

A tale of Variability and Electrical Transformers



Jaime Chavarriaga
Universidad de los Andes



Wait !!... Transformers ?

- What is the relationship among **Software Product Lines** and **Electrical Transformers**?
- Is this the right conference?



Variability Management



Electrical Transformers

SIEMENS





SIEMENS produces
electrical
transformers in
Colombia

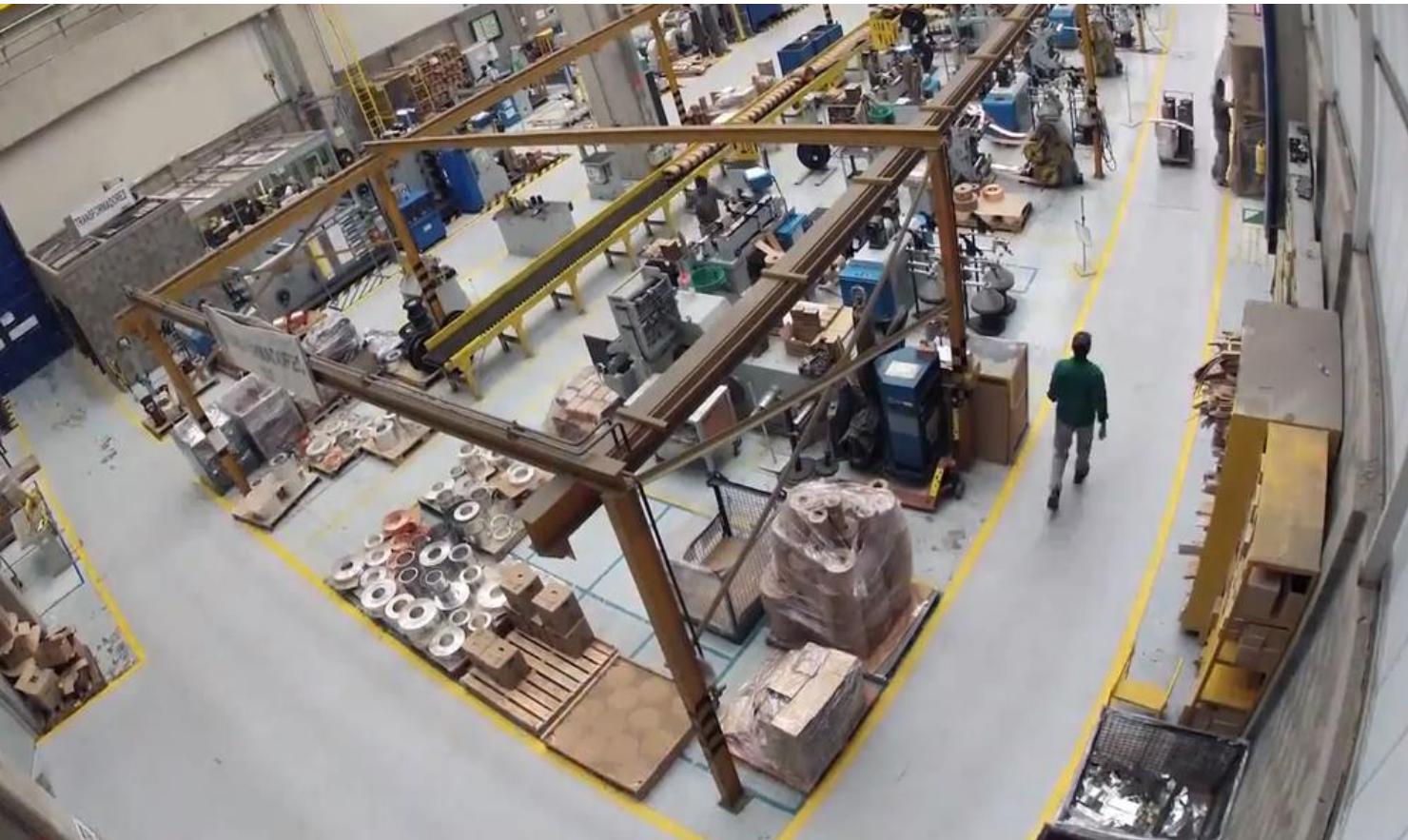
There is a facility
located at 8,5 kms
of the center of
Bogotá



Siemens Transformers

+350 persons

+15000 units/yr.

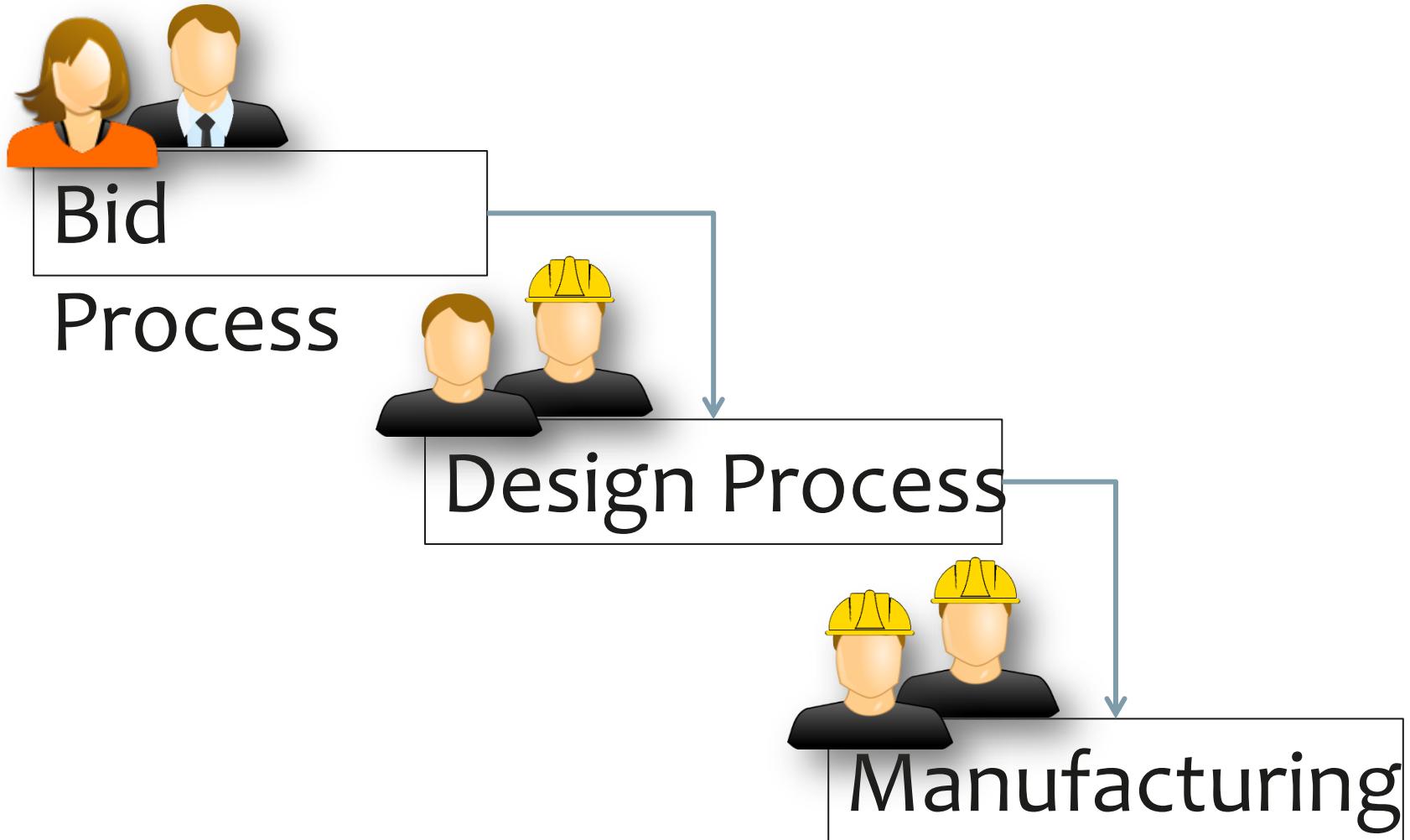




Clients across
all America

**Multiple standards
and norms must be
supported**

**... just for Colombia,
there many national
and proprietary
standards for each
single family.**



Bid Process

I want an electrical
transformer with
Power of 15KVA
a Low Voltage of 214V
and a High Voltage of
4160V
To be installed in
Buenos Aires



Customer
Customer
Requests



Sales Engr
Bid Engr
Bids
Proposals

Bid Process



I want an electrical transformer with Power of 15KVA a Low Voltage of 214V and a High Voltage of 4160V To be installed in Buenos Aires

Customer
Customer Requests



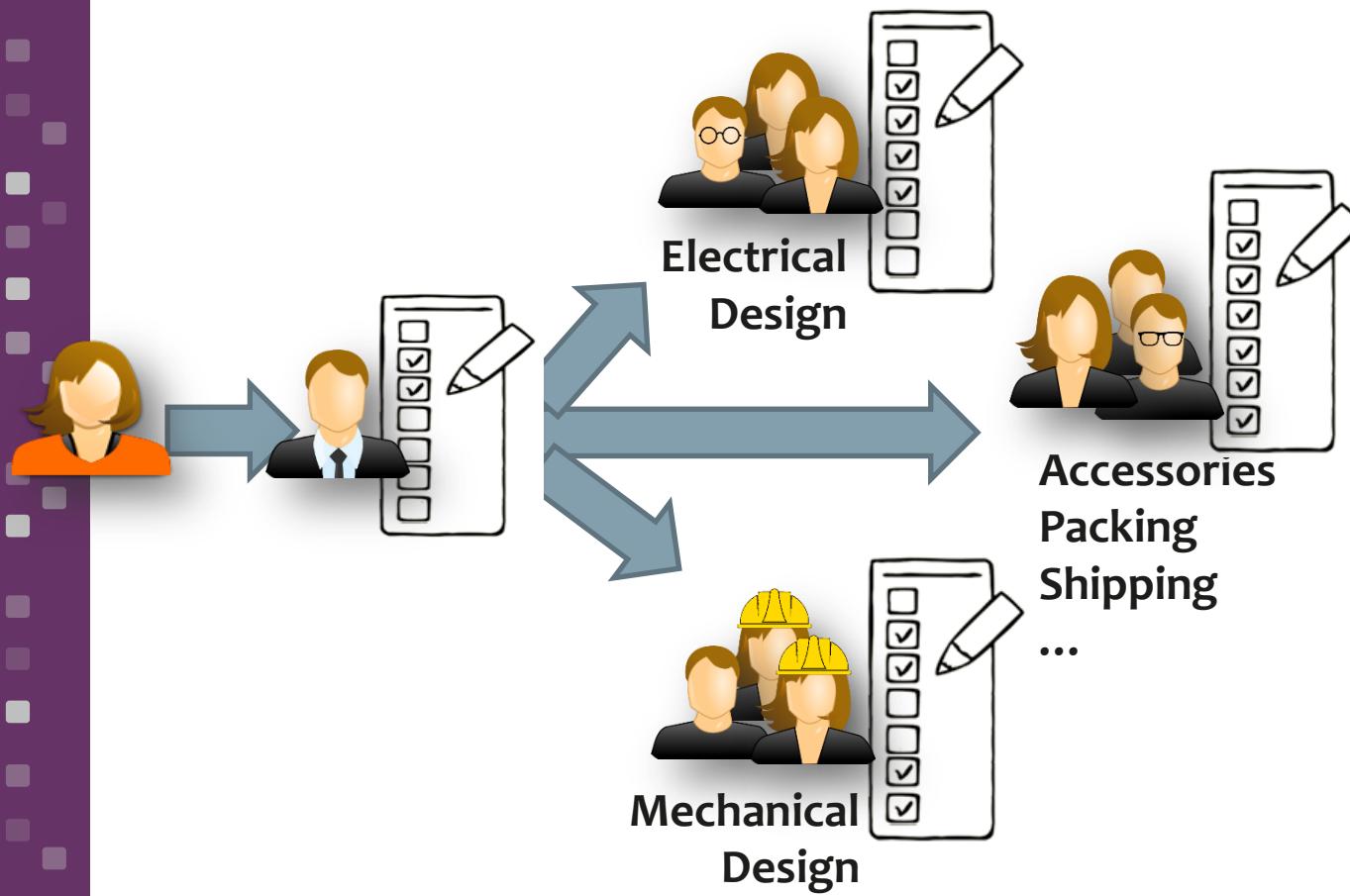
Gotcha !!

