Christian Doppler Laboratory

Software Engineering Integration for Flexible Automation Systems

Improving Multi-Disciplinary Engineering of Industrial Production Systems

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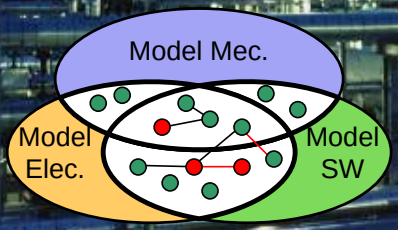
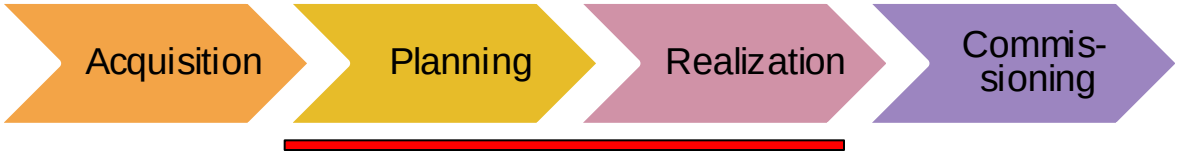
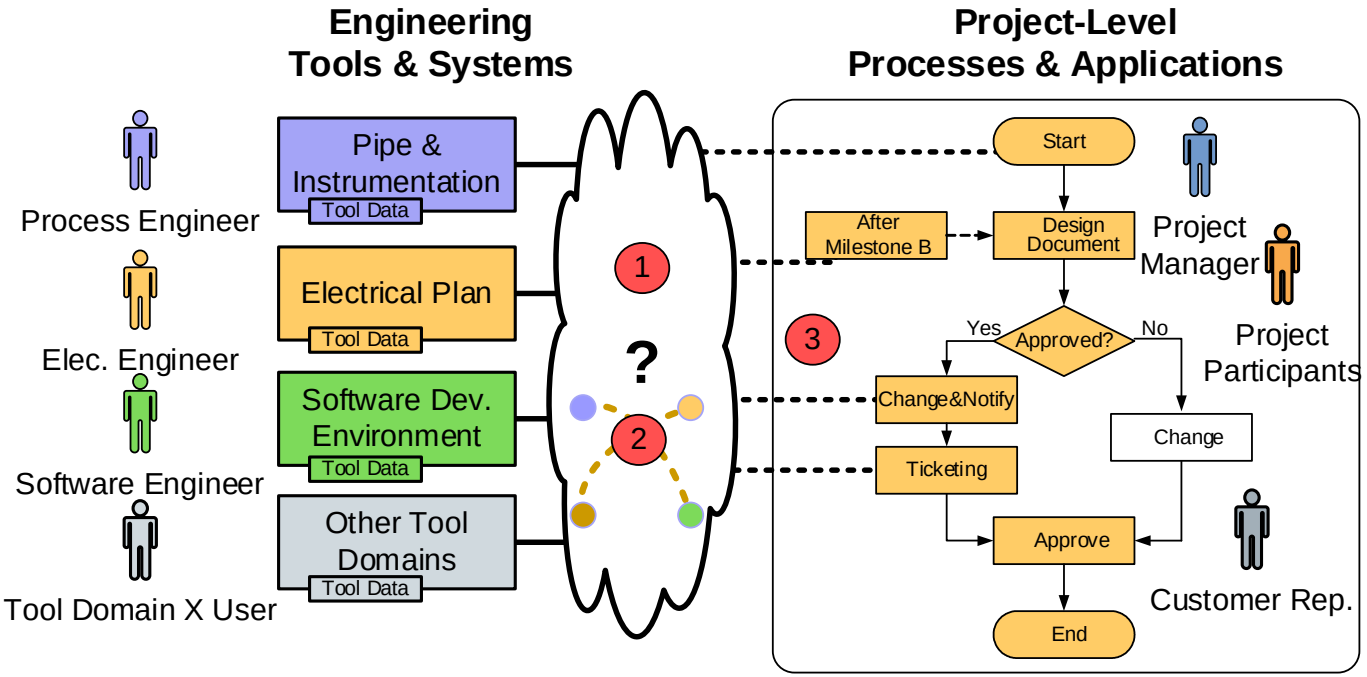
http://cdl.ifs.tuwien.ac.at



Challenges from Heterogeneity in the Engineering Process of Industrial Production Plants



