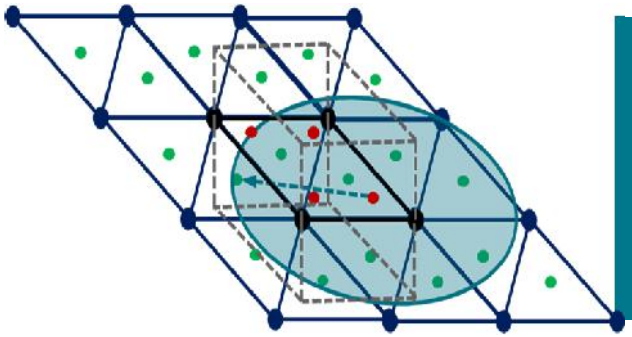
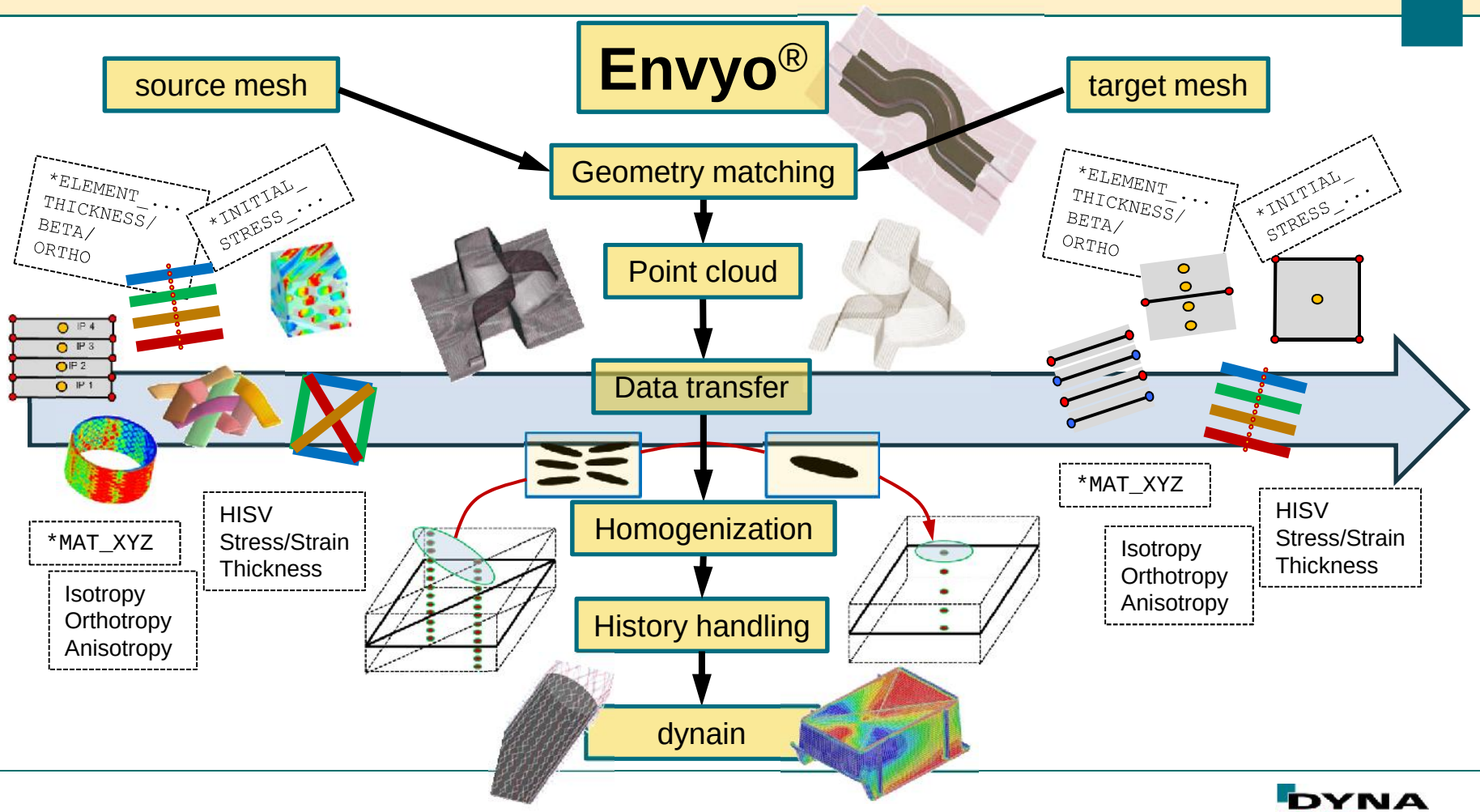
ENVYO® – development status