Will it be pad-mounted or pole-mounted?

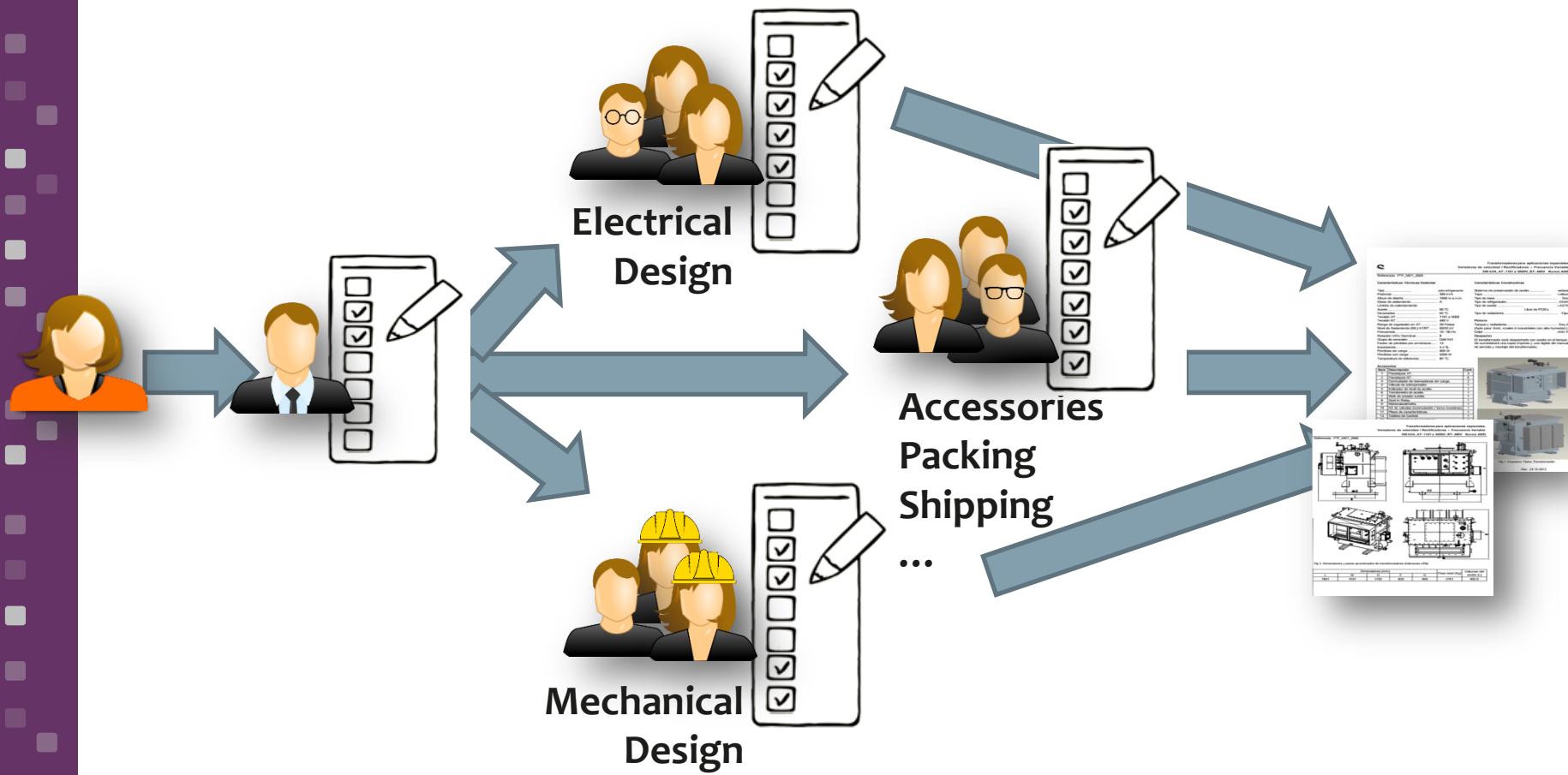
Sales Engr
Bid Engr
Bids
Proposals



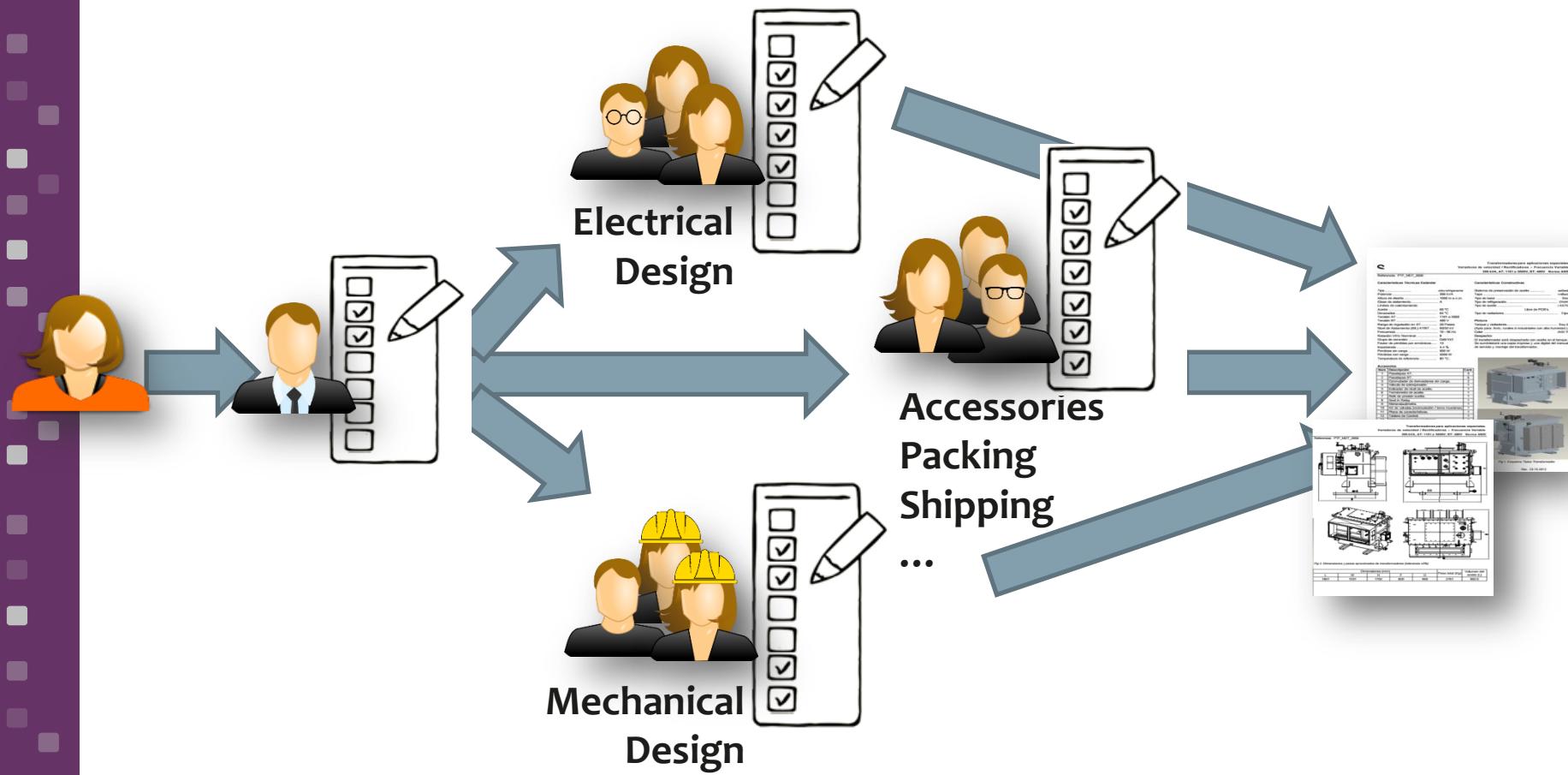
Design Process



Design Process

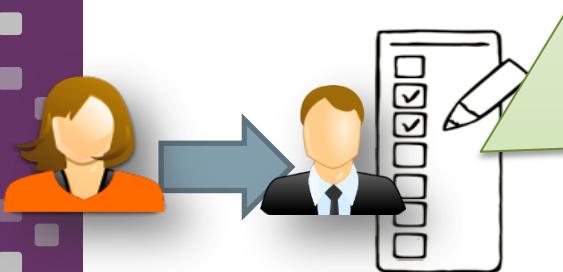


Some Issues to tackle



... for the Sales Engineers

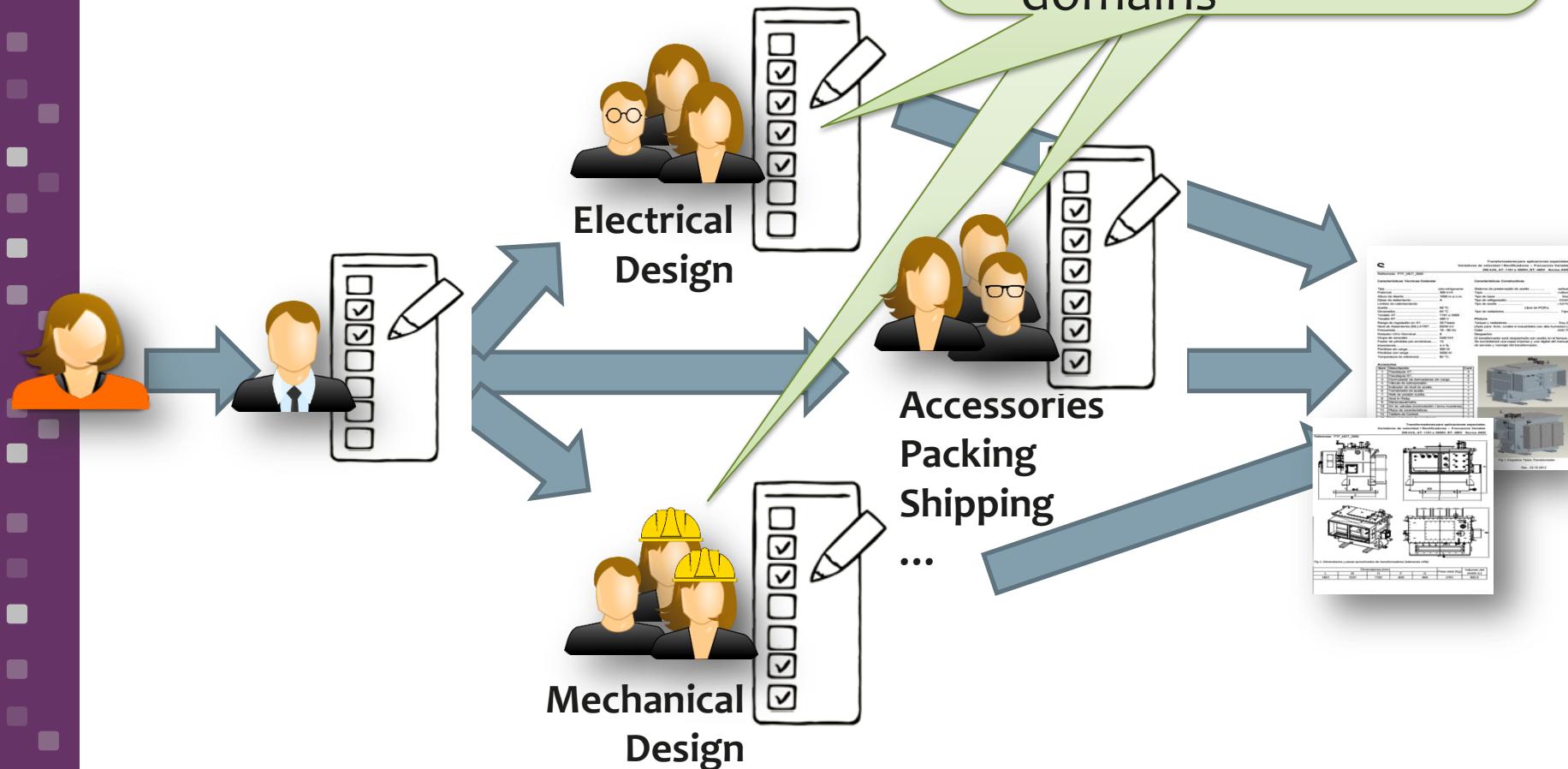
- Detect inconsistencies in the client's requests
- Identify inconsistencies with standards
- Identify already designed similar transformers
- Complete the specification



... for the Engineering Design

Groups

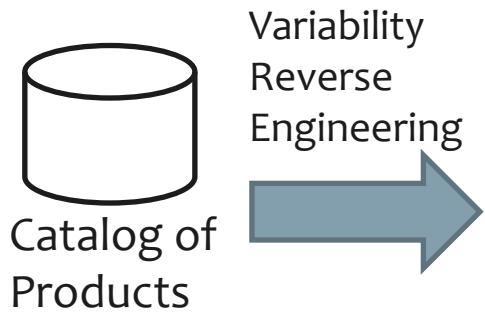