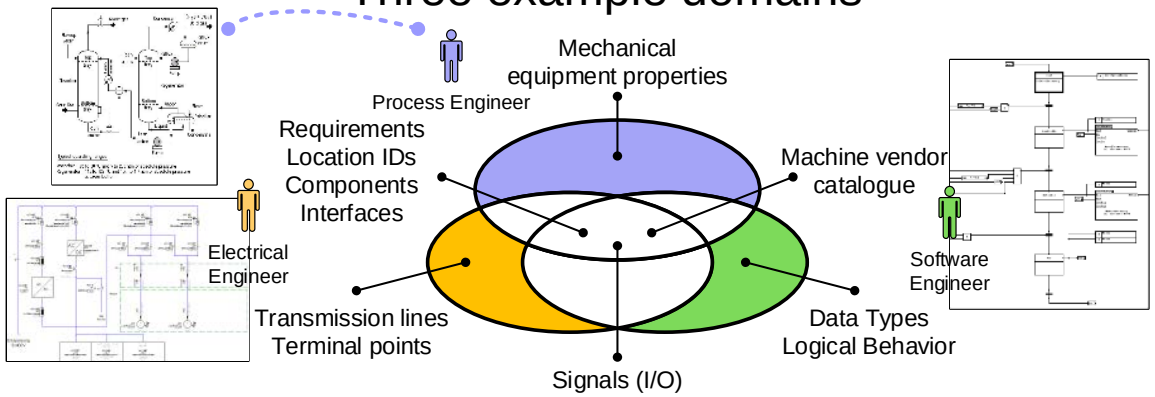
1. **“Engineering Polynesia”**: tool islands with interfaces that do not fit seamlessly.
2. **“Engineering Babylon”**: engineers use project-level concepts, tools do not.
3. **“Engineering Culture Diversity”**: business processes are lived in many ways.



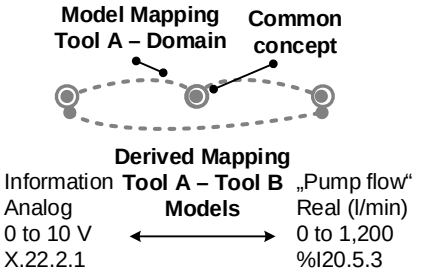
Biffl St., Mordinyi R., Moser T., „Anforderungsanalyse für das integrierte Engineering – Mechanismen und Bedarfe aus der Praxis“, atp edition 5/2012.

