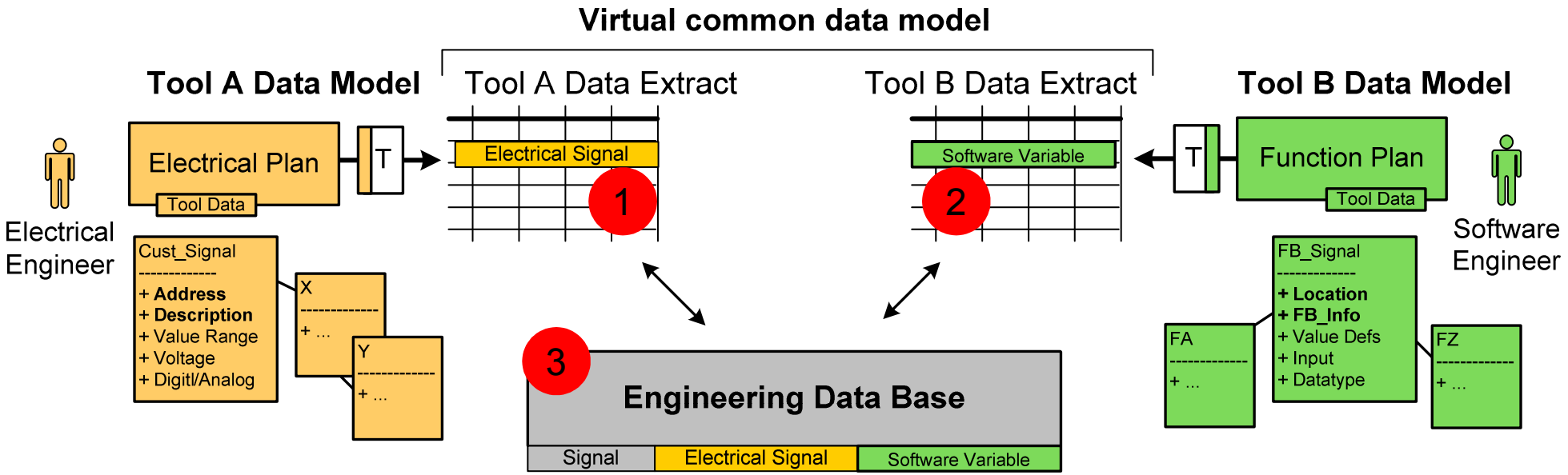
Common Concepts:
Signals & Signal Engineering

Foundation

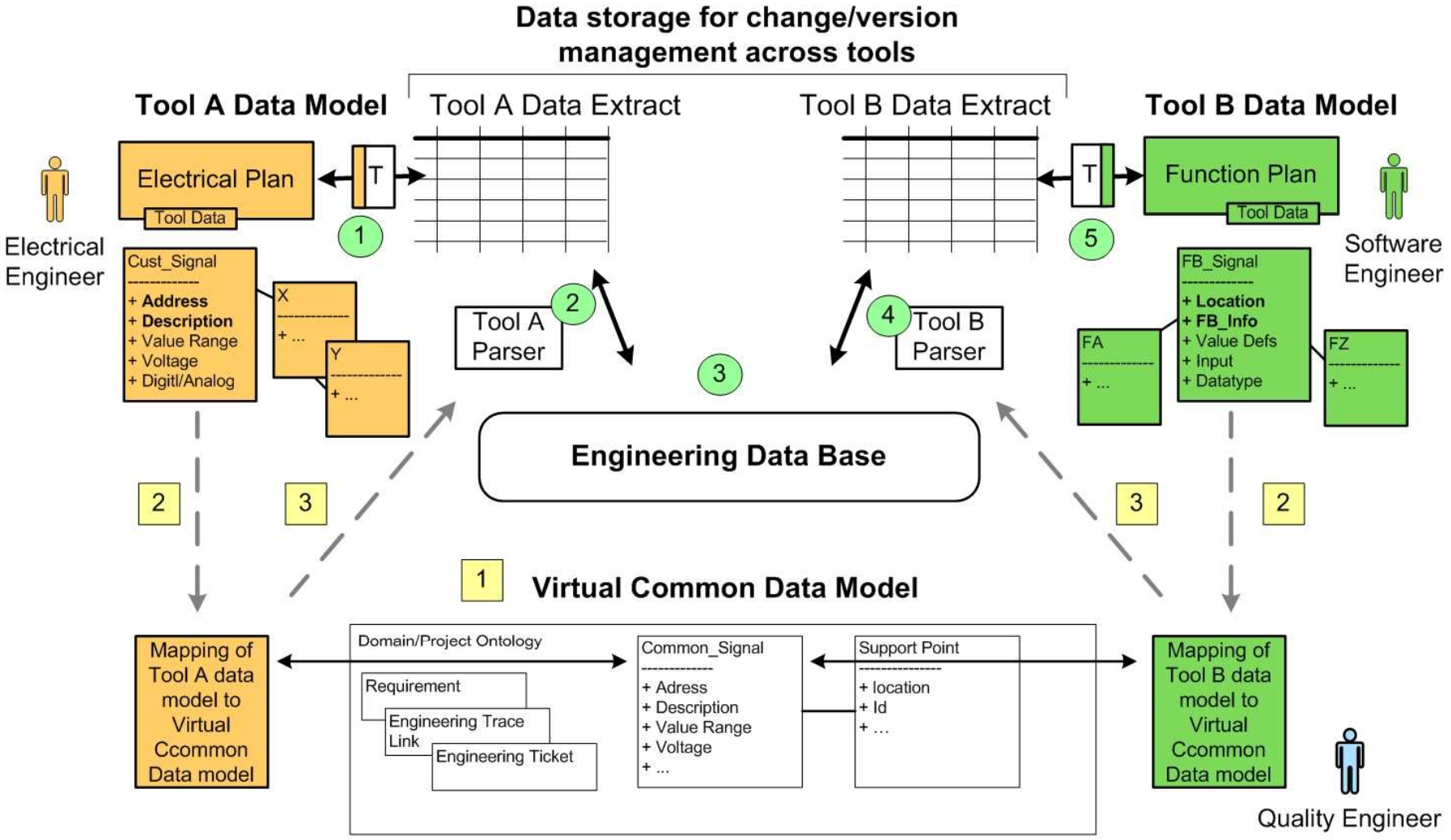
- The signal is a common concept for linking information between disciplines (e.g., mechanical interface, electrical signal (wiring), software I/O variable).

Challenges & Goals

- Consistent signal handling (e.g., up to 40,000 signals in power plants).
- Integration of signals from heterogeneous data models / tools (1) and (2).
- Version management of signal changes across engineering disciplines.
- Common concept based on semantic integration (3).



