



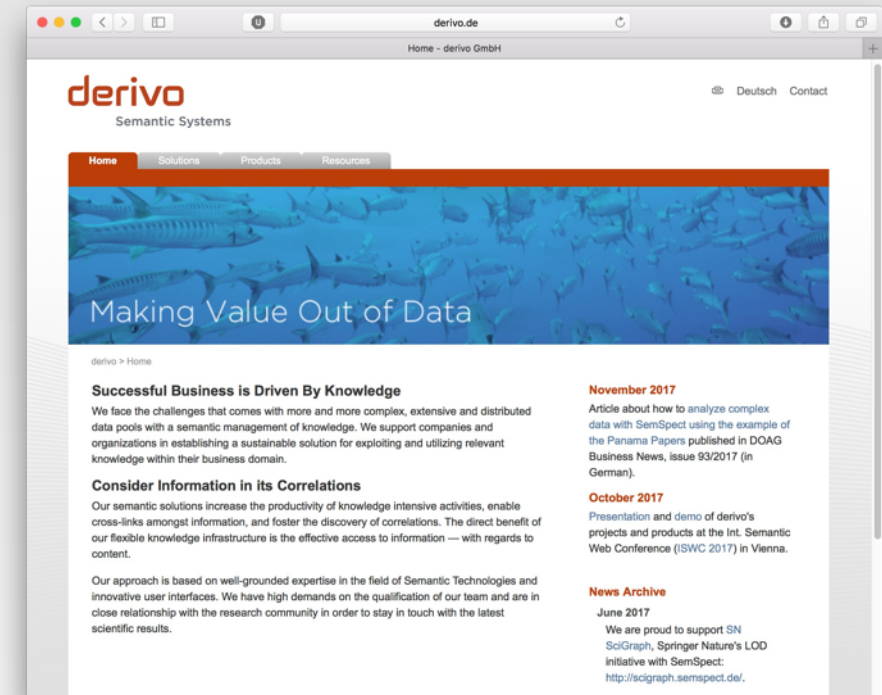
# Knowledge Graphs and Reasoning

What does it take to manage the complexity of real-world industry problems?