Semantic Data Integration with Common Concepts

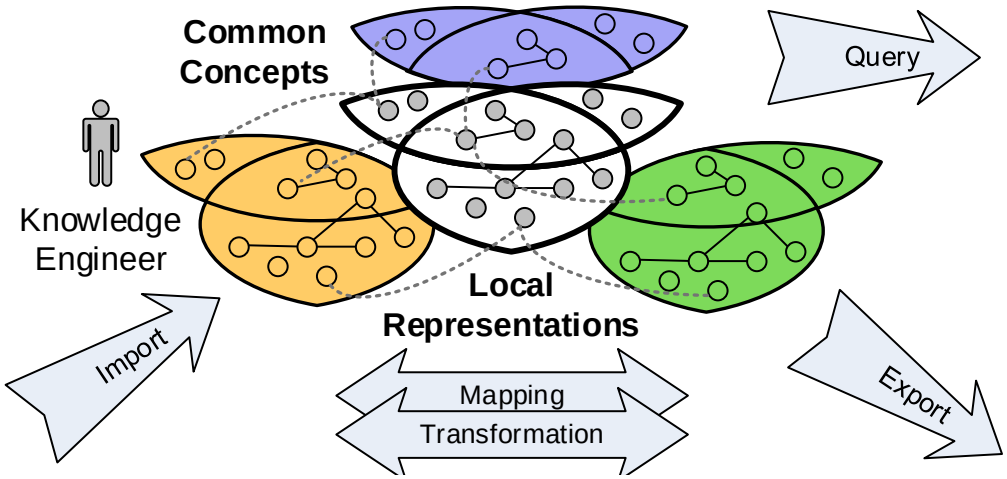
Three example domains



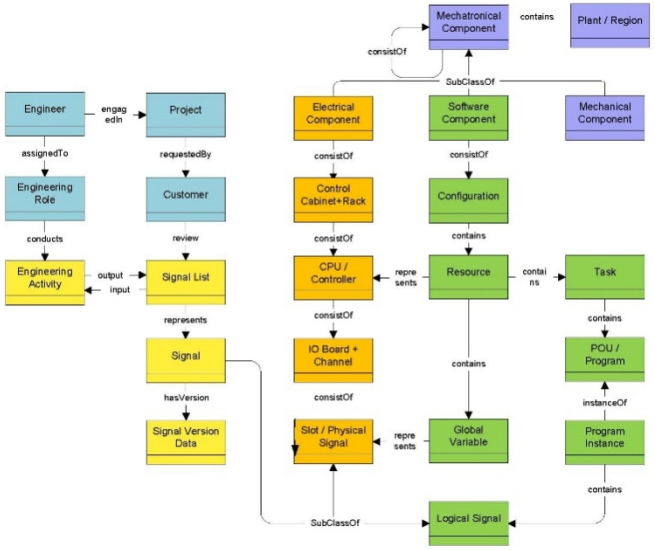
Mapping between concepts



Functions based on mapping common concepts to local representations



Common concept examples



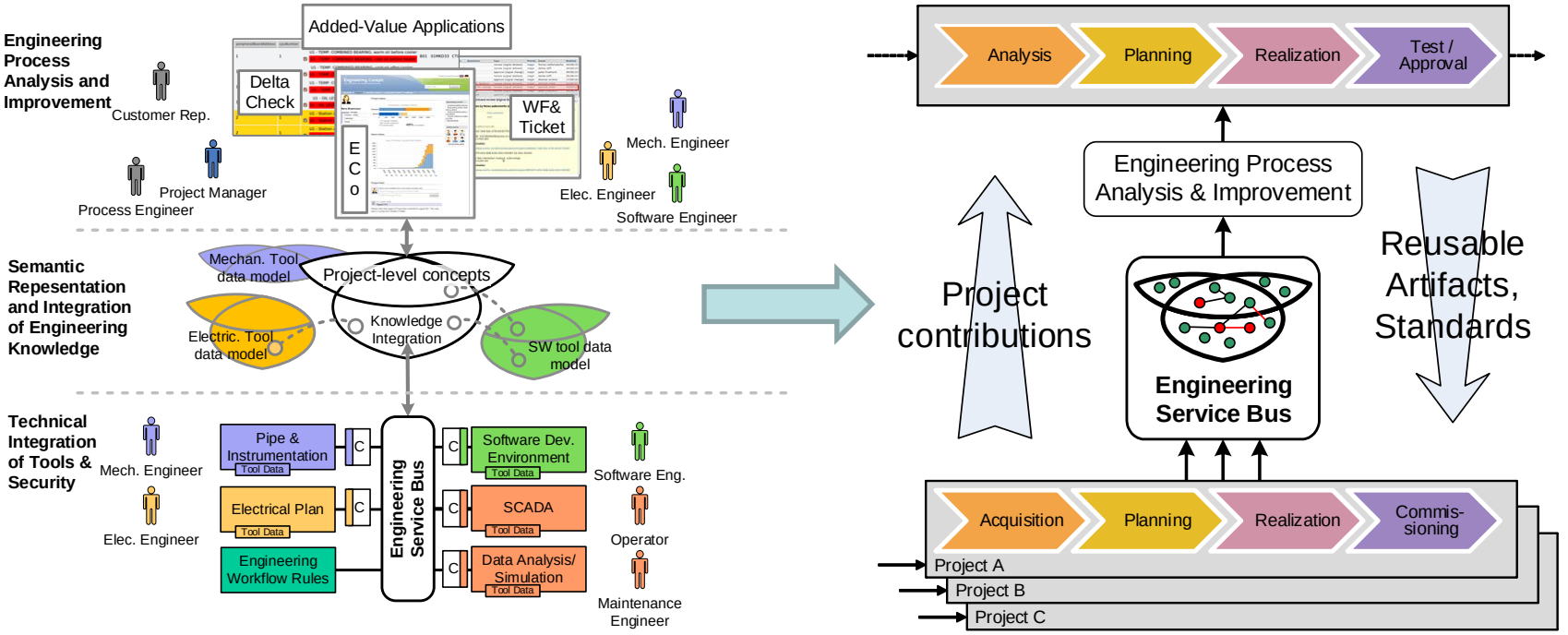
Moser T., Biffl S.: 'Semantic Integration of Software and Systems Engineering Environments', In: IEEE Transactions on Systems, Man, and Cybernetics, Part SMC-C (Application and Reviews), Special issue on Semantics-enabled Software Engineering, 42(1), 2012.

Research Mission and Basic Research Directions

- The mission of the CDL is the research and development of
  - concepts, methods, and tools for
  - the **integration of engineering knowledge**, models, systems & tools
  - to enable system-wide **improvement of engineering processes**
  - along the product life cycle of flexible **industrial automation systems**.

1. Knowledge Representation and Integration

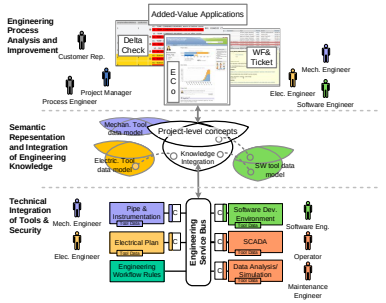
2. Eng. Process Analysis and Improvement



Knowledge Transfer between CDL-Flex and Company Partners

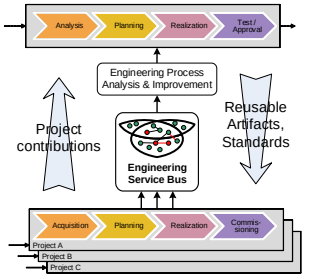
- The company partners, logi.cals and Certicon, involve domain experts at their industry partners for eliciting relevant research challenges and for validating CDL-Flex research prototypes.

