# ARENA2036 DigitPro

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**Strategic partnership for new innovations and research on a new level**

# ARENA2036 – The Research Campus

**ARENA**2036

## <u>A</u>ctive <u>R</u>esearch <u>E</u>nvironment for the <u>N</u>ext generation of <u>A</u>utomobiles

- Developments for Industrial 4.0 and Digitalization

- 3 starting technical research projects + 1 overlapping research area



**DigitPro**
Digital Prototype

- Process Simulation
- Virtual Testing
- Closed Process Chain
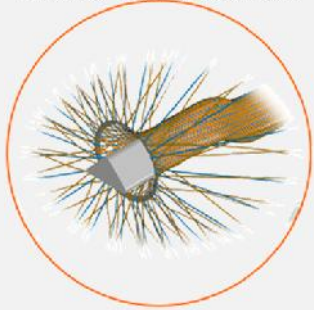
**ForschFab**
Research Factory

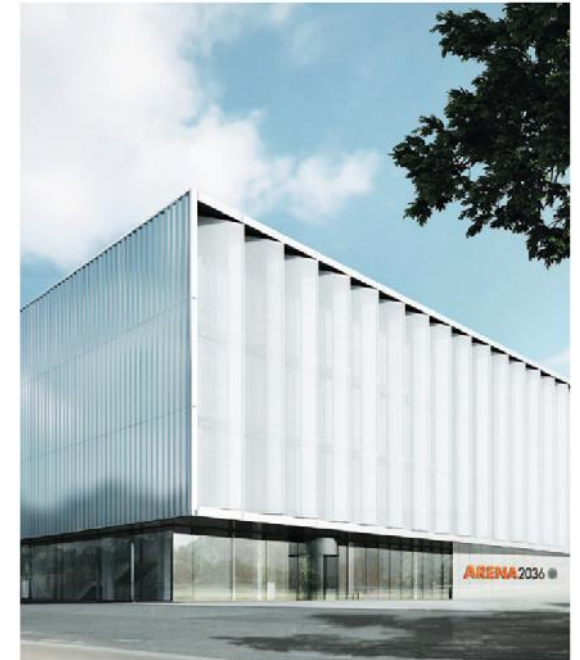- Interchangeable production of future applications

**LeiFu**
Material and Construction

- Light-weight materials
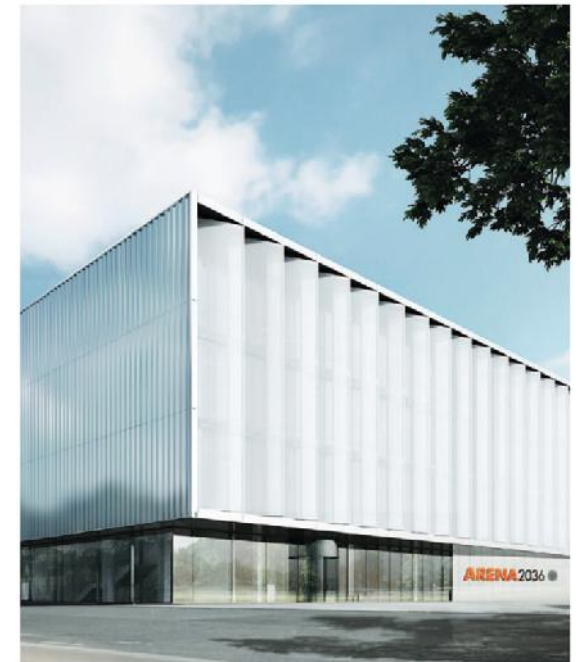- Functional integrity

