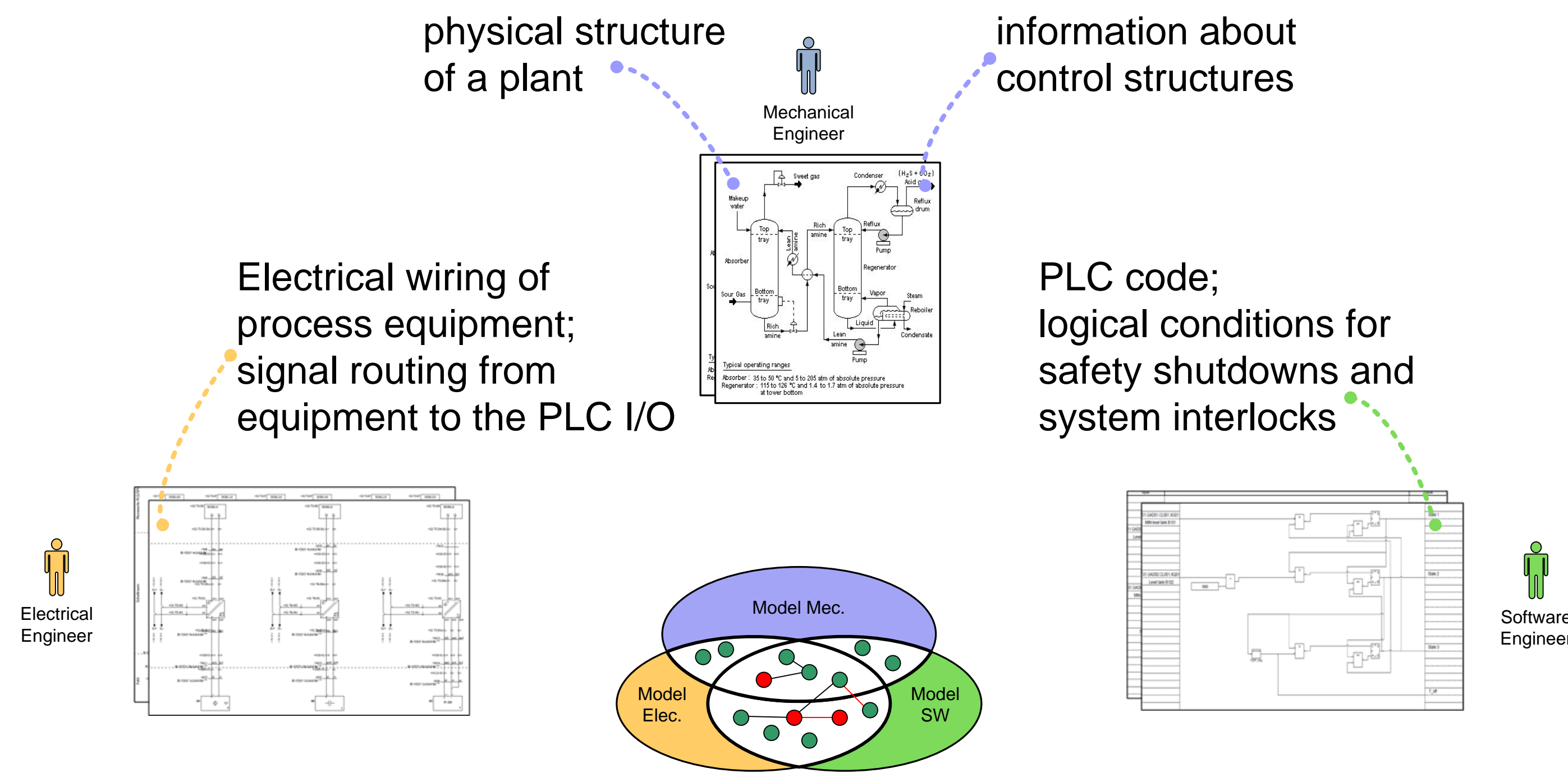


Context and Motivation

Challenges

- Complex, software-intensive and changeable environment
- Participants originate from different engineering disciplines
 - Different backgrounds
 - Dissimilar terminology and workflows
 - Various engineering tools and formats for data representation, storage and exchange
- Project data is dispersed through a variety of heterogeneous data sources
- Relations and dependencies between design artifacts are not explicitly captured



