a demonstration on knowledge-based control system design

Wim Pessemier ICALEPCS 2015 Melbourne

- What are semantic models?
- Where to apply them?
- How to apply them?
- How to build them?
- How to use them?
- Conclusions



• What are semantic models?

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- Models that describe
 - pieces of information (data, descriptions)
 - their relations

• What are semantic models?

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- Models that describe
 - pieces of information (data, descriptions)
 - their relations **meaning (semantics)**

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socket_Y

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plug_X	socket_Y
hasType	hasType
Plug	Socket

GENERIC	
hasType	

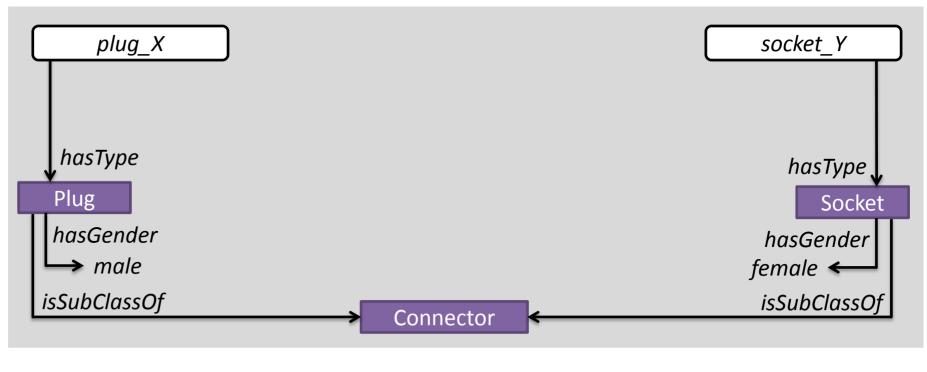
ELECTRIC	
Plug	
Socket	

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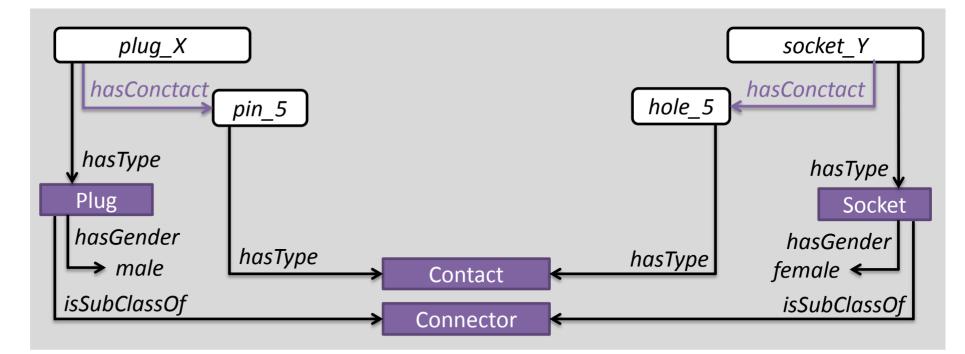
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8

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GENERIC		_	ELECTRIC	
hasType hasGender	isSubClassOf		Plug Socket	Connector hasContact

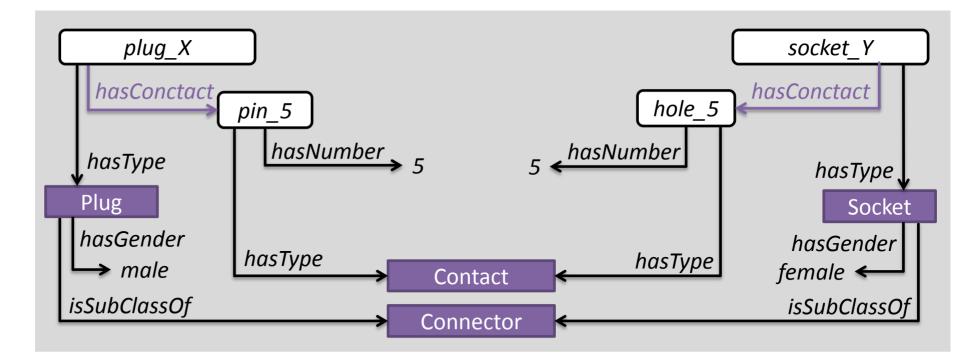
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Contact

GENERIC		_	ELECTRIC	
hasType	isSubClassOf		Plug	Connector
hasGender	hasNumber		Socket	hasContact

• What are semantic models?

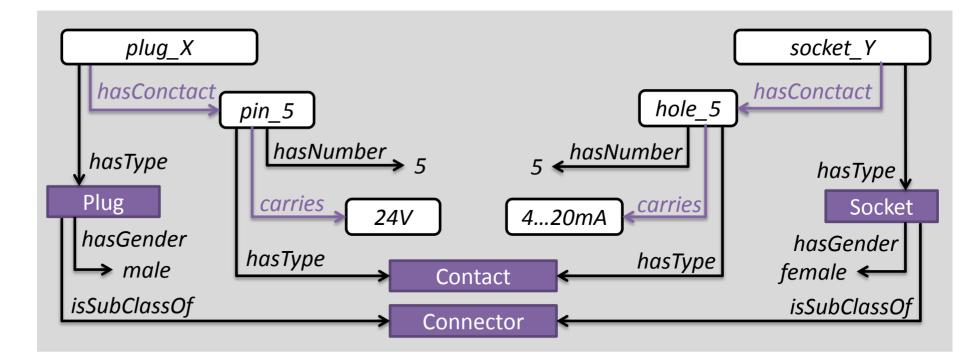
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10

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Contact *carries*

GENERIC		ELECTRIC	
hasType hasGender	isSubClassOf hasNumber	Plug Socket	onnector asContact

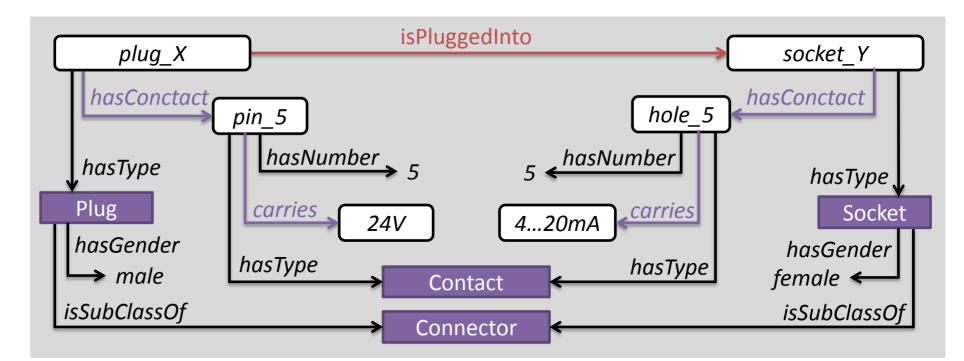
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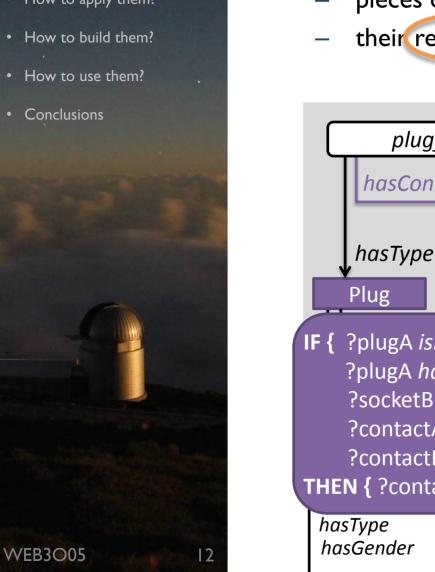
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- Models that describe
 - pieces of information (data, descriptions)
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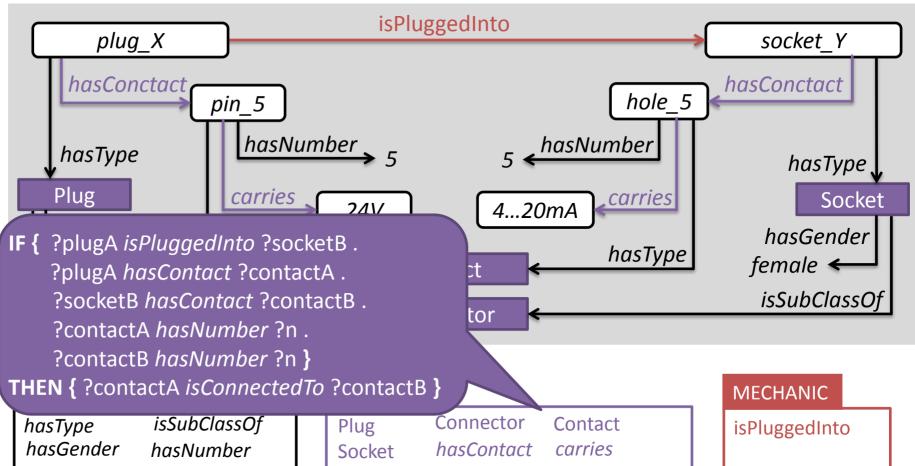


GENERIC		ELECTRIC			_	MECHANIC
hasType hasGender	isSubClassOf hasNumber	1108	onnector <i>asContact</i>	Contact carries		isPluggedInto