Virtual Common Data Model:
Change & Version Management across Tools

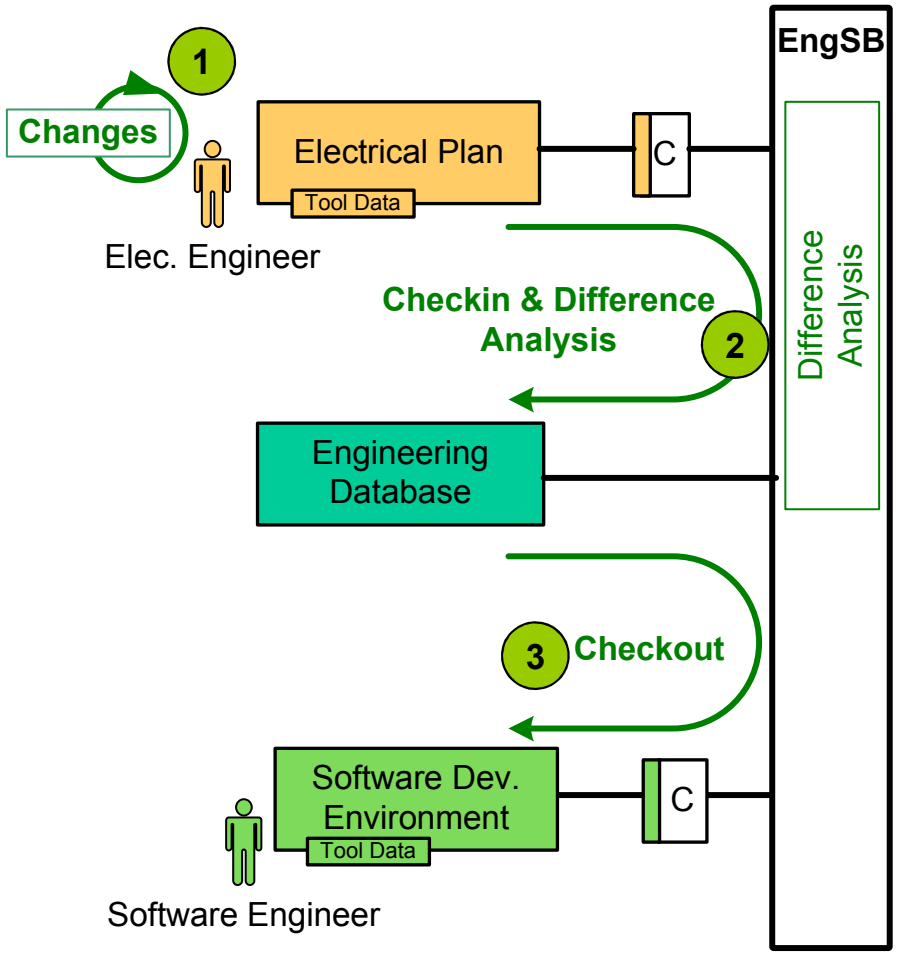


Numbered Circles: (1)
Checkin,
Checkout
Version management

Numbered Squares: [1]
Derive Virtual Common Data Model (VCDM)
Derive Mapping from a tool to VCDM
Configure parser with data mapping

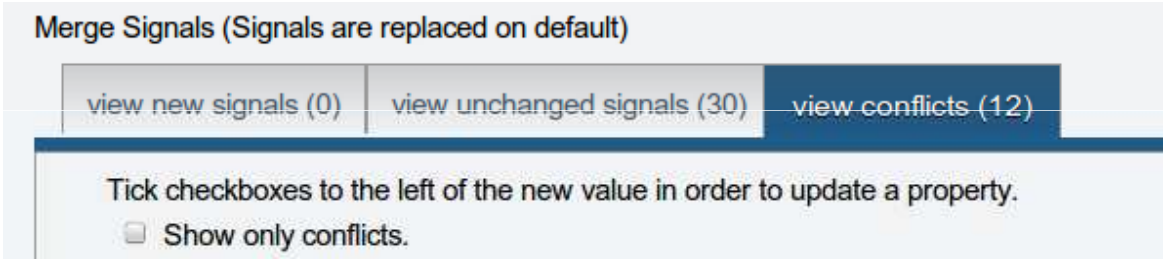
Signal Changes Across Tools and Disciplines

- **Challenges and Goals**
  - Merge changes between signals coming from different disciplines.
- **Conceptual Approach**
  1. Execute Changes.
  2. Check-In and merge changes with Engineering Database
     - Conflicts can be changes semi-automatically.
     - Engineering tickets and notification in case of critical changes and conflicts (e.g., removed signals).
  3. Check-Out merged signal lists.



Pilot Application:
Change & Conflict Identification & Resolution

- **Check in: Status of Imported Signals**



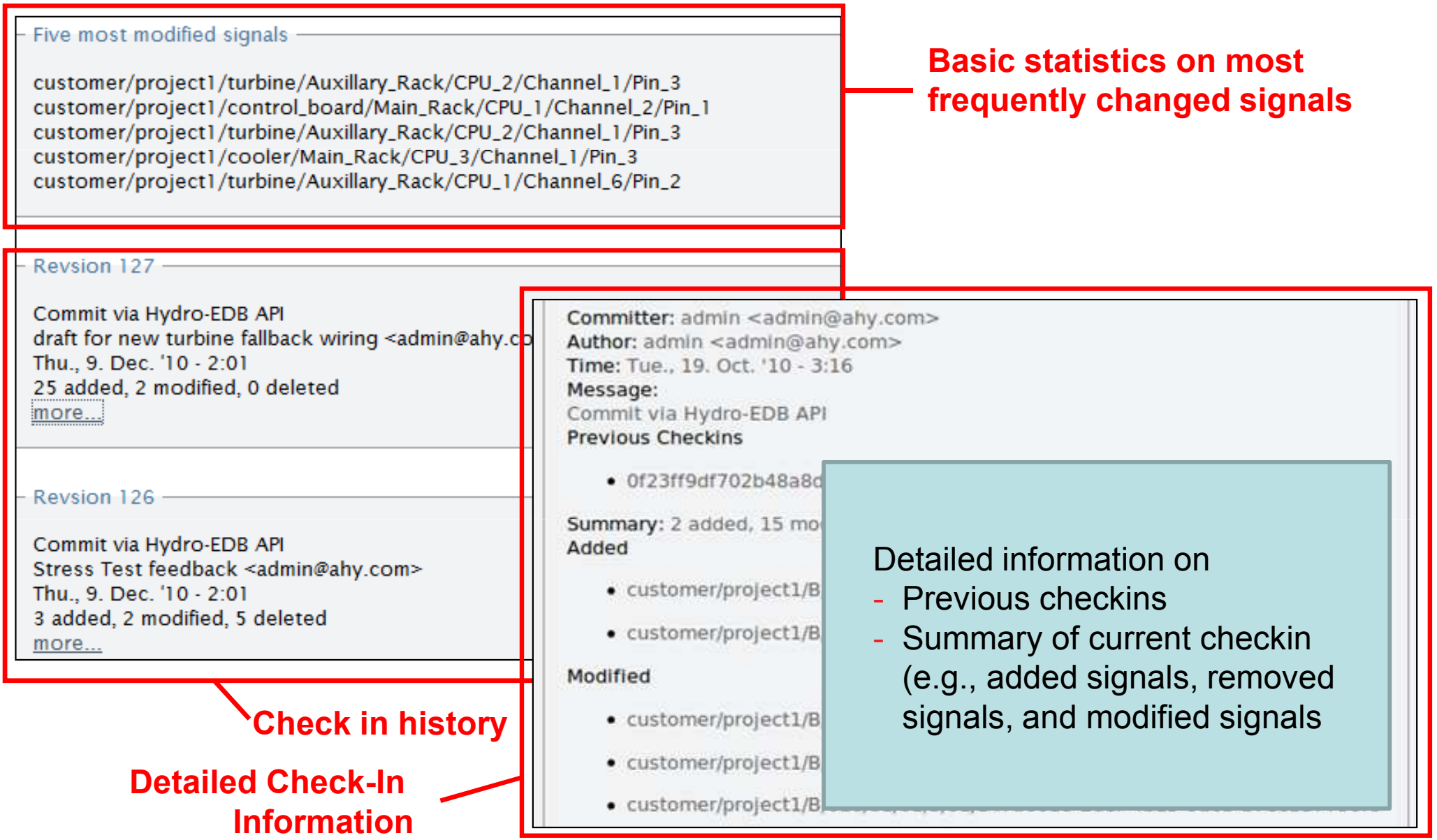
Different Views
- New Signals
- Unchanged Signals
- Changes / Conflicts