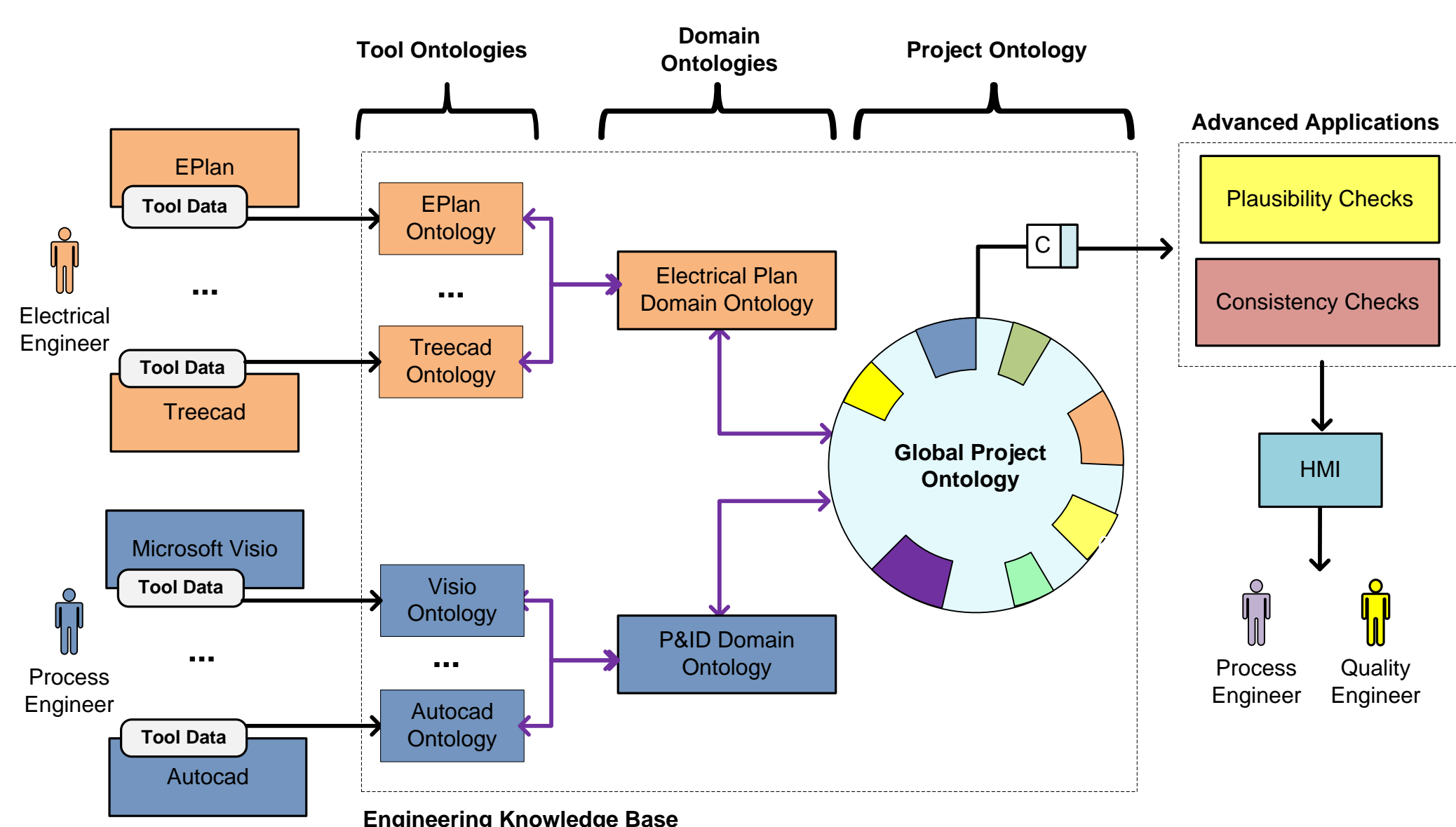
How to ensure consistency of heterogeneous design data **across the whole project?**