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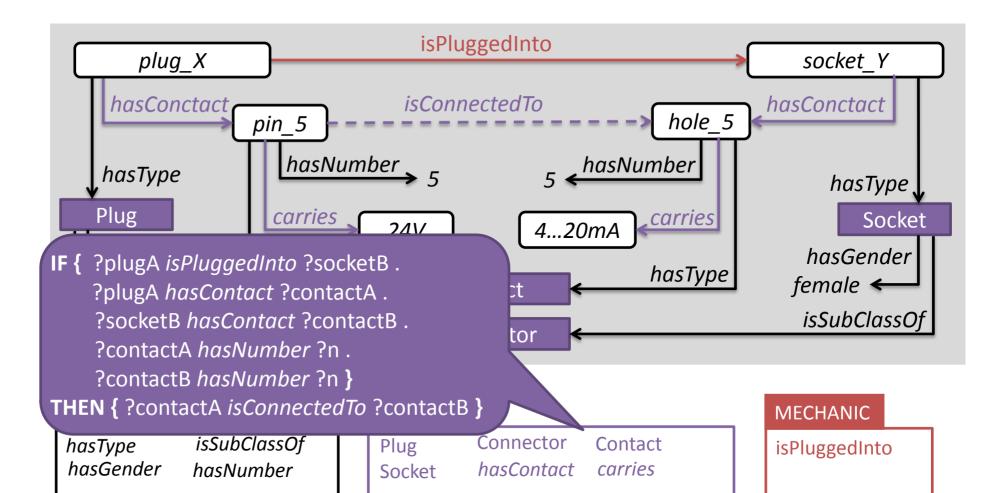


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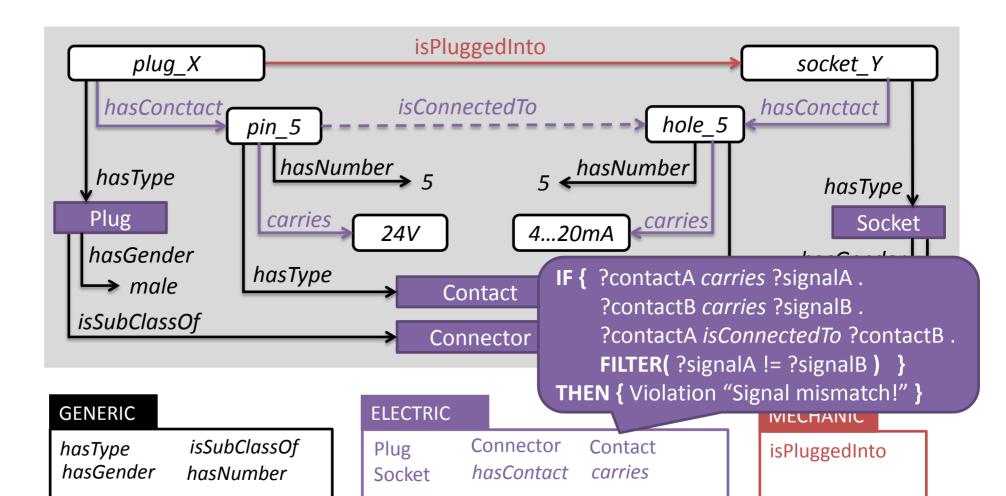


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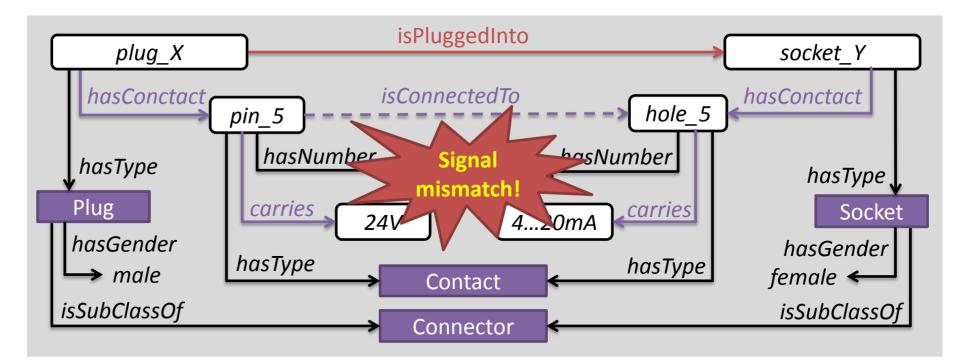
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15

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Where to apply them?

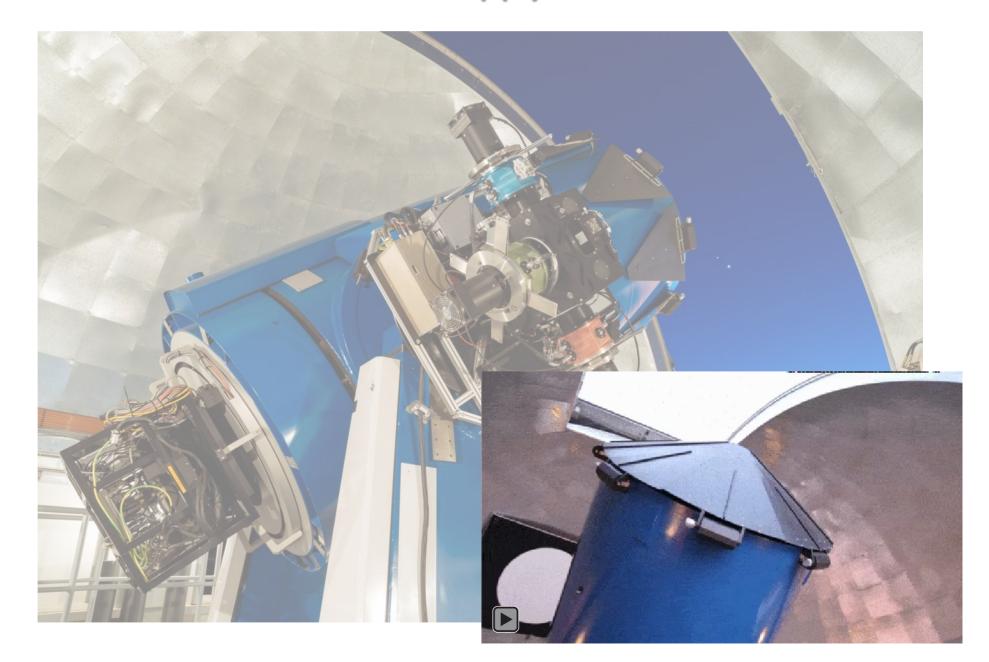


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Where to apply them?



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How to apply them?



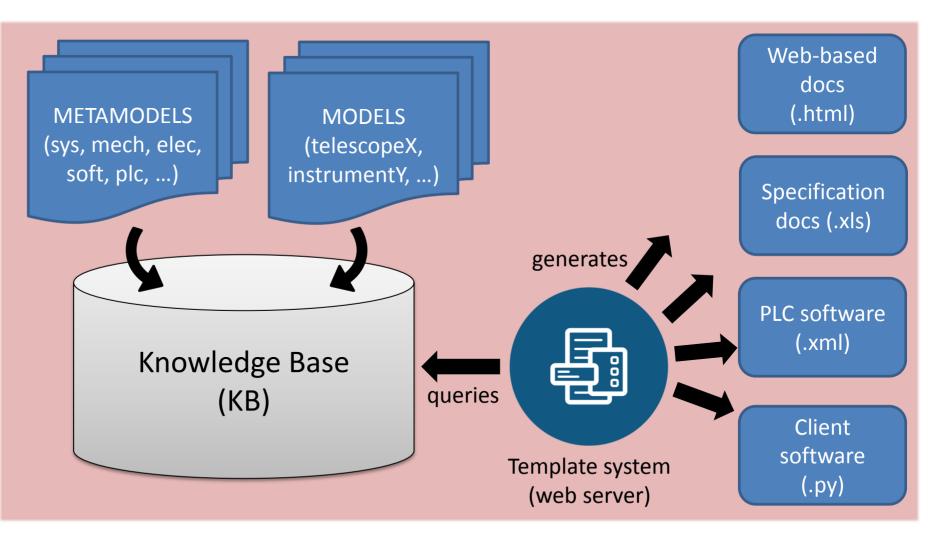
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How to apply them?

Put them in a Knowledge Base and extract information!



OntoManager

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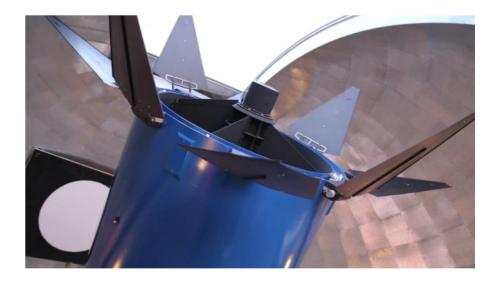
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How to build them?

- Using an existing modeling language?
 - UML, SysML, ... : semantics not sufficiently formal
 - Modeling languages have no
 "programming" capabilities
 (loops, functions, if-then, ...)

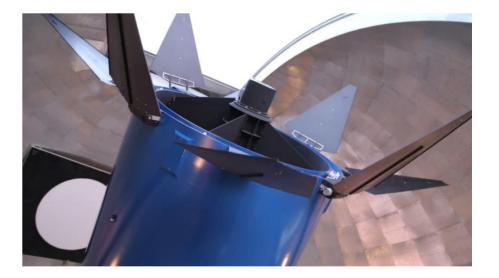


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- Using a Domain Specific Language (DSL)?
 - Internal DSL called Ontoscript
 - Based on coffeescript (~javascript)
 - Idea "adopted" from the Giant Magellan Telescope project [1]

[1] J. M. Filgueira, "GMT software and controls overview", Proc. SPIE 8451, Amsterdam, July 2012, 845111

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Example: model of an I/O module **type**

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How to build them?

