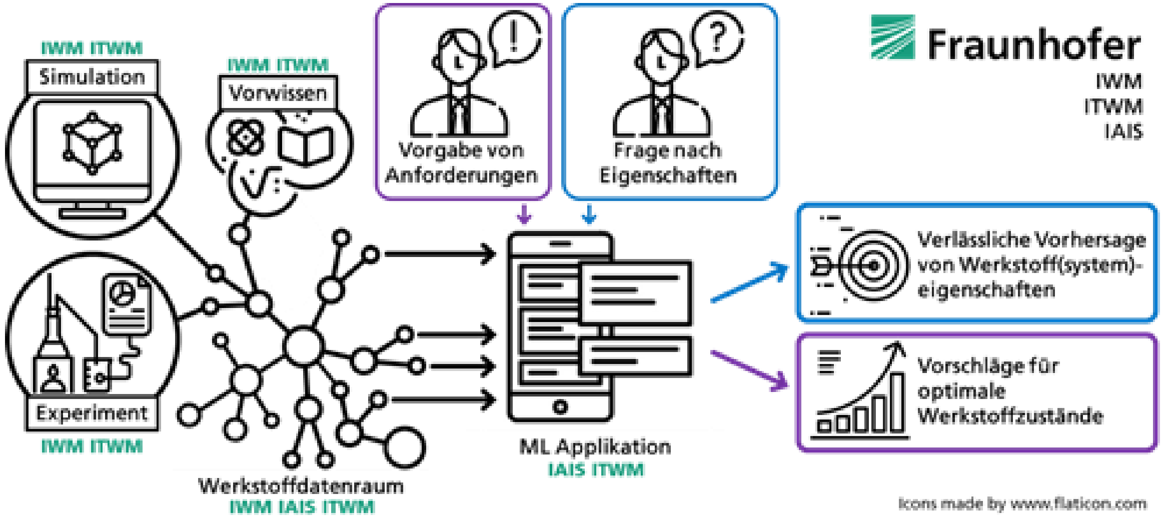
ONLINE-VERANSTALTUNG

Vorhersage von Modellparametern für die Simulation von Kabelbündeln

Abschlusskolloquium
des Fraunhofer-Konsortiums »UrWerk«
zur Entwicklung von unternehmensspezifischen Werkstoff(system)-Datenräumen



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Projektleiter »UrWerk«
Geschäftsfeldleiter »Bauteilsicherheit und Leichtbau«
am Fraunhofer-Institut für Werkstoffmechanik IWM

24.November 2022

Fraunhofer IWM Fraunhofer IAIS Fraunhofer ITWM

ABSCHLUSSKOLLOQUIUM „URWERK“

Vorhersage von Modellparametern für die Simulation von Kabelbündeln

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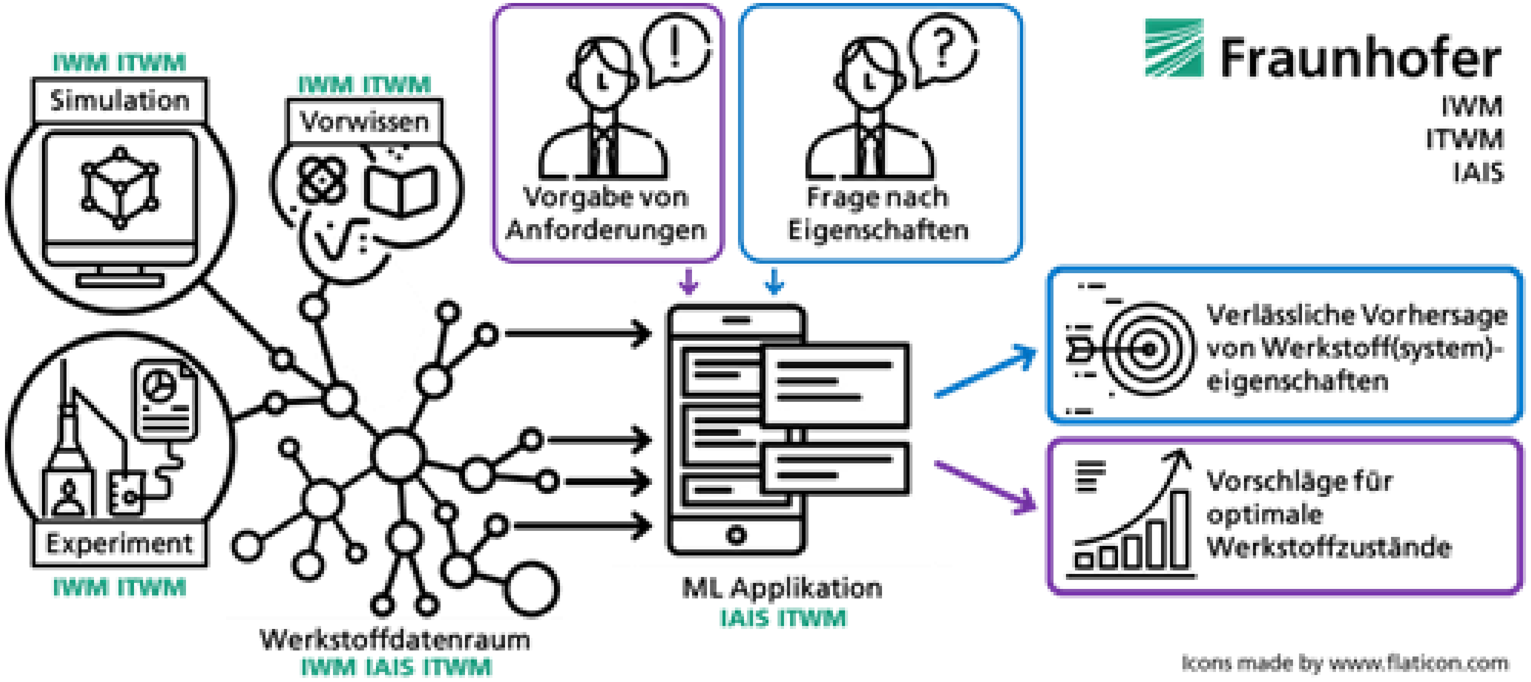
Dominik Jungkenn



