

# Computer aided configuration of mechatronic systems – a new approach to support conceptual design activities in product development

## ProSTEP iViP Symposium 2009

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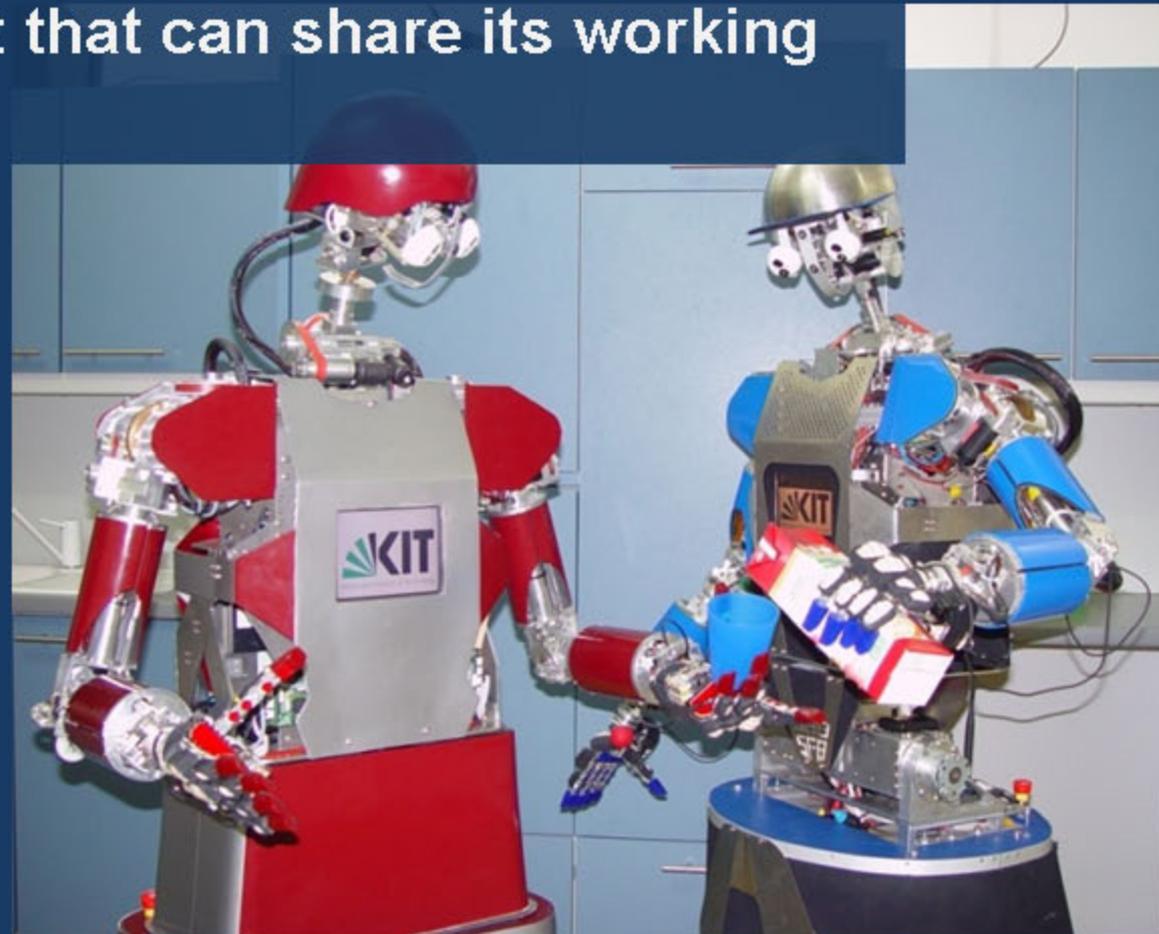
- Motivation
- Approach
- Summary and Outlook

- motivation
- approach
- summary and outlook

- Objective of SFB588: Development of concepts, methods and concrete mechatronic components for a humanoid robot that can share its working space with humans