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Example: model of an I/O module **type**

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Example: model of an I/O module **instance**

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 http://mercator.iac.es/onto/models/external/harting 	121 1: -> symbol: "TC:T1:SSISTS", comment: "Top 1 SSI status", isConnectedTo: cover_elec.connectors.T1.pins[13] 122 2: -> symbol: "TC:T2:SSISTS", comment: "Top 2 SSI status", isConnectedTo: cover_elec.connectors.T2.pins[13]
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 http://mercator.iac.es/onto/models/external/maxon 	124 4: -> symbol: "TC:T4:SSISTS", comment: "Top 4 SSI status", isConnectedTo: cover elec.connectors.T4.pins[13]
 http://mercator.iac.es/onto/models/external/phoenix 	125 5: -> symbol: "TC:B1:SSISTS", comment: "Bottom SSI status", isConnectedTo: cover_elec.connectors.B1.pins[13]
 http://mercator.iac.es/onto/models/external/prehkeytec 	126 6: -> symbol: "TC:B2:SSISTS", comment: "Bottom SSI status", isConnectedTo: cover_elec.connectors.B2.pins[13] 127 7: -> symbol: "TC:B3:SSISTS", comment: "Bottom SSI status", isConnectedTo: cover_elec.connectors.B3.pins[13]
 http://mercator.iac.es/onto/models/mtcs/common/all 	127 3> symbol: "TC:B4:SSIST", comment: "Bottom SSI status", isConnectedTo: cover_elec.connectors.B4.pins[13]
 http://mercator.iac.es/onto/models/mtcs/common/hardware 	129) "slot3"
 http://mercator.iac.es/onto/models/mtcs/common/software 	130 131
 http://mercator.iac.es/onto/models/mtcs/common/statemachines 	131 132 - for [slot, connector], connector2, panel1, panel2] in [['slot4', 'T1', 'T2', 'Top 1', 'Top 2'],
 http://mercator.iac.es/onto/models/mtcs/cover/electronics 	133 ['slot5', 'T3', 'T4', 'Top 3', 'Top 4'],
 http://mercator.iac.es/onto/models/mtcs/cover/mechanics 	134 ['slot6', 'B1', 'B2', 'Bottom 1', 'Bottom 2'],
 http://mercator.iac.es/onto/models/mtcs/cover/software 	135 136 - cover elec.ADD IO MODULE INSTANCE(
 http://mercator.iac.es/onto/models/mtcs/m1/electronics 	135 comment : "SSI module for #(panell) and #(panel2) encoders"
 http://mercator.iac.es/onto/models/mtcs/m1/mechanics 	138 type : beckhoff.EL5002
 http://mercator.iac.es/onto/models/mtcs/m1/software 	<pre>139 - terminals : 140 l: -> symbol: "TC:#{connector1}:SSID+", comment: "#{panel1} SSI encoder Data +" , isConnectedTo: cover elec</pre>
 http://mercator.iac.es/onto/models/mtcs/m3/electronics 	140 1: -> symbol: "IC:#;connector1;:SsL+, comment: #;panel1; SsL encoder Data + , isConnected10: cover_elec 141 2: -> symbol: "IC:#;connector1;:SsL+, comment: #;panel1; SSL encoder Clock + , isConnectedT0: cover_elec
 http://mercator.iac.es/onto/models/mtcs/m3/mechanics 	142 3: -> symbol: "TC:#{connector2}:SSID+", comment: "#{panel2} SSI encoder Data +" , isConnectedTo: cover_elec
 http://mercator.iac.es/onto/models/mtcs/m3/software 	143 4: -> symbol: "TC:#{connector2}:SSIC+", comment: "#{panel2} SSI encoder Clock +", isConnectedTo: cover_elected and the symbol and the
 http://mercator.iac.es/onto/models/mtcs/software 	<pre>144 5: -> sýmbol: "TC:#{connectorl}:SSID-", comment: "#{panell} SSI encoder Data -", isConnectedTo: cover_elec 145 6: -> symbol: "TC:#{connectorl}:SSIC-", comment: "#{panell} SSI encoder Clock -", isConnectedTo: cover_elec</pre>
 http://mercator.iac.es/onto/models/mtcs/telemetry/electronics 	146 7: -> symbol: "TC:#{connector2}:SSID-", comment: "#{panel2} SSI encoder Data -", isConnectedTo: cover elec
 http://mercator.iac.es/onto/models/mtcs/telemetry/mechanics 	147 8: -> symbol: "TC:#{connector2}:SSIC-", comment: "#{panel2} SSI encoder Clock -", isConnectedTo: cover_elec
 http://mercator.iac.es/onto/models/mtcs/telemetry/software 	148) slot 149
 http://mercator.iac.es/onto/models/mtcs/timing/electronics 	149
 http://mercator.iac.es/onto/models/mtcs/timing/mechanics 	151
 http://mercator.iac.es/onto/models/mtcs/timing/software 	152~
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 http://mercator.iac.es/onto/models/test/test_expressions 	

WEB3005

• What are semantic models?

30

- Where to apply them?
- How to apply them?
- How to build them?
- How to use them?
- Conclusions



How to build them?

Example: model of an I/O module **instance**

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WEB3005

- What are semantic models?
- Where to apply them?
- How to apply them?
- How to build them?
- How to use them?
- Conclusions

How to use them?

- What are semantic models?
- Where to apply them?
- How to apply them?
- How to build them?
- How to use them?



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+ Cover + M1 + M3 + Telemetry + Timing	K													

- What are semantic models?
- Where to apply them?
- How to apply them?
- How to build them?
- How to use them?



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+ M1										
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- What are semantic models?
- Where to apply them?
- How to apply them?
- How to build them?
- How to use them?
- Conclusions



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M1 M3										
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Timing										

- What are semantic models?
- Where to apply them?
- How to apply them?
- How to build them?
- How to use them?
- Conclusions



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+ M3 + Telemetry		s									
+ Telemetry											
	± Timing										

- What are semantic models?
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- Conclusions



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+ Telemetry											

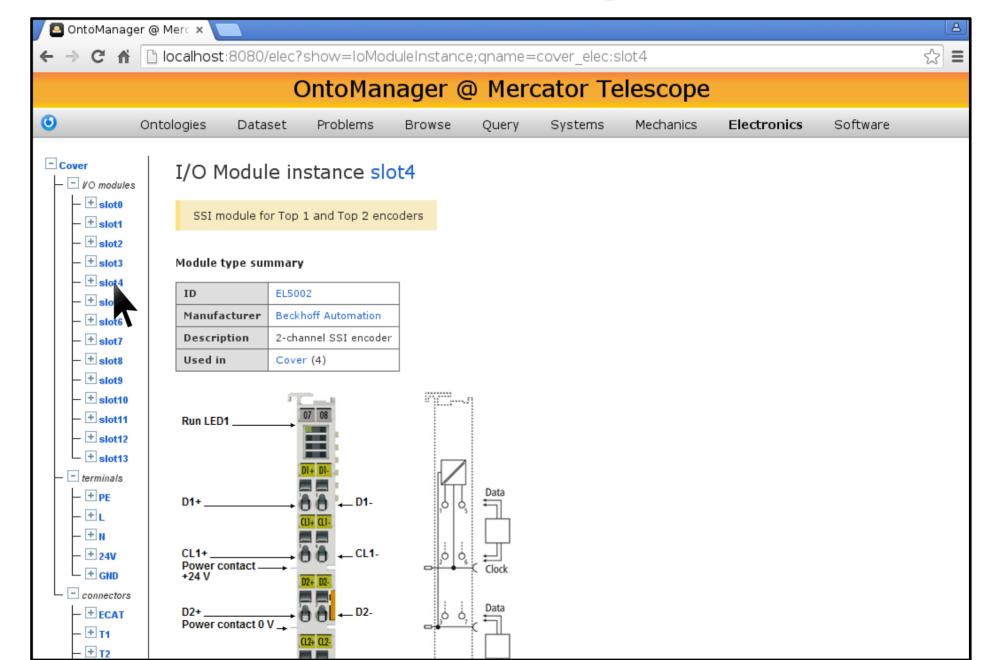
- What are semantic models?
- Where to apply them?
- How to apply them?
- How to build them?
- How to use them?
- Conclusions