- **Highlight & Resolve Differences**

Signal	Update whole row		channelName	inputOutputModule	functionTextOne	region	projectId	customer
0	keep all	**old value:** **new value:**	6	3	H_U#p 110VDC High oil pres pump feeder (Q12 F71 F72) ready H_U#p 110000VDC High oil pres pump feeder (Q12 F71 F72) ready	Tyrkie	Kandil	Sabanci
0	keep all	**old value:** **new value:**	10	7	H_U#p St Service MV cubicle HV fuse fault	Tyrkie	Kandil	Sabanci

Conflicts
- Old & New values
- Selection and Notification
- Confirmation / Change & Conflict Resolution

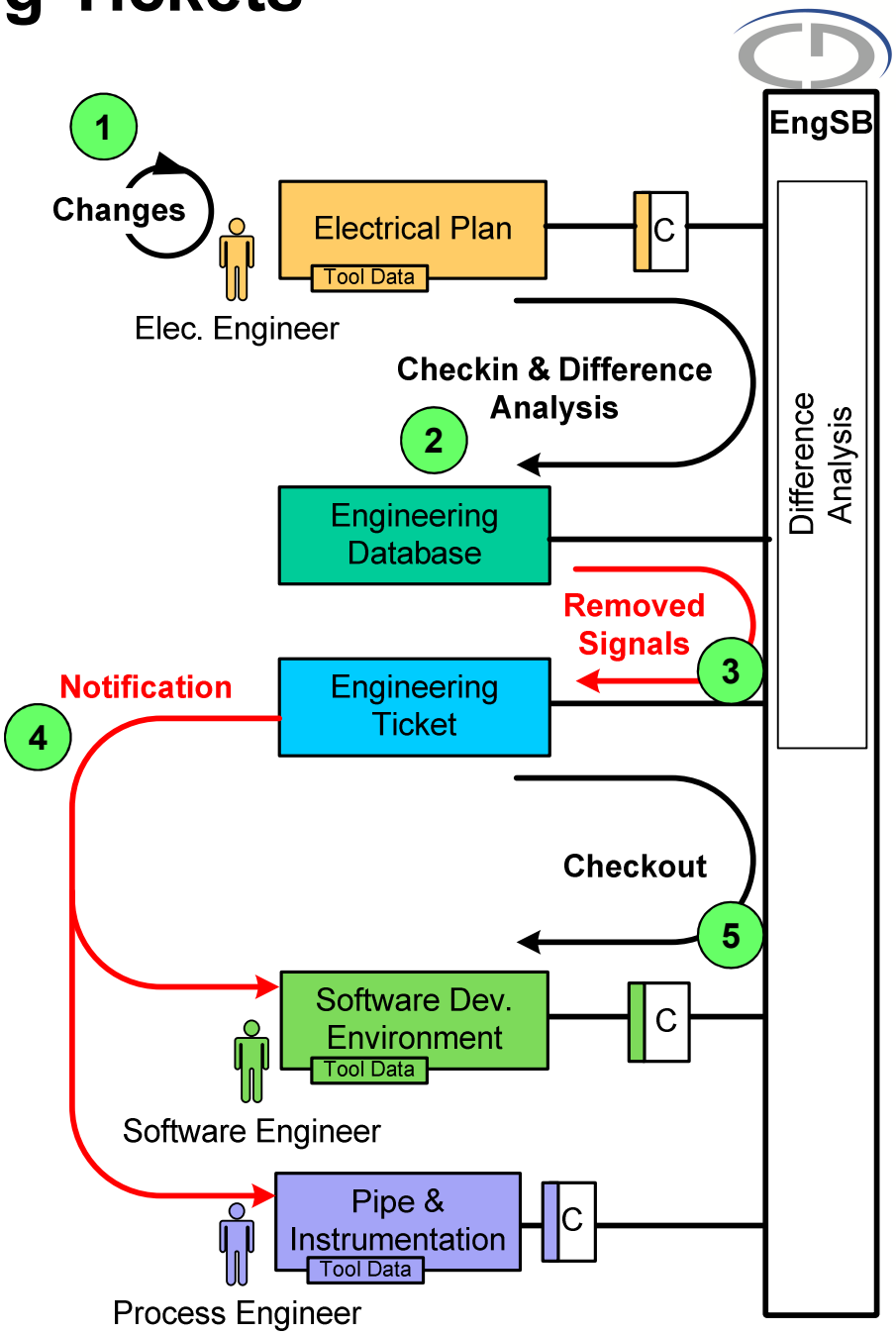
Pilot Application:
History of Signal Data Check-Ins



Notification based on Changes:
Signal Deletion with Engineering Tickets

- **Challenges and Goals**
  - Some conflicts cannot be resolved during check-in, e.g., removed signals
  - Notification required to minimize surprises in the engineering team

- **Conceptual Approach**
  1. Execute Changes
  2. Conduct Difference Analysis
  3. Identify “Removed Signals” → generate Engineering Ticket
  4. Notifiy (multiple) related stakeholders
  5. Checkout

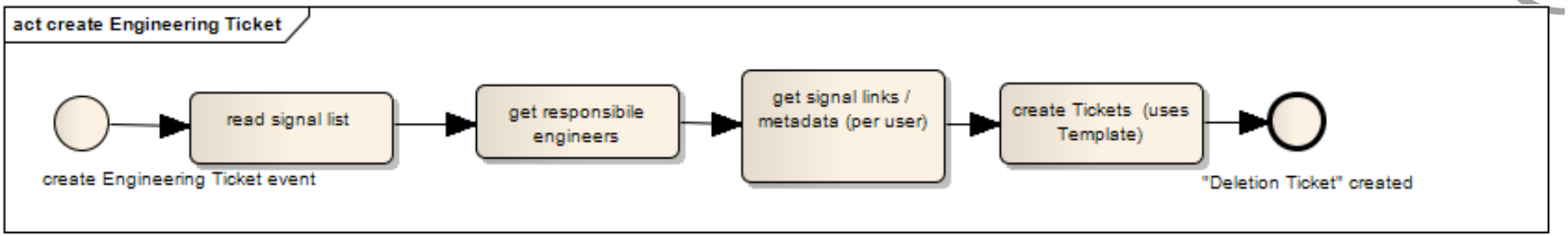


Prototype Implementation:
Engineering Ticket Overview

- **Challenges and Goals:**
  - Notification of stakeholders (e.g., warning on deleted signals)
  - Ensure the correct process steps to deal with “deleted signals”: Clear status of process
- **Approach**
  - Engineering Ticket: “Change Request” that holds all relevant information for the roles involved.
  - Allows tracking the process status
  - Minimizes searching in documents