RECENT DEVELOPMENTS IN ENVYO®

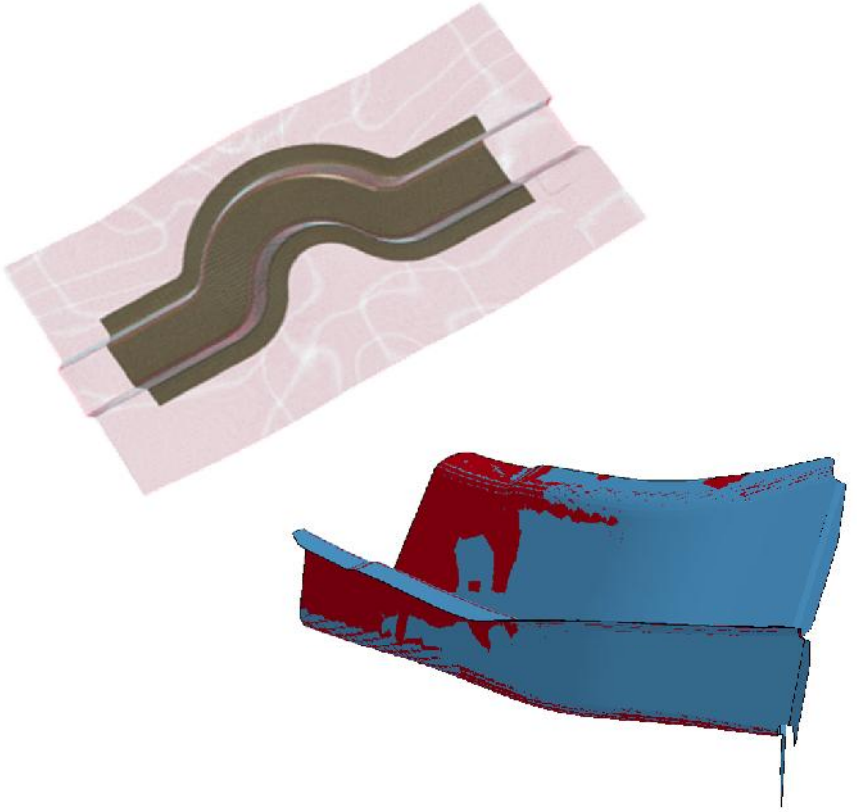
C. Liebold

03/2018 – STUTTGART - GER


Envyo®
source mesh
target mesh
Geometry matching
Point cloud
Data transfer
Homogenization
History handling
dynain
*ELEMENT_... THICKNESS/ BETA/ ORTHO
*INITIAL_ STRESS_...
*MAT_XYZ
Isotropy
Orthotropy
Anisotropy
HISV
Stress/Strain
Thickness
*MAT_XYZ
Isotropy
Orthotropy
Anisotropy
HISV
Stress/Strain
Thickness