- Detect inconsistencies with decisions in other domains



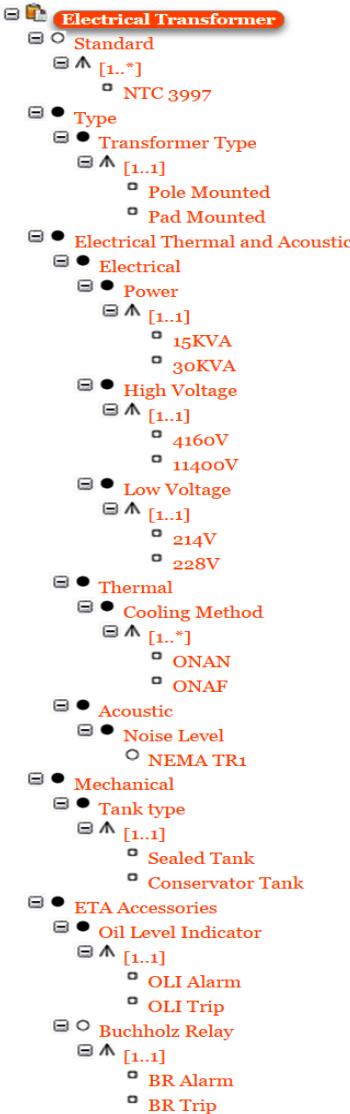
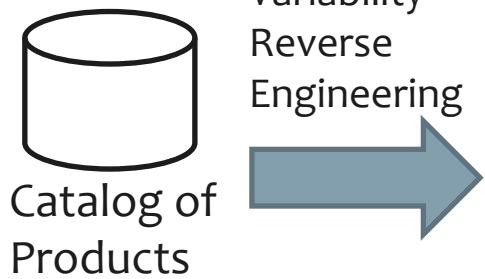
For Early detection of conflicts

Approach: Feature-Based Configuration Process (using a single feature model)

Our First Attempt: A Single Feature Model



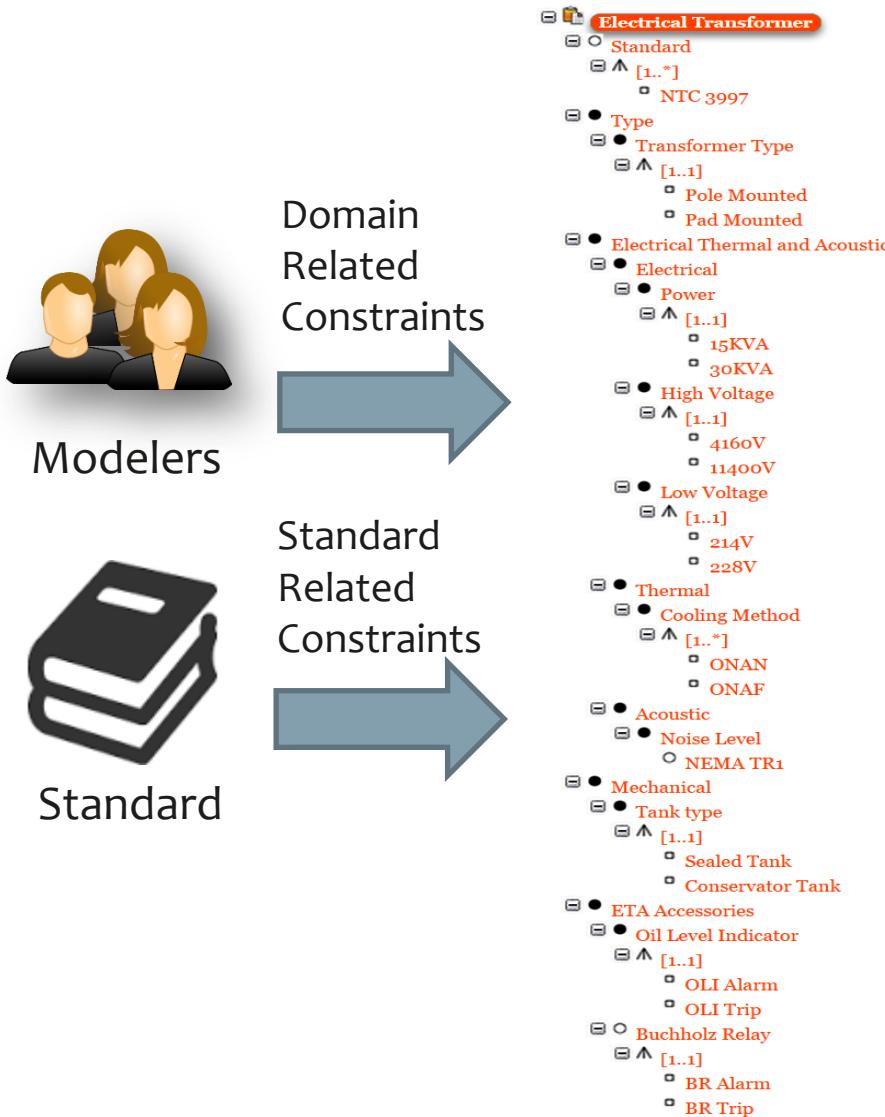
Our First Attempt: A Single Feature Model



This model represents
the existing products...

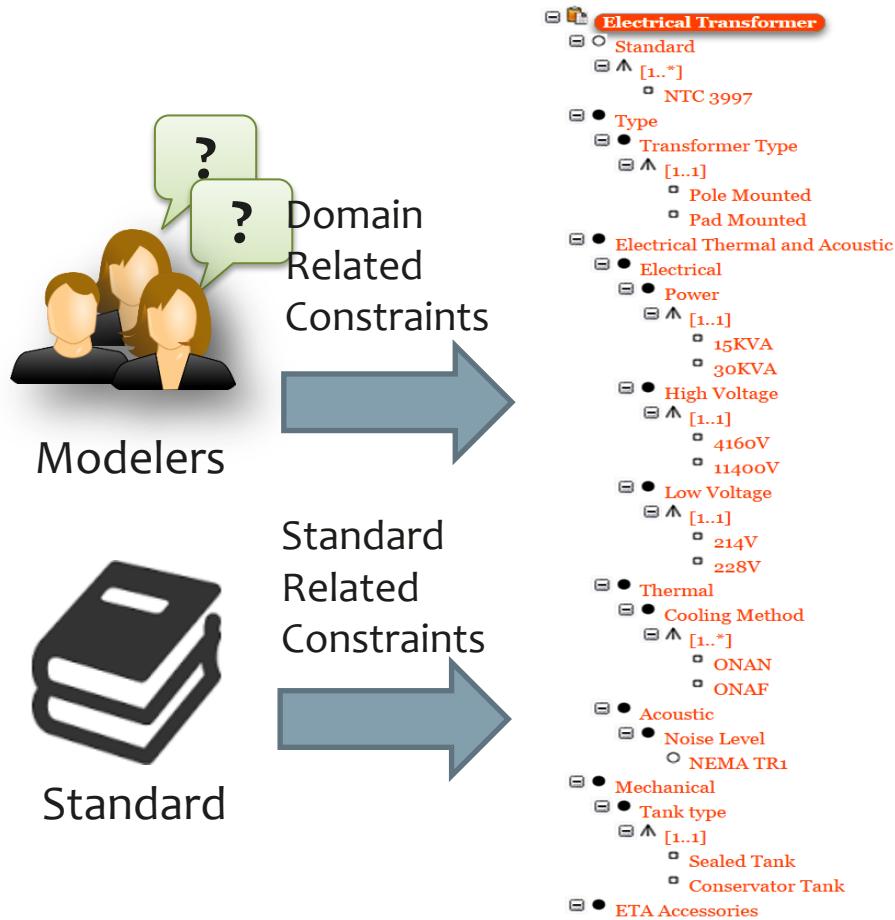
but we want to represent
options to specify
customized
electrical transformers