Ticket	Summary	Component	Status	Resolution	Type	Priority	Owner	Modified
#1	Signal 2345-FDCB-1241 removed	Generator	new		review (signal deleted)	major	florian.waltersdorfer	04/08/10
#3	Signal 9537-A4DJ-2341 removed	Turbine2	assigned		review (signal deleted)	major	stefan.biffl	04/08/10
#8	Signal 4232-FNXX-3283 changed	Turbine1	accepted		approve (signal change)	major	peter.fruehwirt	04/08/10
#9	Signal 1232-UFEW-9231 changed	Generator	new		review (signal deleted)	major	stefan.biffl	04/08/10
#12	Signals changed (4 unapproved)	Schaltzentrale	new		approve (signal change)	major	dietmar.winkler	17/09/10
#11	Signal deletion by florian.waltersdorfer (1 signals)	Turbine	closed	clear for deletion	review (signal deleted)	major	dominik.hofer	24/09/10
#10	Signal deletion by florian.waltersdorfer (2 signals)	Turbine	closed	request for change	review (signal deleted)	major	dominik.hofer	24/09/10
#7	Signal 9324-FWDF-2312 changed	Generator	closed	rejected	review (signal deleted)	major	peter.fruehwirt	04/08/10
#6	Signal 2333-WETD-9452 changed	Schaltzentrale	closed	approved	approve (signal change)	major	peter.fruehwirt	04/08/10
#5	Signal 9122-UWDZ-2332 removed	Schaltzentrale	closed	clear for deletion	review (signal deleted)	major	florian.waltersdorfer	04/08/10
#4	Signal 2312-ZWDA-1237 removed	Schleuse	closed	rejected	review (signal deleted)	major	stefan.biffl	04/08/10
#2	Signal 2781-ADEI-1325 changed	Generator	closed	rejected	approve (signal change)	major	peter.fruehwirt	04/08/10

Prototype Implementation:
“Deletion” Engineering Ticket



- Pre-Defined Ticket Information

Ticket #10 (closed review (signal deleted): request for change) Modify

Signal deletion by florian.waltersdorfer (2 signals)

Opened 3 months ago
Last modified 0 seconds ago

Reported by:	florian.waltersdorfer	Owned by:	dominik.hofer
Priority:	major	Component:	Turbine
Keywords:		Cc:	michael.petritsch

Description (last modified by hydro) (diff)

Reply

Signal Main_Rack/CPU_1/Channel_4/Pin_2 (id: 2d9e6e...) has been deleted.
Type: analog
Text: U1 - TEMP. STATORWINDING/phase U/ centre
KKS: G-MKA20-CT001-B01

Further Information

- http://www.andritz.com/de/hydro/boyabat/links/eplan/2d9e6eb2-7eb6-4dac-b75b-b022b77618d7

Signal Auxiallary_Rack/CPU_2/Channel_1/Pin_3 (389459...) has been deleted.
Type: digital
Text: 400 VAC Main distribution, busbar A, undervoltage
KKS: G-MKA20-CL001-S01

Further Information

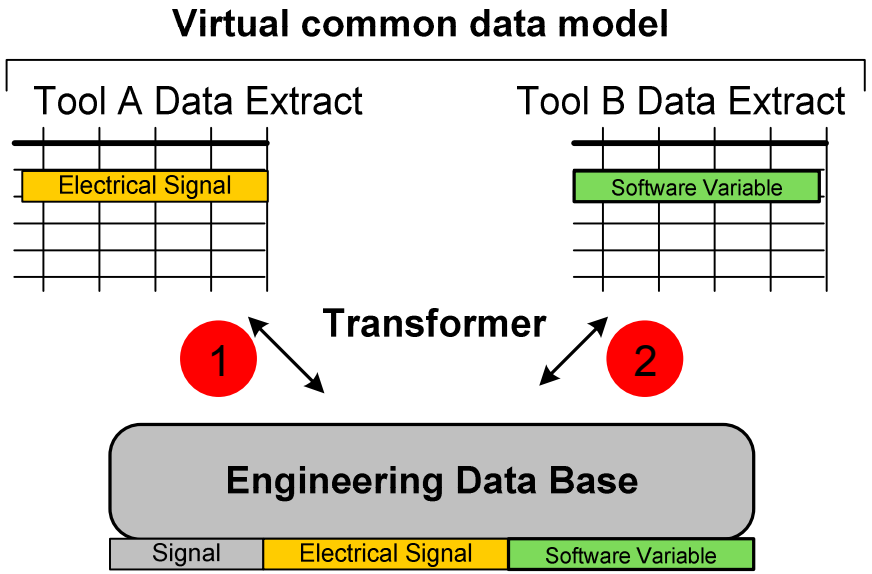
- http://www.andritz.com/de/hydro/boyabat/links/eplan/38945975-a91b-46d6-81de-d3a2119d2967