Khoch3
Creativity – Cooperation – Competence Carrier

ARENA2036 Research Campus @ Vaihingen

Overview on the starting projects

# ARENA2036 – The Research Campus

**ARENA**2036

## **A**ctive **R**esearch **E**nvironment for the **N**ext generation of **A**utomobiles



Scientific partners

Universität Stuttgart
DLR
DITF
Fraunhofer
FKFS

Industrial partners

**Founders**
DAIMLER
BASF
BOSCH Technik fürs Leben
BÄR

**Partners**
FARO
FESTO
KUKA
SCHUNK
pilz
csi
DYNA* MORE
Hewlett Packard Enterprise
SIEMENS
PLUGANDPLAY

**In discussion**
TRUMPF
EWS* Tool Technologies
LÜTZE
SICK Sensor Intelligence
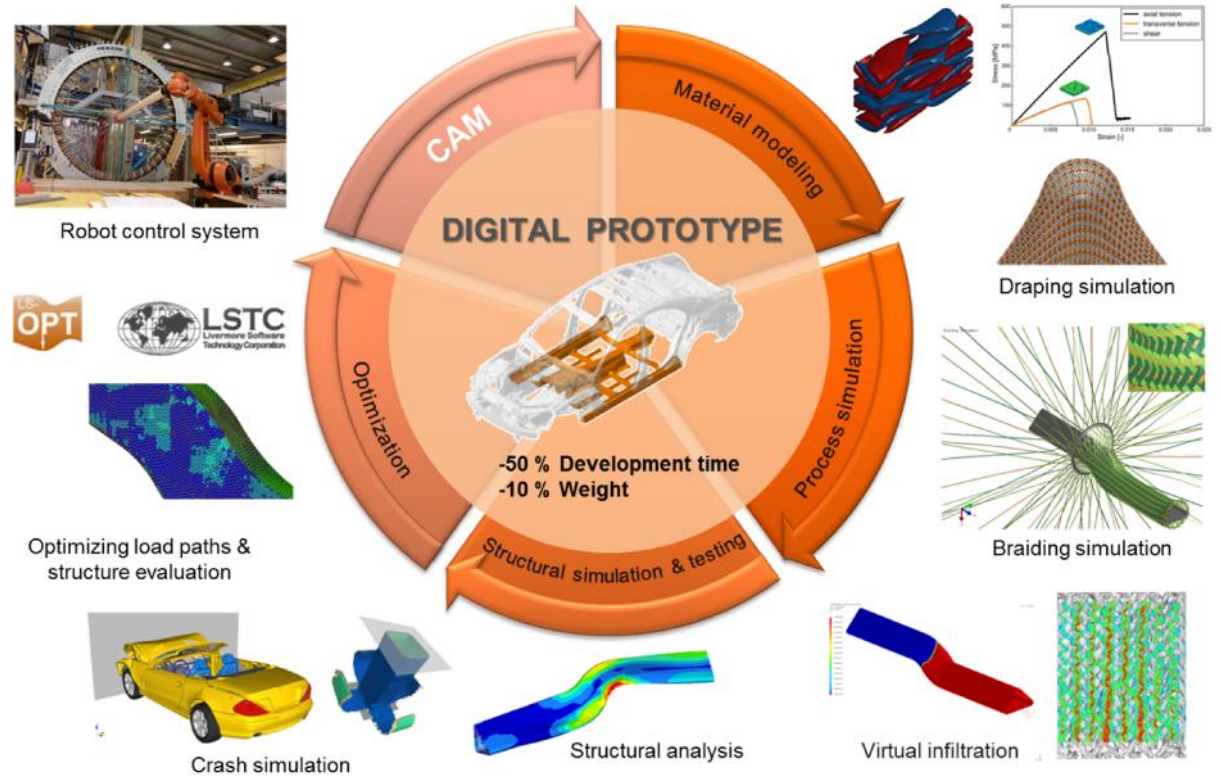SCHMALZ
JOHN DEERE
MAHLE

ARENA2036 Research Campus @ Vaihingen

19 industrial and scientific partners
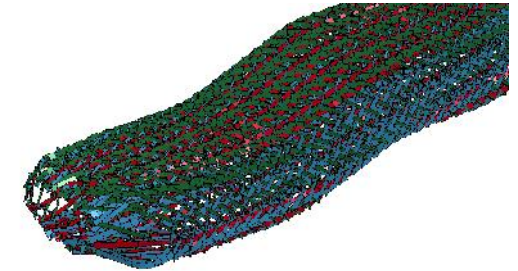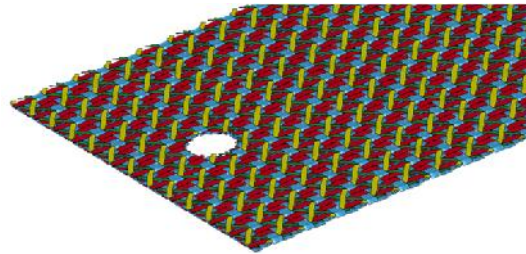
# DigitPro – **Digit**al **Pro**totype