Deutsche  
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**DFG**

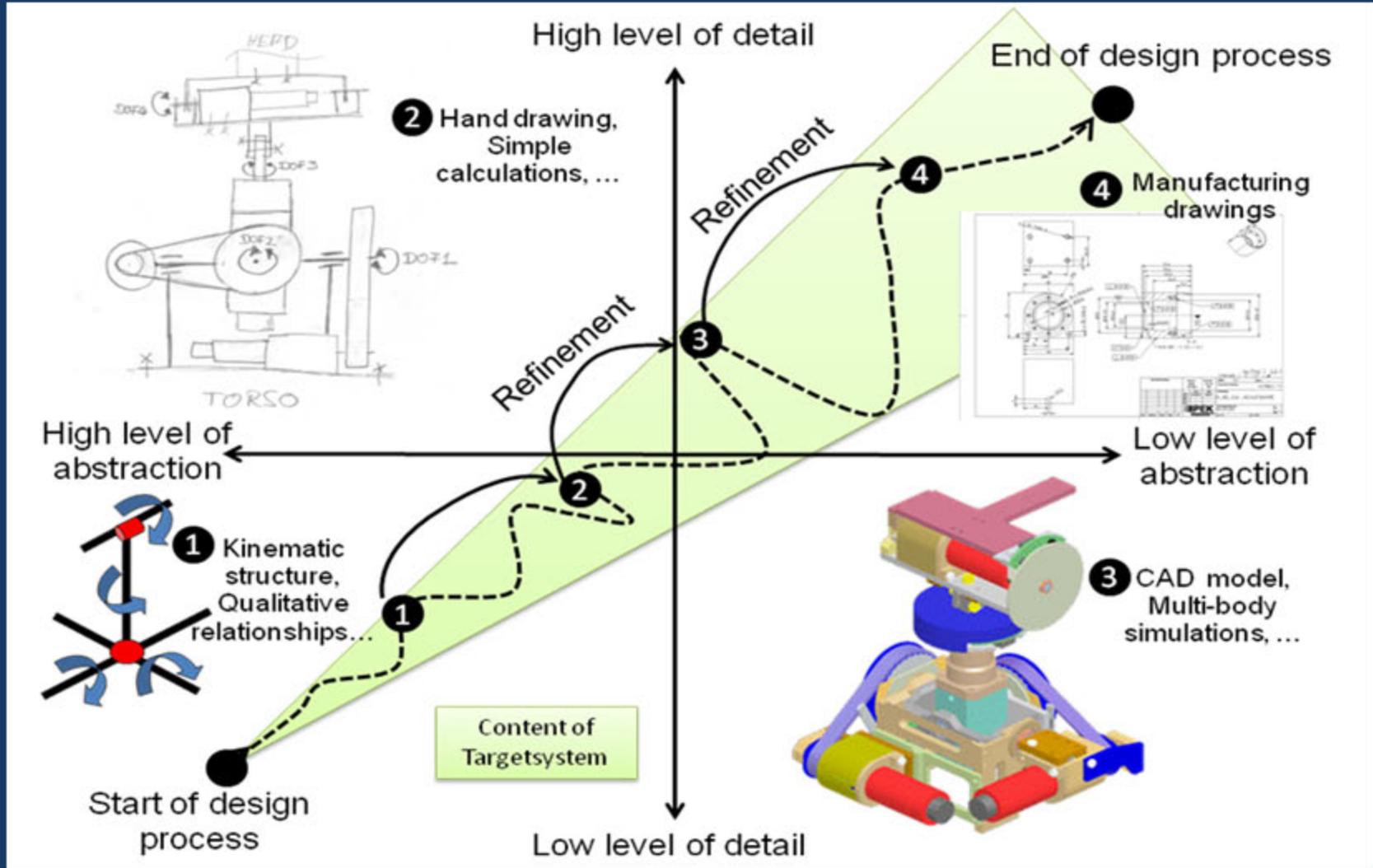


- Objective of SFB588: Development of concepts, methods and concrete mechatronic components for a humanoid robot that can share its working space with humans



- development of ARMAR IV-V
- no evolution but revolution (e.g. elbow)
- application of approved components
- multidomain development  
→ high complexity
  
- How do we determine an “optimal” configuration?
  
- additional challenge:  
→ fast determination of new optimal configurations after changed boundary conditions





Development process often includes divergencies and iterations (fluctuating BCs)

- (semi-) automatic configuration and weighting of (sub-) systems
- computer-aided optimization of generated configurations

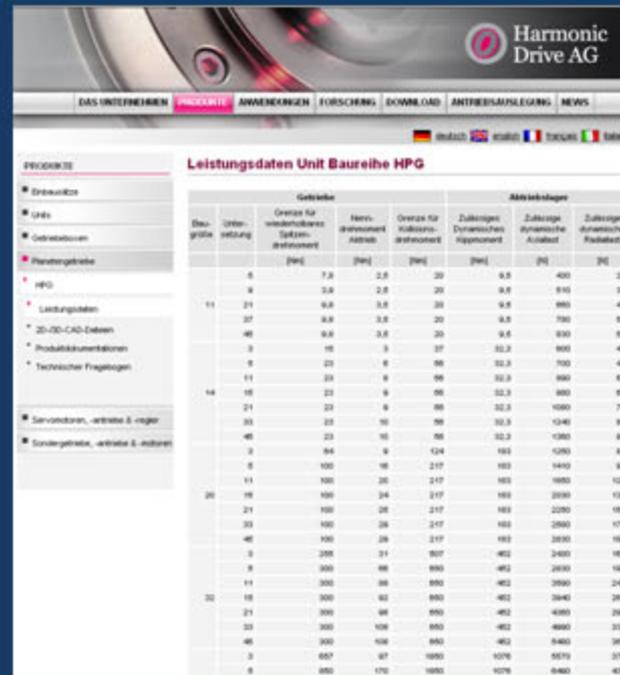


## challenge:

- big number of catalogues with diverse structures
- selection of suitable and foremost compatible components difficult
- diversity of solution hard to oversee
- Which one is the “optimal” configuration?

## idea:

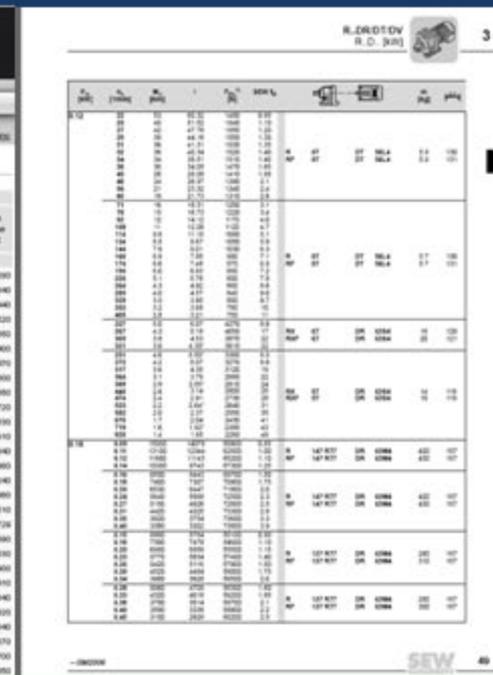
computer-aided generation of suitable and compatible component configurations