Thorsten Liebig | derivo GmbH

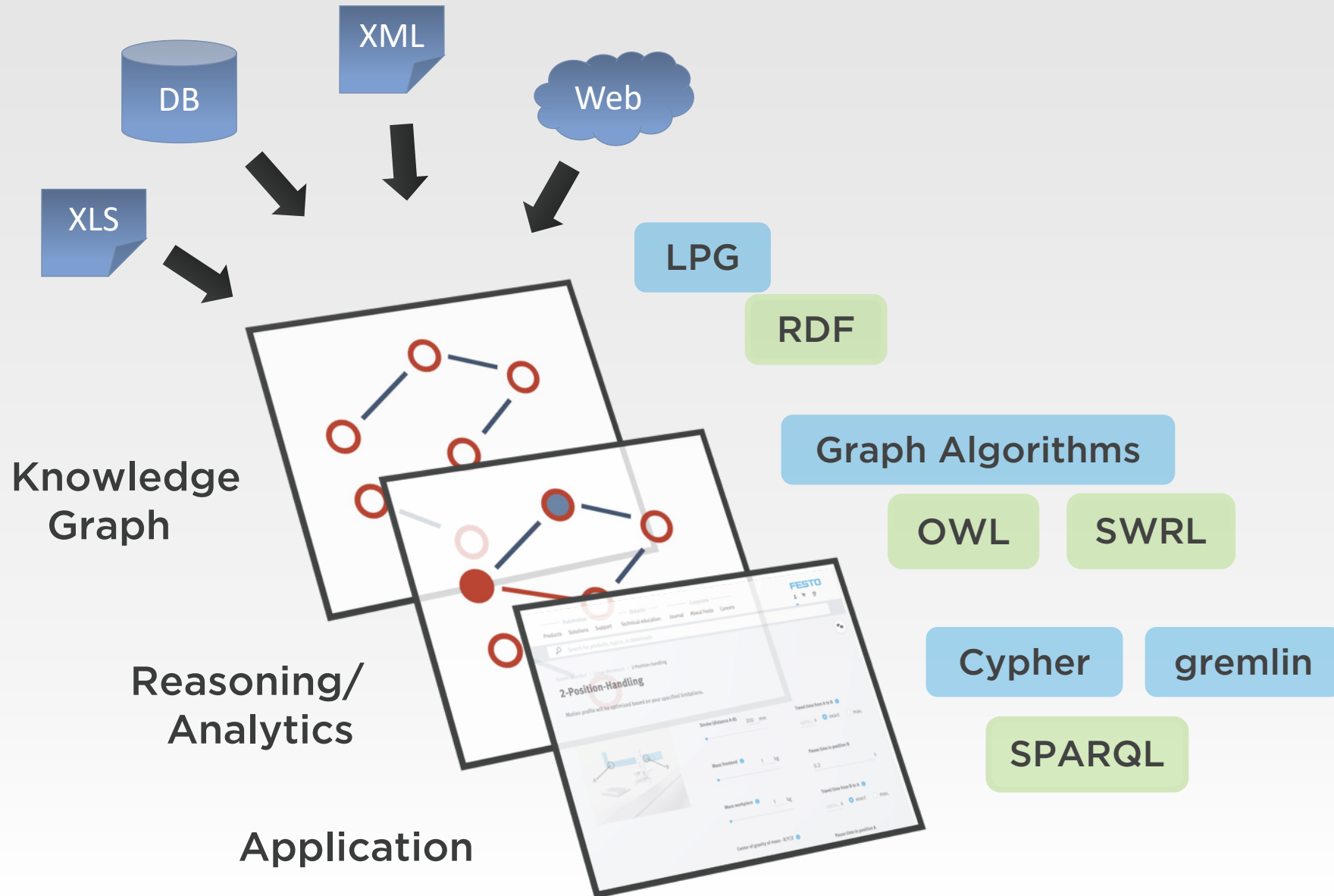
**derivo**

- ▶ SME, est. 2010
- ▶ Background KR & reasoning
- ▶ Consulting and development of semantic software tools & solutions
- ▶ Products:
  - Reasoning:
    - Konclude
    - GraphScale
    - Reseller of RDFox
  - Browsing:
    - SemSpect