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Simulation

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Vorwissen

Vorgabe von Anforderungen

Frage nach Eigenschaften

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Experiment
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Werkstoffdatenraum
IWM IAIS ITWM

ML Applikation
IAIS ITWM

Verlässliche Vorhersage von Werkstoff(system)-eigenschaften

Vorschläge für optimale Werkstoffzustände

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24.11.2022

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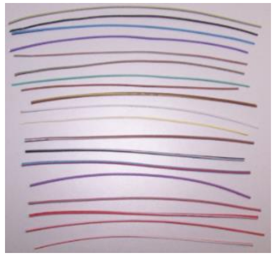
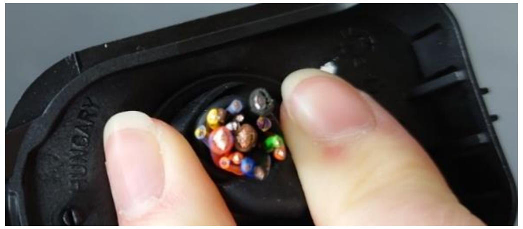
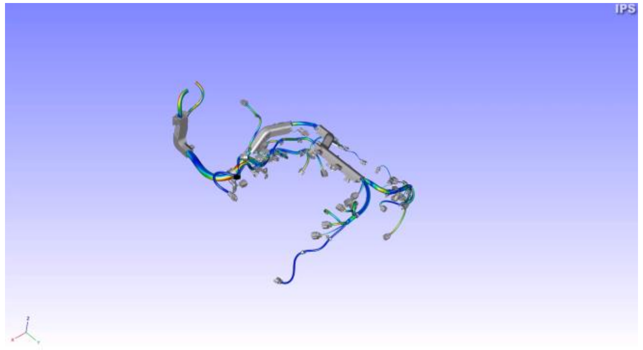
Use Case “Kabelbündel-Steifigkeiten”

Motivation

- IPS Cable Simulation
  - Quick and simple model setup & interactive simulation
  - Requires model parameters: effective stiffness
- MeSOMICS
  - Highly automated measurement system for cables and hoses
- Cable bundles
  - Cables in various combinations (depending on vehicle equipment)
  - Measurements in early phases would hinder the development







Use Case “Kabelbündel-Steifigkeiten”

Tasks in UrWerk

- Estimation of “**Werkstoffsystem**” properties: effective cable bundle stiffness

- Generate an (initial) data base by a **measurement campaign**
  - measure effective properties of cable bundles
  - measure effective properties of underlying cables

Use Case “Kabelbündel-Steifigkeiten”

Generation of data base by measurement campaign

- Generate an (initial) data base by a measurement campaign
  - measure effective properties of underlying cables

Base cables

- > 30 cable types
- Effective bending & torsion stiffness
- Radius
- Length density

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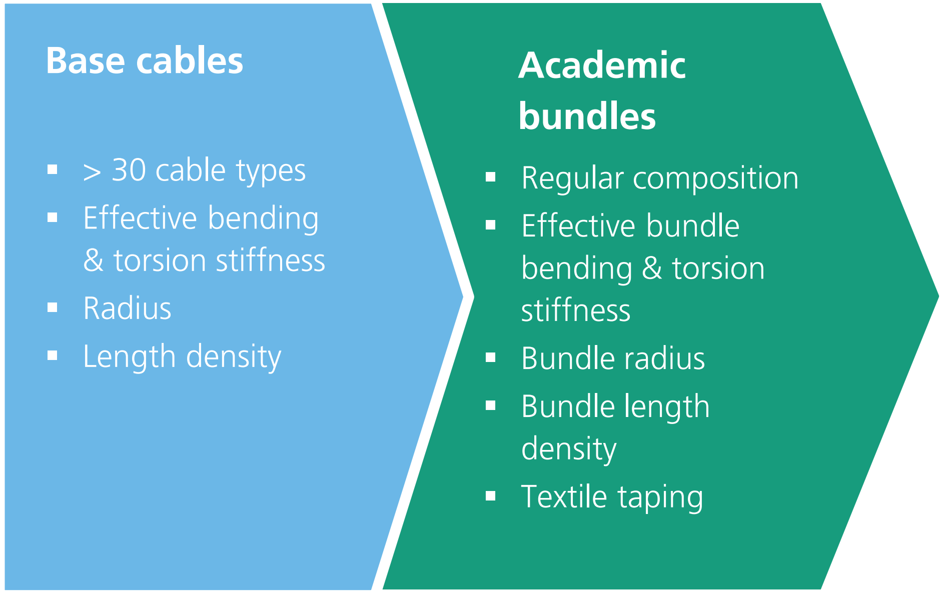