Harmonic Drive AG

Leistungsdaten Unit Baureihe HPG

| Bau-<br>größe | Unter-<br>teilung | Getriebe   |                         |   | Motorleistungen                          |   |                                       |
|---------------|-------------------|--|-------------------------|---|--|---|---------------------------------------|
|               |                   | Grenzen für<br>wiederholbare<br>System-<br>antriebsmomente | Nenn-<br>antriebsmoment | Grenzen für<br>substantive<br>Antriebsmomente | Zulässige<br>Dynamische<br>Nippanmomente | Zulässige<br>dynamische<br>Antriebs-<br>momente | Zulässige<br>dynamische<br>Fliehkraft |
|               |                   | [Nm]   | [Nm]                    | [Nm]  | [Nm]                                     | [Nm]  | [Nm]                                  |
| 5             | 0                 | 7,8  | 2,5                     | 20  | 9,5                                      | 400   | 200                                   |
| 9             | 0                 | 9,8  | 2,5                     | 20  | 9,5                                      | 510   | 240                                   |
| 11            | 21                | 9,8  | 3,5                     | 20  | 9,5                                      | 660   | 440                                   |
|               | 27                | 9,8  | 3,5                     | 20  | 9,5                                      | 700   | 620                                   |
|               | 40                | 9,8  | 3,5                     | 20  | 9,5                                      | 800   | 660                                   |
|               | 0                 | 10   | 3                       | 27  | 10,2                                     | 800   | 400                                   |
|               | 0                 | 22   | 9                       | 96  | 10,2                                     | 700   | 470                                   |
|               | 11                | 22   | 9                       | 96  | 10,2                                     | 800   | 600                                   |
|               | 16                | 22   | 9                       | 96  | 10,2                                     | 800   | 600                                   |
|               | 21                | 22   | 9                       | 96  | 10,2                                     | 1000  | 700                                   |
|               | 35                | 22   | 10                      | 96  | 10,2                                     | 1240  | 800                                   |
|               | 40                | 22   | 10                      | 96  | 10,2                                     | 1200  | 810                                   |
|               | 0                 | 84   | 9                       | 124   | 10,2                                     | 1200  | 810                                   |
|               | 0                 | 100  | 10                      | 217   | 10,2                                     | 1410  | 800                                   |
|               | 11                | 100  | 20                      | 217   | 10,2                                     | 1600  | 1240                                  |
|               | 20                | 100  | 24                      | 217   | 10,2                                     | 2000  | 1300                                  |
|               | 21                | 100  | 20                      | 217   | 10,2                                     | 2200  | 1610                                  |
|               | 33                | 100  | 20                      | 217   | 10,2                                     | 2000  | 1720                                  |
|               | 40                | 100  | 20                      | 217   | 10,2                                     | 2000  | 1600                                  |
|               | 0                 | 200  | 21                      | 607   | 40,2                                     | 2400  | 1600                                  |
|               | 0                 | 300  | 30                      | 600   | 40,2                                     | 2600  | 1600                                  |
|               | 11                | 300  | 30                      | 600   | 40,2                                     | 2600  | 2410                                  |
|               | 16                | 300  | 30                      | 600   | 40,2                                     | 2600  | 2640                                  |
|               | 21                | 300  | 30                      | 600   | 40,2                                     | 2600  | 2600                                  |
|               | 33                | 300  | 30                      | 600   | 40,2                                     | 2600  | 2140                                  |
|               | 40                | 300  | 30                      | 600   | 40,2                                     | 2400  | 2070                                  |
|               | 0                 | 607  | 47                      | 1600  | 107,6                                    | 3070  | 2700                                  |
|               | 0                 | 800  | 170                     | 1600  | 107,6                                    | 3400  | 4000                                  |



SEW R. D. 300

| Modell   | Leistung [kW] | Umschaltzeit [s] | Wärmeabfuhr | IP   | Effizienz | Wärmeabfuhr | IP   | Effizienz |
|----------|---------------|------------------|-------------|------|-----------|-------------|------|-----------|
| SEW 100  | 0,12          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 110  | 0,18          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 120  | 0,25          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 130  | 0,37          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 140  | 0,55          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 150  | 0,75          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 160  | 1,1           | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 170  | 1,5           | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 180  | 2,2           | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 190  | 3,0           | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 200  | 4,0           | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 210  | 5,5           | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 220  | 7,5           | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 230  | 11,0          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 240  | 15,0          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 250  | 22,0          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 260  | 30,0          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 270  | 40,0          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 280  | 55,0          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 290  | 75,0          | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 300  | 110,0         | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 310  | 150,0         | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 320  | 200,0         | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 330  | 275,0         | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 340  | 370,0         | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 350  | 500,0         | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 360  | 675,0         | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 370  | 900,0         | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 380  | 1200,0        | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 390  | 1600,0        | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 400  | 2100,0        | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 410  | 2800,0        | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 420  | 3700,0        | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 430  | 5000,0        | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 440  | 6750,0        | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 450  | 9000,0        | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
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| SEW 470  | 16000,0       | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 480  | 21000,0       | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 490  | 28000,0       | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 500  | 37000,0       | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 510  | 50000,0       | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 520  | 67500,0       | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
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| SEW 560  | 210000,0      | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 570  | 280000,0      | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 580  | 370000,0      | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 590  | 500000,0      | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 600  | 675000,0      | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 610  | 900000,0      | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 620  | 1200000,0     | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 630  | 1600000,0     | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 640  | 2100000,0     | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 650  | 2800000,0     | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 660  | 3700000,0     | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 670  | 5000000,0     | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 680  | 6750000,0     | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 690  | 9000000,0     | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 700  | 12000000,0    | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 710  | 16000000,0    | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 720  | 21000000,0    | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 730  | 28000000,0    | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 740  | 37000000,0    | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 750  | 50000000,0    | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 760  | 67500000,0    | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 770  | 90000000,0    | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 780  | 120000000,0   | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 790  | 160000000,0   | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 800  | 210000000,0   | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 810  | 280000000,0   | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 820  | 370000000,0   | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 830  | 500000000,0   | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 840  | 675000000,0   | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 850  | 900000000,0   | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 860  | 1200000000,0  | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 870  | 1600000000,0  | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 880  | 2100000000,0  | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 890  | 2800000000,0  | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 900  | 3700000000,0  | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 910  | 5000000000,0  | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 920  | 6750000000,0  | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 930  | 9000000000,0  | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 940  | 12000000000,0 | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 950  | 16000000000,0 | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 960  | 21000000000,0 | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 970  | 28000000000,0 | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 980  | 37000000000,0 | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 990  | 50000000000,0 | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |
| SEW 1000 | 67500000000,0 | 0,1              | 1           | IP54 | 0,75      | 1           | IP54 | 0,75      |