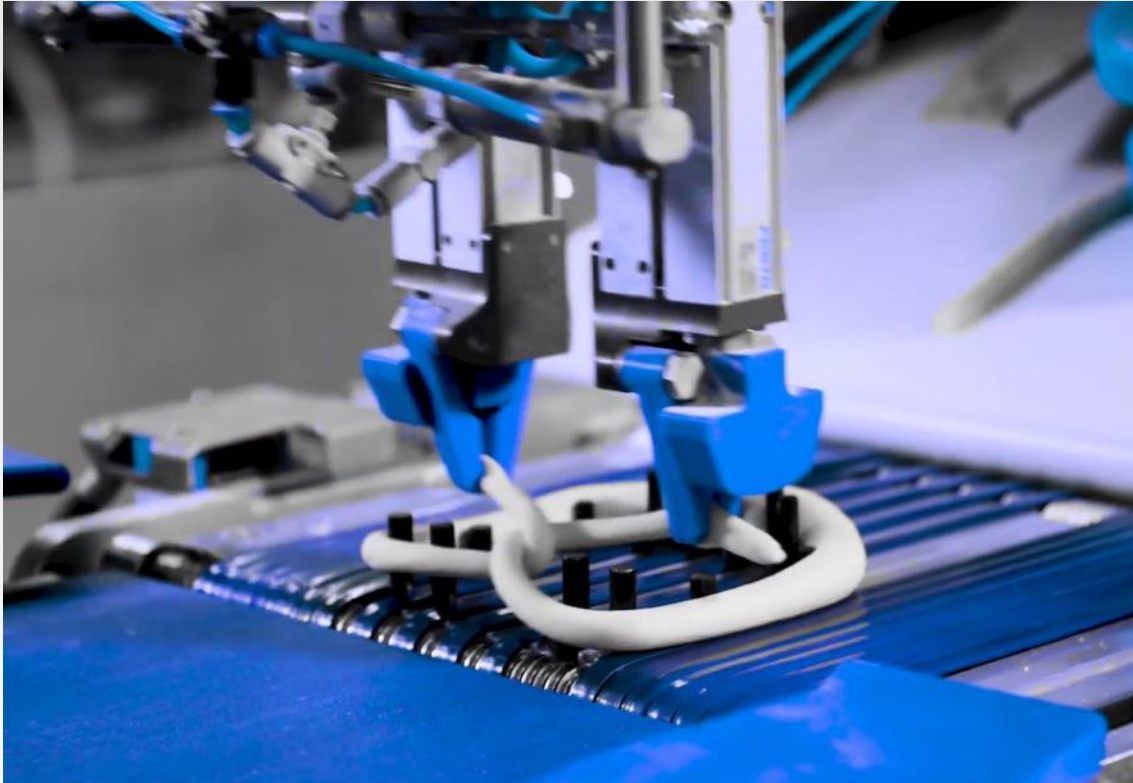


**BOSCH** **BERTELSMANN**  
**FESTO** **SIEMENS**  
**SCHAEFFLER** **SPRINGER NATURE**

# Knowledge Graph Stack



# Festo



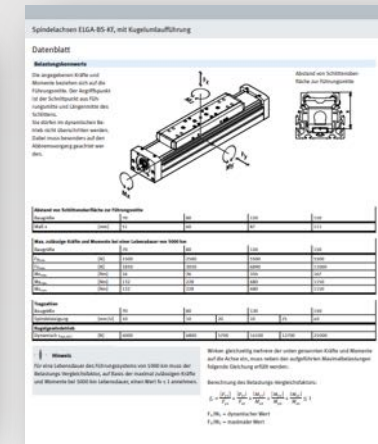
The exploded view diagram illustrates the assembly of the PANTO 1000 robotic arm. The main components shown are:

- Base Arm:** A long, horizontal aluminum arm with a T-slot profile, featuring the "PANTO" logo.
- Vertical Support:** A vertical aluminum support structure that connects the base arm to the horizontal arm.
- Horizontal Arm:** A shorter horizontal aluminum arm that extends from the vertical support.
- End Effector:** A vertical assembly at the end of the horizontal arm, including a gripper mechanism and a mounting bracket.
- Gripper:** A small, rectangular gripper mechanism with two fingers, designed to hold and move objects.
- Mounting Components:** Various brackets, bolts, and screws used to assemble the arm.
- Control Unit:** A small, rectangular control unit with a cable, likely for power or data connection.
- Cable:** A coiled cable with connectors at both ends, used for connecting the control unit to the arm.

The screenshot displays the Oracle SQL Developer environment. The main window shows a table named 'TABLE' with the following columns and data:

ID	NAME	ADDRESS	PHONE	EMAIL	EMPLOYEE_ID	EMPLOYEE_NAME
1	ALLEN	12010 VIA LINDA DRIVE	(917) 503-9931	ALLEN_A	2008	ALLEN, ALLEN
2	WARD	12084 VIA LINDA DRIVE	(917) 503-9931	WARD_W	2009	WARD, WARD
3	MARTIN	12084 VIA LINDA DRIVE	(917) 503-9931	MARTIN_M	2010	MARTIN, MARTIN
4	MARTIN	12084 VIA LINDA DRIVE	(917) 503-9931	MARTIN_M	2011	MARTIN, MARTIN
5	MARTIN	12084 VIA LINDA DRIVE	(917) 503-9931	MARTIN_M	2012	MARTIN, MARTIN
6	MARTIN	12084 VIA LINDA DRIVE	(917) 503-9931	MARTIN_M	2013	MARTIN, MARTIN
7	MARTIN	12084 VIA LINDA DRIVE	(917) 503-9931	MARTIN_M	2014	MARTIN, MARTIN
8	MARTIN	12084 VIA LINDA DRIVE	(917) 503-9931	MARTIN_M	2015	MARTIN, MARTIN
9	MARTIN	12084 VIA LINDA DRIVE	(917) 503-9931	MARTIN_M	2016	MARTIN, MARTIN
10	MARTIN	12084 VIA LINDA DRIVE	(917) 503-9931	MARTIN_M	2017	MARTIN, MARTIN

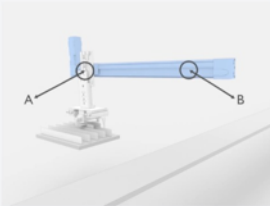
The interface also shows a sidebar with a tree view of the database structure, including a 'TABLE' folder containing the 'TABLE' object. The top menu bar includes options like 'File', 'Edit', 'Tools', 'Window', and 'Help'. The bottom status bar shows the current table and its columns.