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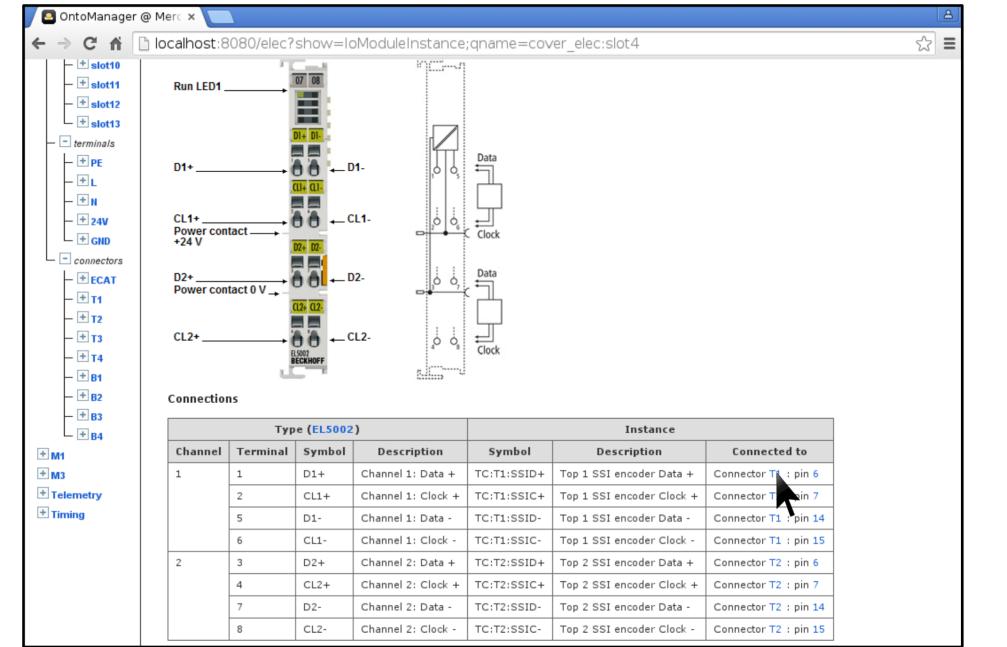
- What are semantic models?
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- How to apply them?
- How to build them?
- How to use them?
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- Where to apply them?
- How to apply them?
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- How to apply them?
- How to build them?
- How to use them?
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	+ slot3		Gene	der	female								
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1 1	+ slot5		Desc	ription	D-sub 15 fem	ale connector							
	+ slot6 + slot7		Fits	to	D-sub 15 M								
1 1	+ slot7		Used	d in	Cover (8), M1	(1), M3 (2)							
1 1	+ slot9		_										
1 1	+ slot10 + slot11		8 15	••••	•••••	•) 1 9							
	+ slot12		D	A-15S (Fem	ale Socket Front	View)							
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	+ GND		2	2	Pin 2	TC:T1:GND MOT	Top 1 GND of motor		Cover : terminal (GND			
	connectors + ECAT		3	3	Pin 3	TC:T1:MMON	Top 1 motor monitor						
	± T1		4	4	Pin 4	TC:T1:MDIR	Top 1 motor direction		I/O module slot1 :				
	± T2		5	5	Pin 5	TC:T1:GND ENC	Top 1 GND of encoder		Cover : terminal (GND			

• What are semantic models?

- Where to apply them?
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- + slot8 - + slot9								
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- + slot11	15	••	• • • •	• / 9				
- + slot12		DA-15S (Fem	nale Socket Front	View)				
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- + 24V	1	1	Pin 1	TC:T1:GND HM	Top 1 GND of holding magnet	Cover : terminal GND		
+ GND	2	2	Pin 2	TC:T1:GND MOT	Top 1 GND of motor	Cover : terminal GND		
- connectors	3	3	Pin 3	TC:T1:MMON	Top 1 motor monitor			
- + ECAT	4	4	Pin 4	TC:T1:MDIR	Top 1 motor direction	I/O module slot1 : terminal 1		
- ± T1 - ± T2	5	5	Pin 5	TC:T1:GND ENC	Top 1 GND of encoder	Cover : terminal GND		
—	6	6	Pin 6	TC:T1:SSID+	Top 1 SSI Data +	I/O module slot4 : terminal 1		
- ± 14	7	7	Pin 7	TC:T1:SSIC+	Top 1 SSI Clock +	I/O module slot4 : terminal 2		
— + B1	8	8	Pin 8	TC:T1:PE	Top 1 Earth	Cover : terminal PE		
— + B2	9	9	Pin 9	TC:T1:+24V HM	Top 1 +24V of holding magnet	I/O module slot12 : terminal 2		
— + B3	10	10	Pin 10	TC:T1:+24V MOT	Top 1 +24V of motor	I/O module slot8 : terminal 2		
- + B4	11	11	Pin 11	TC:T1:MSPEED	Top 1 motor speed	I/O module slot2 : terminal 1		
+ M1	12	12	Pin 12	TC:T1:+24V ENC	Top 1 +24V of encoder	Cover : terminal 24V		
+ M3 + Telemetry	13	13	Pin 13	TC:T1:SSISTS	Top 1 SSI status	I/O module slot3 : terminal 1		
Telemetry Timing	14	14	Pin 14	TC:T1:SSID-	Top 1 SSI Data -	I/O module slo		
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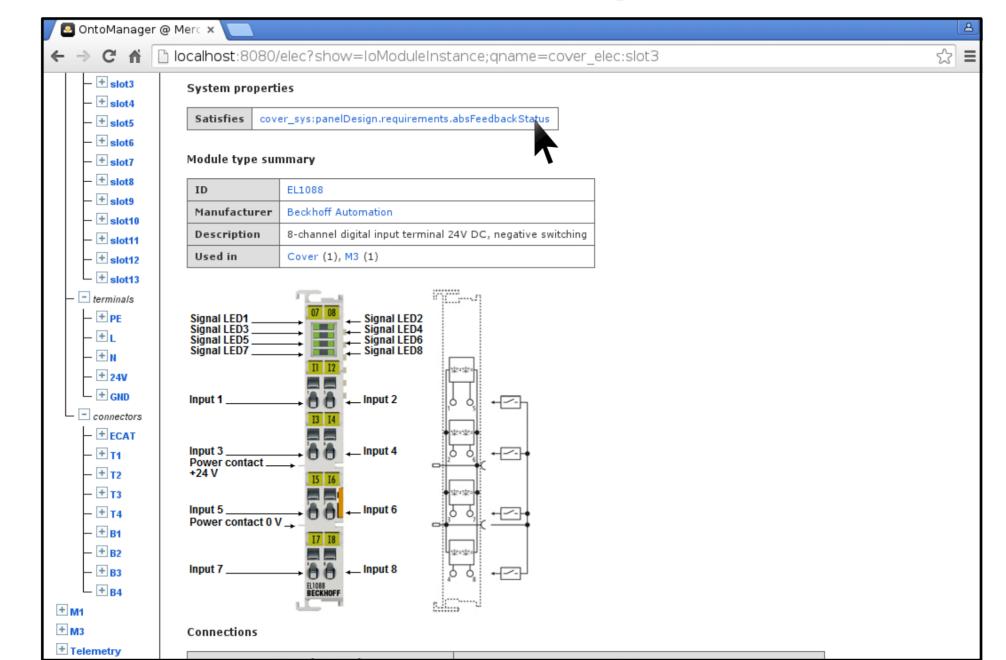
- What are semantic models?
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- How to apply them?
- How to build them?
- How to use them?
- Conclusions



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- + slot8 - + slot9	ID	EL1088							
- + slot10	Manufacturer	Beckhoff Automation							
- + slot11	Description	8-channel digital input te	erminal 24V DC, neg	ative switching					
- + slot12	Used in	Cover (1), M3 (1)							
+ slot13 - • terminals + • PE + L + 1 + N + 24V + GND • connectors + ECAT + T1 + T2	Signal LED1 Signal LED3 Signal LED5 Signal LED7 Input 1 Power contact +24 V	07 08 → Signal LE → Nignal LE → Signal LE	D6			ł			

- What are semantic models?
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- What are semantic models?
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- How to use them?
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- What are semantic models?
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- What are semantic models?
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- + slot2 - + slot3 - + slot4 - + slot5	System propert Satisfies cov	ies er_sys:panelDesign.requi	rements.absFeed	lbackStatus						
- + slot6 - + slot7	Module type su	mma ry								
— 🕂 slot8 — 🕂 slot9	ID	EL1088								
- + slot10	Manufacturer	Beckhoff Automation								
- + slot11	Description	8-channel digital input t	erminal 24V DC,	negative sv	witching					
— 🕂 slot12	Used in	Cover (1), M3 (1)								
+ slot13 - terminals + PE + L + L + N + 24V + GND - connectors + ECAT - + T1 + T2	Signal LED1 Signal LED3 Signal LED5 Signal LED7 Input 1 Power contact +24 V		D4 D6	•						

- What are semantic models?
- Where to apply them?
- How to apply them?
- How to build them?
- How to use them?
- Conclusions



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٩	Ontologies Data	set Problems	Browse (Query Sys	tems Me	echanics	Electronics	Software	
Cover Cover Cover	I/O Modul	e instance <mark>slo</mark>	t3						
— (+) slot0 — (+) slot1	Digital input t	erminal to read the sta	tus of the SSI er	ncoders of all 8	over panels				
- + slot2 - + slot3 - + slot4	System propert	es							
- + slot5	Satisfies cov	er_sys:panelDesign.requi	rements.absFeedb	ackStatus					
—	Module type su	nmary							
— 🛨 slot8 — 🛨 slot9	ID	EL1088							
- + slot10	Manufacturer	Beckhoff Automation			_				
- 🕂 slot11	Description		erminal 24V DC, n	negative switching	_				
- + slot12	Used in	Cover (1), M3 (1)							
+ slot13 - = terminals + + PE + L + N + 24V	Signal LED1 Signal LED3 Signal LED5 Signal LED7	→ 07 08 → Signal LI → Signal LI → Signal LI → Signal LI	D6						
GND Gonnectors Connectors	Input 1		↓ ↓ + • *						
- ± T1 - ± T2	Input 3 Power contact +24 V	\rightarrow \bigcirc \bigcirc \leftarrow Input 4							

- What are semantic models?
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- How to use them?
- Conclusions