- closed simulation process chain

- from preliminary design to the final component

- micro, meso and macro modeling

- different simulation software tools

- HDF5 Format

- digital fingerprint

- braided components
- **O**pen-**R**eed-**W**eaving components
  **-50% development time**
  **mind. -10% weight**



DIGITAL PROTOTYPE

-50 % Development time
-10 % Weight

Robot control system

Draping simulation

Braiding simulation

Optimizing load paths & structure evaluation

Crash simulation

Structural analysis

Virtual infiltration

Defined targets for the starting phase

4

# DigitPro – **Digit**al **Pro**totyp



- ENVYO® is a multi-purpose mapping tool for LS-DYNA, introduced to public at the 14th German LS-DYNA User's Meeting.

- Four different mapping schemes have been realized:
  - Closest Point
  - Search Radius
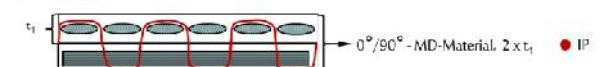  - Ondulation consideration
  - RVE Mapping

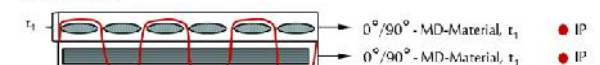**properly transform results from process simulations onto structural meshes**



Development of Mapping Routines for Braided and Weaving Structures

# DigitPro – **Digit**al **Pro**totyp
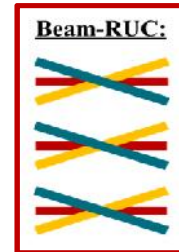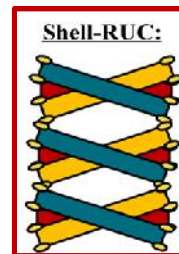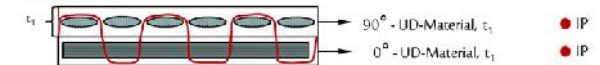
- Closest Point
    - All fibers defined by the user are considered
    - Equivalent thickness distribution based on a given user input

- Search Radius
    - A search radius will be considered
    - If a specific fiber ID cannot be found within a certain vicinity of an element, a resin material ID will be assigned instead
    - Equivalent thickness distribution based on a given user input

- Ondulation consideration
    - Ordering of the fiber assignment in target mesh not based on user input but on distance to the target element
    - Thickness is considered based on the offset of found elements

- RVE Mapping
    - RVEs are detected within a search radius
    - Material cards from a database will be assigned

**properly transform results from process simulations onto structural meshes**



MID 2000
MID 3000
MID 24
MID 2002
MID 3002
MID 4002
MID 24
MID 24
MID 4003

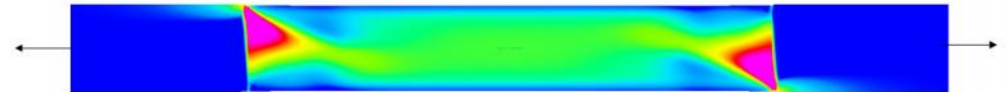Explanation of the different routines

# DigitPro – **Digit**al **Pro**totyp
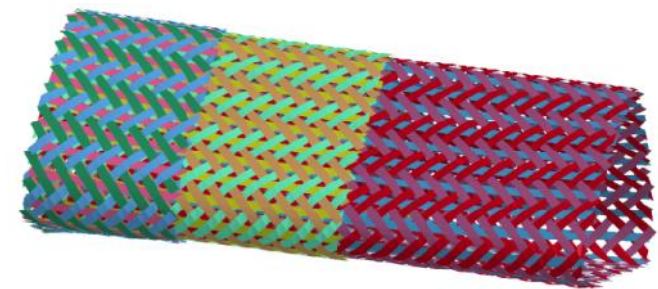
- Averaging of fiber directions possible:



```
$#---------------------------
$# Source - PIDs
$#---------------------------
NumSourcePIDs=12
SourcePid#1=2000
SourcePid#2=3000
SourcePid#3=4000
...
NumFibers=1
FiberID#1=1
TargetThickness=1.
NPLANE=1
NTHICK=2
ThroughThicknessAveraging=YES
NumberOfFiberBundles=8
FiberBundle#1:
Lay=3,IP=1,Fib=1
Lay=6,IP=1,Fib=1
Lay=9,IP=1,Fib=1
Lay=12,IP=1,Fib=1
```

```
FiberBundle#2:
Lay=2,IP=1,Fib=1
Lay=5,IP=1,Fib=1
Lay=8,IP=1,Fib=1
Lay=11,IP=1,Fib=1
...
MapStress=NO
MapStrain=NO
$#---------------------------
$# END-OF-FILE
$#---------------------------
```