System Selection > Linear Movement > 2-Position-Handling

## 2-Position-Handling

Motion profile will be optimized based on your specified limitations.



**Stroke (distance A-B)**  
  
 200 mm

**Mass loadend**  
  
 1 kg

**Mass workpiece**  
  
 1 kg

**Center of gravity of mass - X<sub>G</sub>/Z**  
 mm  mm  mm

**Travel time from A to B**  
 optional S ☒ exact ☐ max.  
 s

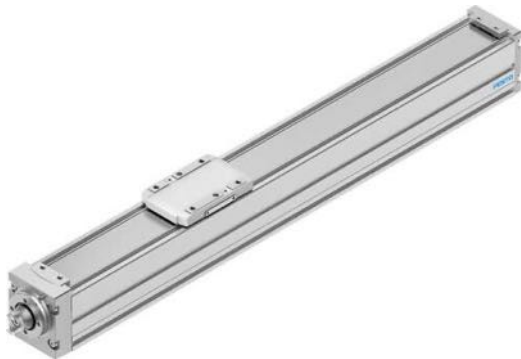
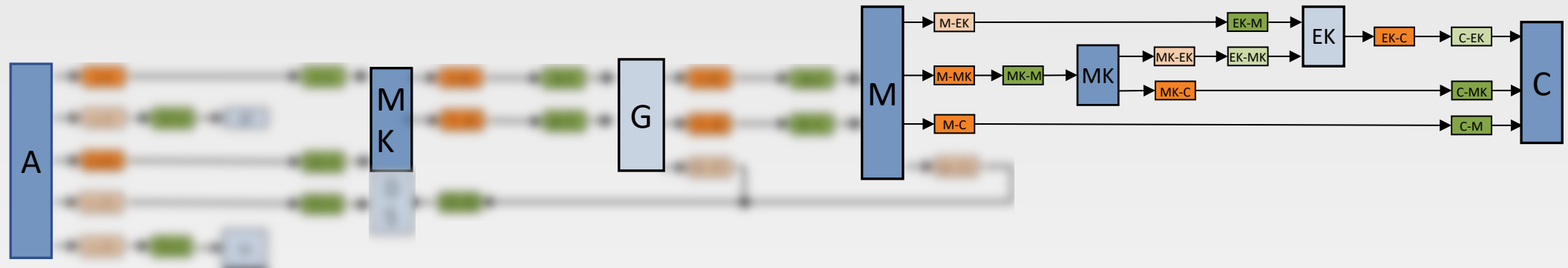
**Pause time in position B**  
 s