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Electrical design

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9	Ontologies	Dataset	Problems	Browse	Query	Systems	Mechanics	Electronics	Software	
Company	y Beckhoff									
compan	y Deckhon									
Logo										
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Summary										
Summary Short name	Beckhoff									
-	Beckhoff Beckhoff Automatic	on								
Short name			panels,							
Short name	Beckhoff Automatic		panels,							
Short name Long name Description	Beckhoff Automatic		panels,							
Short name Long name Description	Beckhoff Automatic	Cs, I/O, control	panels,				Used in			
Short name Long name Description Products	Beckhoff Automatic	Cs, I/O, control				over (1), M1 (1	Used in), M3 (1), Telemetr	y (1), Timing (1)		
Short name Long name Description Products ID	Beckhoff Automatic Produces IPCs, PLC	Cs, I/O, control De with ID switch	scription	witching		over (1), M1 (1), M3 (1), Telemetr	y (1), Timing (1)		
Short name Long name Description Products ID EK1101	Beckhoff Automatic Produces IPCs, PLC	Cs, I/O, control De with ID switch put terminal 24	scription V DC, negative st	witching	C), M3 (1), Telemetr	y (1), Timing (1)		
Short name Long name Description Products ID EK1101 EL1088	Beckhoff Automatic Produces IPCs, PLC EtherCAT Coupler 8-channel digital in	Cs, I/O, control De with ID switch uput terminal 241 utput terminal 24	scription V DC, negative so 4V DC	witching	с с	over (1), M3 (1), M3 (1), Telemetr	y (1), Timing (1)		
Short name Long name Description Products EK1101 EL1088 EL2008	Beckhoff Automatic Produces IPCs, PLC EtherCAT Coupler 8-channel digital in 8-channel digital ou 4-channel digital ou	De with ID switch put terminal 24 utput terminal 24 utput terminal 24	scription V DC, negative so 4V DC 24 V DC, 2 A	witching	с с м	over (1), M3 (1 over (1)), M3 (1), Telemetr	y (1), Timing (1)		
Long name Description Products EK1101 EL1088 EL2008 EL2024	Beckhoff Automatic Produces IPCs, PLC EtherCAT Coupler 8-channel digital in 8-channel digital ou 4-channel digital ou	De with ID switch put terminal 24 utput terminal 24 utput terminal 24	scription V DC, negative so 4V DC 24 V DC, 2 A	witching	с с м	over (1), M3 (1 over (1)), M3 (1), Telemetr	y (1), Timing (1)		
Short name Long name Description Products ID EK1101 EL1088 EL2008 EL2024	Beckhoff Automatic Produces IPCs, PLC EtherCAT Coupler 8-channel digital in 8-channel digital ou 4-channel digital ou	De with ID switch uput terminal 24 utput terminal 24 utput terminals 24 utput terminals 24 utput terminals 24 utput terminals 24	scription V DC, negative so 4V DC 24 V DC, 2 A 5 V DC		с с м м	over (1), M3 (1 over (1)), M3 (1), Telemetr))	y (1), Timing (1)		

- What are semantic models?
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- How to build them?
- How to use them?
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Electrical design

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TID	Description	Used in						
EK1101	EtherCAT Coupler with ID switch	Cover (1), M1 (1), M3 (1), Telemetry (1), Timing (1)						
EL1088	8-channel digital input terminal 24V DC, negative switching	Cover (1), M3 (1)						
EL2008	8-channel digital output terminal 24V DC	Cover (1)						
EL2024	4-channel digital output terminals 24 V DC, 2 A	M1 (1)						
EL2124	4-channel digital output terminals 5 V DC	M1 (2)						
EL2622	2-channel relay	Cover (5), M1 (1)						
EL3024	4-channel analog input terminals 420mA, differential inputs, 12 bit	M1 (2), Telemetry (1)						
EL3102	2-channel analog input terminals -10+10 V, differential input, 16 bit	M1 (1)						
EL3164	4-channel analog input terminal 010 V, single-ended, 16 bit	M1 (1)						
EL3202-0010	2-channel input terminals PT100 (RTD) for 4-wire connection, high-precision	Telemetry (7)						
EL3351	1-channel resistor bridge terminal (strain gauge)	M1 (3)						
EL3681	Digital multimeter	Cover (1)						
EL4008	8-channel analog output terminal 010V, 12 bit	Cover (1)						
EL4022	2-channel analog output terminal 420 mA, 12 bit	M1 (1)						
EL5001	1-channel SSI encoder	M1 (1), M3 (1)						
EL5002	2-channel SSI encoder	Cover (4)						
EL5101	1-channel incremental encoder	M1 (1), M3 (1)						
EL6001	RS-232 serial communication	Timing (1)						
EL6688	IEEE 1588 external synchronisation interface	Timing (1)						
EL6751	CANopen master/slave controller	M3 (1)						
EL9070	Shield terminal	Telemetry (2)						
EL9186	Potential distribution terminal, 8 x 24V	M1 (1), Telemetry (1)						
EL9187	Potential distribution terminal, 8 x 0V	M1 (2), Telemetry (1)						
EL9410	Power supply terminals for E-bus (with diagnostics)	M1 (1)						
EL9505	Power supply terminals 5 V	M1 (1)						

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- How to apply them?
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Ontologies Dataset Problems Browse Query Systems Mechanics Electronics Software Cover F of oncodies F of oncodies I/O Module instance slot3 Digital input terminal to read the status of the SSI encoders of all 8 cover panels System properties Satisfies cover_systemalDesign.requirements.absFeedbackStatus Module type summary D EL088 Satisfies cover_locare Beckhoff Automation Description 8-channel digital input terminal 24V DC, negative switching Used in Cover (1), M3 (1) Signal LED1 Signal LED2 Signal LED3 Signal LED3 Signal LED3 Signal LED4 Signal LED3 Signal LED4 Signal LED4 Signal LED3 Signal LED5 Signal LED4 Signal LED5 Signal LED5 Signal LED5 Signal LED2 Signal LED4 Signal LED5 Signal LED5 Signal LED5 Signal LED5	1		OntoMan	ager @	Merc	ator Te	elescope			
Image: Promodules Image: Promodules Image: Promodules Digital input terminal to read the status of the SSI encoders of all 8 cover panels Image: Promodules System properties Image: Promodule status System properties Image: Promodule status Satisfies Image: Promodule status System properties Image: Promodule status Satisfies Image: Promodule status Satisfies Image: Promodule status Satisfies Image: Promodule status Satisfies Image: Promodule status Signal LED3)	Ontologies Data		-				Electronics	Software	
Image: Digital input terminal to read the status of the SSI encoders of all 8 cover panels Image: Digital input terminal to read the status of the SSI encoders of all 8 cover panels Image: Digital input terminal to read the status of the SSI encoders of all 8 cover panels Image: Digital input terminal to read the status of the SSI encoders of all 8 cover panels Image: Digital input terminal to read the status of the SSI encoders of all 8 cover panels Image: Digital input terminal to read the status of the SSI encoders of all 8 cover panels Image: Digital input terminal to read the status of the SSI encoders of all 8 cover panels Image: Digital input terminal to read the status of the SSI encoders of all 8 cover panels Image: Digital ED3 Satisfies Image: Digital ED3 Signal ED4 Image: Digital ED5 Signal ED4 Image: Digital ED5 Signal ED5 Image: Digital ED5 Signal ED5 Image: Digital ED5 Signal ED5 Image: Digital ED5 Signal ED6 Image: Digital ED5 Signal ED6 Image: Digital ED5 Signal ED5 Image: Digital ED5 Signal ED5 Image: Digital ED5 Signal ED6 Image: Digital ED5 Signal ED6 Image: Digital ED5 Signal ED6	- I/O modules	I/O Modu	le instance <mark>slo</mark>	t3						
- + slot3 System properties + slot4 - f slot5 + slot5 Satisfies - slot7 Module type summary - + slot8 ID - + slot8 ID - + slot9 Manufacturer - + slot10 Description - + slot11 Description - + slot12 Used in - + slot13 cover (1), M3 (1) - + slot13 signal LED2 - + slot14		Digital input f	terminal to read the sta	tus of the SSI	encoders of	f all 8 cover pa	nels			
Image: solution of the solution	- + slot2 - + slot3 System properties									
Module type summary + slot3 + slot3 + slot10 - + slot11 - + slot12 - + slot13 - + slot13 - + pe - + pe - + pe + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + l + - + l + - + - + - + - + - + - + - + - +		Satisfies cov	/er_sys:panelDesign.requi	rements.absFee	dbackStatus					
ID EL1088 Manufacturer Beckhoff Automation Description 8-channel digital input terminal 24V DC, negative switching Used in Cover (1), M3 (1) + slot13 - - + pe Signal LED1 - + pe Signal LED3 - + N Signal LED5 - + N Signal LED5 - + N Signal LED6 - + R Signal LED7 - + N Signal LED7 - + N Signal LED3 - + R Signal LED2 - + N Signal LED3 - + N Signal LED4 - + N Signal LED5 - + N Signal LED7 - + N Signal LED7 - + N Signal LED8 - + N Signal LED7 - + N - +	— 🕂 slot7	Module type su	mmary							
Imanufacturer Beckhoff Automation Description 8-channel digital input terminal 24V DC, negative switching Used in Cover (1), M3 (1) Imaufacturer Signal LED1 Imaufacturer Signal LED1 Imaufacturer Signal LED1 Imaufacturer Signal LED1 Imaufacturer Signal LED2 Imaufacturer Signal LED3 Imaufacturer Imaufacturer Imaufacturer Imaufacturer Imaufacturer Imaufacturer Imaufacturer Imaufacturer Imaufacturer Imaufacturer Imaufacturer Imaufacturer Imaufacturer		ID	EL1088							
Used in Cover (1), M3 (1) Used in Cover (1), M3 (1) Used in Cover (1), M3 (1) Used in Cover (1), M3 (1) Signal LED1 Signal LED2 Signal LED3 Signal LED5 Signal LED5 Signal LED5 Signal LED7 Input 1 Cover (1), M3 (1) Used in Cover (1), M3 (1) Signal LED2 Signal LED2 Signal LED3 Signal LED4 Signal LED8 Used in Cover (1), M3 (1) Used in Cover (1), M3 (1) Used in Cover (1), M3 (1) Signal LED2 Signal LED3 Signal LED3 Signal LED4 Signal LED8 Used in Cover (1), M3 (1) Used in Cover (1), M3 (1) Used in Cover (1), M3 (1) Signal LED3 Signal LED3 Signal LED4 Signal LED5 Signal LED8 Signal LED8 Signa		Manufacturer	Beckhoff Automation							
Image: solution of the second seco		Description	8-channel digital input t	erminal 24V DC,	, negative sv	vitching				
Imput 1 Imput 1 Imput 2		Used in	Cover (1), M3 (1)							
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$										
Signal LED3 Signal LED5 Signal LED5 Signal LED7 + N + 24V + GND Input 1 - connectors Signal LED3 Signal LED5 Signal LED5 - Signal LED6 Signal LED8 - Input 2 - Input 2			07 08							
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		Signal LED1 Signal LED3	Signal Li	D2 D4						
□ connectors Input 1 Input 2 ↓ □ connectors		Signal LED5	Signal Li	D8						
connectors	- + 24V		II I2	[±±±]						
	+ GND	Input 1	🖥 💧 🔔 Input 2		+[Z]h					
			13 14							
$- \div \text{ECAT}$ $- \div \text{Input 3} \longrightarrow 0 \oplus \leftarrow \text{Input 4} \qquad $		Input 3								
$ \begin{array}{c c} - \begin{array}{c} + & T_1 \\ \hline & Power \ contact \\ - \begin{array}{c} + & T_2 \end{array} \end{array} \begin{array}{c} 0 \\ + & 24 \\ \end{array} \begin{array}{c} 0 \\ + & 75 \\ \end{array} \begin{array}{c} 0 \\ + & 75 \\ \end{array} \begin{array}{c} 0 \\ - & 1 \\ \end{array} \begin{array}{c} 0 \\ \end{array} \begin{array}{c} 0 \\ - & 1 \\ \end{array} \begin{array}{c} 0 \end{array} \begin{array}{c} 0 \\ \end{array} \begin{array}{c} 0 \end{array} \begin{array}{c} 0 \\ \end{array} \begin{array}{c} 0 \end{array} \begin{array}{c}$		Power contact								