State of the art reference simulation

Simulation with the new mapping approach

Explanation of the different routines

# DigitPro – **Digit**al **Pro**totyp
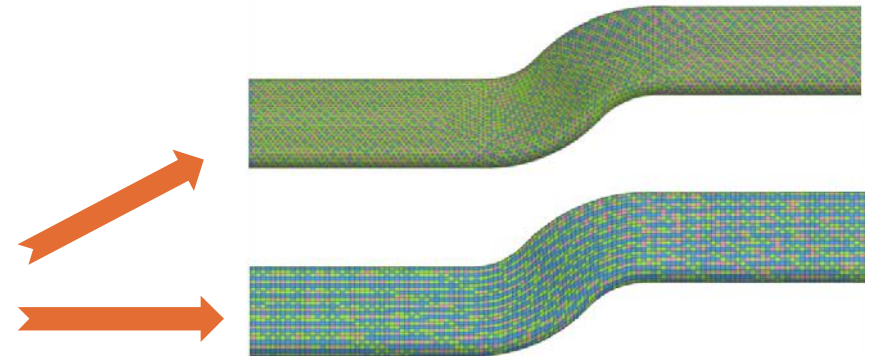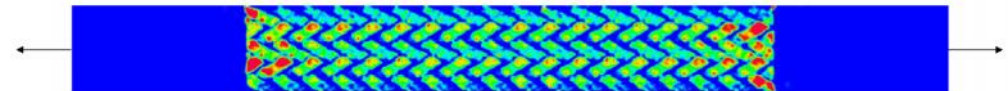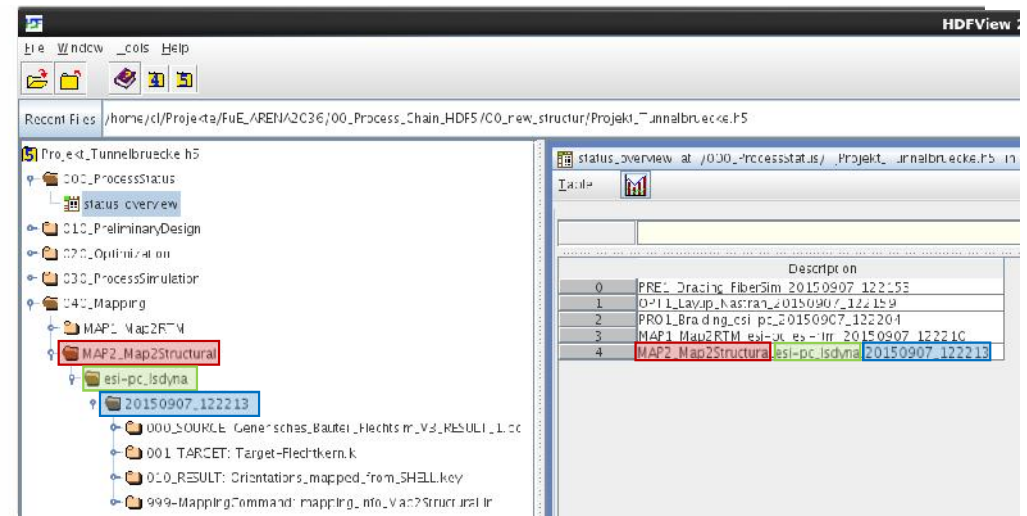
- **Link to an HDF5 data storage container has been realized**
  - Binary storage format
  - Solver independent
  - Well be extended within the VMAP project
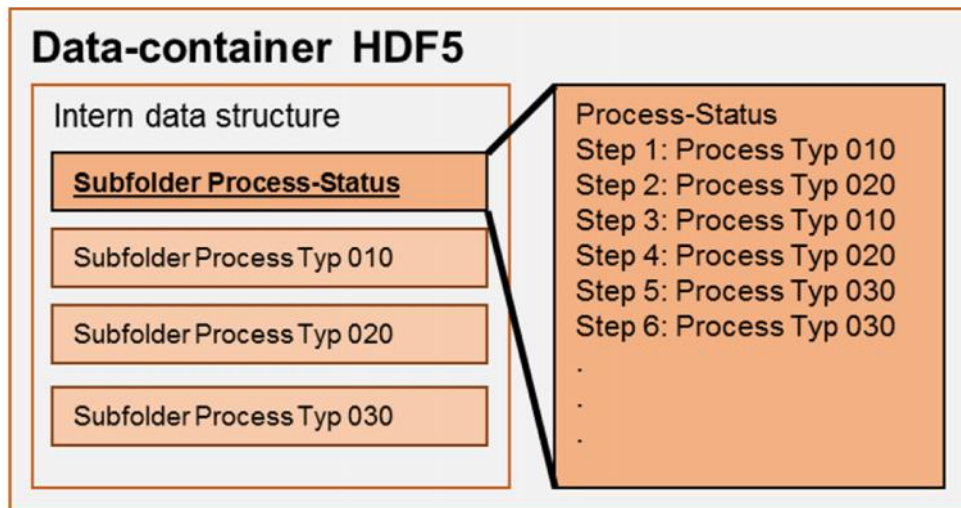