**Travel time from B to A**  
 optional S ☒ exact ☐ max.  
 s

**Pause time in position A**  
 s

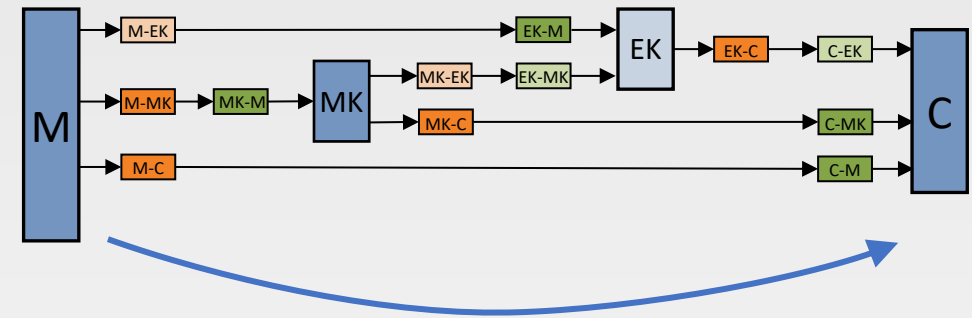
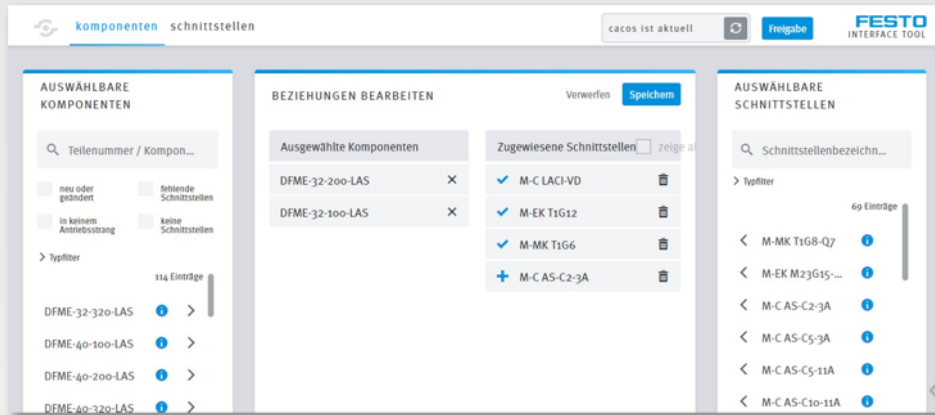
**Maximum speed**  
 optional m/s

# Festo Use-Case





# Festo Use-Case



```
Motor(?m), (not (MotorWithEncoder))(?m), Controller(?c), Motorcable(?mk),
has-interface(?m, ?mcs), M-C(?mcs), interface-compatible(?mcs, ?cms), C-M(?cms),
has-interface(?c, ?cms),
has-interface(?m, ?mmks), M-MK(?mmks), interface-compatible(?mmks, ?mkms), MK-M(?mkms),
has-interface(?mk, ?mkms),
has-interface(?mk, ?mkcs), MK-C(?mkcs), interface-compatible(?mkcs, ?cmks), C-MK(?cmks),
has-interface(?c, ?cmks),
->
direct-compatibel(?m, ?c)
```

SWRL + NAF

incremental  
reasoning

OWL 2 RL

# Drive Train Demo Configurator

**FESTO** FSP Demo: Konfigurator elektrischer Antriebsstränge

### Achse

		RF		HD		HD		GRF			
		SP	ZR	GF	KF	BS	TB	TB	BS	LS	
EGSK	EGSP	DGE	DMES	EGC	ELGA	ELGR	SLTE	EGSL			
Portal								Schlitten			
						G					
BS		LS				ZR					
DNCE		EPCO		ESBF		DGEA		ERMB		ERMO	
Ausleger								Dreh			
Spindel								Zahnriemen			
Externe Führung								Integrierte Führung			
Minimum working range: <input type="radio"/> off											

Produkt suchen... 563

DGE-12-1/2-ZR

DGE-12-1/2-ZR-KF-GK

DGE-18-1/2-SP

DGE-18-1/2-SP-HD18-GK

DGE-18-1/2-SP-KF-GK

DGE-18-1/2-SP-KF-GV

DGE-18-1/2-ZR

DGE-18-1/2-ZR-HD18-GK

DGE-18-1/2-ZR-KF-GK

DGE-18-1/2-ZR-KF-GV

DGE-25-1/2-SP

DGE-25-1/2-SP-HD25-GK

DGE-25-1/2-SP-HD40-GK

DGE-25-1/2-SP-KF-GA

### Anbausatz

EAMM-A	EAMM-U
Axial	Parallel
Dichtsatz	Schraubenbausatz
Integriert	

Produkt suchen... 499

EAMM-A-D100-100A

EAMM-A-D100-100A-S1

EAMM-A-D100-1200

EAMM-A-D100-1200-S1

EAMM-A-D100-140A

EAMM-A-D100-140A-S1

EAMM-A-D19-28A

EAMM-A-D19-40A

EAMM-A-D19-40P

EAMM-A-D19-42A

EAMM-A-D32-32B

EAMM-A-D32-35A-40A

EAMM-A-D32-35A-40P

EAMM-A-D32-40A

### Getriebe

EMGC	EMGA	EMGC
Winkelgetriebe	Planetengetriebe	
≤ 5:1	> 5:1 und ≤ 16:1	> 16:1
Integriert	kein Getriebe	