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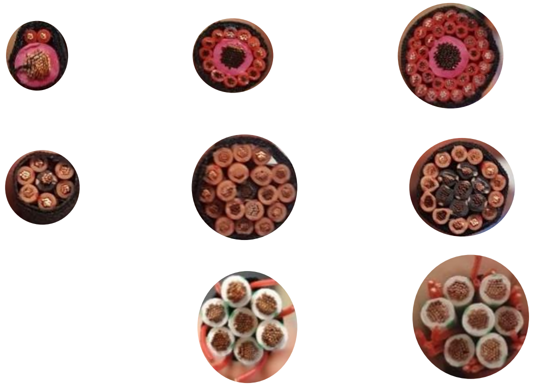
Academic bundles

- Regular composition
- Effective bundle bending & torsion stiffness
- Bundle radius
- Bundle length density
- Textile taping



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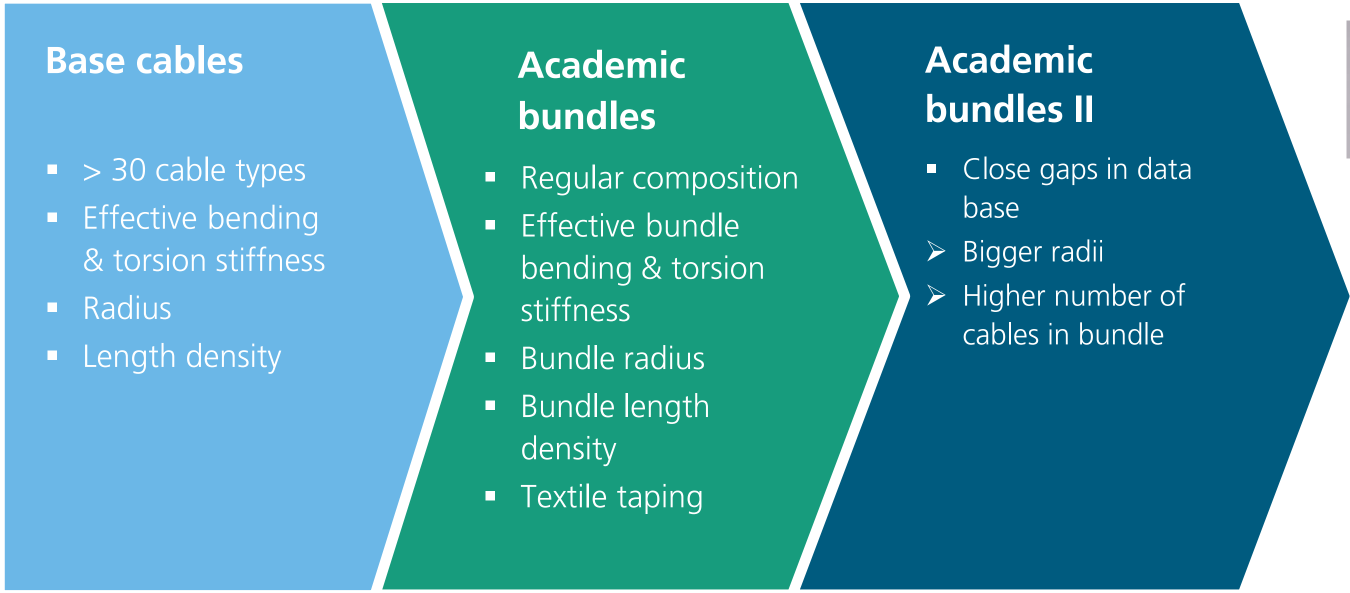