Interdisciplinary Inconsistencies in Design Data

- Require analysis of heterogeneous data produced by different tools and stored in dissimilar data formats to identify them
- Usually their identification has to be done manually by project engineers, which is time and effort consuming and error-prone task
- If not identified on early stages can potentially lead to costly corrections during commission or even failures during operation

Solution: Knowledge-Based Approach

- Each **tool ontology** captures data format and terminology of concrete tool.
 - **Domain ontologies** generalize differences between different tools used in given domain.
 - **Global project ontology** contains only knowledge that is important to represent the interconnections between data from different disciplines and tools.
- A **set of mappings** is determined between each tool ontology and corresponding domain ontology, as well as between each domain ontology and project ontology.



Research Contributions & Challenges

Contributions:

- 1 Representation of design knowledge in knowledge base, determination and explicit specification of interrelations between content of different design artefacts through mappings.
- 2 Providing a technique for effective querying of knowledge-base in order to check the consistency of project design data.
- 3 Identification of a set of checks that will be useful towards consistency checking and inconsistencies detection in a wide range of ASE projects.

Challenges:

- 1 Semantic heterogeneity.
- 2 Struggling with complexity: finding a compromise between completeness of knowledge and convenience of use.

Evaluation: Case Study Based on Data from Industry Partner

1 Background

- Signals are used as common concepts that link information across different engineering disciplines.
- Signals include process interfaces (e.g., wiring and piping), electrical signals (e.g., voltage levels), and software I/O variables.
- Main target is to integrate signals from different tools and to ensure their consistency across the engineering project.

3 Possible checks

- **“Integration test”** - whether all sensors are properly wired and connected to appropriate software variables.
- **Within one signal** - e.g., identifying of missing hardware address.
- **Within set of signals** - e.g., checking whether all signals that belong to a specific device have the same value in “location” field.

2 Input Data

- Output signals from 2 engineering tools (stored in Excel spreadsheets).