Produkt suchen... 279

EMGA-120-P-Q3-SAS-100

EMGA-120-P-Q3-SAS-140

EMGA-120-P-Q5-SAS-100

EMGA-120-P-Q5-SAS-140

EMGA-160-P-Q3-SAS-140

EMGA-160-P-Q5-SAS-140

EMGA-40-P-Q3-EAS-40

EMGA-40-P-Q3-SAS-40

EMGA-40-P-Q3-SST-42

EMGA-40-P-Q5-EAS-40

EMGA-40-P-Q5-SAS-40

EMGA-40-P-Q5-SST-42

EMGA-60-P-Q3-EAS-60

EMGA-60-P-Q3-SAS-55

### Motor

EMCA	EMME-AS	EMMS-AS	MTR	EMMS-ST
EC	Servo		Schritt	
Kurz		Mittel	Lang	
Single Turn	Ohne	Resolver	Multi Turn	
Mit Bremse		Ohne Bremse		
Integriert				

Produkt suchen... 410

EMCA-EC-67-M-1TE-CO

EMCA-EC-67-M-1TEB-CO

EMCA-EC-67-M-1TM-CO

EMCA-EC-67-M-1TMB-CO

EMCA-EC-67-S-1TE-CO

EMCA-EC-67-S-1TEB-CO

EMCA-EC-67-S-1TM-CO

EMCA-EC-67-S-1TMB-CO

EMME-AS-100-M-HS-AM

EMME-AS-100-M-HS-AMB

EMME-AS-100-M-HS-AMX

EMME-AS-100-M-HS-AMXB

EMME-AS-100-M-HS-AS

EMME-AS-100-M-HS-ASB

### Kontroller

CMMP	CMMO	CMMS-ST	SFC-DC
Premium	Standard		
Multi Turn	Single Turn	Resolver	
Profinet	CANopen	Profibus	EtherNet
Integriert			