- What are semantic models?
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Electrical design

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M1
 M3
 Telemetry
 Timing

- D4

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Connections

	Type (EL1088)			Instance	
Channel	Terminal	Symbol	Description	Symbol	Description	Connected to
1	1	I1	Input 1	TC:T1:SSISTS	Top 1 SSI encoder status	Connector T1 : pin 13
2	2	12	Input 2	TC:T2:SSISTS	Top 2 SSI encoder status	Connector T2 : pin 13
3	3	13	Input 3	TC:T3:SSISTS	Top 3 SSI encoder status	Connector T3 : pin 13
4	4	I4	Input 4	TC:T4:SSISTS	Top 4 SSI encoder status	Connector T4 : pin 13
5	5	15	Input 5	TC:B1:SSISTS	Bottom SSI encoder status	Connector B1 : pin 13
6	6	16	Input 6	TC:B2:SSISTS	Bottom SSI encoder status	Connector B2 : pin 13
7	7	17	Input 7	TC:B3:SSISTS	Bottom SSI encoder status	Connector B3 : pin 13
8	8	18	Input 8	TC:B4:SSISTS	Bottom SSI encoder status	Connector B4 : pin 13

Interface

Variable	Туре	Description	Linked variable
input1	BOOL	Input 1	interface.parts.cover.parts.top.parts.pt .encoderErrorSignal
input2	BOOL	Input 2	interface.parts.cover.parts.top.parts.p
input3	BOOL	Input 3	interface.parts.cover.parts.top.parts.p3.encoderErrorSignal
input4	BOOL	Input 4	interface.parts.cover.parts.top.parts.p4.encoderErrorSignal
input5	BOOL	Input 5	interface.parts.cover.parts.bottom.parts.p1.encoderErrorSignal
input6	BOOL	Input 6	interface.parts.cover.parts.bottom.parts.p2.encoderErrorSignal
input7	BOOL	Input 7	interface.parts.cover.parts.bottom.parts.p3.encoderErrorSignal
input8	BOOL	Input 8	interface.parts.cover.parts.bottom.parts.p4.encoderErrorSignal
WcState	BOOL	EtherCAT Working counter state	interface.parts.cover.parts.io.parts.slot3.wcState
InfoDataState	UINT	EtherCAT state (INIT, PREOP, OP,)	interface.parts.cover.parts.io.parts.slot3.infoData

• What are semantic models?

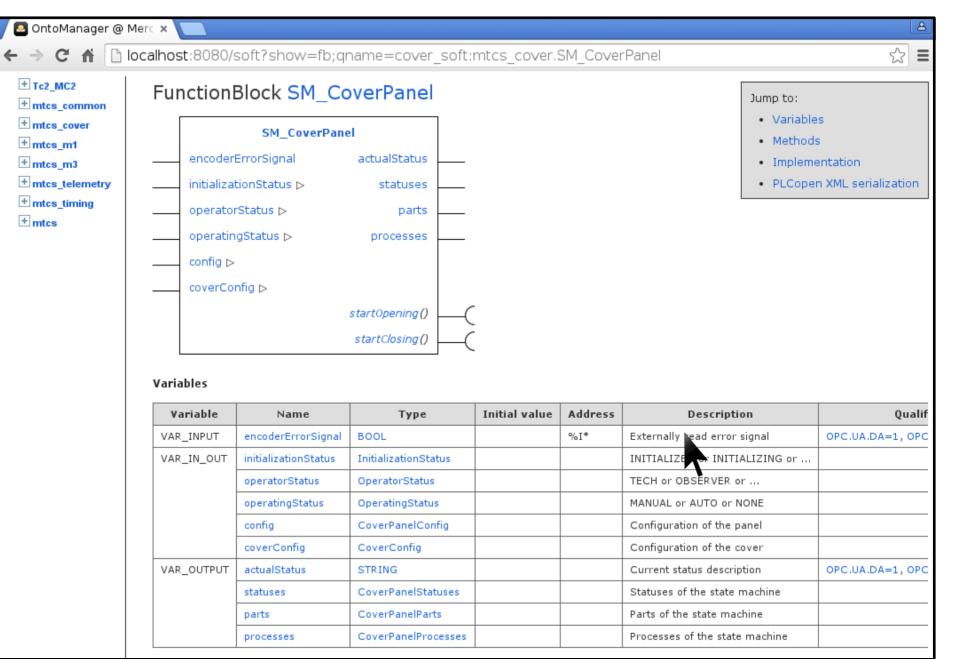
- Where to apply them?
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 Tc2_MC2 mtcs_comm mtcs_cover mtcs_m1 mtcs_m3 mtcs_telem mtcs_timing mtcs 	etry	encoderi initializat operator	nfig ⊳						Jump to: • Variable • Method: • Impleme • PLCoper	5
		ariable	Name	Туре		Initial value	Address	Descriptio		Qualif
		R_INPUT	encoderErrorSignal	BOOL		initial value	%I*	Externally read error s		OPC.UA.DA=1, OPC
		R_IN_OUT	initializationStatus	InitializationState	us			INITIALIZED or INITIA	-	
			operatorStatus	OperatorStatus				TECH or OBSERVER or		
			operatingStatus	OperatingStatus				MANUAL or AUTO or N	ONE	
			config	CoverPanelConfi	ig			Configuration of the pa	anel	
			coverConfig	CoverConfig				Configuration of the co	ver	
	VAR	R_OUTPUT	actualStatus	STRING				Current status descript	tion	OPC.UA.DA=1, OPC

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Software design

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	VAR_INPUT	encoderErrorSignal	BOOL	%	·I*	Externally read error signal	OPC.UA.DA=1, OPC
	VAR_IN_OUT	initializationStatus	InitializationStatus			INITIALIZED or INITIALIZING or	
		operatorStatus	OperatorStatus			TECH or OBSERVER or	
		operatingStatus	OperatingStatus			MANUAL or AUTO or NONE	
		config	CoverPanelConfig			Configuration of the panel	
		coverConfig	CoverConfig			Configuration of the cover	
	VAR_OUTPUT	actualStatus	STRING			Current status description	OPC.UA.DA=1, OPC
		statuses	CoverPanelStatuses			Statuses of the state machine	
		parts	CoverPanelParts			Parts of the state machine	
		processes	CoverPanelProcesses			Processes of the state machine	

Methods

startOpening()

Comment	Start openi	Start opening the panel								
Return type	RequestRe	equestResults								
Interface	Variable	Variable Name Type Initial value Address Description Qualifiers								
Implementation	start0pen	<pre>startOpening := THIS^.processes.startOpening.request();</pre>								

startClosing()