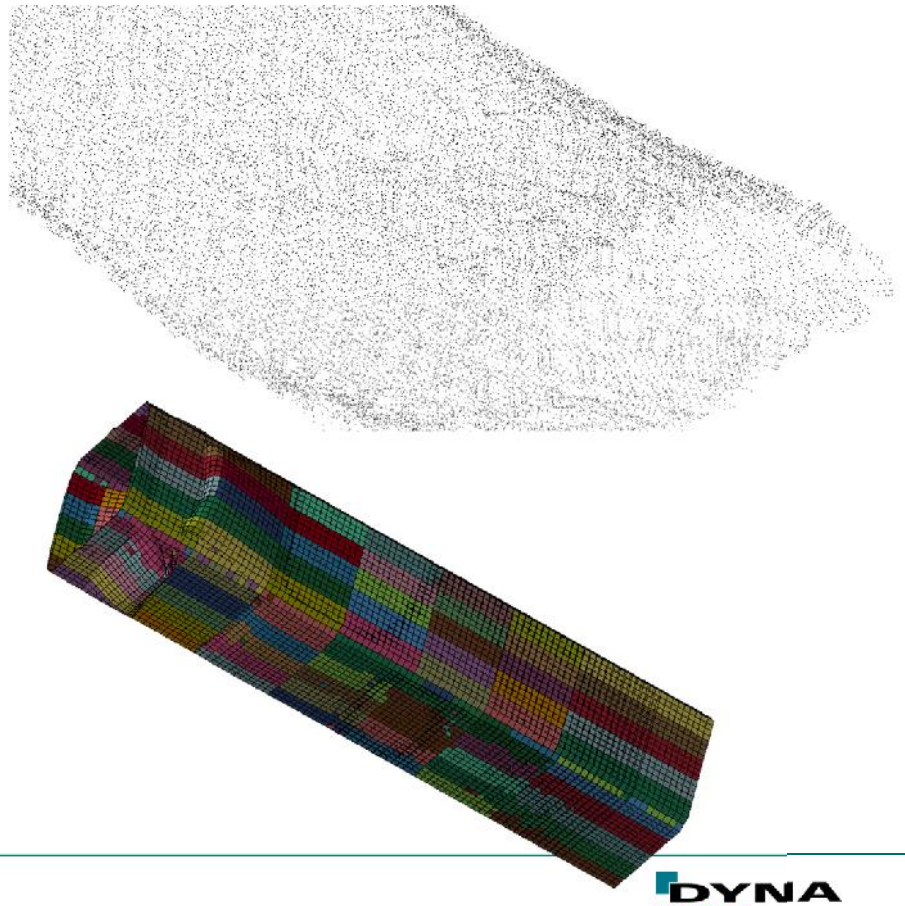
Geometry matching

- Two automatic matching algorithms implemented:
  - 4-Point Congruent Sets
  - Iterative Closest Point
- Mesh operations:
  - Scaling
  - Rotation
  - Transformation
- Unit system conversion



Point Cloud generation

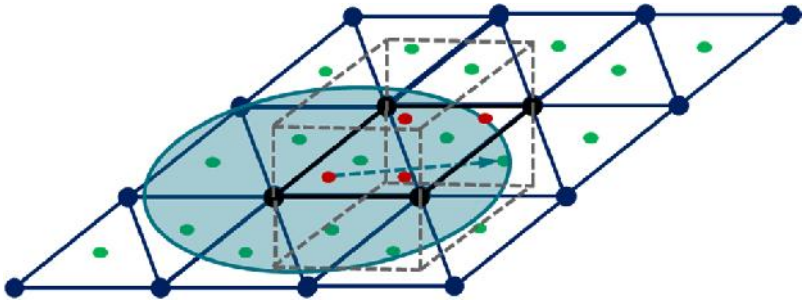
- Mapping based on point clouds
  - Element based (beam, (t)shell- and solid elements)
  - Integration point based (under- and fully integrated elements)
  - Node based
- Bucket sort algorithm for significant mapping speed-up

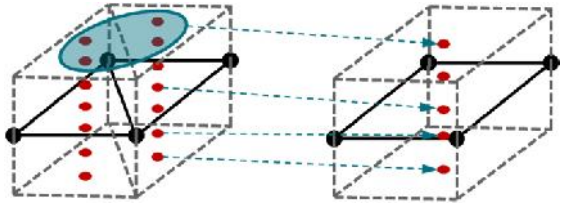


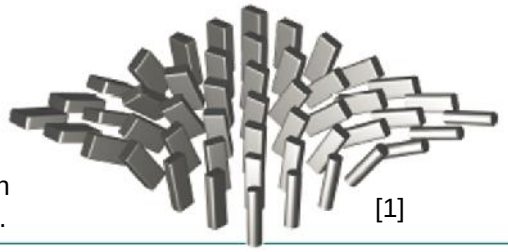
Data transfer

- Mapping based on a closest point search
- Investigations made for scalar value averaging and interpolation
- Investigations made for tensorial data averaging and interpolation