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Academic bundles II

- Close gaps in data base
- ➢ Bigger radii
- ➢ Higher number of cables in bundle

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- Generate an (initial) data base by a measurement campaign
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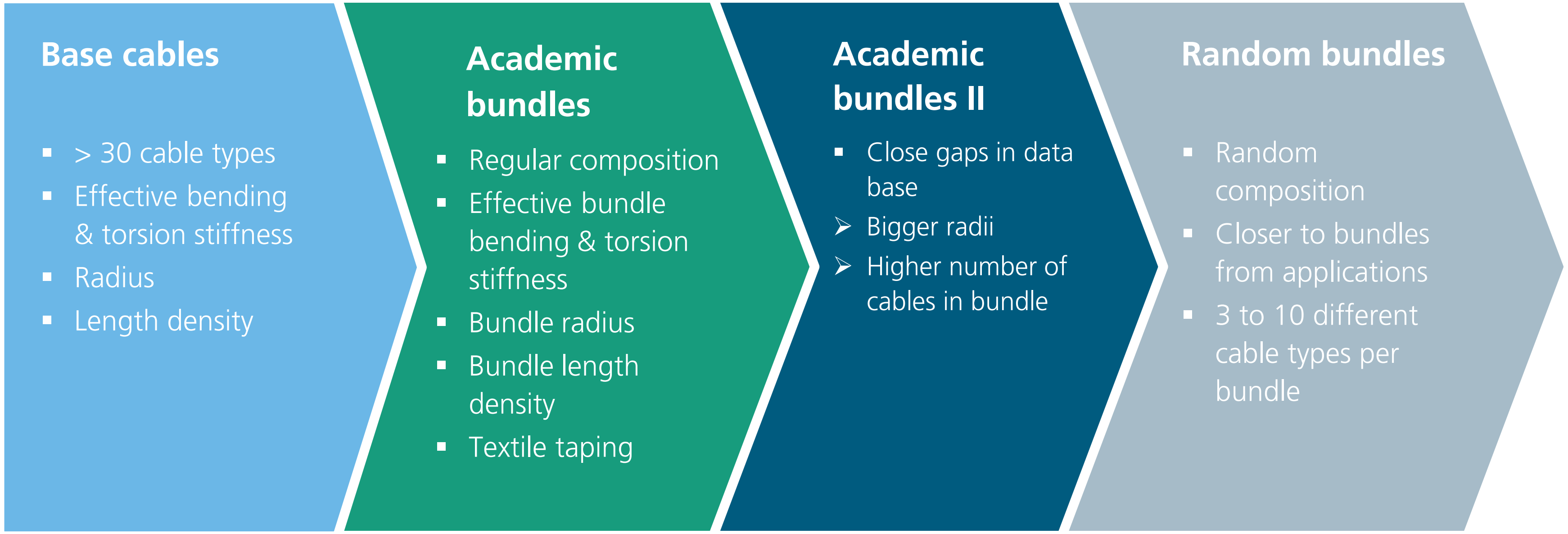

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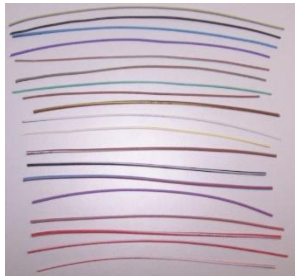
Random bundles

- Random composition
- Closer to bundles from applications
- 3 to 10 different cable types per bundle

Use Case “Kabelbündel-Steifigkeiten”

Generation of data base by measurement campaign



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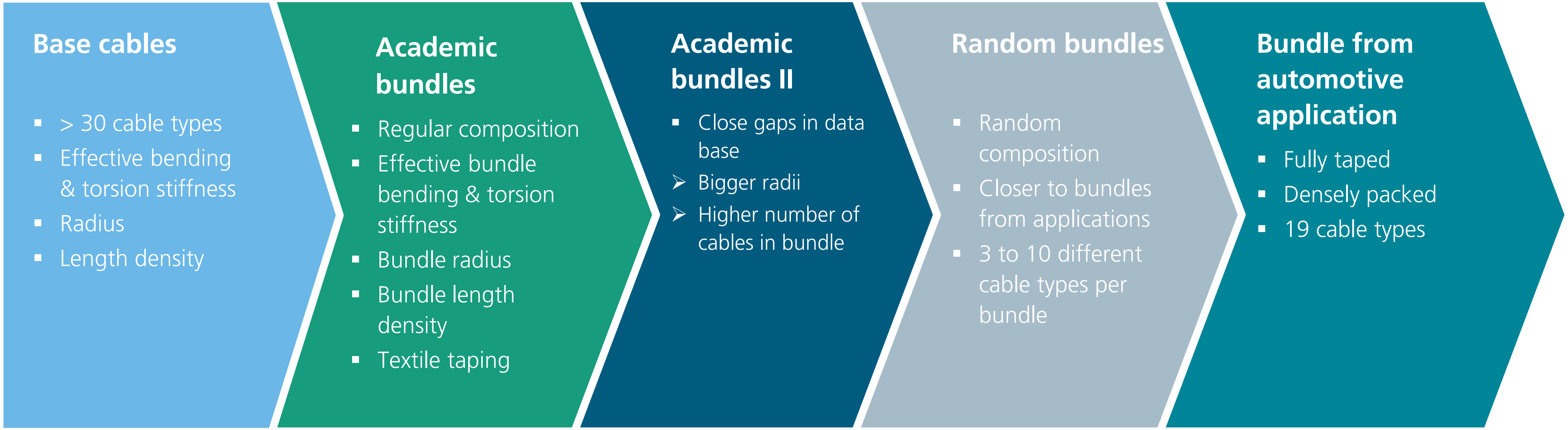

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Bundle from automotive application

- Fully taped
- Densely packed
- 19 cable types

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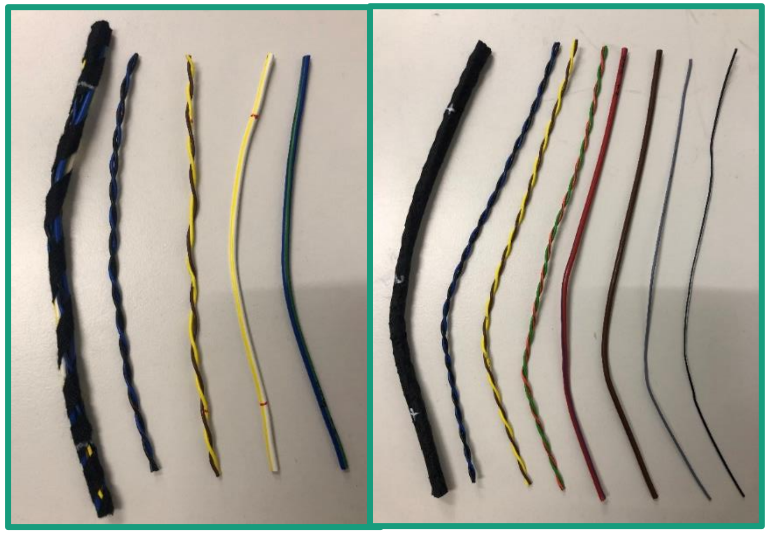