Comment	Start closin	Start closing the panel								
Return type	RequestRe	equestResults								
Interface	Variable	Variable Name Type Initial value Address Description Qualifiers								
Implementation	startClos	<pre>startClosing := THIS[^].processes.startClosing.request();</pre>								

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Software design

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implementation | startOpening := (Hist, processes, startOpening, request();

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startClosing()

Comment	Start closin	Start closing the panel								
Return type	RequestRe	RequestResults								
Interface	Variable	Variable Name Type Initial value Address Description Qualifiers								
Implementation	startClos	<pre>startClosing := THIS^.processes.startClosing.request();</pre>								

Implementation

parts.axis(isEnabled := operatorStatus.tech AND (operatingStatus.manual AND initializationStatus.initialized), standstillTolerance := config.standstillTolerance); parts.motorRelay(isEnabled := parts.axis.isEnabled); statuses.busyStatus(isBusy := parts.axis.statuses.busyStatus.busy OR parts.motorRelay.statuses.busyStatus.busy); statuses.apertureStatus(isOpen := (ABS(config.openPosition - parts.axis.actPos.degrees.value)) < config.openTolerance, isClosed := (ABS(config.closedPosition - parts.axis.actPos.degrees.value)) < config.closedTolerance);</pre> statuses.healthStatus(isGood := parts.axis.statuses.healthStatus.isGood AND (NOT(encoderErrorSignal)) hasWarning := parts.axis.statuses.healthStatus.hasWarning); statuses.openingStatus(isOpening := parts.axis.statuses.motionStatus.backward, isClosing := parts.axis.statuses.motionStatus.forward); processes.startOpening(isEnabled := operatorStatus.tech AND (operatingStatus.manual AND initializationStatus.initialized) processes.startClosing(isEnabled := operatorStatus.tech AND (operatingStatus.manual AND initializationStatus.initialized)

PLCopen XML serialization

1 -	<pre>kpou name="SM_CoverPanel" pouType="functionBlock"></pre>
2 -	<interface></interface>
	<inputvars></inputvars>
4 -	<variable address="%I*" name="encoderErrorSignal"></variable>
5	<type><bool></bool></type>
6 -	<adddata></adddata>

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	v	ariable	Name	Туре	1	(nitial value	Address	Description	n	Qualif
	VAR	_INPUT	encoderErrorSignal	BOOL			%I*	Externally read error si		OPC.UA.DA=1, OPC
	VAR	IN_OUT	initializationStatus	InitializationStatu	ıs			INITIALIZED or INITIA	IZING or	
			operatorStatus	OperatorStatus				TECH or OBSERVER or		
			operatingStatus	OperatingStatus				MANUAL or AUTO or NO	NE	
			config	CoverPanelConfi	g			Configuration of the pa	nel	
			coverConfig	CoverConfig				Configuration of the co	ver	
	VAR	_OUTPUT	actualStatus	STRING				Current status descripti	on	OPC.UA.DA=1, OPC

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t mtcs_telemetry	File	/lhome/wimpe/w	ork/onto/onton	nanager/env/	OntoManager/ont	tomanager/genera	ted/mtcs_cover.xm	1	
+ mtcs_timing	Status	File has been rea	d						
+ mtcs	Code generation	Not running							
	Generate PLCop	en XML Dow	vnload PLCop	en XML					
	PyUAF serialization	n							
	File	/lhome/wimpe/w	ork/onto/onton	nanager/env/	OntoManager/ont	tomanager/genera	ted/pyuaf/mtcs_cov	/er.py	
	Status	File has been rea	d						
	Code generation	Not running							
	Generate pyUAF	code Downl	oad pyUAF co	ode					
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- How to apply them?
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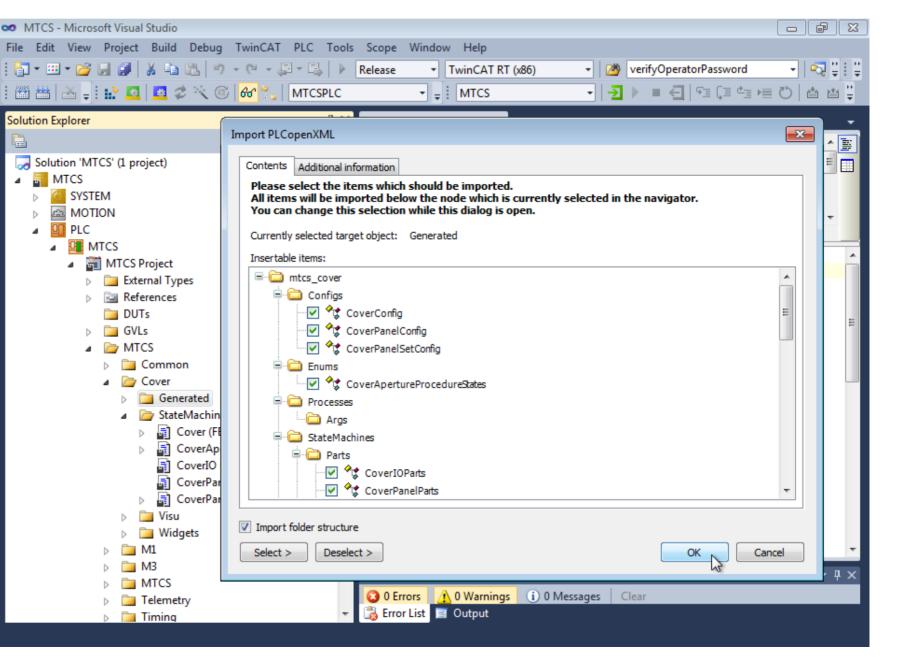
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- Generated Python code (client side)
 - Based on our OPC UA library "UAF": <u>http://github.com/uaf/uaf</u>

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• What are semantic models?

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- Generated Python code (client side)
 - Based on our OPC UA library "UAF": <u>http://github.com/uaf/uaf</u>

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- sourcePicoseconds		
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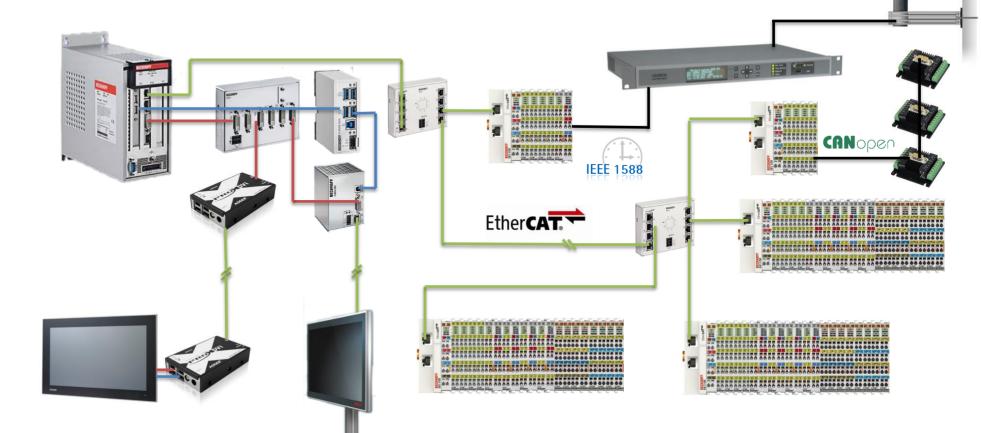
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	>>>		

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# Currently in operation:

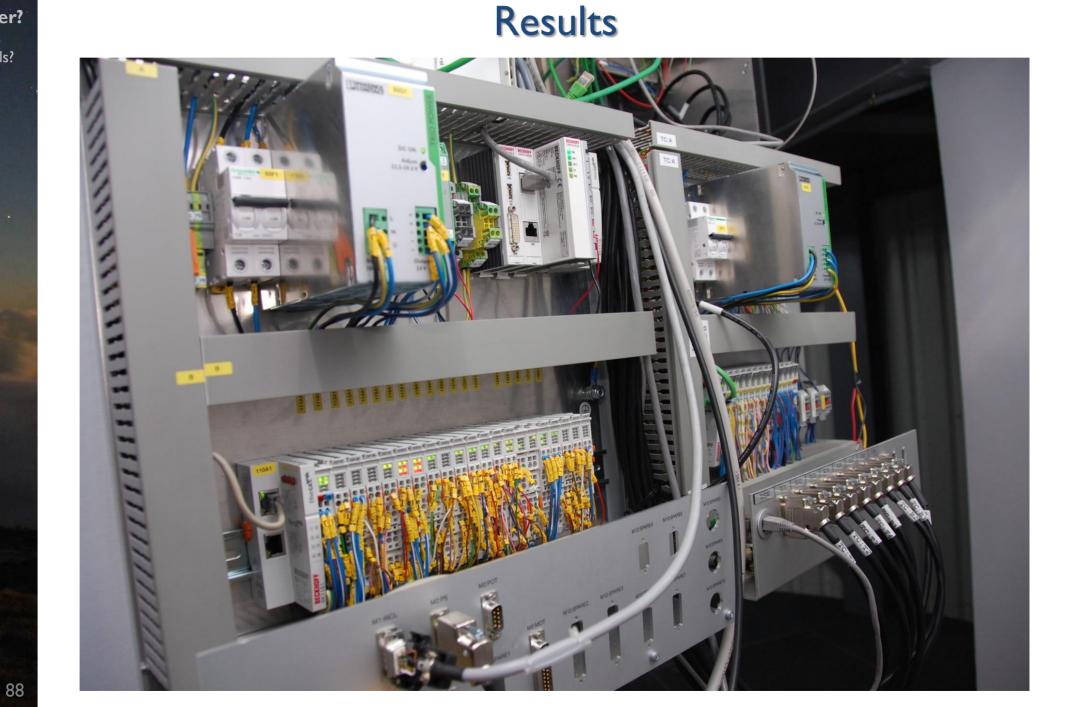
– I PLC

- 5 subsystems
- 55 I/O modules
- 159 PLC Function Block definitions (626 instances)