Produkt suchen... 22

CMMO-ST-C5-1-DION

CMMO-ST-C5-1-DIOP

CMMO-ST-C5-1-LKP

CMMP-AS-C10-11A-P3-M0

CMMP-AS-C10-11A-P3-M3

CMMP-AS-C15-11A-P3-M3

CMMP-AS-C2-3A-M0

CMMP-AS-C2-3A-M3

CMMP-AS-C20-11A-P3

CMMP-AS-C5-11A-P3-M0

CMMP-AS-C5-11A-P3-M3

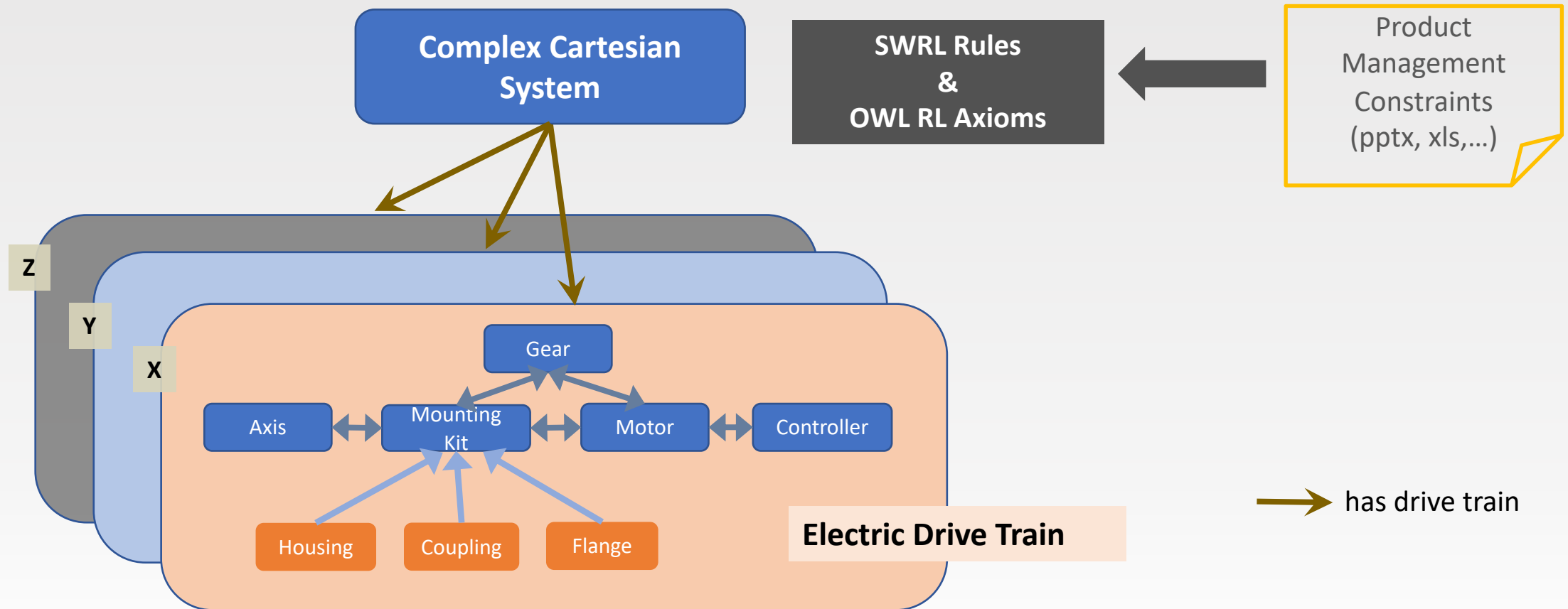
CMMP-AS-C5-3A-M0

CMMP-AS-C5-3A-M3

CMMS-ST-C8-7-G2



# Capturing Automation Systems with KGs



SemSpect

Exploration

Categories

Search categories and saved explorations

Anbausätze in Bestellungen (121)

HGO drive train (3.678)

HGO system (124,149)

HGO-System (sellable) (123,716)

Optimized Motion Series (OMS) (1,725)

Welche Getriebe (10)

adapter (37)

axis (675)

cable (147)

cleared product (93)

compatible motors (405)

connecting shaft (5)

controller (70)

country (1)

customer (255)

gear (325)

handling guide module (axis) (99)

motor (671)

mounting kit (656)

order (4,409)

part of a drive link (561)

shaft trunnion (6)

Saved explorations

Custom categories

Max Objects: 500

Search

Dossier

HGO system124,149

HGO-System (sellable)123,716

3D gantry (HGO YXCR) (sellable)95,712

YXCR-2 (verkaufbar)40,000

YXCR-4 (verkaufbar)30,720

YXCR-3 (verkaufbar)24,704

2D linear gantry (HGO YXCL) (sell)17,720

2D planar surface gantry (HGO Y...9,040

YXCL-3 (verkaufbar)7,168

YXCL-4 (verkaufbar)5,440

YXCL-2 (verkaufbar)5,040

order4,409

YXCF-4 (verkaufbar)3,840

HGO drive train3,678

YXCF-2 (verkaufbar)3,584

HGO drive train EHMYY2,648

Optimized Motion Series (OMS)1,725

YXCF-3 (verkaufbar)1,472

single-axis system (HGO YXCS) (...1,244

EPCO OMS1,200

axis675

axis family675

motor671

mounting kit656

HGO drive train EHMXX648

motor family565

part of a drive link561

compatible motors405

HGO drive train EHMZY373

ELGR OMS360

# Festo Electric Motion Sizing

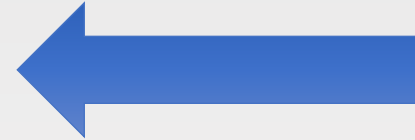
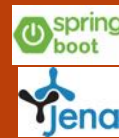
$$m_{max1}^{drive} = \frac{j^{gear} \cdot (M_{motor}^{gear} - M_{friction}^{gear} - M_{friction}^{gear} - M_{friction}^{gear} - M_{friction}^{gear} - M_{friction}^{gear}) - M_{friction}^{gear}}{d_{gear} \cdot M_{friction}^{gear} \cdot \left( \alpha_{total}^{app} + |\sin(\alpha^{app})| \cdot g \cdot \left( 1 + F_{friction}^{app} \right) \right)} - \frac{-2 \cdot F_{friction}^{app} - 2 \cdot d_{gear}^{app} \cdot M_{friction}^{gear}}{\alpha_{total}^{app} + |\sin(\alpha^{app})| \cdot g \cdot \left( 1 + F_{friction}^{app} \right)} - \frac{F_{friction}^{app} \cdot \left( m_{load}^{app} + m_{piston}^{app} + m_{rod}^{app} + m_{rod}^{app} \cdot \alpha_{total}^{app} \right) \cdot g \cdot |\sin(\alpha^{app})|}{\alpha_{total}^{app} + |\sin(\alpha^{app})| \cdot g \cdot \left( 1 + F_{friction}^{app} \right)} - \left( m_{piston}^{app} + m_{rod}^{app} + m_{rod}^{app} \cdot \alpha_{total}^{app} \right)$$