Our First Attempt: A Single Feature Model



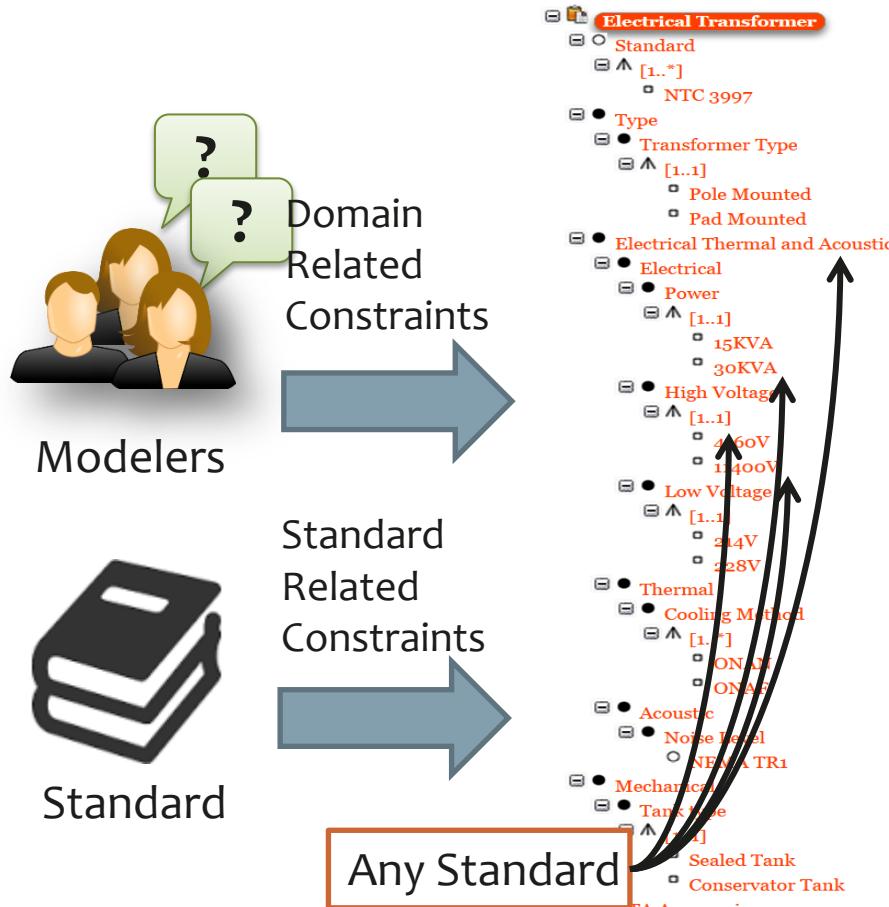
Additional constraints
must be included
to represent domain-
and standards-related
constraints

Our First Attempt: A Single Feature Model



For a single family, with a single standard, we ended with +400 features and +120 cross-tree constraints

Our First Attempt: A Single Feature Model



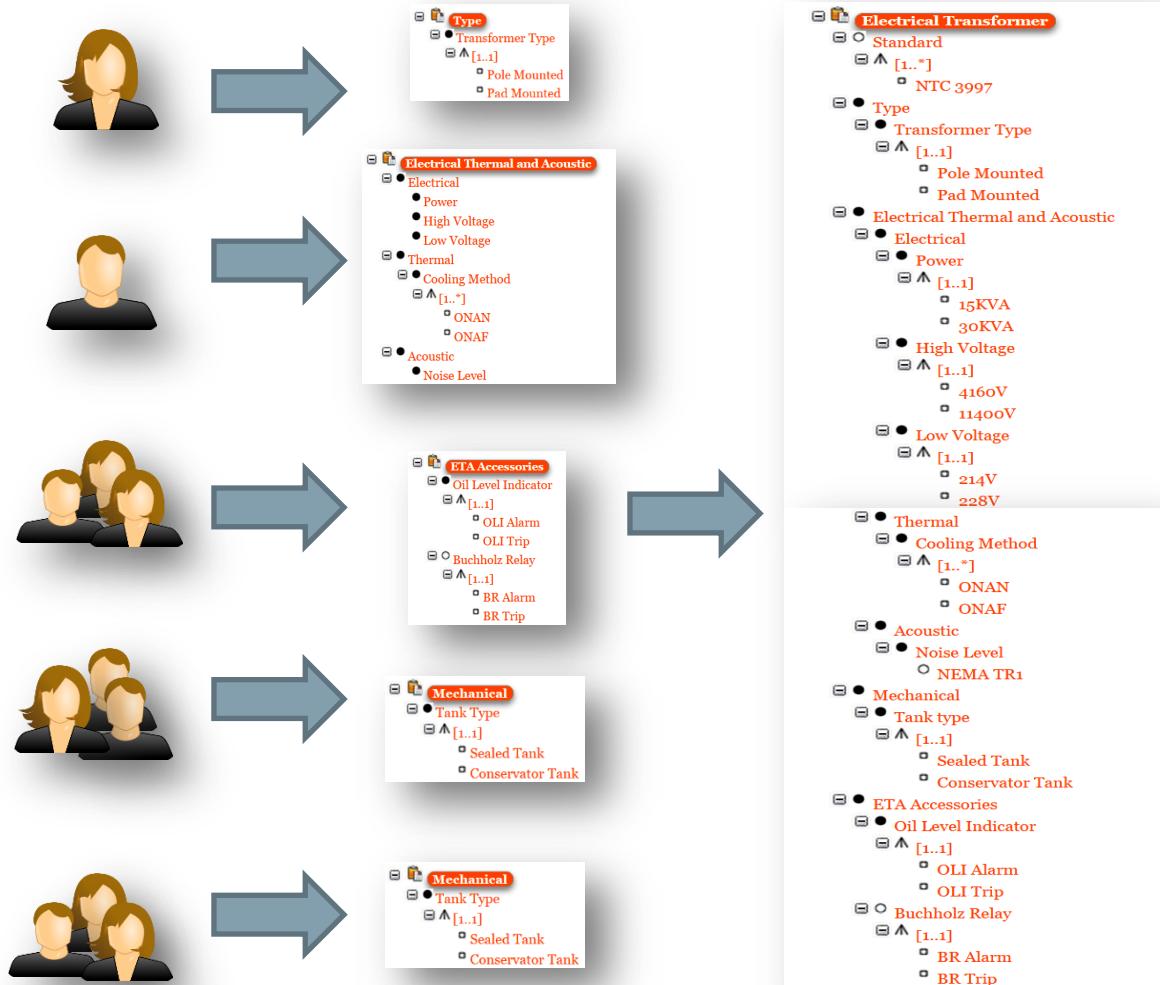
Because each standard imposes different constraints on branches, adding a new standard was a challenge

**Trying to create
a single feature model
did not help us
to define, review and analyze
the features in each domain,
the inter-domain constraints and
the cross-cutting constraints defined by
the diverse standards.**

A Revisited Approach: Using Multiple Feature Models to represent the configuration options

A Revisited Approach

- 1 Separation of Domains
- 2 Model each domain
- 3 Model inter-domain relationships
- 4 Model standards
- 5 Merge the Models
- 6 Analysis and User Validation



1 Separation of Domains

System

Installation

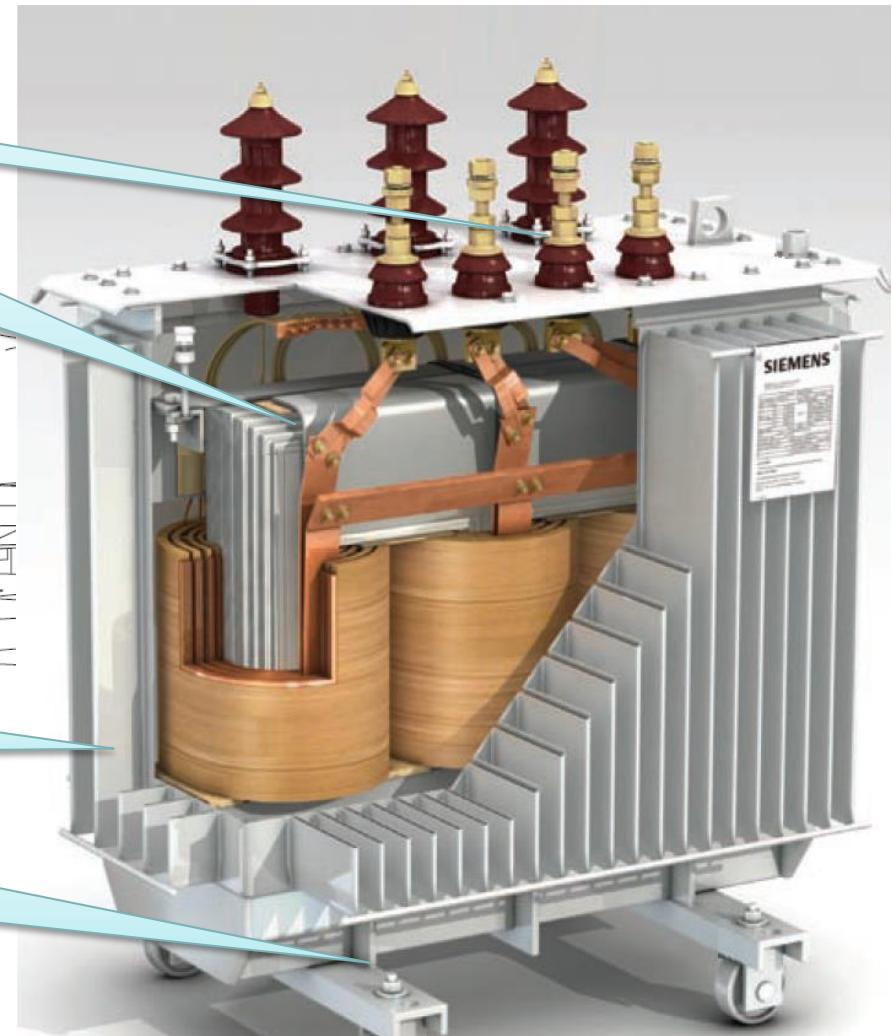
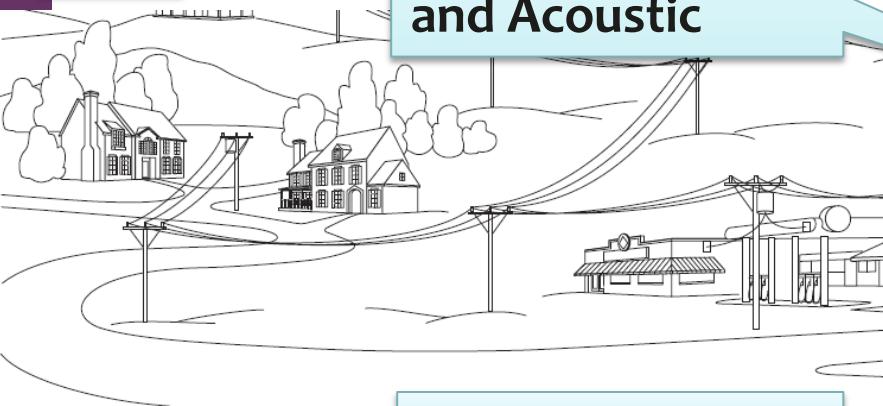
Type