**process steps**          **process status**

HDF5 data storage container

# DigitPro – **Digit**al **Pro**totyp

- Workflow
  - One user has to define an initial data structure:

```
$#---------------------------
$# Main mapping definition
$#---------------------------
ENVYO=HDF5-DEFINITION
$#---------------------------
$# In- and output meshes
$#---------------------------
HDF5-Structure=SimStages.txt
HDF5-File_Target=MyHDF5-File.h5
$#---------------------------
$# END-OF-FILE
$#---------------------------
```

```
020_OPTIMIZATION
030_PROCESS_SIMULATION
    001_BRAIDING
    002_INFILTRATION
040_MAPPING
    001_Map2Structural
    002_Map2RTM
050_STRUCTURAL
080_MATERIAL_DATABASE
090_CAD
```
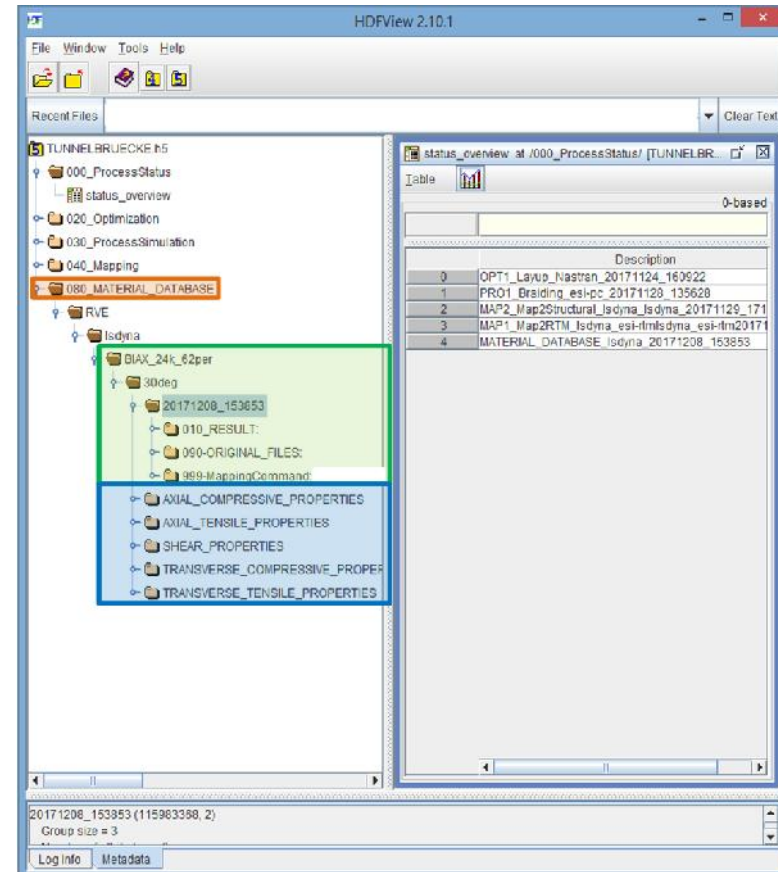
HDF5 exchange workflow as realized in ARENA2036