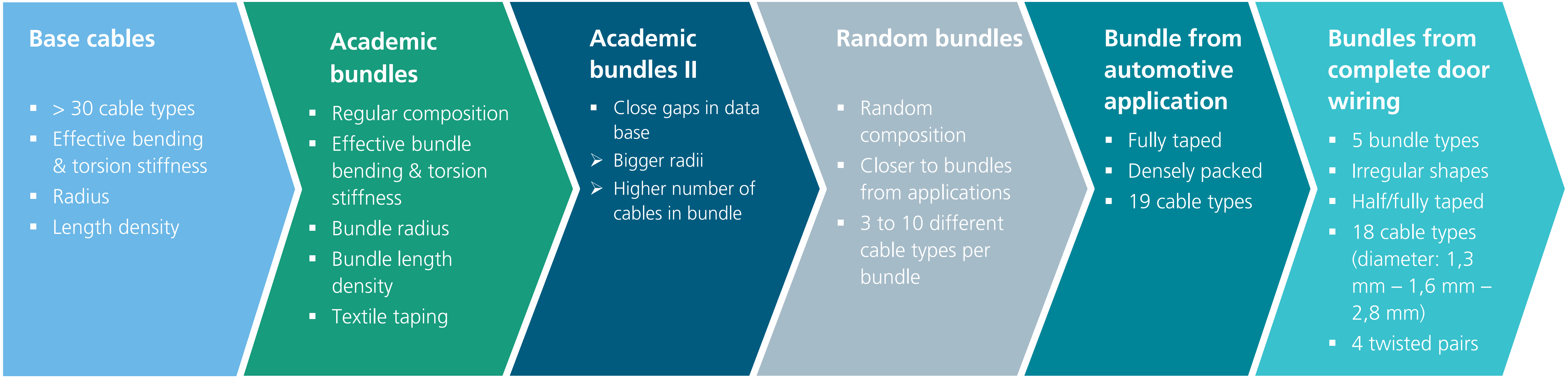

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Academic bundles II

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Random bundles

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- 3 to 10 different cable types per bundle

Bundle from automotive application

- Fully taped
- Densely packed
- 19 cable types

Bundles from complete door wiring

- 5 bundle types
- Irregular shapes
- Half/fully taped
- 18 cable types (diameter: 1,3 mm – 1,6 mm – 2,8 mm)
- 4 twisted pairs

Use Case “Kabelbündel-Steifigkeiten”

Tasks in UrWerk

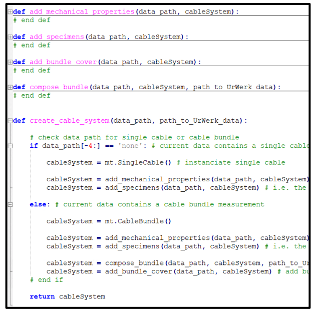
- Estimation of “**Werkstoffsystem**” properties: effective cable bundle stiffness

- Generate an (initial) data base by a **measurement campaign**
  - measure effective properties of cable bundles
  - measure effective properties of underlying cables

- Convenient data storage utilizing **ontological description**
  - Develop ontology for cables and cable bundles
  - → Intuitive virtual composition of bundles
  - Python scripts for up- and download