- Motivation
- Approach
- Summary and Outlook

maxon motor

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driven by precision

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Your shopping cart (0)

Total: EUR 0.00  
excl. VAT



## Product Finder

Please select a product using the search possibilities below

Types: 
 Power rating (W): 
 Ø (mm): 
 max. length (mm): 
 Nominal torque up to [Nm]:

Results per page
 Results : 1 to 10 of 1230 hits
1/123

### Products

- ▼ maxon DC motor
  - A Program
  - A-max Program
  - RE Program
  - RE-max Program
- ▶ maxon EC motor
- ▶ maxon gear
- ▶ maxon tachometer
- ▶ maxon motor control
- ▶ maxon accessories

### Quick search

### Direct order

▶ Direct order

### Login

- ▶ Forgotten your password?
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### Results

| Order No. | Program  | Max. Ø (mm) ↑↓ | P [W] ↑↓ | Un [V] ↑↓ | n <sub>0</sub> [min <sup>-1</sup> ] ↑↓ | M <sub>n</sub> [Nm] ↑↓ | Downloads | Combine with | Price EUR 1 pc(s) | Quantity                       |
|-----------|--|----------------|----------|-----------|--|------------------------|-----------|--------------|-------------------|--------------------------------|
| 2516...   | A 2516 Ø16 mm, Precious Metal Brushes, 0.8 Watt                    | 16             | 0.8      | 12        | 16100                                  | 0.654                  |           |              | 25.80             | <input type="text" value="1"/> |
| 2516...   | A 2516 Ø16 mm, Precious Metal Brushes, 0.8 Watt                    | 16             | 0.8      | 24        | 18200                                  | 0.661                  |           |              | 30.20             | <input type="text" value="1"/> |
| 2516...   | A 2516 Ø16 mm, Precious Metal Brushes, 0.8 Watt                    | 16             | 0.8      | 4.5       | 16600                                  | 0.759                  |           |              | 25.80             | <input type="text" value="1"/> |
| 2520...   | A 2520 Ø20 mm, Precious Metal Brushes, 1.2 Watt                    | 20             | 1.2      | 9         | 13400                                  | 0.998                  |           |              | 28.47             | <input type="text" value="1"/> |
| 2520...   | A 2520 Ø20 mm, Precious Metal Brushes, 1.2 Watt                    | 20             | 1.2      | 12        | 13000                                  | 0.858                  |           |              | 33.33             | <input type="text" value="1"/> |
| 2520...   | A 2520 Ø20 mm, Precious Metal Brushes, 1.2 Watt                    | 20             | 1.2      | 6         | 13600                                  | 1.07                   |           |              | 33.33             | <input type="text" value="1"/> |
| 200938    | A-max 12 Ø12 mm, Precious Metal Brushes CLL, 0.5 Watt, CE approved | 12             | 0.5      | 3         | 13700                                  | 0.866                  |           |              | 31.27             | <input type="text" value="1"/> |
| 265389    | A-max 12 Ø12 mm, Precious Metal Brushes CLL, 0.5 Watt, CE approved | 12             | 0.5      | 4.5       | 11700                                  | 0.935                  |           |              | 31.27             | <input type="text" value="1"/> |
| 265390    | A-max 12 Ø12 mm, Precious Metal Brushes CLL, 0.5 Watt, CE approved | 12             | 0.5      | 6         | 12600                                  | 0.921                  |           |              | 31.27             | <input type="text" value="1"/> |

No combination in progress - Add with this function an article in the combination.