# DigitPro – **Digit**al **Pro**totyp

- ## Workflow
  - One user has to define an initial data structure

  - Further data can be assigned to the respective sub-folders

```
$#--------------------------------
$# Main mapping definition
$#--------------------------------
ENVYO=RVE-POSTPROCESSING
$#--------------------------------
In- and output meshes
$#--------------------------------
PushToHDF5DataBase=YES
HDF5-File_Target=MyHDF5-File.h5
WriteOriginalFiles=YES
WriteResultFiles=YES
RVE_INFO=braid_data.txt
$#--------------------------------
$# ARENA2036 - File Status
$#--------------------------------
DevelopmentStage=080_MATERIAL_DATABASE
$#--------------------------------
$# END-OF-FILE
$#--------------------------------
```



HDF5 exchange workflow as realized in ARENA2036

# DigitPro – **Digit**al **Pro**totyp

- Workflow

  - One user has to define an initial data structure

  - Further data can be assigned to the respective sub-folders

  - The next user can read the assigned data



```
$#---------------------------
$# Main mapping definition
$#---------------------------
ENVYO=HDF5-Output
$#---------------------------
$# In- and output meshes
$#---------------------------
HDF5-File_SOURCE=MyHDF5-File.h5
NumStages=1
ProcessStages=LAST
Files=ALL
$#---------------------------
$# END-OF-FILE
$#---------------------------
```

HDF5 exchange workflow as realized in ARENA2036

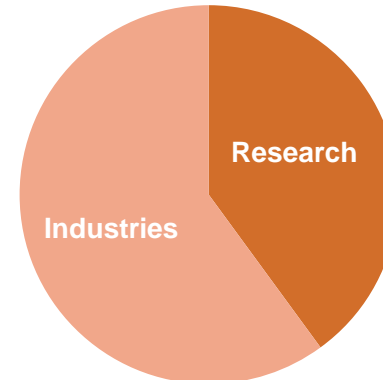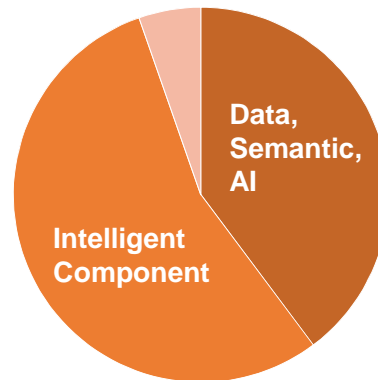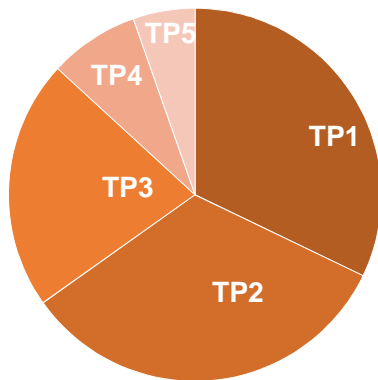# DigitPro – **Digit**al **Pro**totype

- Within the **ARENA**2036 research campus, a multi-scale, integrative simulation environment is being established, allowing to consider multiple manufacturing processes

- The developed mapping, homogenization and data exchange platform is solver independent