ETA Accessories

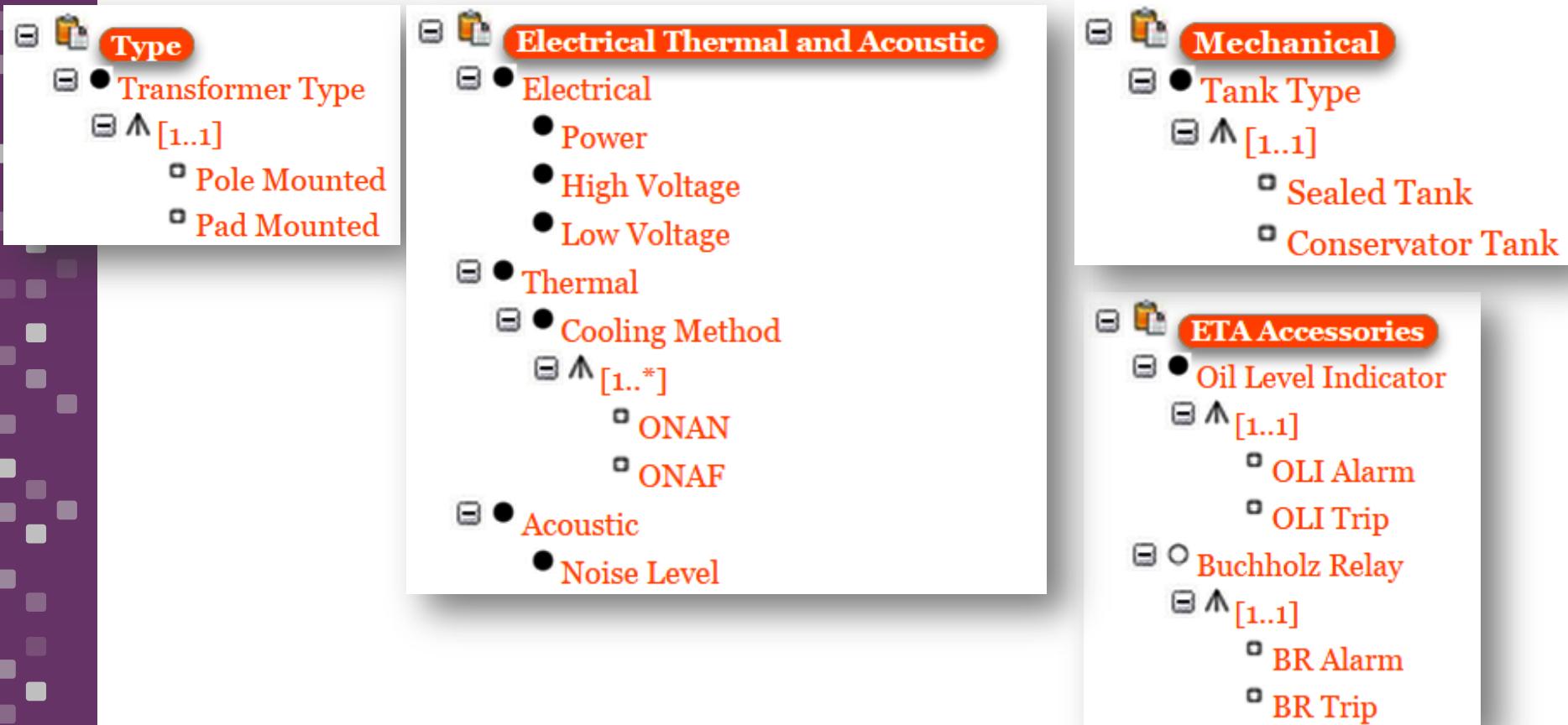
Electrical, Thermal
and Acoustic

Mechanical

Mechanical
Accessories

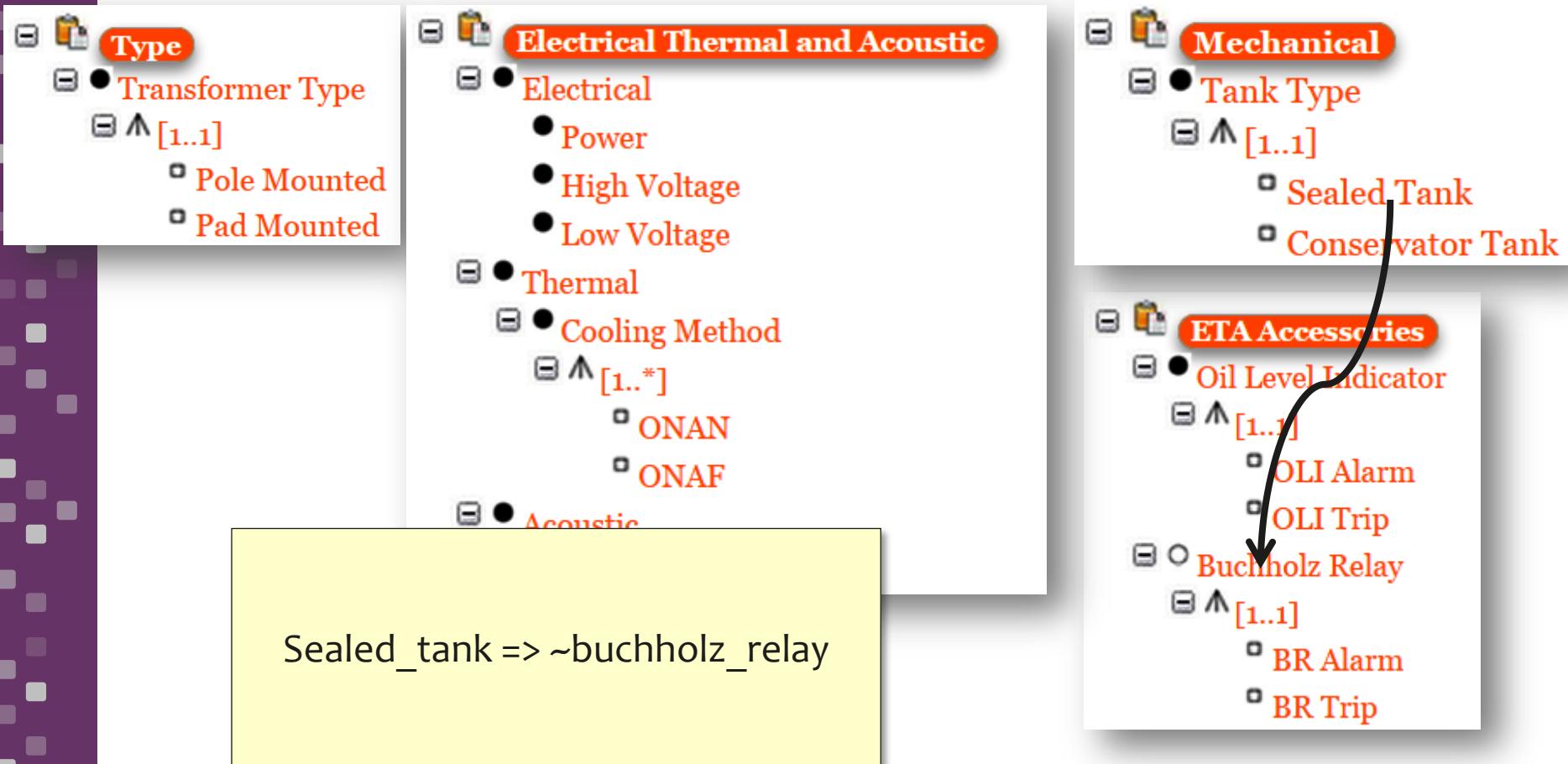


2 Model each domain

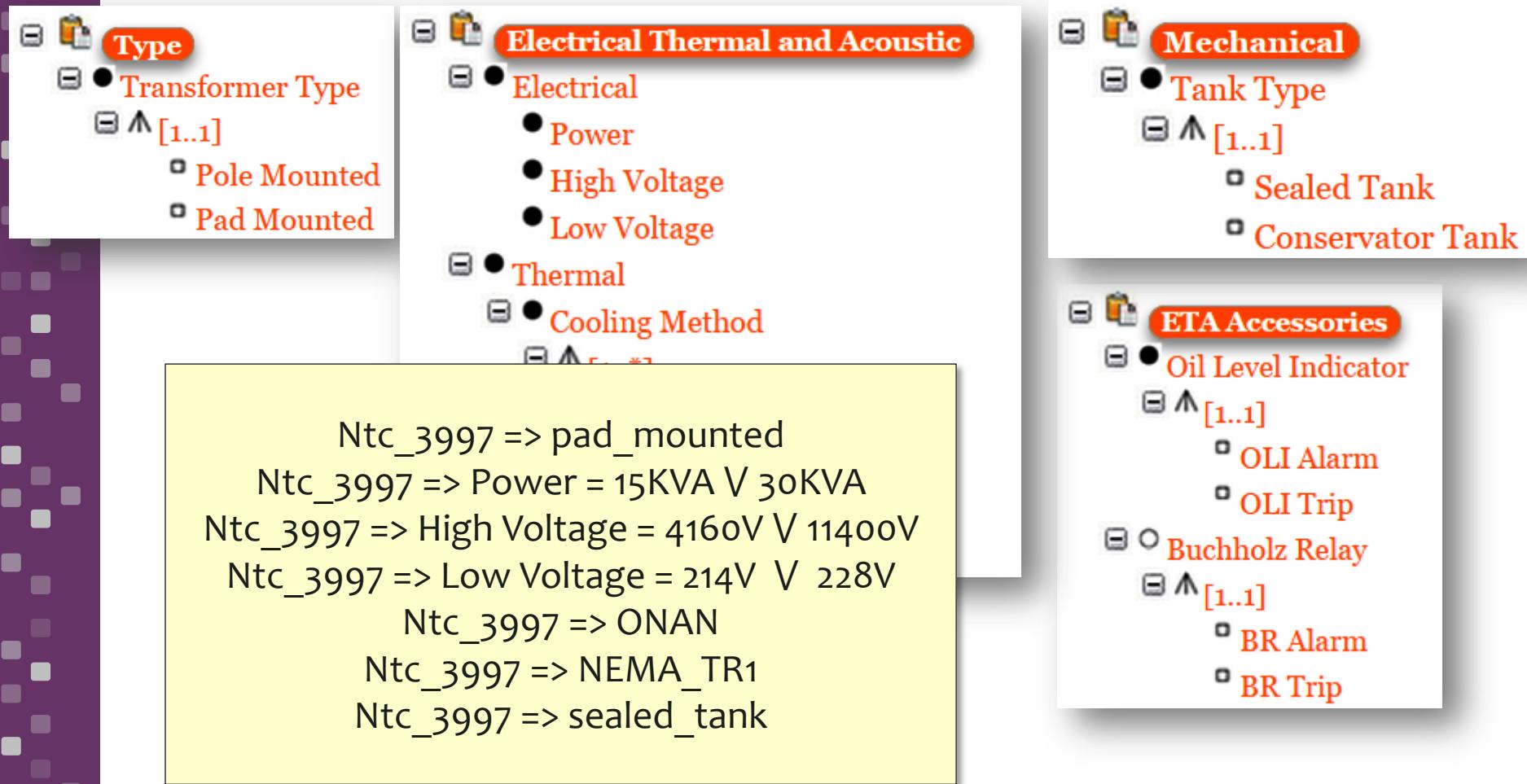


They were easier to build, understand and review by modelers

3 Model Inter-domain relationships



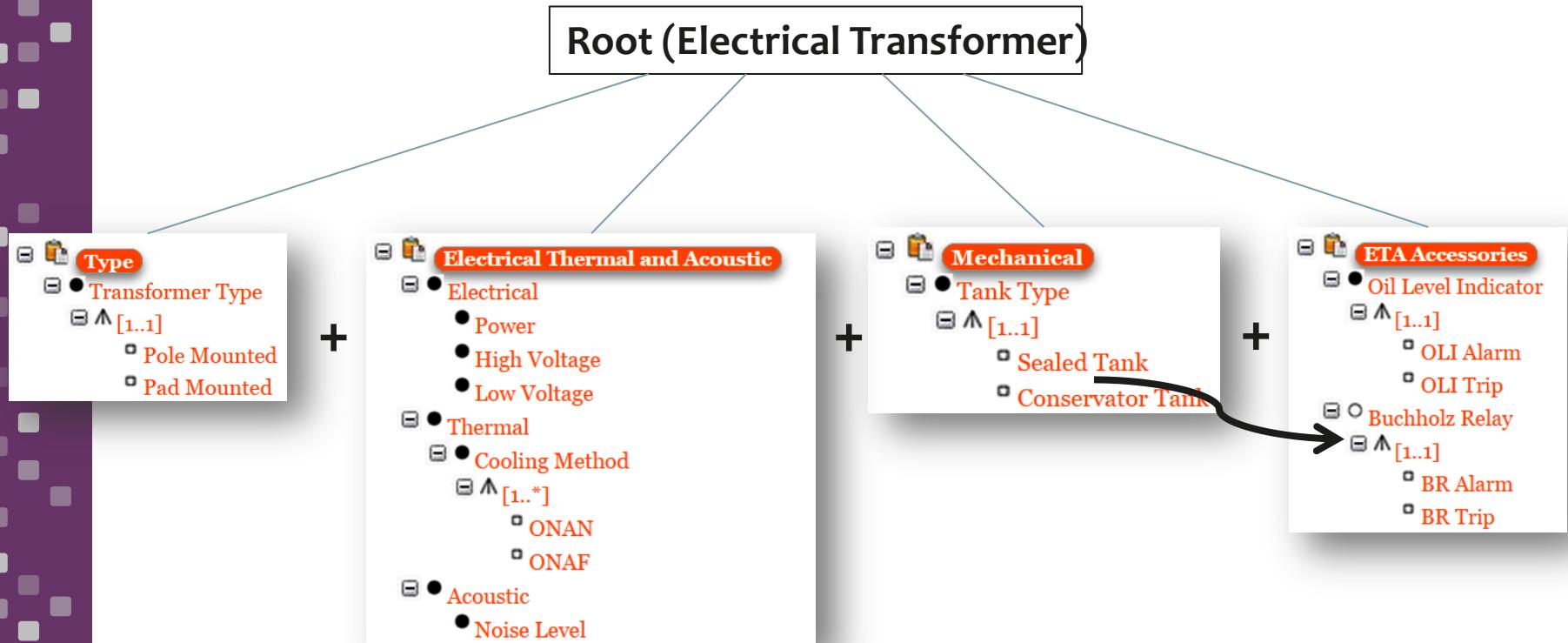