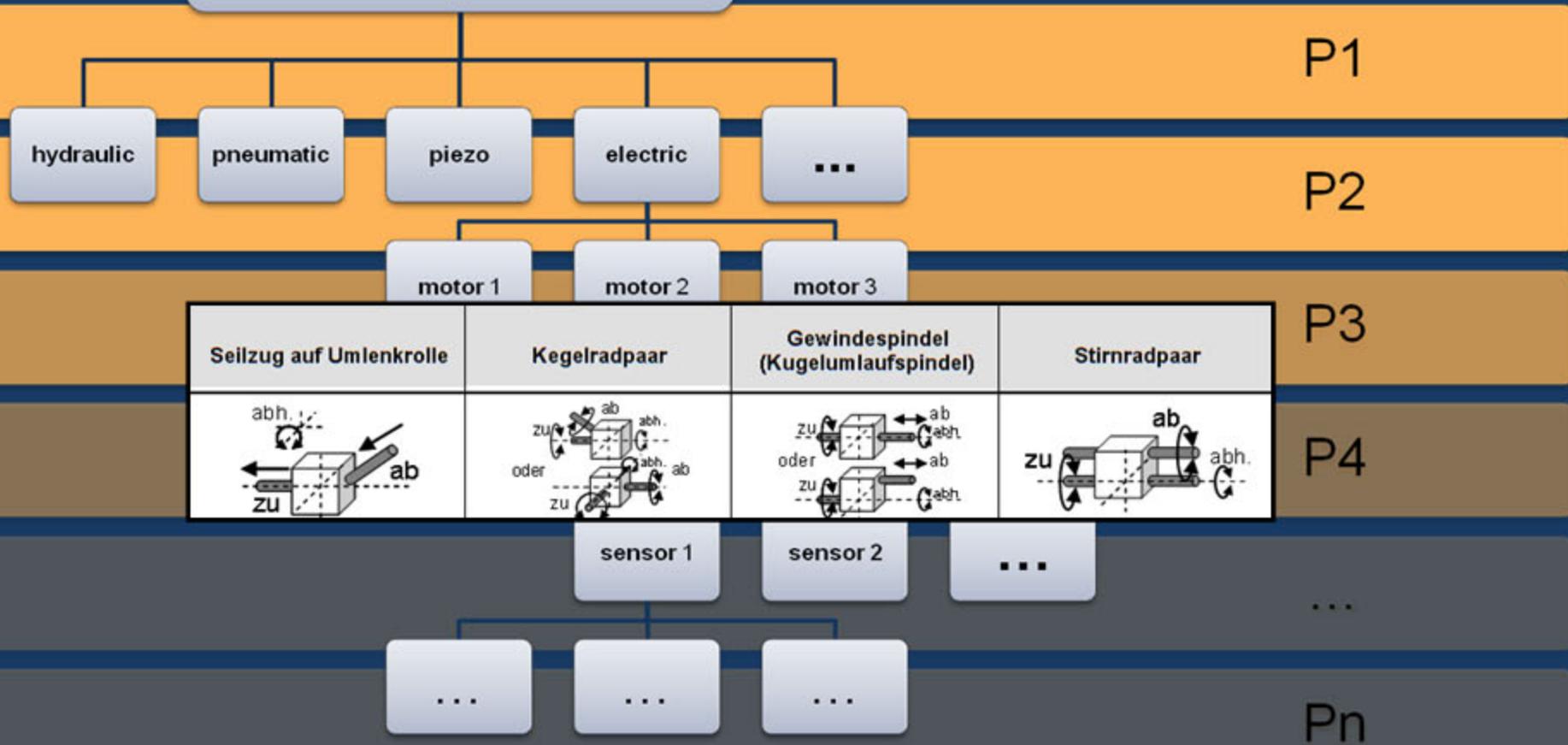
Stock program
  Standard program
  Special program

- Are there any existing configurations for subsystems, with which the requirements can be fulfilled?
- Are there configurations of subsystems, that are compatible to each other?
- **precondition:**  
All component parameters must be stored in a proper classification.

## Two-stage method:

- **phase 1 – configuration phase**  
computer-aided **selection of suitable configurations (not only components!)** using standardized component libraries
  
- **phase 2 – optimization phase**  
computer-aided **determination of free parameters** (search of optimal configuration, placement of configurations within design space, ...)

system of objectives  
 (e.g.: drive unit for nodding the head)



P1  
 P2  
 P3  
 P4  
 ...  
 Pn

- precondition :  
All component parameters must be stored in a proper classification:      Excel-Sheet → XML