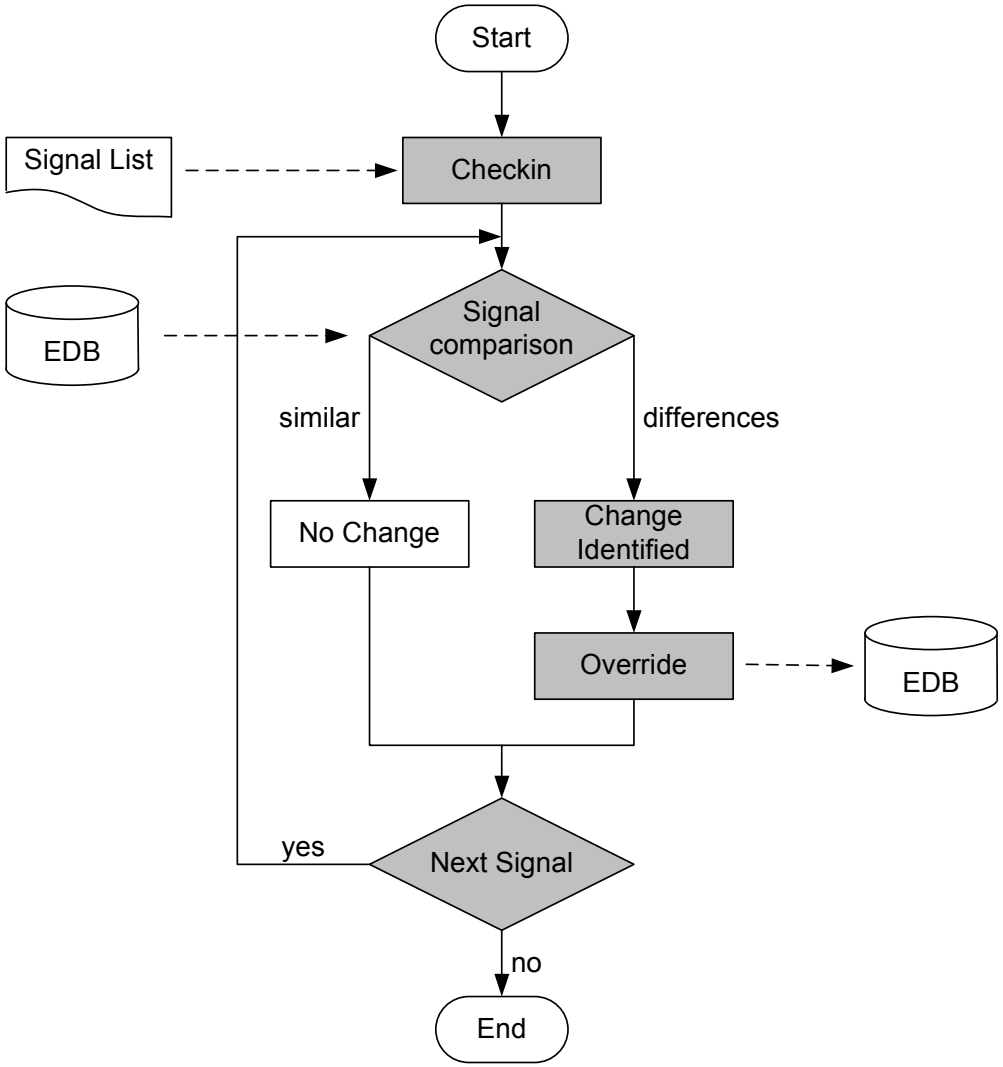
Data Source:
Project Role Concept

Data source:
Engineering Database

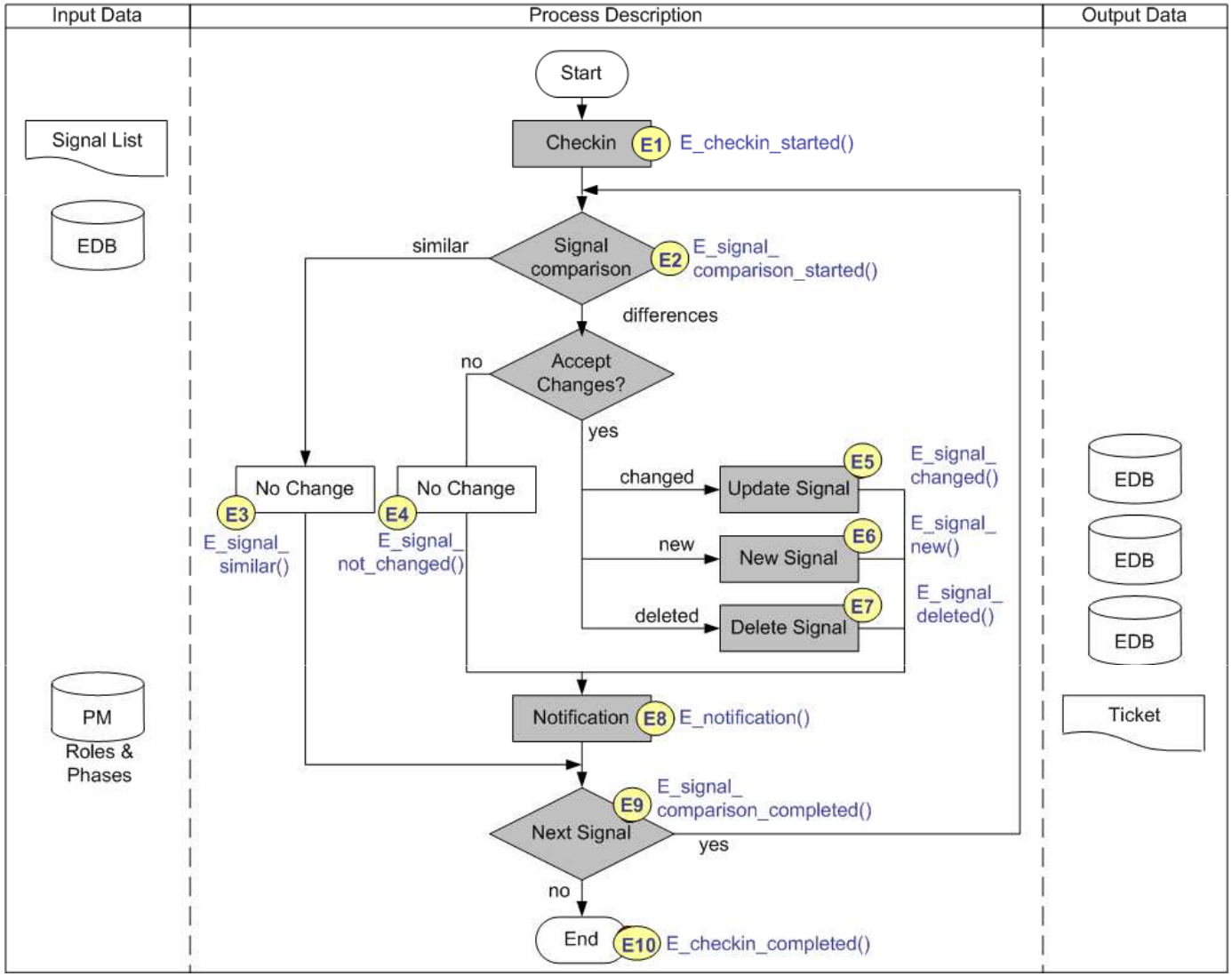
Process Measurement and Analysis:
Basic Signal Check-In Workflow

- Check-In of new signal list.
- Signal comparison with EDB.
- Pass new signals / unchanged signals to EDB.
- Manual confirmation of changed signals and override signal in EDB.





Process Measurement and Analysis:
Signal Change Management Process with Events



- **Signal Changes**
  - Modified signals
  - New signals
  - Removed signals
  - Accepted / rejected signals
- Notification of changes to related stakeholders
- Events (E1 .. E10) enable process observation and project control
- Evaluation: pilot application based on historical data.

Process Measurement and Analysis:
Feasibility Study Concept

- **Goal:**
  - Verification and validation of signal change management (process behavior)
  - Definition of project metrics, i.e., number of change per engineering phase / check-in sequence) for project monitoring and control.

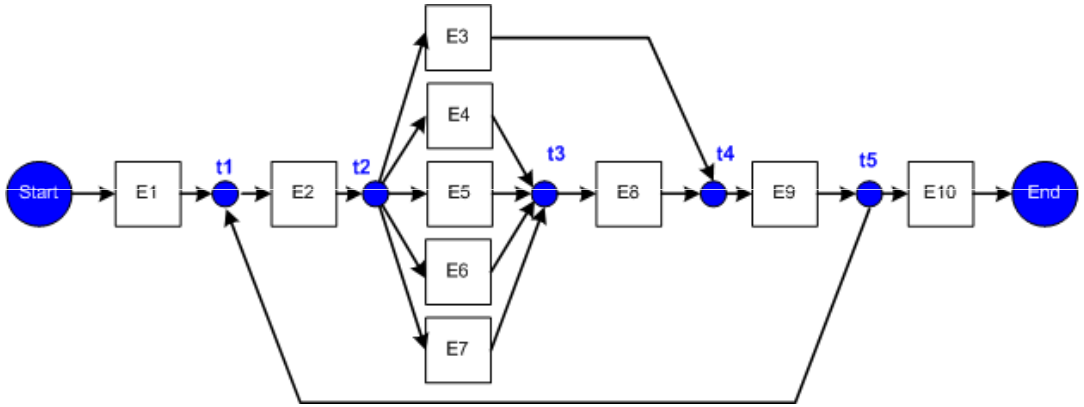
- **Measurement Data & Metrics**
  - Events (E1 … E10)
  - Definition of Product and Project Metrics based on signal changes.