4 Modeling of Standards



5 Merge Feature Models - Domains



5 Merge Feature Models - Domains

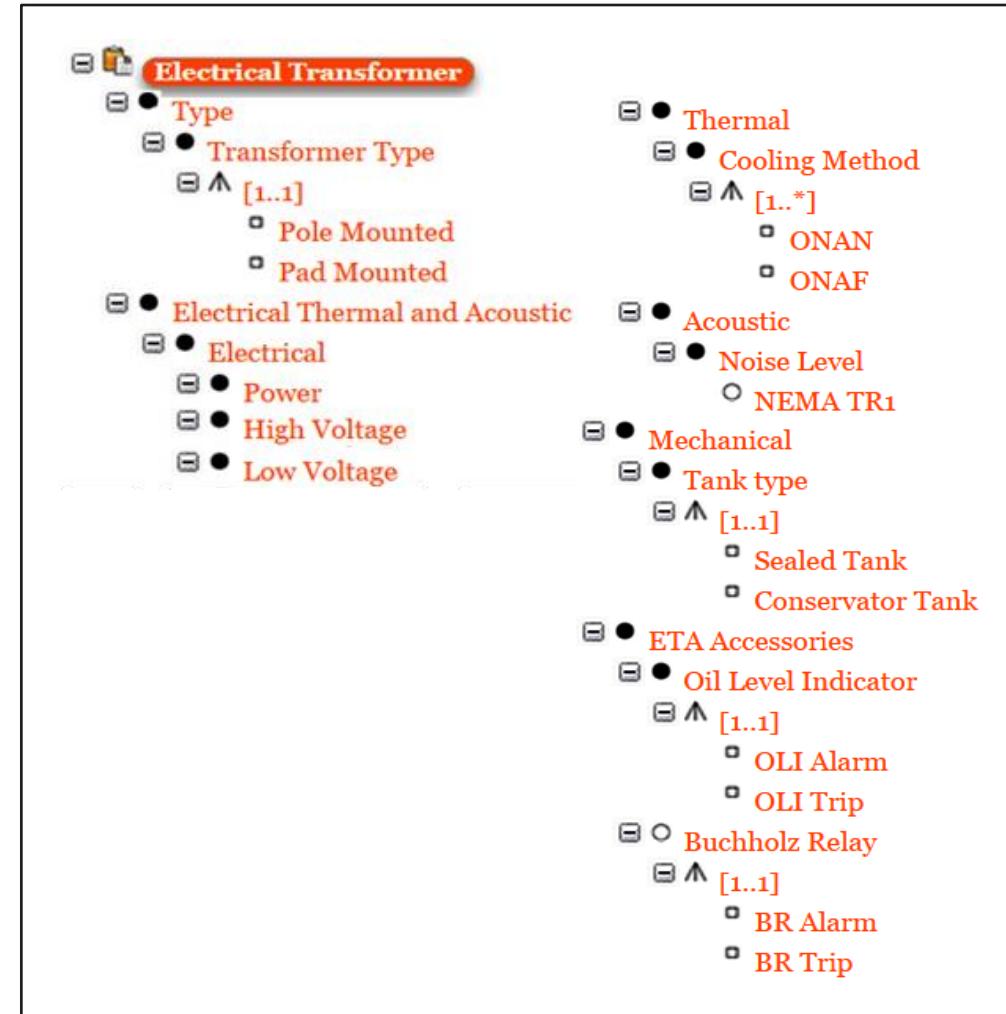


5 Merge Feature Models - Standards

Ntc_3997

- => pad_mounted
- => Power = 15KVA V 30KVA
- => High Voltage = 4160V V 11400V
- => Low Voltage = 214V V 228V
- => ONAN
- => NEMA_TR1
- => sealed_tank