Knowledge Representation and Integration



1. Early Risk Management with the **Multi-Model Dashboard**
2. Quality-Assured Tool Networks with the **Semantic Dropbox**
3. **Simulation Integration Framework**

Engineering Process Analysis and Improvement



1

PM Multi-Model Dashboard

Constraint Name	Owner	Status	Value	Unit	Last Update
ME.WeldingCell.Robot1.Location within area	ME_02	Published	True	Bool	2.2.2014; 17:49

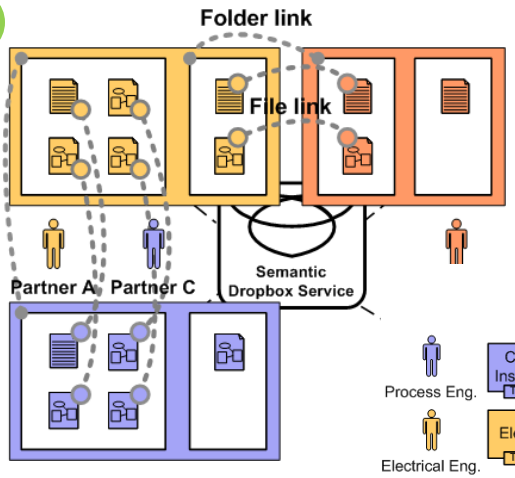
Constraint List

Constraint Name	Owner	Status	Value	Unit	Last Update
PE.WeldingCell.StationTime below time limit	QA_04	Requested	N/A	Bool	N/A
PE.WeldingCell.Robot1.AddedvalueDuration below limit	QA_04	Published	False	Bool	10.4.2014; 10:25
WeldingCell.Conveyer.Drive1 engineered	QA_04	Published	False	Bool	17.3.2014; 21:24
ME.WeldingCell.Robot1.Location within area	ME_02	Published	True	Bool	2.2.2014; 17:49
ME.WeldingCell.GeoStation.Location within area	ME_02	Published	True	Bool	2.2.2014; 17:49

Parameter List

Parameter Name	Source	Status	Value	Unit	Last Update
PE.WeldingCell.StationTime	ME_01	Requested	N/A	s	N/A
RP.WeldingCell.Robot1.AddedValueRatio	RP_01	Requested	N/A	%	N/A
RP.WeldingCell.Robot1.Welding.Duration	RP_02	Published	18	s	10.4.2014; 10:22
RP.WeldingCell.Robot1.Handling.Duration	RP_02	Published	4	s	10.4.2014; 10:22
RP.WeldingCell.Robot1.Motion1.Duration	RP_02	Published	6	s	10.4.2014; 10:25
RP.WeldingCell.Robot1.Motion2.Duration	RP_02	Published	5	s	10.4.2014; 10:25
ME.WeldingCell.Robot1.Location	ME_03	Published	(13.3; 21.8)	(m;m)	2.2.2014; 17:49
ME.WeldingCell.GeoStation.Location	ME_03	Published	(16.4; 23.4)	(m;m)	2.2.2014; 17:49
ME.WeldingCell.Robot1.MaxSpeed	ME_01	Published	52	m/s	14.8.2013; 06:50
ME.WeldingCell.Conveyer.Size	ME_02	Published	1,325	mm	17.3.2014; 21:24
ME.WeldingCell.Conveyer.Maxspeed	ME_02	Published	10	m/s	17.3.2014; 21:24
ME.WeldingCell.Conveyer.Drive1	ME_02	Published	True	Bool	17.3.2014; 21:24
PP.WeldingCell.Conveyer.FailureTimer	PP_03	Requested	N/A	s	N/A
PP.WeldingCell.Conveyer.Drive1.Signal1	PP_03	Published	False	Bool	13.3.2014; 06:49
EE.WeldingCell.Conveyer.Drive1.Signal1	EE_04	Published	True	Bool	14.8.2013; 06:50