- **Material**:
  - Real world project (hydro power plant) with three different signal lists in early phases of development (approx. 700 signals per list).

- **Process**:
  - Check-in of different signal lists
  - Capturing event data
  - Analysis of event data for process evaluation and determination of product metrics.

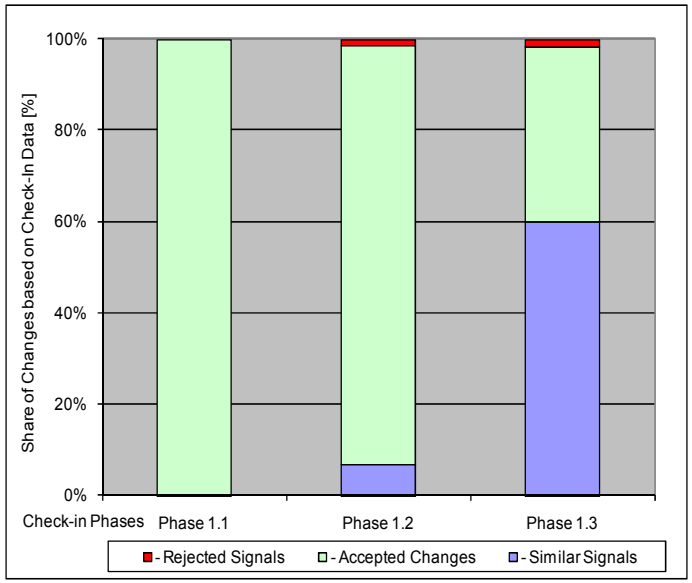
Process Measurement and Analysis:
Results of the Feasibility Study

- **Process Evaluation with ProM***

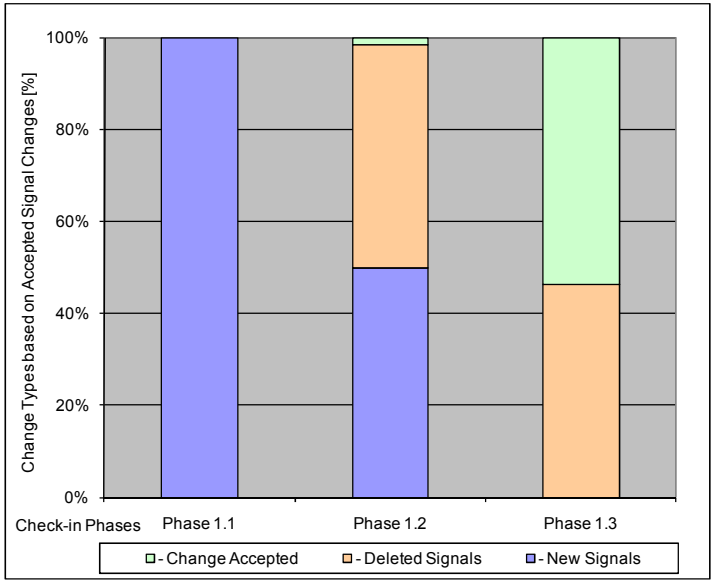


Legend:
E1: E_checkin_started()
E2: E_signal_comparison_started()
E3: E_signal_similar()
E4: E_signal_not_changed()
E5: E_signal_changed()
E6: E_signal_new()
E7: E_signal_deleted()
E8: E_notification()
E9: E_signal_comparison_completed()
E10: E_checkin_completed()

- **Project monitoring and observation** based on event data



Share of Signal Changes



Share of Signal Change Type

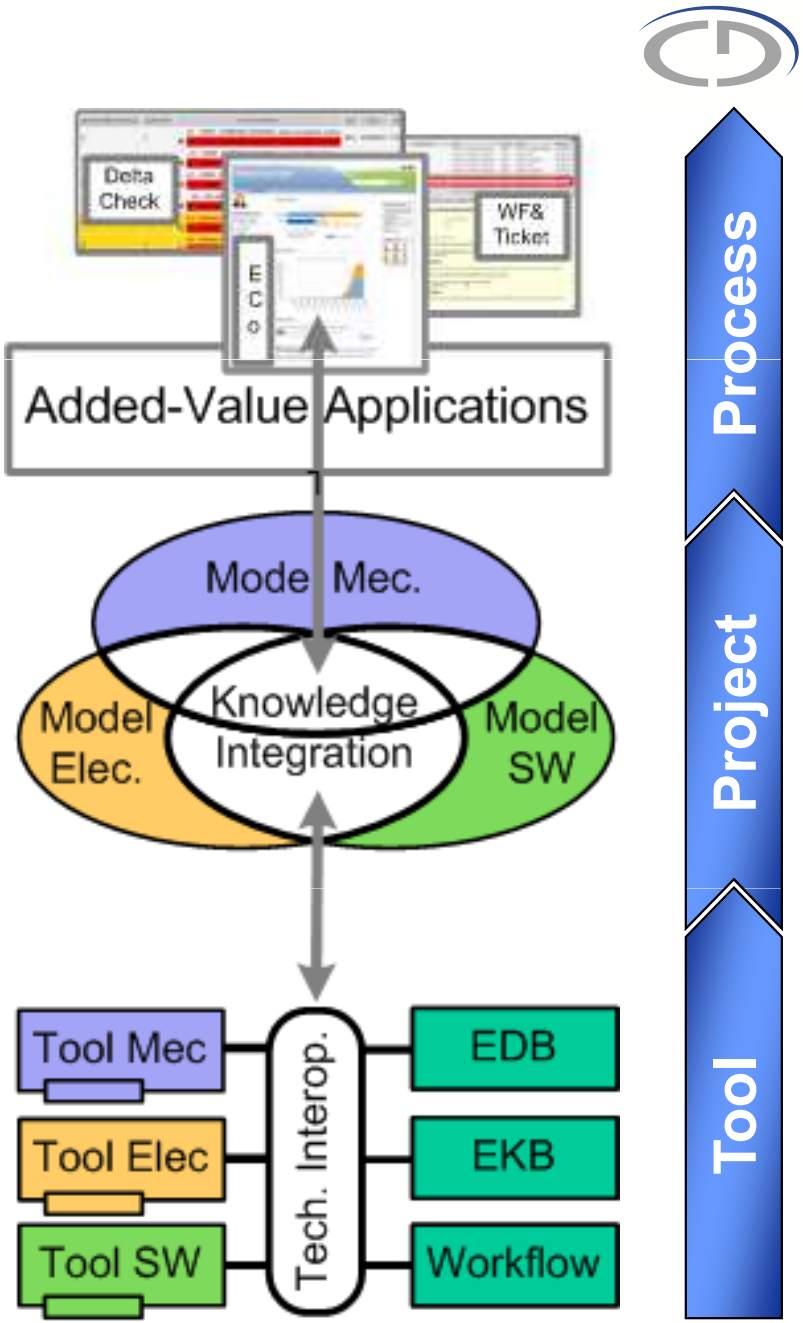
*ProM: Process Mining Workbench: http://prom.win.tue.nl/tools/prom6/

Added-Value Contributions on three Levels

- **Added-value application examples**
  - Interact with project-level engineering knowledge and data.
  - Engineering Cockpit.
  - Use Case “Signal Deletion with Tickets”.
  - Efficient change conflict resolution.