+

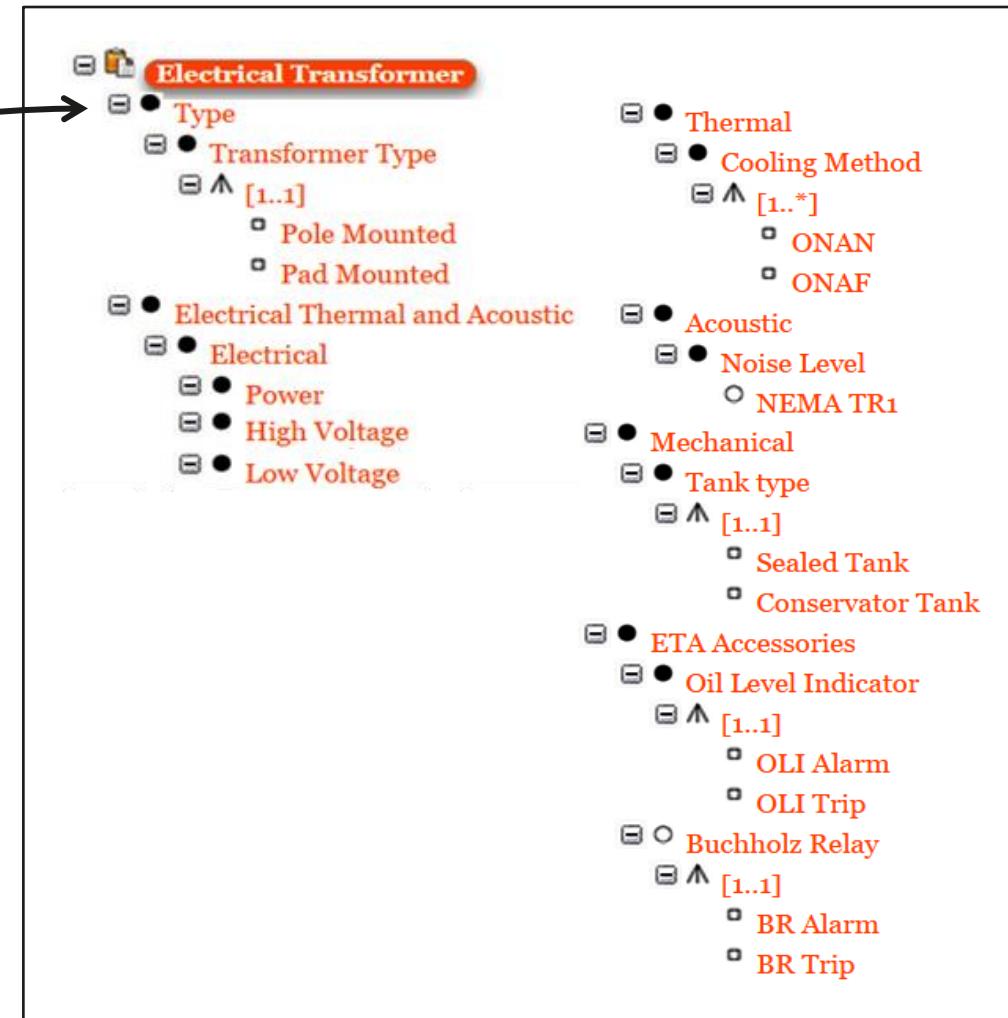


5 Merge Feature Models - Standards

Add an standard

Ntc_3997
=> pad_mounted
=> Power = 15KVA V 30KVA
=> High Voltage = 4160V V 11400V
=> Low Voltage = 214V V 228V
=> ONAN
=> NEMA_TR1
=> sealed_tank

+

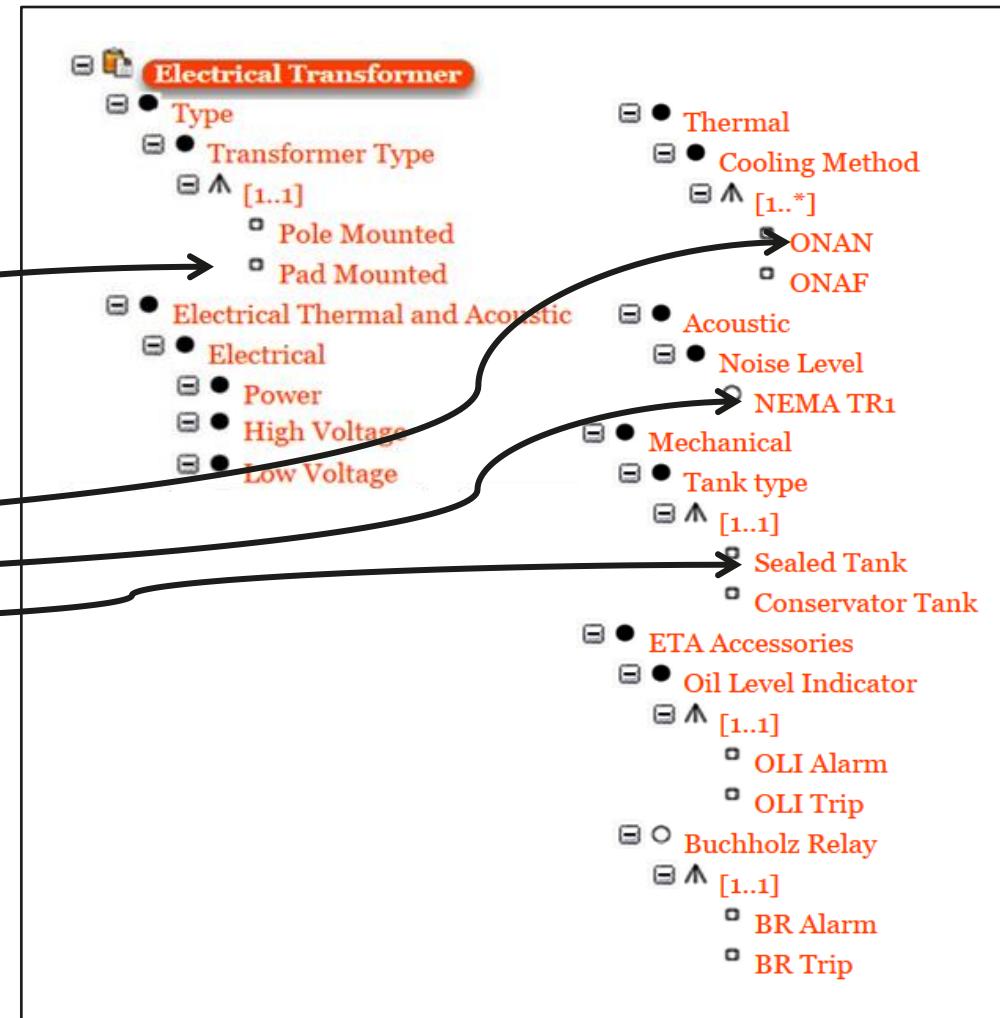


5 Merge Feature Models - Standards

Introduce constraints

Ntc_3997

=> pad_mounted
=> Power = 15KVA V 30KVA
=> High Voltage = 4160V V 11400V
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=> ONAN
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=> sealed_tank