- Optimization and CAM interfaces are under investigation
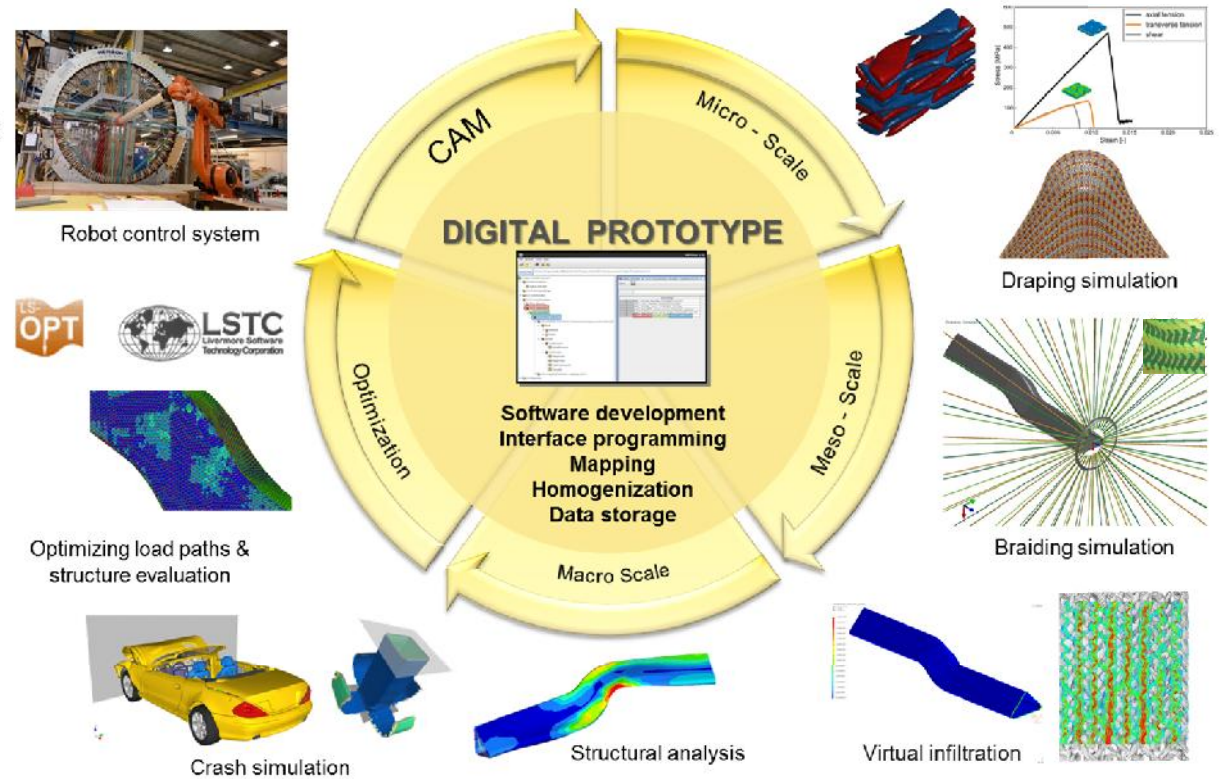
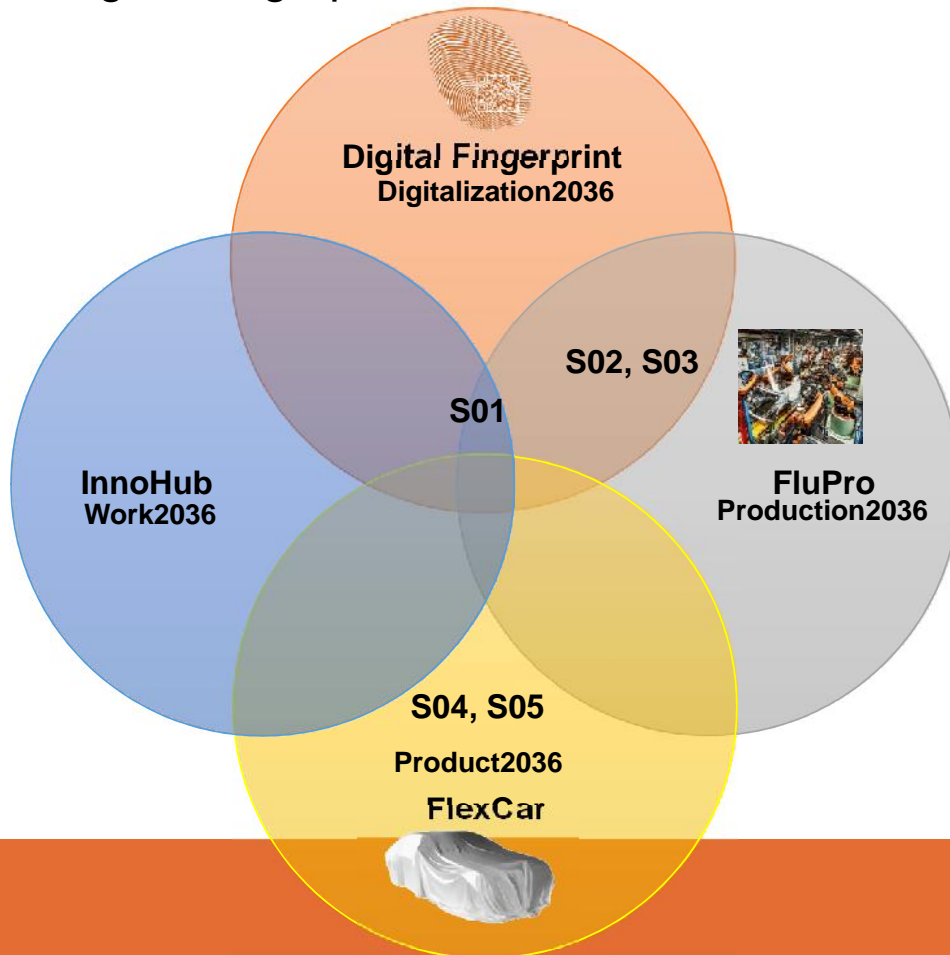**DigitPro – the Digital Prototype: closing the simulatoin process chain**