SimPhoNy

OSP-core CUDS API



```
def add_mechanical_properties(data_path, cableSystem):
# end def

def add_specimens(data_path, cableSystem):
# end def

def add_bundle_cover(data_path, cableSystem):
# end def

def compose_bundle(data_path, cableSystem, path_to_UrWerk_data):
# end def


def create_cable_system(data_path, path_to_UrWerk_data):

    # check data path for single cable or cable bundle
    if data_path[-4:] == 'none': # current data contains a single cable

        cableSystem = mt.SingleCable() # instanciate single cable

        cableSystem = add_mechanical_properties(data_path, cableSystem)
        cableSystem = add_specimens(data_path, cableSystem) # i.e. the

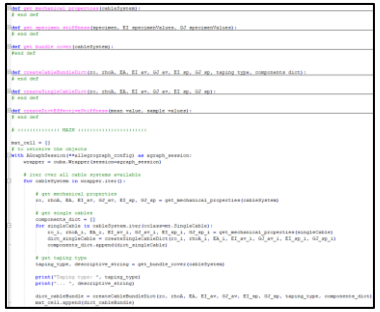
    else: # current data contains a cable bundle measurement

        cableSystem = mt.CableBundle()

        cableSystem = add_mechanical_properties(data_path, cableSystem)
        cableSystem = add_specimens(data_path, cableSystem) # i.e. the

        cableSystem = compose_bundle(data_path, cableSystem, path_to_Ur
        cableSystem = add_bundle_cover(data_path, cableSystem) # add bu
    # end if

    return cableSystem
```



```
def get_mechanical_properties(cableSystem):
# end def

def get_specimen_stiffness(specimen, EI_specimenValues, GJ_specimenValues):
# end def

def get_bundle_cover(cableSystem):
#end def


def createCableBundleDict(ro, rhoA, EA, EI_av, GJ_av, EI_sp, GJ_sp, taping_type, components_dict):
# end def

def createSingleCableDict(ro, rhoA, EA, EI_av, GJ_av, EI_sp, GJ_sp):
# end def

def createDictEffectiveStiffness(mean_value, sample_values):
# end def

# :::::::::::::: MAIN ::::::::::::::::::::::

mat_cell = []
# to retreive the objects
with AGraphSession(**allegrograph_config) as agraph_session:
    wrapper = cuba.Wrapper(session=agraph_session)

    # iter over all cable systems available
    for cableSystem in wrapper.iter():

        # get mechanical properties
        ro, rhoA, EA, EI_av, GJ_av, EI_sp, GJ_sp = get_mechanical_properties(cableSystem)

        # get single cables
        components_dict = []
        for singleCable in cableSystem.iter(oclass=mt.SingleCable):
            ro_i, rhoA_i, EA_i, EI_av_i, GJ_av_i, EI_sp_i, GJ_sp_i = get_mechanical_properties(singleCable)
            dict_singleCable = createSingleCableDict(ro_i, rhoA_i, EA_i, EI_av_i, GJ_av_i, EI_sp_i, GJ_sp_i)
            components_dict.append(dict_singleCable)

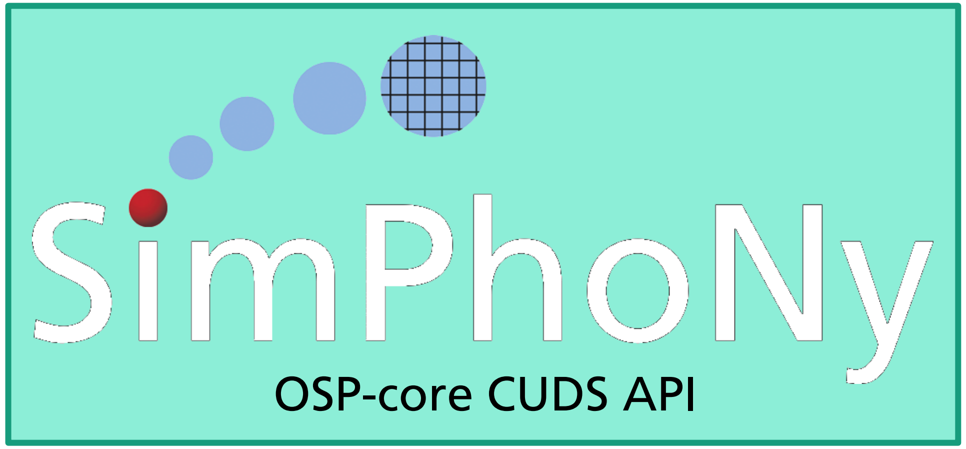
        # get taping type
        taping_type, descriptive_string = get_bundle_cover(cableSystem)

        print("Taping type: ", taping_type)
        print("... ", descriptive_string)

        dict_cableBundle = createCableBundleDict(ro, rhoA, EA, EI_av, GJ_av, EI_sp, GJ_sp, taping_type, components_dict)
        mat_cell.append(dict_cableBundle)
```

Virtual composition of cable bundles

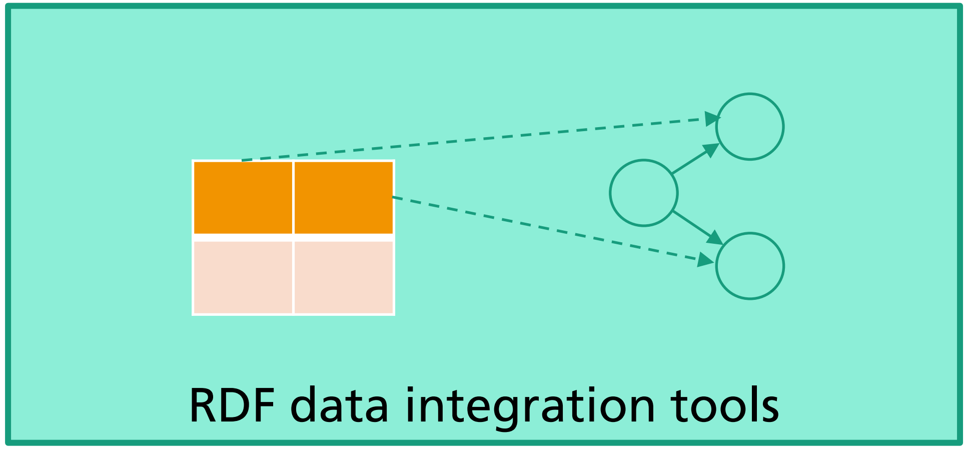
Cable Bundle use case



OSP-core CUDS API

- Very generic and flexible.
- Python interface to the ontology and data.