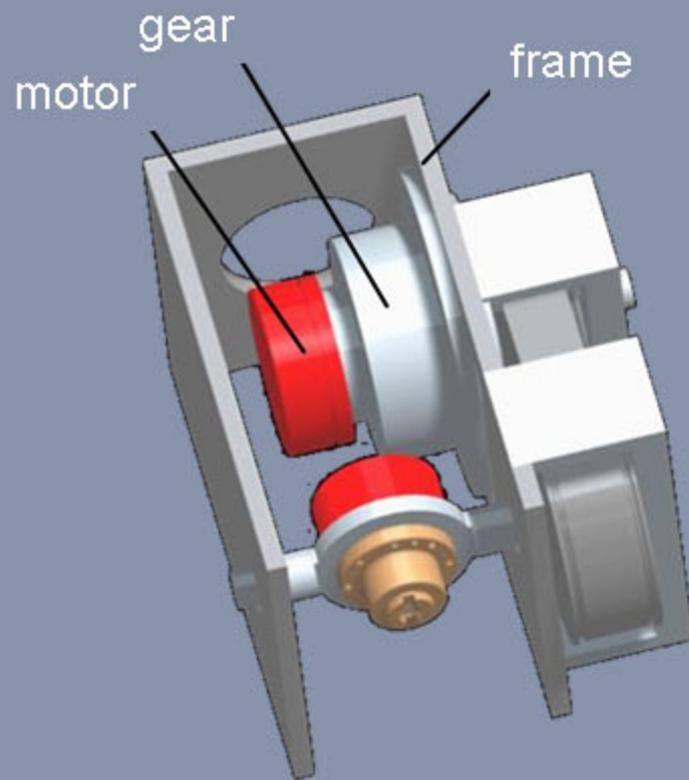
| manufacturer     | product id     | torque    | efficiency factor | dimension x | dimension y | dimension z | diameter  | voltage   |
|------------------|----------------|-----------|-------------------|-------------|-------------|-------------|-----------|-----------|
| SEW              | S/00102        | 10        | 0.91              | 45          | 90          | 177         | 4         | 24        |
| <b>SEW</b>       | <b>S/00103</b> | <b>15</b> | <b>0.91</b>       | <b>35</b>   | <b>85</b>   | <b>185</b>  | <b>6</b>  | <b>12</b> |
| SEW              | S/00104        | 20        | 0.89              | 34          | 93          | 105         | 6         | 12        |
| <b>SEW</b>       | <b>S/00105</b> | <b>25</b> | <b>0.90</b>       | <b>33</b>   | <b>81</b>   | <b>100</b>  | <b>11</b> | <b>12</b> |
| SEW              | S/00106        | 30        | 0.85              | 31          | 99          | 193         | 12        | 24        |
| <b>SEW</b>       | <b>S/00107</b> | <b>35</b> | <b>0.92</b>       | <b>31</b>   | <b>100</b>  | <b>184</b>  | <b>5</b>  | <b>12</b> |
| SEW              | S/00108        | 40        | 0.93              | 35          | 84          | 106         | 6         | 12        |
| <b>Maxon</b>     | <b>m-33541</b> | <b>35</b> | <b>0.82</b>       | <b>31</b>   | <b>85</b>   | <b>178</b>  | <b>10</b> | <b>24</b> |
| Maxon            | m-33542        | 20        | 0.86              | 45          | 88          | 137         | 8         | 12        |
| <b>Maxon</b>     | <b>m-33543</b> | <b>15</b> | <b>0.85</b>       | <b>32</b>   | <b>100</b>  | <b>150</b>  | <b>2</b>  | <b>12</b> |
| Maxon            | m-33544        | 10        | 0.87              | 38          | 94          | 181         | 10        | 24        |
| <b>Faulhaber</b> | <b>F14235</b>  | <b>20</b> | <b>0.83</b>       | <b>30</b>   | <b>86</b>   | <b>194</b>  | <b>4</b>  | <b>12</b> |
| Faulhaber        | F14236         | 23        | 0.79              | 32          | 94          | 137         | 9         | 12        |
| <b>Faulhaber</b> | <b>F14237</b>  | <b>27</b> | <b>0.81</b>       | <b>42</b>   | <b>99</b>   | <b>192</b>  | <b>5</b>  | <b>12</b> |
| Faulhaber        | F14238         | 32        | 0.81              | 31          | 95          | 175         | 7         | 12        |
| <b>Parker</b>    | <b>512p</b>    | <b>15</b> | <b>0.81</b>       | <b>40</b>   | <b>100</b>  | <b>187</b>  | <b>7</b>  | <b>12</b> |
| Parker           | 513p           | 12        | 0.76              | 43          | 87          | 196         | 5         | 12        |

## ■ Precondition :

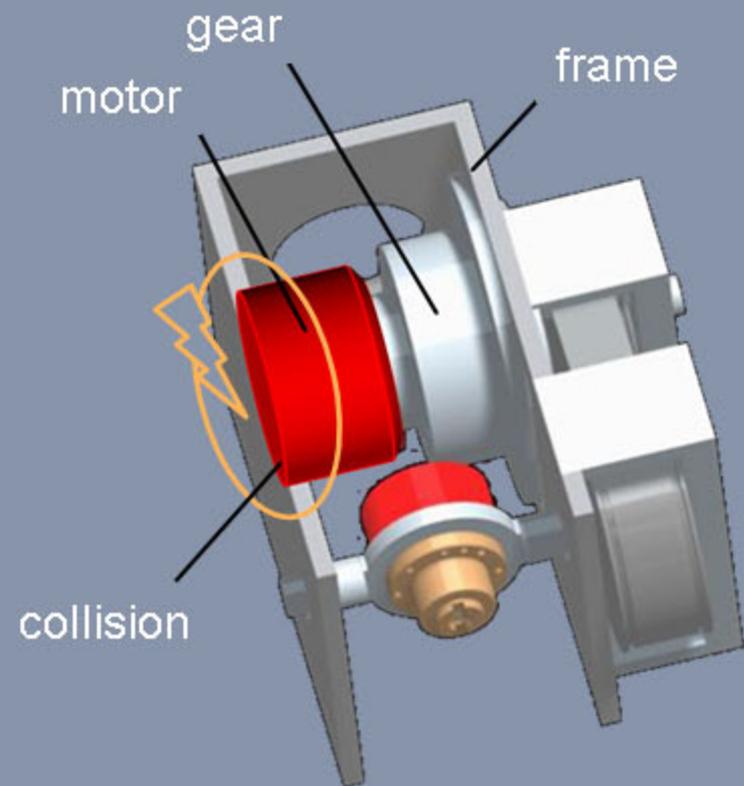
All component parameters must be stored in a proper classification:      Excel-Sheet → XML