2



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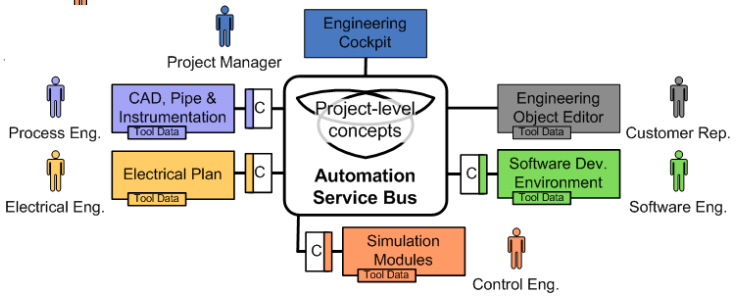
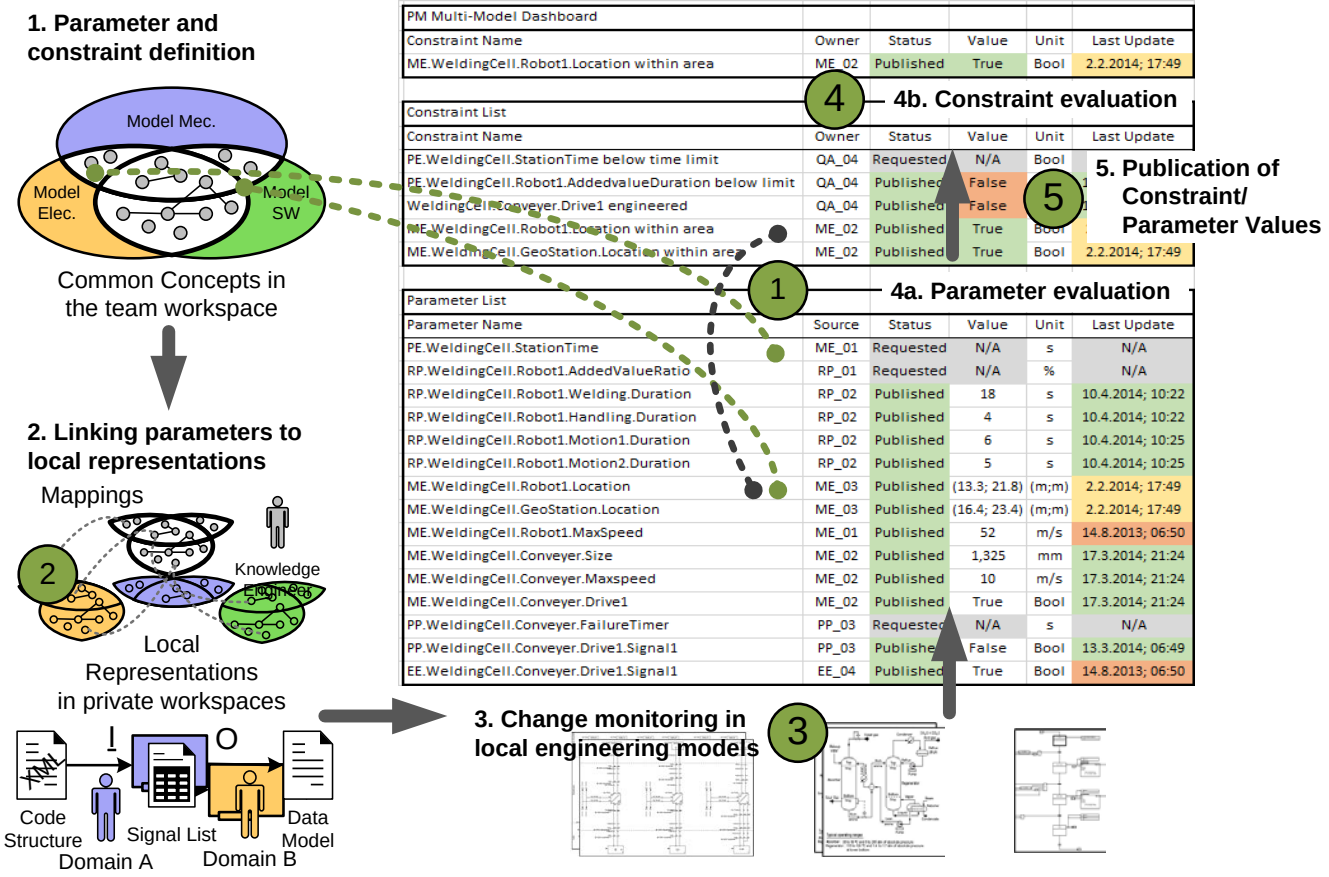


Winkler D., Mordinyi R., Biffl S.: 'Research Prototypes versus Products: Lessons Learned from Software Development Processes in Research Projects', Proc. 20th EuroSPI Conference on Systems Software and Service Process Improvement, Springer, 2013.