Fatigue use case

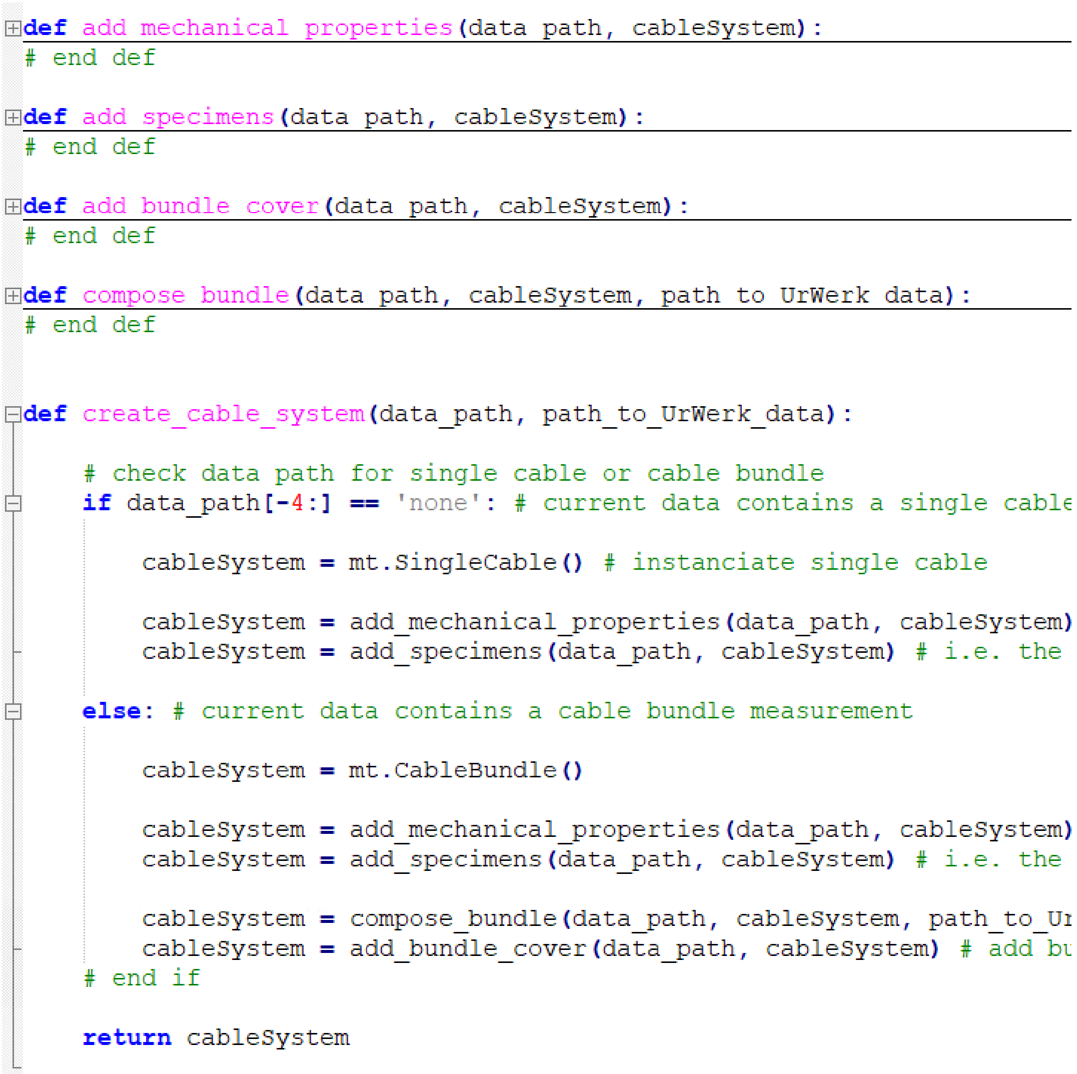


RDF data integration tools

- Not as flexible.
- More standardized.
- Closer to an "easy to use" solution (filling a template instead of actual programming).

Virtual composition of cable bundles

- *The ontology description allows storage of measured data in an intuitive, structured way*
- **Create single cable CUDS object**
  - add measured mechanical properties and single specimen data
- **Create cable bundle CUDS object**
  - add measured mechanical properties and single specimen data
  - Compose bundle **by adding cable CUDS objects**
  - and specify bundle cover („taping“ type)
- **→ virtual bundle composition**



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def add mechanical properties(data path, cableSystem):
# end def

def add specimens(data path, cableSystem):
# end def

def add bundle cover(data path, cableSystem):
# end def

def compose bundle(data path, cableSystem, path to UrWerk data):
# end def


def create_cable_system(data_path, path_to_UrWerk_data):