Robot control system

Optimizing load paths & structure evaluation

Crash simulation

Structural analysis

DIGITAL PROTOTYPE

Software development
Interface programming
Mapping
Homogenization
Data storage

CAM

Micro - Scale

Meso - Scale

Macro Scale

Optimization

Draping simulation

Braiding simulation

Virtual infiltration

The Digital Prototype as Part of ENVYO® - Development History and Applications within the ARENA2036 Environment

DigitPro – **Digit**aler **Pro**totyp

# Digital Fingerprint - Overview



**Partners** Constellium, DITF (Deutsche Institute für Textil+Faserforschung), CSI, DXC.technology, BOSCH Technik fürs Leben, IFB Institut für Flugzeugbau / Institute of Aircraft Design, DLR, DYNAMORE, DAIMLER

**Associates** Altair, SIEMENS, Fraunhofer IPA

**Supportive** FESTO, FARO

**Statistics:**

| | |
|---|---|
| Personal efforts: | 448 PM |
| Budget tot: | 3,96 Mio € |
| Budget Funding: | 2,42 Mio € |
| Tot. funding: | 61,02 % |
| Industrial funding: | 40,00 % |
| relation Industry/Research: | 2,27 |

Pie chart 1: TP1, TP2, TP3, TP4, TP5

Pie chart 2: Data, Semantic, AI; Intelligent Component

Pie chart 3: Research; Industries

What's next?

# DigitPro – **Digit**aler **Pro**totyp

**ARENA**2036

## Digital Fingerprint - Tasks



- Connection of all steps along the process chain of industrial 4.0

- Generation of a common data platform for all data arising along the components life-time

- Automated data flow between the processes

- Intelligent component and coupling to interpretation tools (e.g. FE analysis)

- Connection to processing tools (CAM) and highly flexible, automated processes

- Component specific data storage

- Component evoluation using stored and generated data

Project interaction
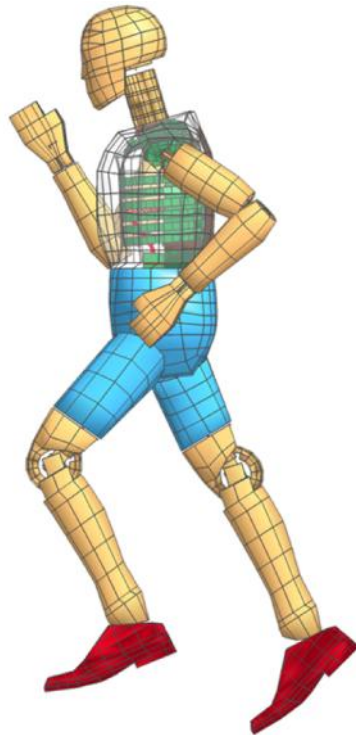
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