Multi-Model Dashboard During Engineering

Cooperation with the CDL ASE at JKU Linz



Knowledge Representation and Integration

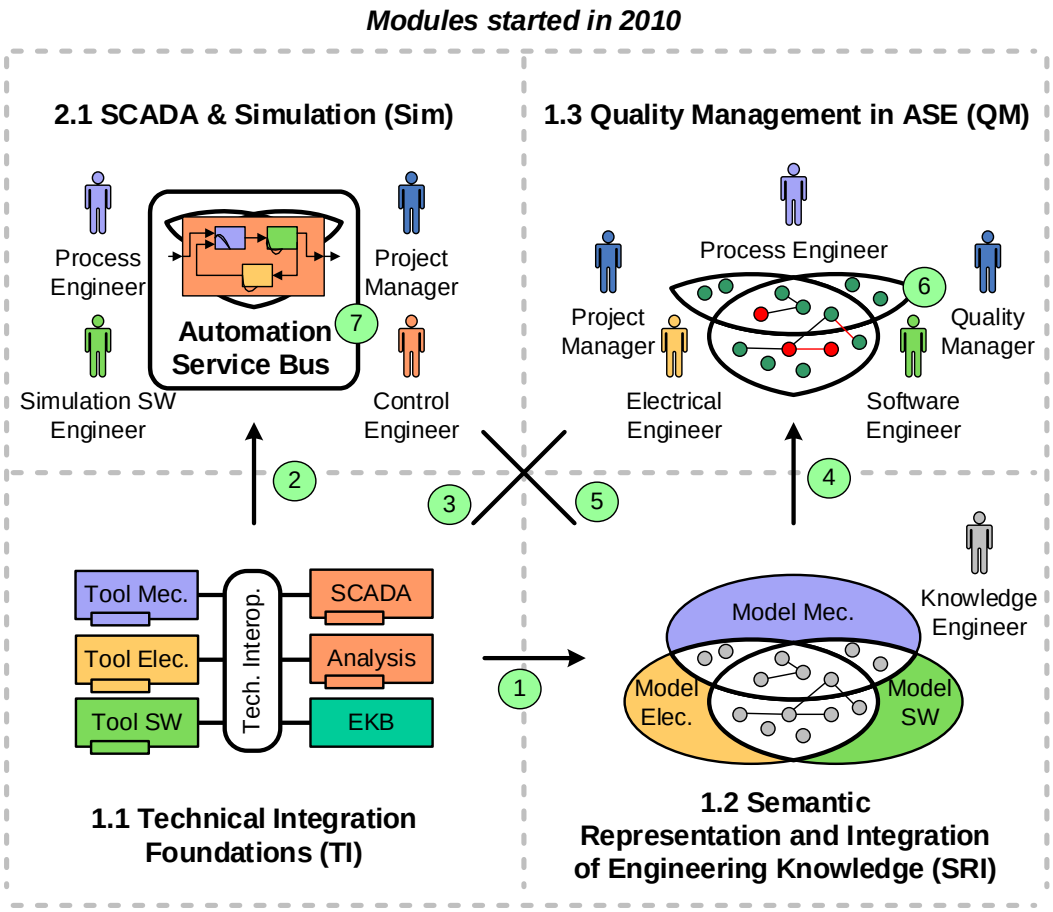
- Constraint and parameter definition.
- Mapping parameters to local representations.
- Change monitoring in local eng. models.

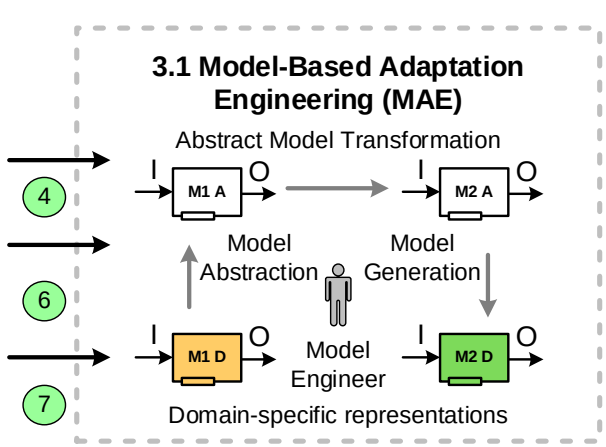
Engineering Process Improvement

- Early risk analysis with tool support.
- Automation of the MMD process, change analysis, and notification.

Biffl S., Winkler D., Mordinyi R., Scheiber S., Holl G.: 'Efficient Monitoring of Constraints in a Multi-Disciplinary Engineering Project with Semantic Data Integration in the Multi-Model Dashboard Process', In: Proc. IEEE Int. Conf. Emerging Technologies & Factory Automation (ETFA), 2014.