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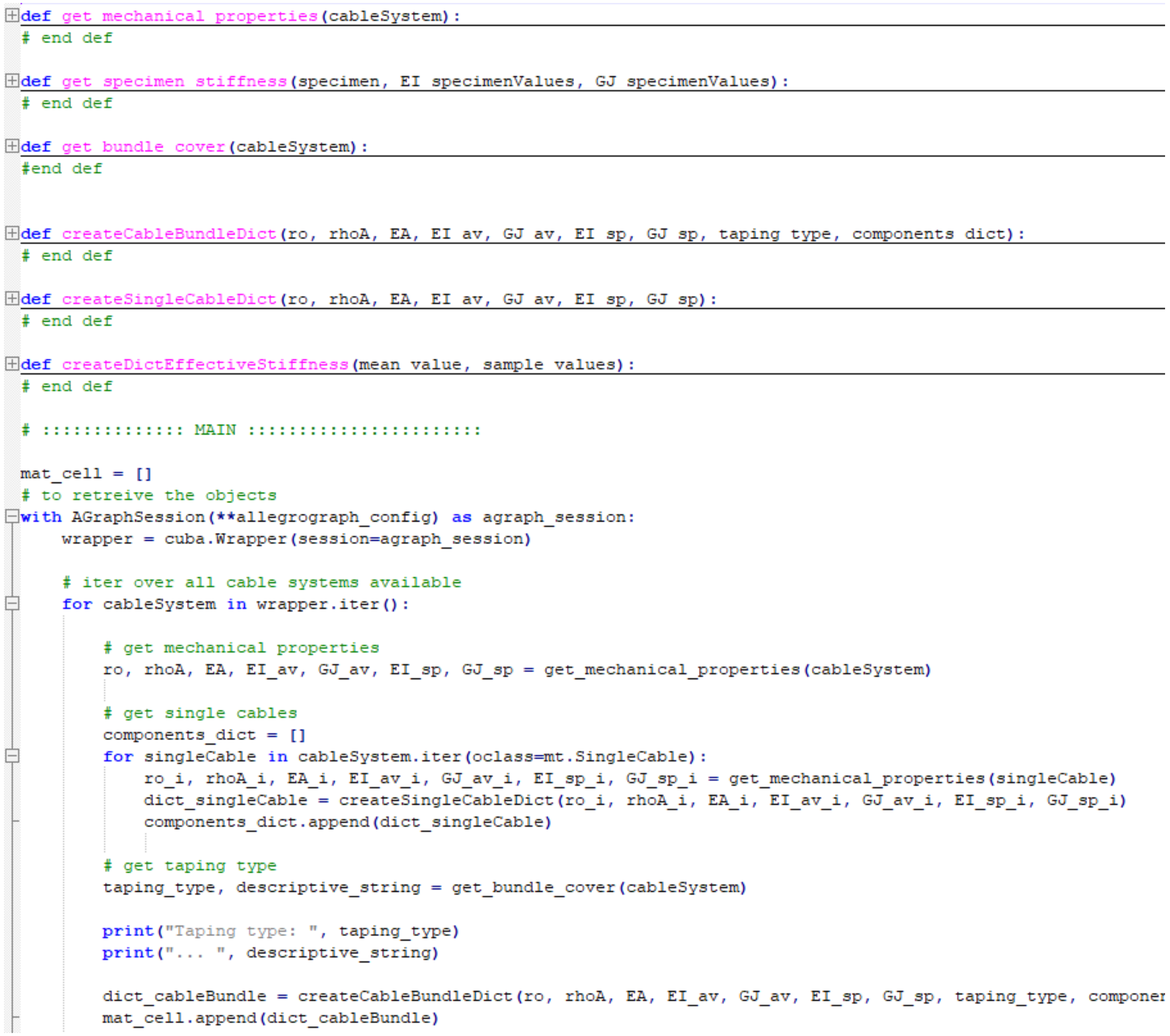
    # end if

    return cableSystem
```

Data download / Data query

- *The ontology description allows storage of measured data in an intuitive, structured way*

- For analysis of data, bundle and cable **data must be downloaded**
  - Python script getting back data



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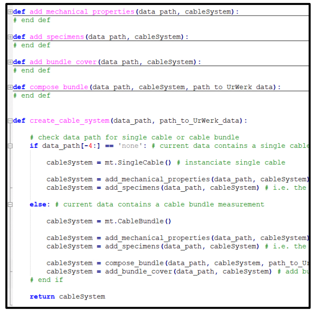

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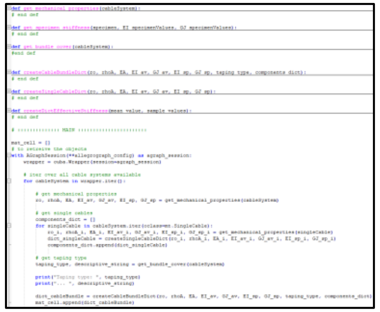

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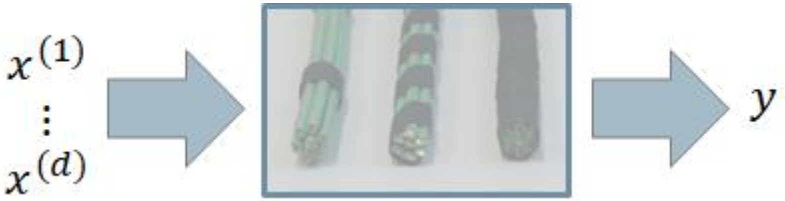
- Develop, analyze and train a suitable **ML algorithm** for the
  - estimation of effective cable bundle properties (y)
  - based on given effective cable properties ($x^{(1)}, \dots, x^{(d)}$)



Vielen Dank für Ihre Aufmerksamkeit!

Kontakt

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Bereich *Mathematik für die Fahrzeugentwicklung*

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