Tool 1							Tool 2						
A	B	C	D	E	F	G	A	B	C	D	E	F	G
1	PLC address	“Data Type”	“Symbolic address”	“Function text”	“Signal number”		1	PLC address	“Data Type”	“Symbolic address”	“Function text”	“Signal number”	
2	0101.01.01.00	“NAME”	“UM”	Temp. Stator Winding / phase U / centre”	“TO”		2	0101.01.01.00	“NAME”	“UM”	Temp. Stator Winding / phase U / centre”	“TO”	
3	0101.01.01.01	“NAME”	“UM”	Temp. Stator Winding / phase V / centre”	“TO”		3	0101.01.01.01	“NAME”	“UM”	Temp. Stator Winding / phase V / centre”	“TO”	
4	0101.01.01.02	“NAME”	“UM”	Temp. Stator Winding / phase W / centre”	“TO”		4	0101.01.01.02	“NAME”	“UM”	Temp. Stator Winding / phase W / centre”	“TO”	
5	0101.01.01.03	“NAME”	“UM”	Temp. oilpan of combined bearing”	“OMKX0”		5	0101.01.01.03	“NAME”	“UM”	Temp. oilpan of combined bearing”	“OMKX0”	
6	0101.01.01.04	“NAME”	“UM”	Temp. upper Guide Bearing of Cooler - warm	“TO”		6	0101.01.01.04	“NAME”	“UM”	Temp. upper Guide Bearing of Cooler - warm	“TO”	
7	0101.01.01.05	“NAME”	“UM”	Temp. Oilpan of upper Guide Bearing”	“OMKX0”		7	0101.01.01.05	“NAME”	“UM”	Temp. Oilpan of upper Guide Bearing”	“OMKX0”	
8	0101.01.01.06	“NAME”	“UM”	Spere”	“TO”		8	0101.01.01.06	“NAME”	“UM”	Spere”	“TO”	
9	0101.01.01.07	“NAME”	“UM”	Spere”	“TO”		9	0101.01.01.07	“NAME”	“UM”	Spere”	“TO”	
10	0101.01.01.08	“NAME”	“UM”	Temp. oil after bearing - warm oil before	“TO”		10	0101.01.01.08	“NAME”	“UM”	Temp. oil after bearing - warm oil before	“TO”	
11	0101.01.01.09	“NAME”	“UM”	Temp. oil after bearing - cold oil after Cool	“TO”		11	0101.01.01.09	“NAME”	“UM”	Temp. oil after bearing - cold oil after Cool	“TO”	
12	0101.01.01.10	“NAME”	“UM”	Temp. oil after bearing - cold oil after Cool	“TO”		12	0101.01.01.10	“NAME”	“UM”	Temp. oil after bearing - cold oil after Cool	“TO”	
13	0101.01.01.11	“NAME”	“UM”	Spere”	“TO”		13	0101.01.01.11	“NAME”	“UM”	Spere”	“TO”	
14	0101.01.01.12	“NAME”	“UM”	Temp. Stator Winding / phase U / centre”	“TO”		14	0101.01.01.12	“NAME”	“UM”	Temp. Stator Winding / phase U / centre”	“TO”	
15	0101.01.01.13	“NAME”	“UM”	Temp. Stator Winding / phase V / centre”	“TO”		15	0101.01.01.13	“NAME”	“UM”	Temp. Stator Winding / phase V / centre”	“TO”	
16	0101.01.01.14	“NAME”	“UM”	Temp. Stator Winding / phase W / centre”	“TO”		16	0101.01.01.14	“NAME”	“UM”	Temp. Stator Winding / phase W / centre”	“TO”	
17	0101.01.01.15	“NAME”	“UM”	Temp. oilpan of combined bearing”	“OMKX0”		17	0101.01.01.15	“NAME”	“UM”	Temp. oilpan of combined bearing”	“OMKX0”	
18	0101.01.01.16	“NAME”	“UM”	Temp. upper Guide Bearing of Cooler - warm	“TO”		18	0101.01.01.16	“NAME”	“UM”	Temp. upper Guide Bearing of Cooler - warm	“TO”	
19	0101.01.01.17	“NAME”	“UM”	Temp. Oilpan of upper Guide Bearing”	“OMKX0”		19	0101.01.01.17	“NAME”	“UM”	Temp. Oilpan of upper Guide Bearing”	“OMKX0”	
20	0101.01.01.18	“NAME”	“UM”	Spere”	“TO”		20	0101.01.01.18	“NAME”	“UM”	Spere”	“TO”	
21	0101.01.01.19	“NAME”	“UM”	Temp. thrust bearing”	“OMKX0”		21	0101.01.01.19	“NAME”	“UM”	Temp. thrust bearing”	“OMKX0”	
22	0101.01.01.20	“NAME”	“UM”	Temp. thrust bearing”	“OMKX0”		22	0101.01.01.20	“NAME”	“UM”	Temp. thrust bearing”	“OMKX0”	

- Data transformations (based on discussion with domain experts)

Tool 1 Data Model

RANGE: String
L0: String
L1: String
L2: String
L3: String
SIG: String
Exp.: “XQ03”

VCDM

kkks0:String
kkks1:String
kkks2:String
kkks3:String
PhysicalPin

Tool 2 Data Model

RANGE: String
Sig-1:String
Sig-2:String
Sig-3:String
Sig-4:String
Exp: “XQ03”
Symbolic address:String