Research Areas in the CDL-Flex





1.1 Technical Integration Foundations

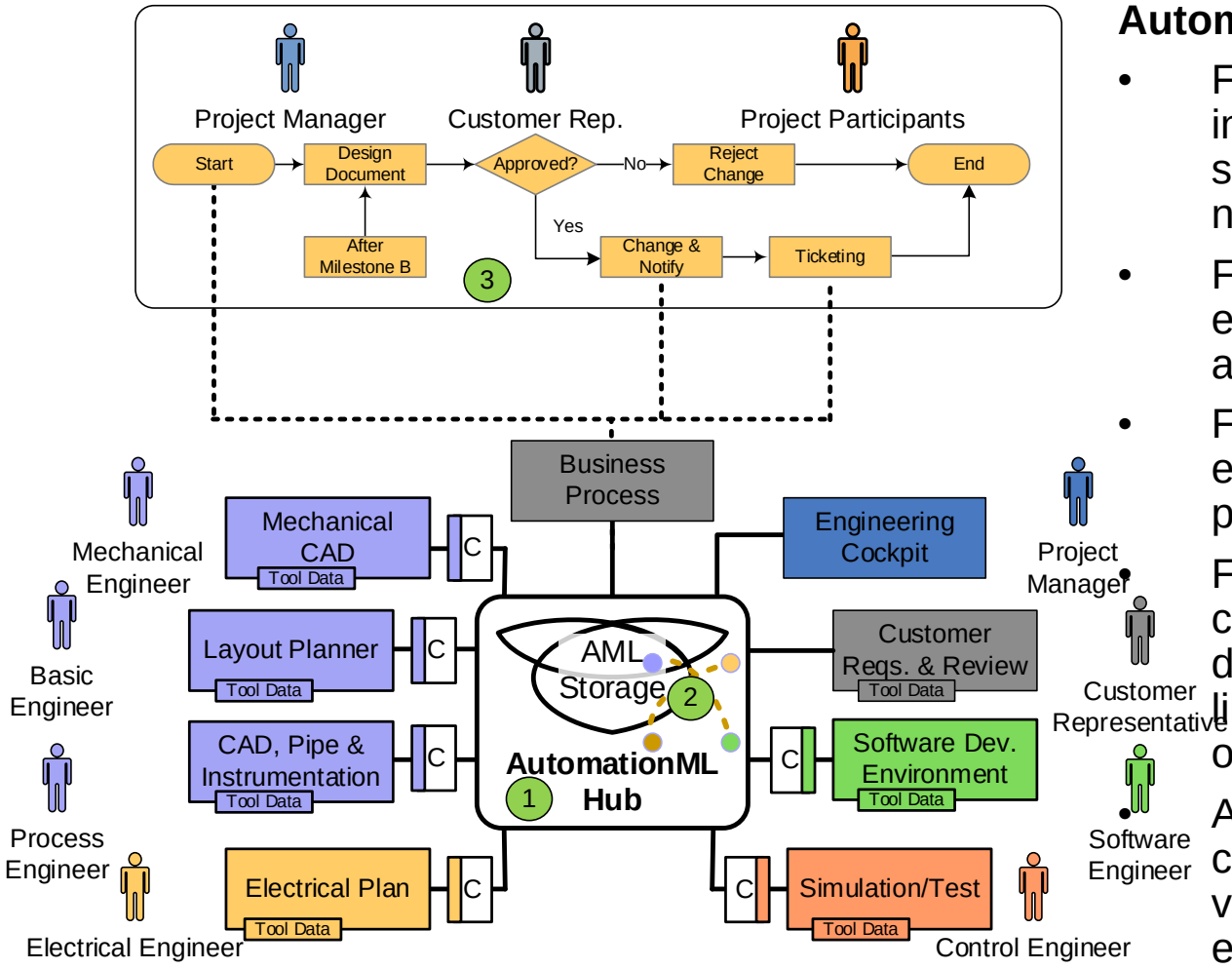
1.2 Semantic Representation and Integration of Engineering Knowledge