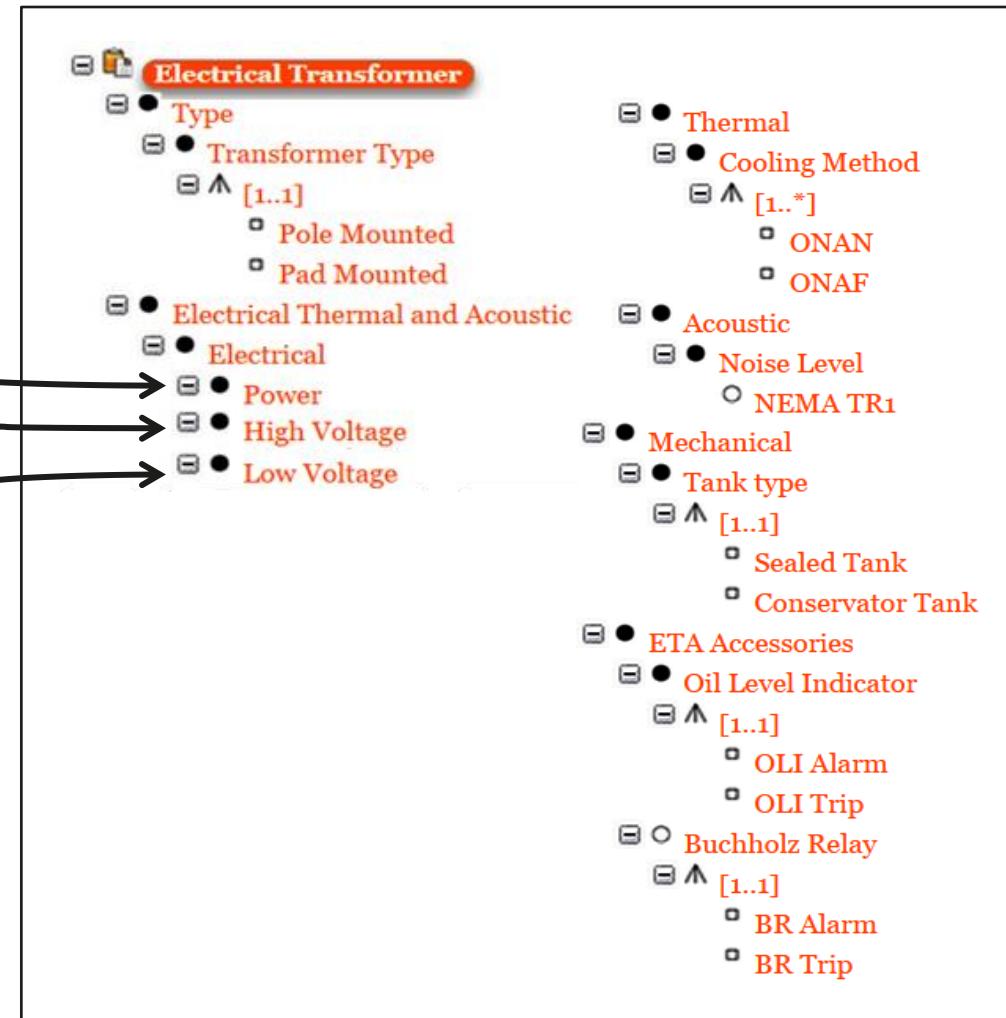


5 Merge Feature Models - Standards

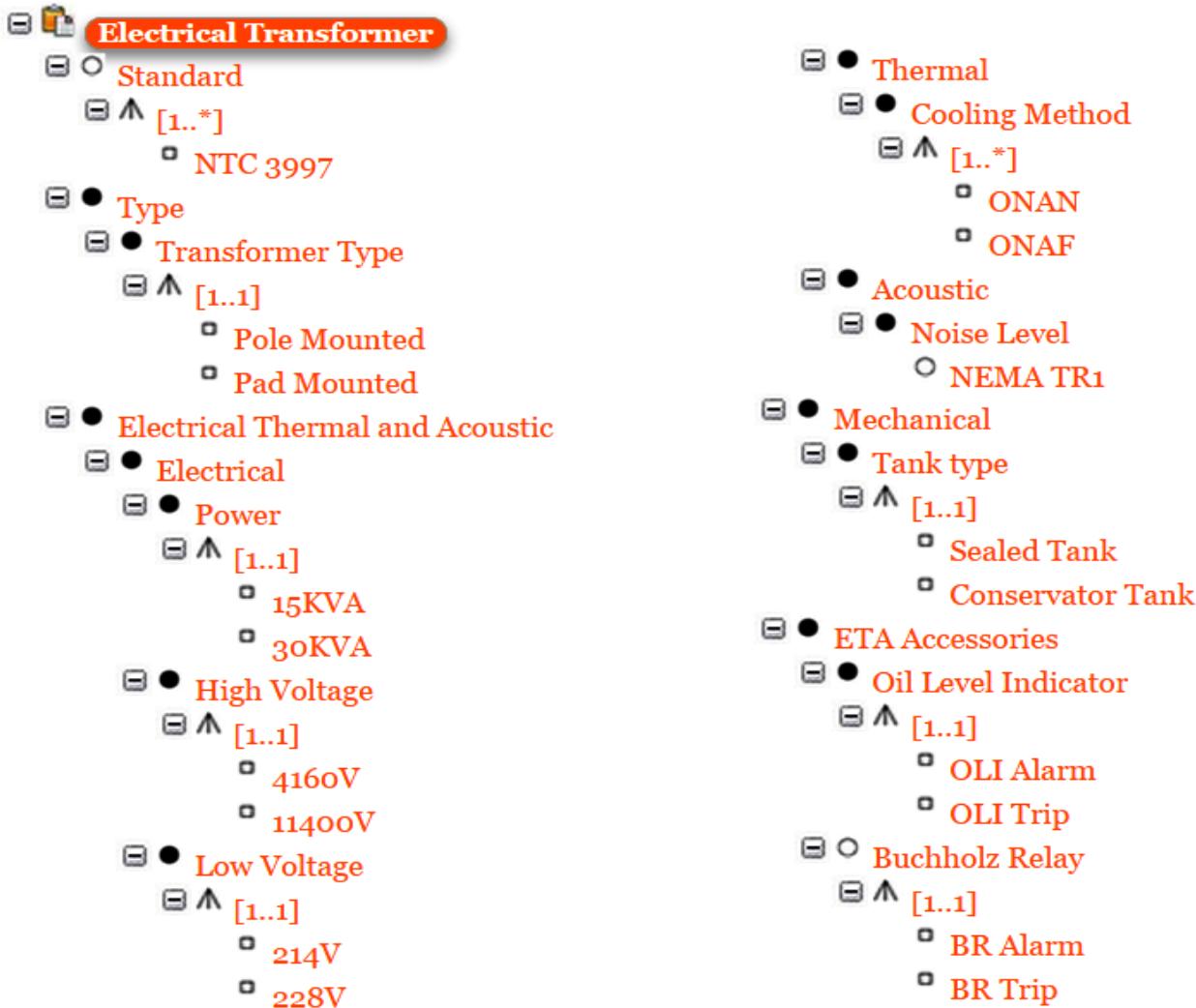
Add values and constraints

Ntc_3997

=> pad_mounted
=> Power = 15KVA V 30KVA
=> High Voltage = 4160V V 11400V
=> Low Voltage = 214V V 228V
=> ONAN
=> NEMA_TR1
=> sealed_tank



5 Merge Feature Models - Standards



6 Analysis and User Validation

Continuous Validation/Testing of the Models

- Peer-review



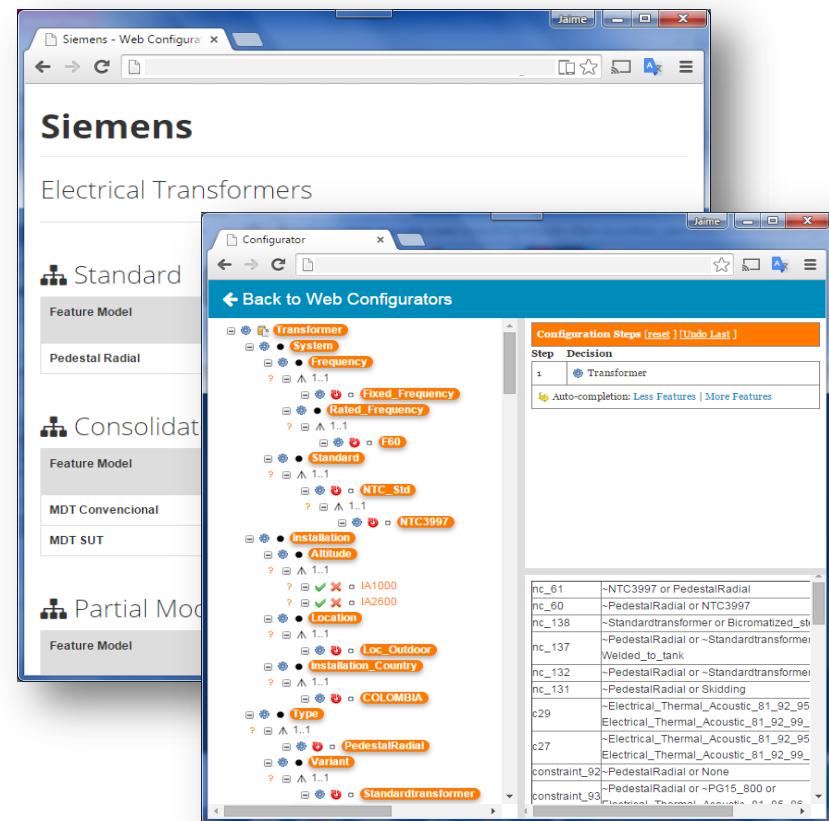
- Automated analysis
- Tests using products from the existing catalogs

CATALOGO MDT 2050 - 2069.xls [Compatibility Mode] - Microsoft Excel									
	A	B	C	D	E	F	G	H	I
Z	ID	1	2	3	4	5	6	7	8
1 DATOS PORTAFOLIO DE TRANSFORMADORES SAT									
3	Período	LÍNEA	Referencia s Standard	SAP SA Fas.	SAP SH Fas.	SPRIBER SA Fas.	SPRIBER SHF Fas.	Ref Cliente	
4	2050	MDT	0	0	0	0	1001231011 EL INGENIERO	7062	ICONTE
5	2001	MDT	0	0	0	0	1001231045 FONTELCO	7030	ICONTE
6	2002	MDT	0	0	0	0	1001234176 Cemento San Marcos	6180	ICONTE
7	2003	MDT	0	2.5E+10	0	0	1001234187 CEMENTO SANTO DOMINGO	7110	ICONTE
8	2004	MDT	0	0	0	0	1001233803 Industria y Comercio	6647	ICONTE
9	2005	MDT	0	0	0	0	1001232840 INDUSTRIAS Y COMERCIO	6647	ICONTE
10	2006	MDT	0	2.5E+10	0	0	1001232824 Medidas Eléctricas	7602	ICONTE
11	2007	MDT	0	2.6E+10	0	0	1001232832 DI TECNODAMA	7190	ICONTE
12	2008	MDT	0	0	0	0	1001232833 Fisa Italia	7718	ICONTE
13	2009	MDT	0	2.5E+10	0	0	1001232834 FONTELCO	7235	ICONTE
14	2010	MDT	0	0	0	0	1001232835 FONTELCO	7235	ICONTE
15	2011	MDT	0	0	0	0	1001232836 Proteles	6755	ICONTE
16	2012	MDT	0	0	0	0	1001232837 PROTELES	7230	ICONTE
17	2013	MDT	0	0	0	0	1001232843 Medidas Eléctricas	7534	ICONTE
18	2014	MDT	0	0	0	0	1001232844 PROTELES	7650	ICONTE
19	2015	MDT	0	0	0	0	1001235170 Aeronca Misionero	7780	ICONTE
20	2016	MDT	0	0	0	0	1001235171 Aeronca Misionero	7890	ICONTE
21	2017	MDT	0	0	0	0	1001235172 Aeronca Misionero	7900	ICONTE
22	2018	MDT	0	0	0	0	1001635436 Inomega	6839	ICONTE
23	2019	MDT	0	0	0	0	1001635437 INOMEGA	6420	ICONTE
24	2020	MDT	0	0	0	0	1001523100 CONTELCO	8319	ICONTE
25	2021	MDT	0	0	0	0	1001523101 CONTELCO	7800	ICONTE
26	2022	MDT	0	0	0	0	1001523102 CONTELCO	8917	ICONTE
27	2023	MDT	0	2.6E+10	0	0	1001523103 CONTELCO	8218	ICONTE
28	2024	MDT	0	0	0	0	1001523104 CONTELCO	8918	ICONTE
29	2025	MDT	0	2.5E+10	0	0	1001524646 UNICENTRO	7201	ICONTE
30	2026	MDT	0	2.5E+10	0	0	1001524647 UNICENTRO	7101	ICONTE
31	2027	MDT	0	2.5E+10	0	0	AMT250000001 OLEOPATRIZ	6535	ICONTE
32	2028	MDT	0	2.5E+10	0	0	AMT250000002 OLEOPATRIZ	7055	ICONTE
33	2029	MDT	0	2.5E+10	0	0	AMT250000014 ALFAKER DEL CARIBE	7548	ICONTE
34	2030	MDT	0	2.5E+10	0	0	AMT250000015 ALFAKER DEL CARIBE	7548	ICONTE
35	2031	MDT	0	2.5E+10	0	0	AMT250000017 INGEMERC	7688	ICONTE
36	2032	MDT	0	2.5E+10	0	0	AMT250000047 INGEMERC	7026	ICONTE
37	2033	MDT	0	2.5E+10	0	0	AMT250000048 INGEMERC	7027	ICONTE
38	2034	MDT	0	0	0	0	AMT250000051 INGEMERC	6518	ICONTE
39	2035	MDT	0	2.5E+10	0	0	AMT250000052 INGEMERC	7120	ICONTE
40	2036	MDT	0	2.5E+10	0	0	1001235011 OVOCOL	6230	ICONTE
41	2037	MDT	0	2.5E+10	0	0	1001235012 OVOCOL	6230	ICONTE
42	2038	MDT	0	2.5E+10	0	0	1001523200 INGEMERC	6131	ICONTE
43	2039	MDT	0	2.5E+10	0	0	1001523320 CORREDOR	7110	ICONTE
44	2040	MDT	0	2.5E+10	0	0	1001523333 INGEMERC	7055	ICONTE
45	2041	MDT	0	2.5E+10	0	0	AMT250000014 FRIGORIFICO Y ALMACENES	6556	ICONTE
46	2042	MDT	0	2.5E+10	0	0	AMT250000015 FRIGORIFICO Y ALMACENES	7055	ICONTE
47	2043	MDT	0	2.5E+10	0	0	1001235173 DISICO	7740	ICONTE
48	2044	MDT	0	2.5E+10	0	0	1001235174 DISICO	7740	ICONTE
49	2045	MDT	0	2.5E+10	0	0	1001235175 DISICO	7740	ICONTE
							PERENCIO 6308VA SUT	8583	ANSI

Tool Support

Our tools use/extend
SPLIT...

- Create Feature Models from standards
- Merge Feature Models
- Analyze single and merged Feature Models
- Configure multiple feature models
- Perform tests and validations



Some Lessons Learned and Conclusions

Lesson Learned

① Modeling

- Using a single feature model is tough
- Multiple feature models facilitates the modeling
- The separation of domains is an iterative process
- Each standard can be modeled independently
- Incremental modeling facilitates the work

domains : 10 – 123 features

standards: 69 – 71 features



Lesson Learned

② Models Validation

- Incremental modeling → Continuous Testing
- We can test the models using product catalogs and reviews

③ Tools

- Existing tools has limited support to multiple FMs
- Partial configurations can be used to lead the process

④ Impact on other Processes

- This allowed engineers to define and enforce standards in the company



Questions?

Jaime Chavarriaga, Uniandes

ja.chavarriaga908@uniandes.edu.co