➢ **Maximum user control**





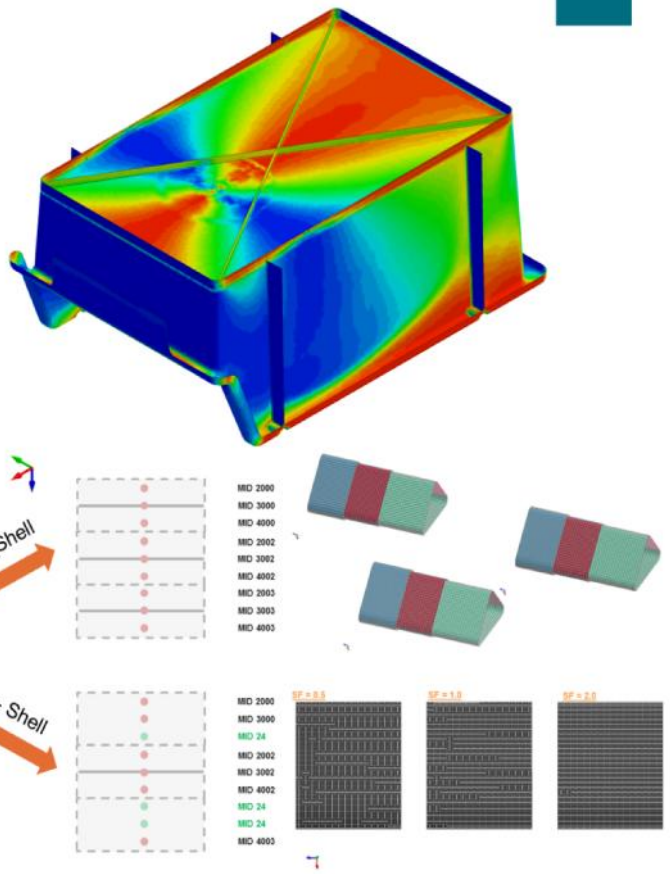


[1]

[1] Gahm, J.: Microstructural Feature-based Processing and Analysis of Diffusion Tensor MRI, PhD – thesis, University of California, Los Angeles, CA, USA, 2014.

Homogenization / History handling

- Adjust mapped data for intended LS-DYNA analysis
  - Calculate β_i for composite elements such as: *ELEMENT_SHELL_COMPOSITE / *ELEMENT_SOLID_ORTHO
  - move positions of specific history variables when changing the material model
  - Assign specific material or part IDs to designated areas
  - Calculate material properties for certain material models (*MAT_157)

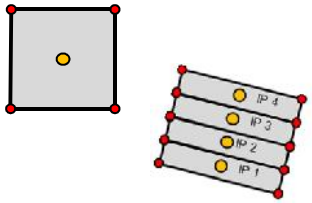


dynain – file for a lot of conceivable applications

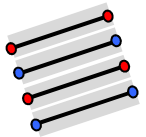
- BEAM – SHELL
- BEAM – ALE_MESH

- SHELL – SHELL
- SHELL – TSHELL
- SHELL – STACKED_SHELL
- SHELL – SOLID
- SHELL – SOLID (GENERATION)