- **Semantic integration on project level**
  - Project-level concepts.
  - Mapping to tool concepts.

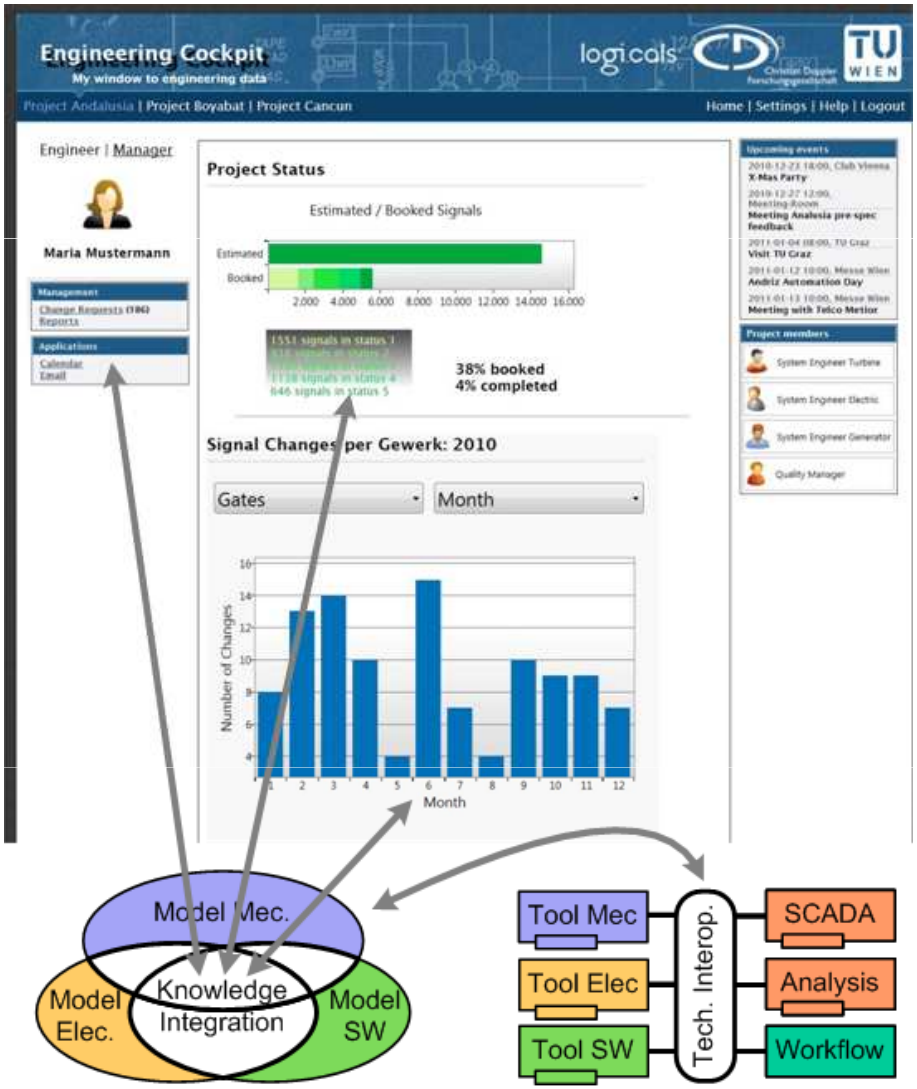
- **Technical integration of tools**
  - Engineering tools.
  - Infrastructure, Security.
  - Application-specific components.



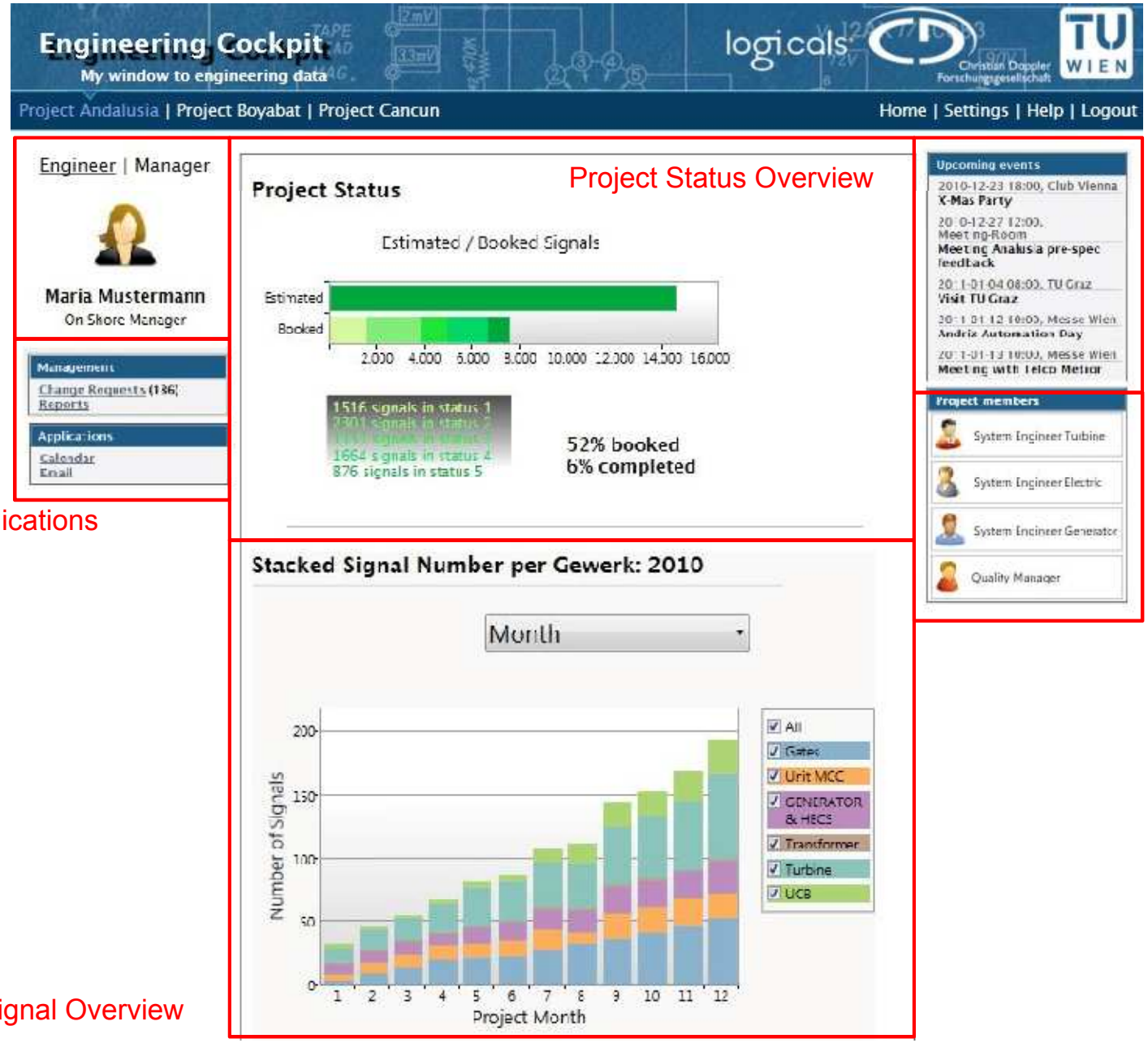
Prototype Implementation:
Engineering Cockpit