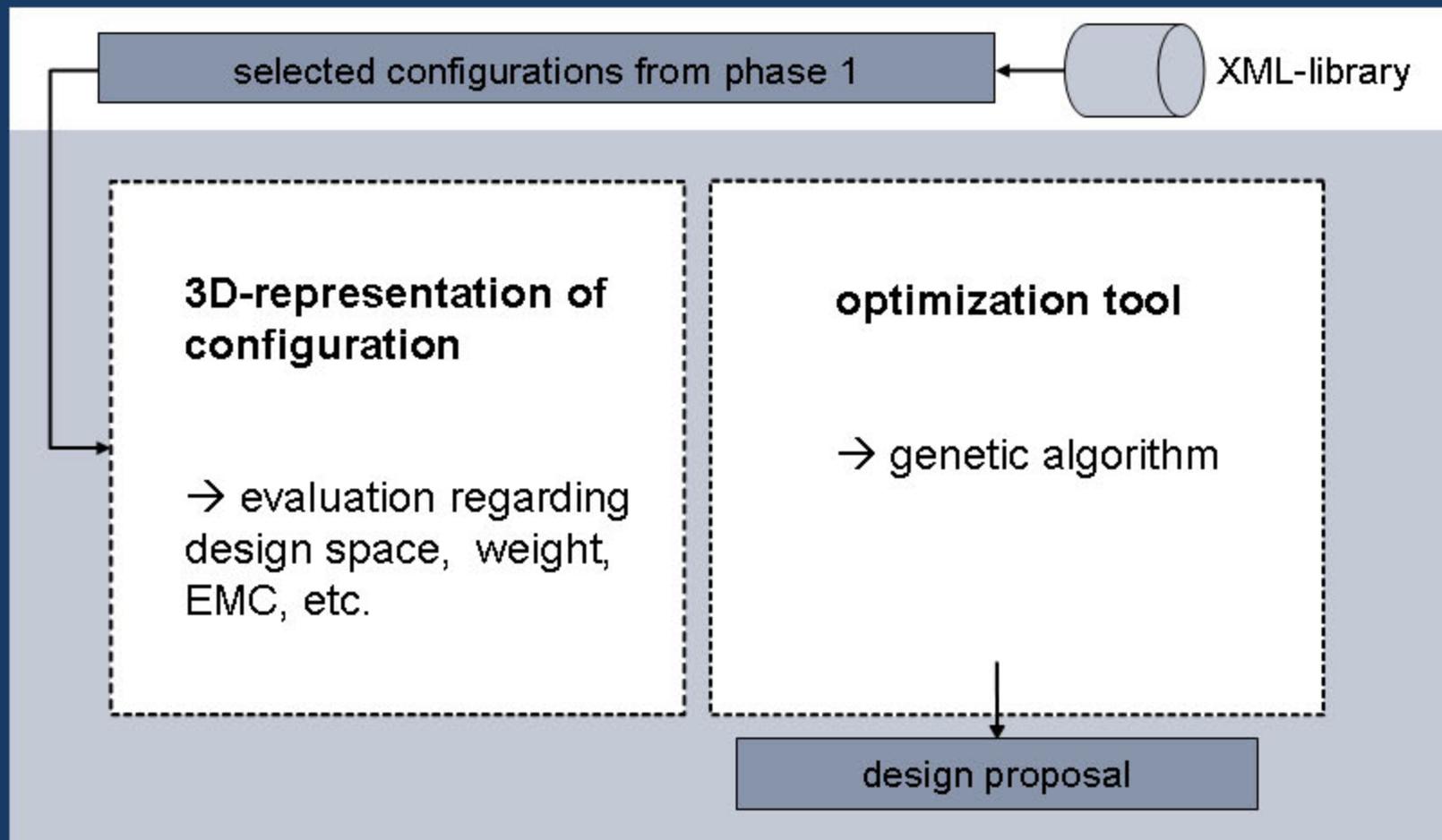
```
<root>
  <title> manufacturer</title>
  <parameter>
    <label> torque [Nm]</label>
    <value> 10 </value>
  </parameter >
  < parameter >
    <label> voltage [V]</label>
    <value> 24 </value>
  </ parameter >
  ...
</root>
```