(3.57)

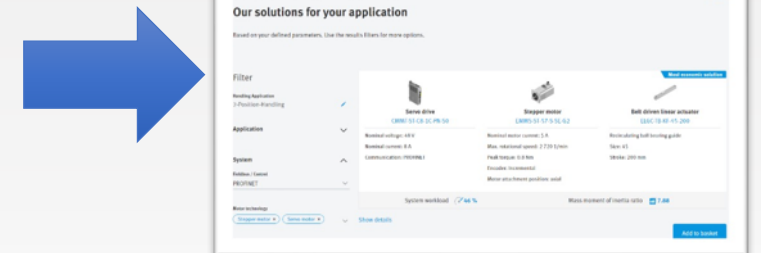


50-200 queries

Query Service

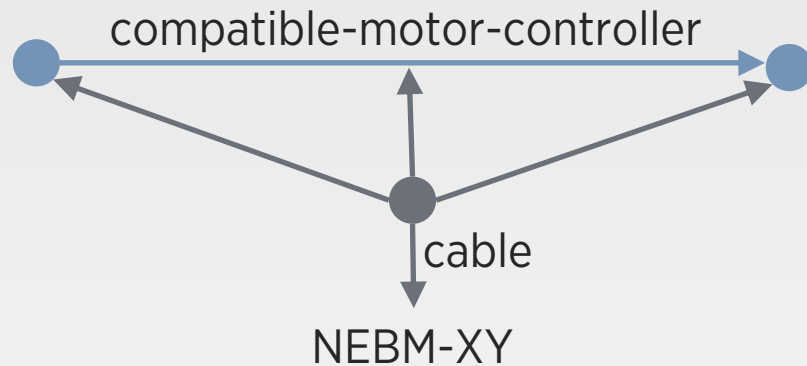


Simulation Service

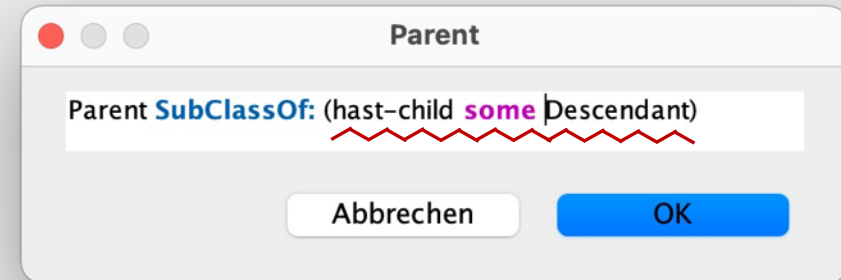


# Technical Lessons Learned

- RDF Reification sometimes is necessary



- Carefully check you language fragment: OWL 2 RL > SWRL > Datalog



- Real-world may require negation (NAF) + existentials (skolems) + aggregation

```
deptAvgSalary[?d,?z] :-  
    Department[?d],  
    AGGREGATE( worksFor[?x,?d],  
                salary[?x,?s] ON ?d BIND AVG(?s) AS ?z) .
```

# Conceptual Lessons Learned And Wrap-Up

- Understand and know the use-case: the type of queries that are asked frequently
- Invest in your KG model – it pays off in the end (it creates added value)
- Use standards (Cypher, RDF, OWL, SPARQL, R2RML, SHACL, SHEX, ...)

## **Knowledge Graph Technology and Reasoning:**

- Increases data quality a lot
- Brings data and knowledge together:
  - declarative and understandable
  - exchangeable and independent from specific tools
  - flexibility