1.3 Quality Management in ASE

2.1 SCADA & Simulation

3.1 Model-Based Adaptation Engineering

AutomationML Hub Concept to Provide Access to Data in AutomationML Tool Networks

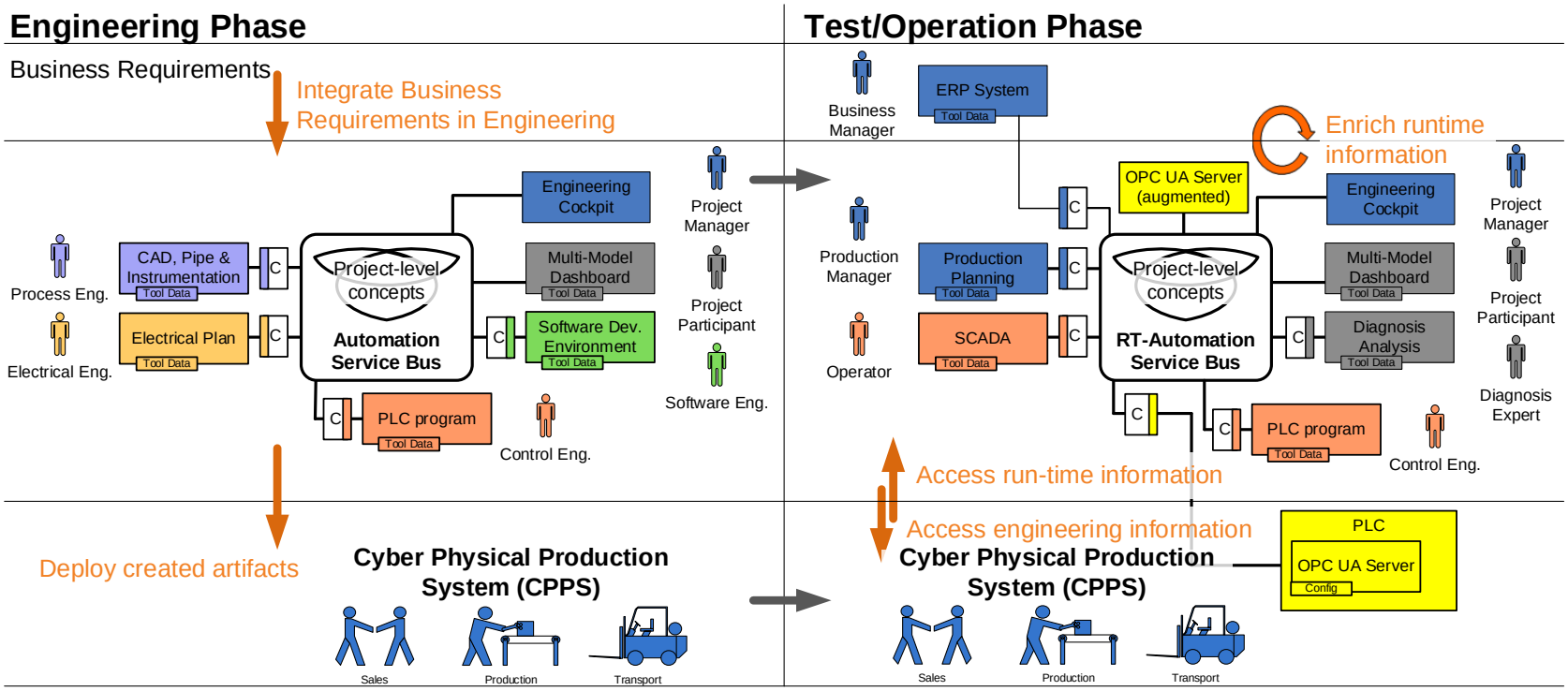


AutomationML Hub contributions:

- Facilitates the efficient integration and versioned storage of data in tool networks.
- Facilitates consistent and efficient querying of data across disciplines.
- Facilitates the automation of engineering processes on the project level.
- Facilitates consistent combination of engineering data with project information like the process status of objects.
- Automated detection of changes between data versions and triggering of engineering processes.
- Foundation for data analysis.

Biffl S., Mätzler E., Wimmer M., Lüder A., Schmidt N.: Linking and Versioning Support for AutomationML: A Model-Driven Engineering Perspective', In: Proc. Int. Conf. Industrial Informatics (IndIn) 2015, p. 499-506; IEEE, 2015.

Industrie 4.0: Engineering Knowledge at Run Time



- Cooperation TU Wien PhD college „Cyber-Physical Production Systems“
  - Provide selected engineering knowledge at run time
  - Facilitate the diagnosis of run-time data with engineering knowledge
- Cooperation with AutomationML researchers and domain experts
- Cooperation with CDL MEVSS at JKU Linz on variability modeling

CDL-Flex Summary Program Presentations

Flexible Integration of Engineering Environments with the AutomationML Hub

- Dr. Richard Mordinyi, Dr. Dietmar Winkler, Research Area Leads
- Heinrich Steininger, CTO of the company partner logi.cals Austria

Semantic Web for Intelligent Engineering Applications

- Dr. Marta Sabou, Research Area Lead

Knowledge-based Simulation Model Design and Integration

- Dr. Radek Sindelar, Research Module Lead
- Prof. Dr. Vladimir Marik, Czech Technical University, Prag
- Chairman of the company partner CertiCon a.s.

Model-Driven Adaptation Engineering

- Doz. Dr. Manuel Wimmer, Research Module Lead
- Peter Lieber, Founder of the company partner LieberLieber

CDL-Flex in the Context of *Industrie 4.0* at TU Wien

- Prof. Dr. Detlef Gerhard, Dean of the Faculty for Mechanical and Industrial Engineering
- Head of the Doctoral College „Cyber-Physical Production Systems“