## configuration 1



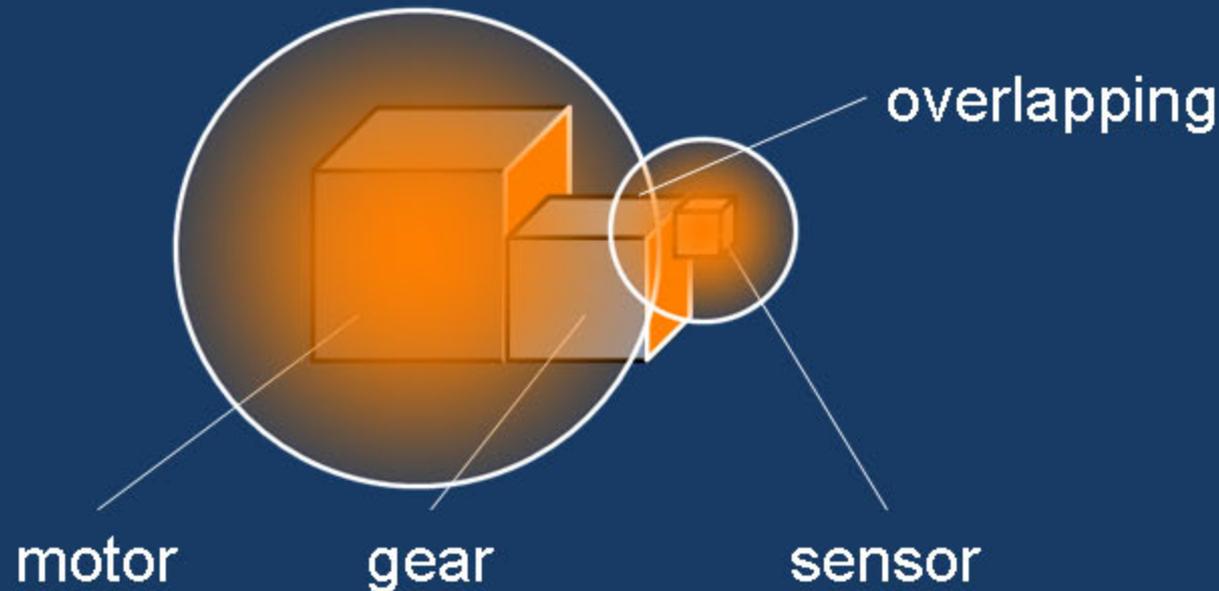
## configuration 2

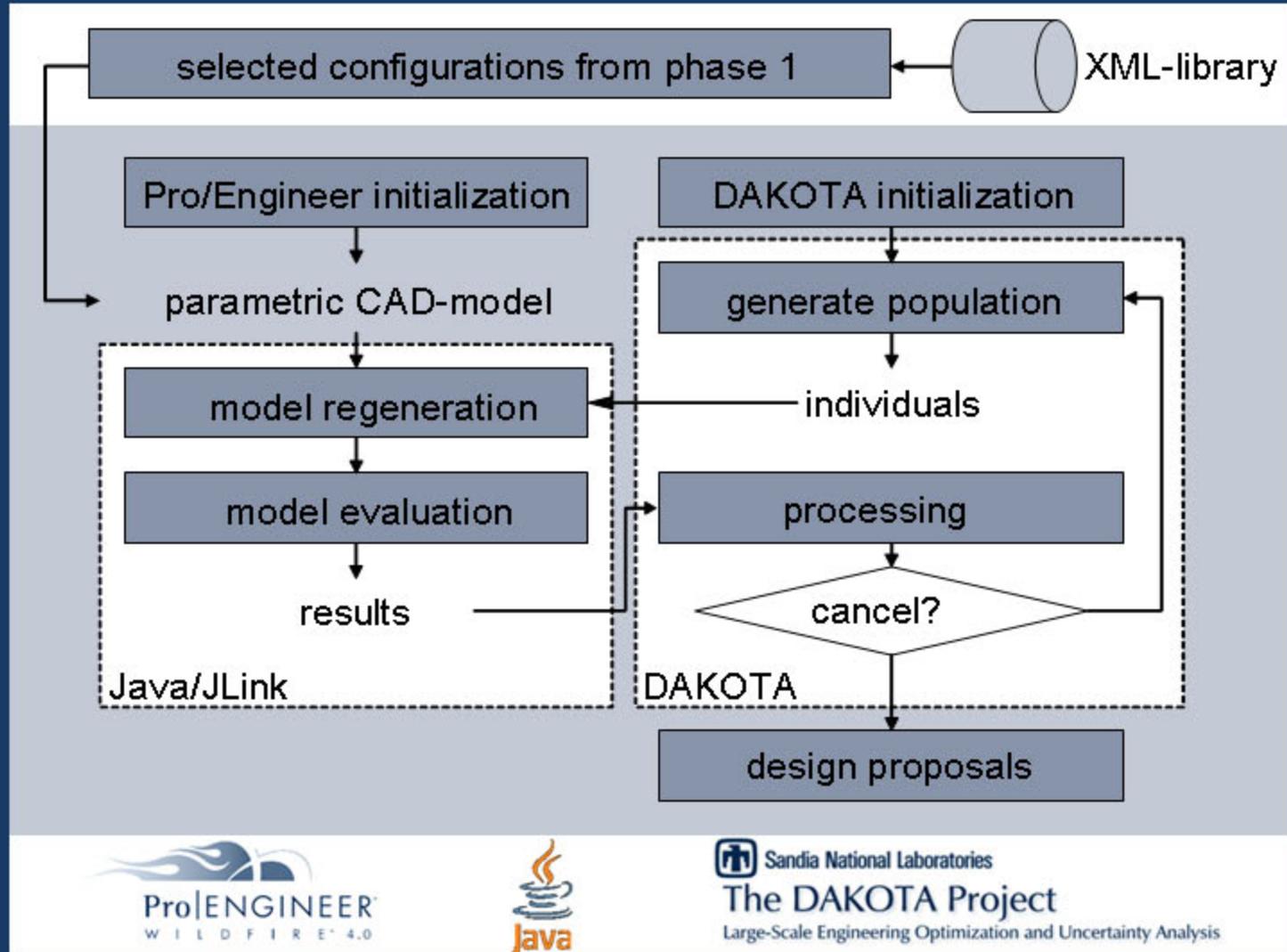




## ■ example: electromagnetic compatibility

- based on CAD-models including information regarding mechanical interfaces
- automatic checking of diverse constraints
  - evaluation of configurations resp. concept





- Motivation
- Approach
- Summary and Outlook

## ■ Summary:

- Support configuration process using computer-aided methods
- Reduce risk to forget possible solutions
- Make sure to find optimal configurations
- Implementation still under progress

## ■ Outlook:

- Integration of other software tools like Matlab/Simulink:
  - simulation and evaluation of dynamic behavior
  - exchange of CAD-Data between ProE Simulink via XML
- Implementation as a completely automated process
- Refeeding of already know solutions / integration in PDM-System

Thank you for your attention