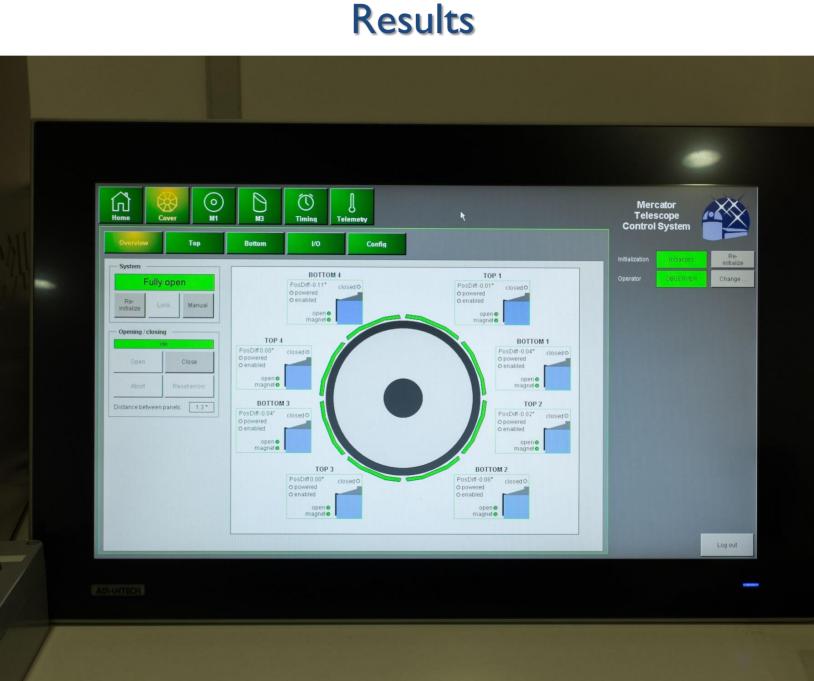


**Results** 

- What are semantic models?
- Where to apply them?
- How to apply them?
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SH

• What are semantic models?

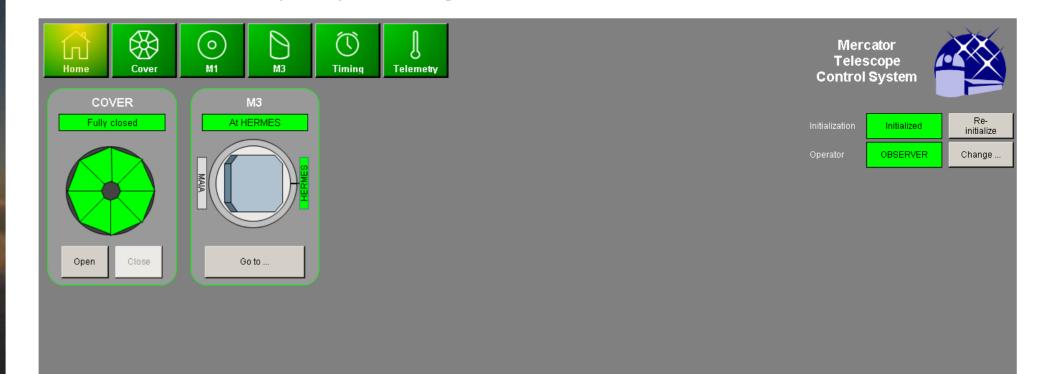
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WEB3005

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### User Interface (HMI) running on the PLC



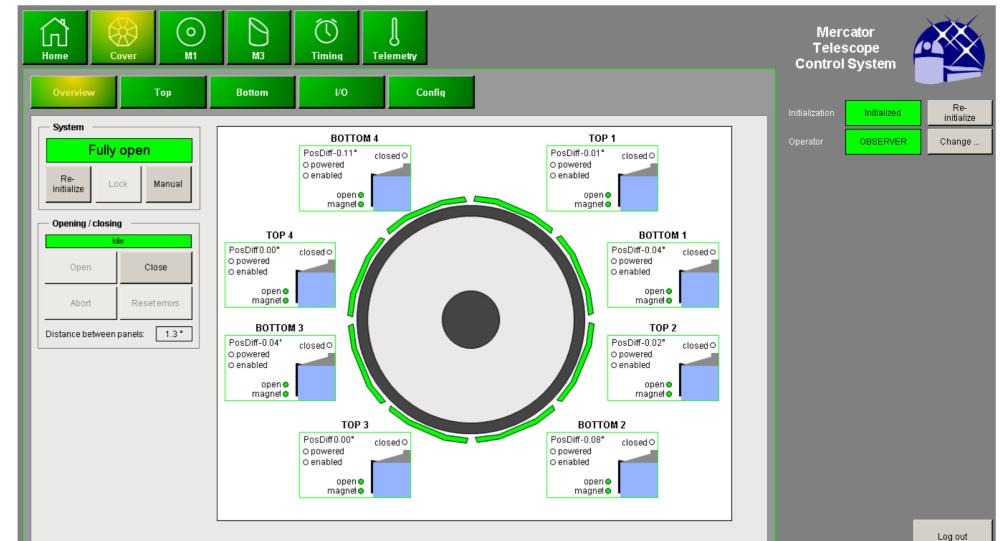
Results

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lacksquare

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### User Interface (HMI) running on the PLC

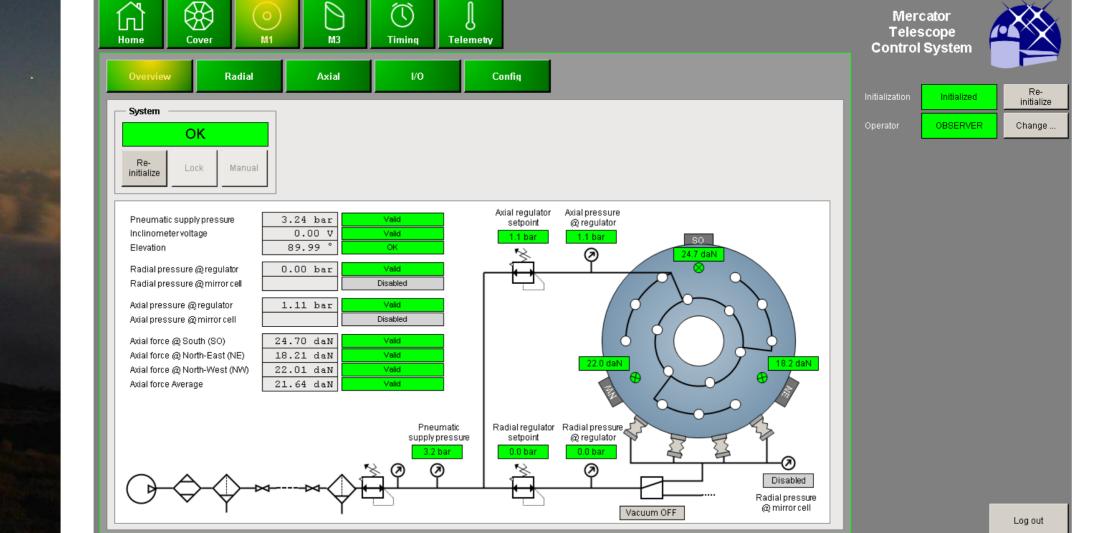


**Results** 

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- What are semantic models?
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# Conclusions

So, why semantics matter?

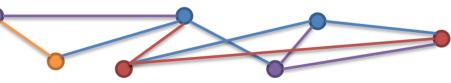
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WEB3005

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I. Because every piece of information is just one query "away"

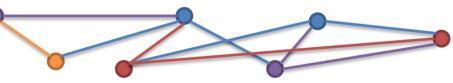


→ organize, integrate, browse, find (query) information

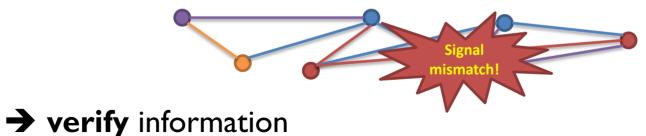
- What are semantic models?
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Because every piece of information is just one query "away"



- → organize, integrate, browse, find (query) information
- 2. Because well defined semantics allow model verification

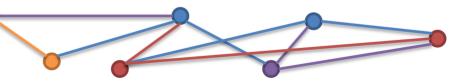


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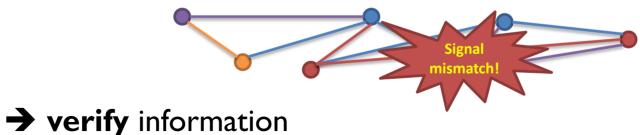
# So, why semantics matter?

Because every piece of information is just one query "away"



- → organize, integrate, browse, find (query) information
- 2. Because well defined semantics allow model verification

share information



3. Because they're a key enabling technology for future "smart" systems



# Thanks!

### Any questions?

wim.pessemier@ster.kuleuven.be