In distributed (automation) engineering projects …

- Data sets of several engineering groups evolve concurrently, often **without project-wide version management and progress tracking**.
- Lead engineers and managers get a **clear picture only shortly before project milestones**, seeing risks unnecessarily late.
- Our prototype solution will provide engineers and managers with
  - a platform to organize and perform specific inter-domain and inter-tool tasks.
  - means to collaborate efficiently within the engineering team.
  - integrated data on project progress and risks as soon as the engineer groups check in their local data sets to allow adjustments early.



Prototype Implementation:
Engineering Cockpit – Management View



Role-based Project View

Project Status Overview

Role-based Events

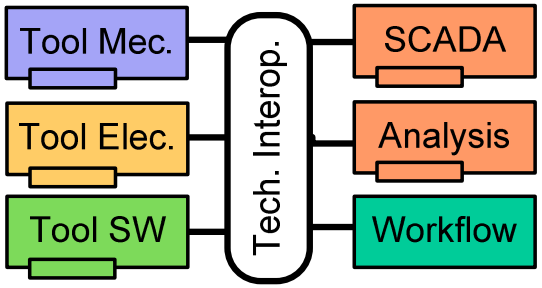
Role-based Status & Applications

Project Related Stakeholders

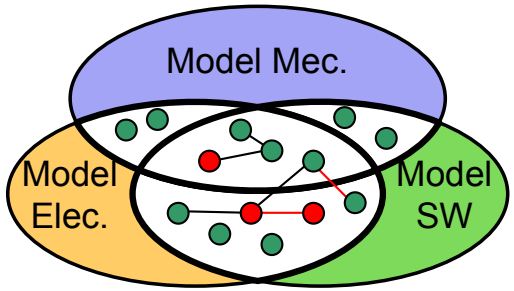
Signal Overview

Conclusion and Further Work

- Automation systems engineering projects
  - Contributions from several engineering disciplines
  - Need for version management across semantically heterogeneous data models in engineering tools and projects



- Automation Service Bus (ASB) and Engineering Database (EDB) concept enables
  - Version management
  - Change & conflict detection and resolution
  - Integrated quality assurance activities

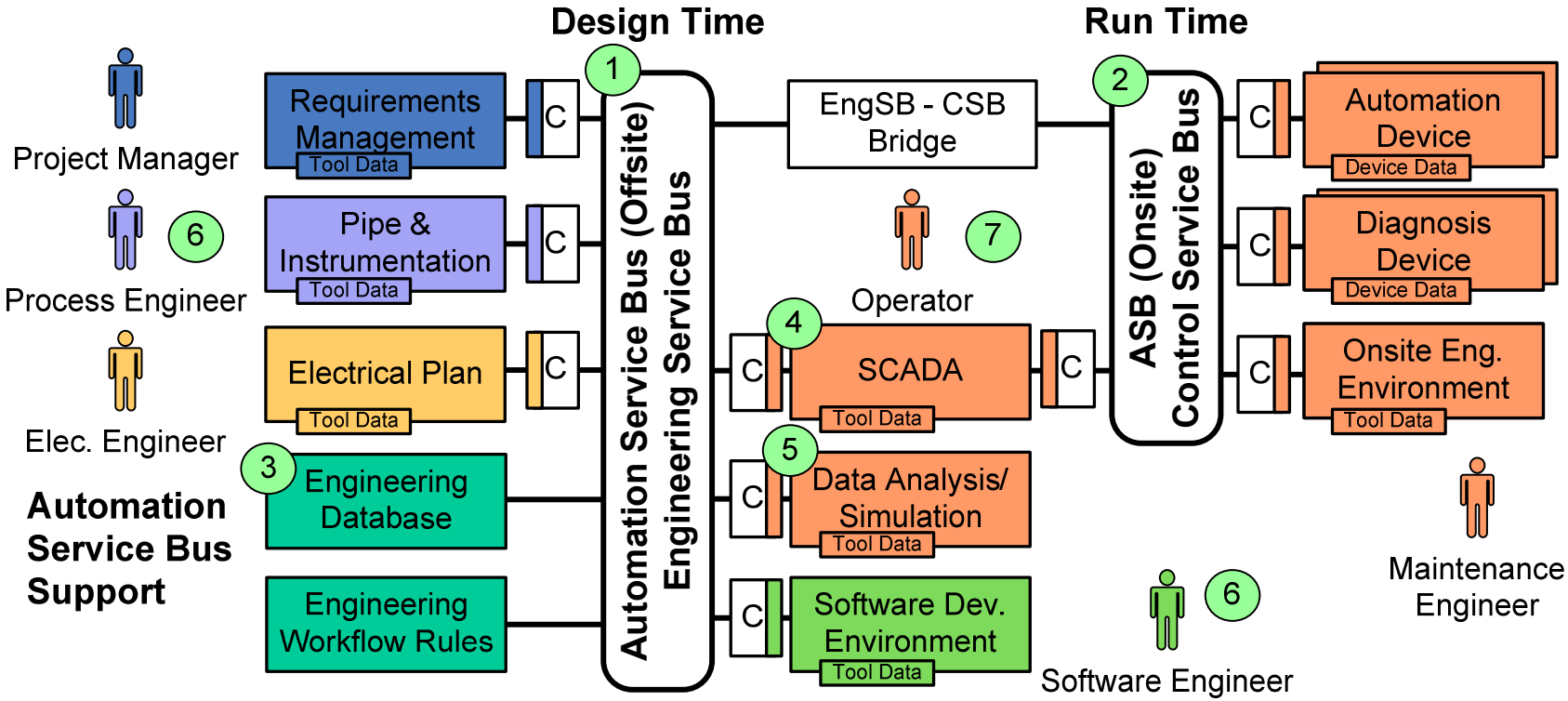


- Further research work
  - Identify new use cases from heterogeneous application domains.
  - Identify candidate industry partners for research prototype development.

BACKUP

Automation Service Bus (ASB)

Goal: Approaches for the integration of software tools in automation engineering.



- Technical Integration: Engineering Service Bus (1), Control Service Bus (2).
- Semantic Integration: Engineering Database (3).
- Flexible integration of SCADA (4) with data analysis/simulation (5).
- Defect detection approaches for design time (6) and run time (7).