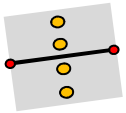
- SOLID – SHELL
- SOLID – SOLID



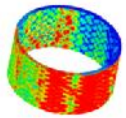
- ABAQUS2DYNA



- PCL - SHELL

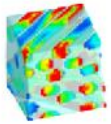


- MOLDEX3D – SOLID
- MOLDEX3D_MUCELL - SOLID
- MOLDFLOW – SHELL
- MOLDFLOW – SOLID



- GCODE-PATH

- HDF5 - Support

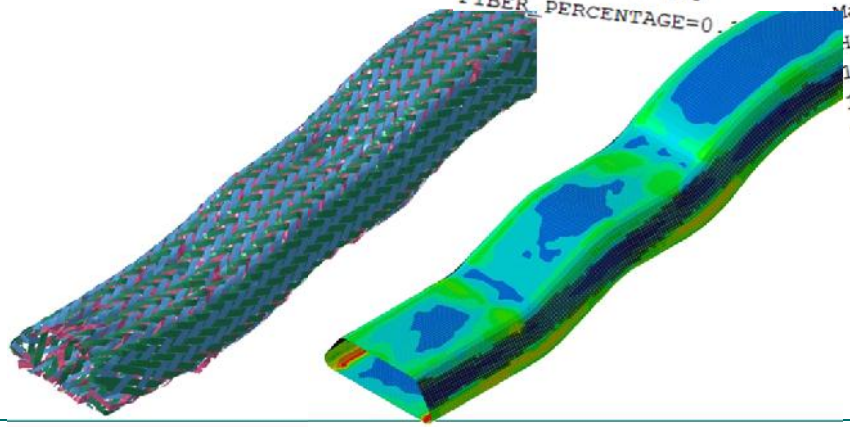


SHELL – SHELL mapping capabilities

- Various options for shell – shell mapping
  - Switch of history variables
  - Handling of history variables
    - Scalar values
    - Tensorial values
  - RVE – detection
  - Stress mapping
  - Strain mapping
  - Thickness mapping

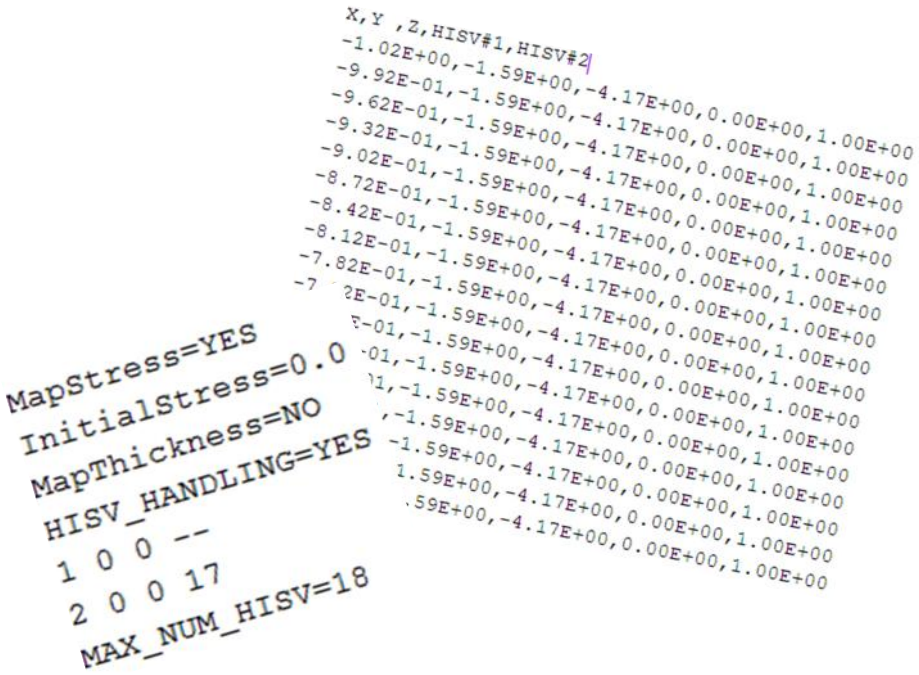
```
ROTATING_YARNS 3000 4000
REINFORCING_YARNS 2000
UD 1
BIAX_30 30
BIAX_40 40
BIAX_50 50
BIAX_60 60
TRIAX_30 300
TRIAX_40 400
TRIAX_50 500
TRIAX_60 600
$#-------------
TargetThickness=3.0
ResinMatID=24
SEARCH_RADIUS=1.0
FIBER_PERCENTAGE=0.
```

```
$#-------------------------
$# Source - PIDs
$#-------------------------
NumSourcePIDs=1
SourcePid#1=5
$#-------------
NPLANEs=4
NTHICK=5
IntegrationRule=Gauss
MapStrain=NO
MapStress=YES
InitialStress=0.0
MapThickness=YES
HISV_HANDLING=YES
13 0 0 10
17 0 0 14
18 0 0 6
MAX_NUM_HISV=18
$#-------------------------
$# END-OF-FILE
$#-------------------------
```



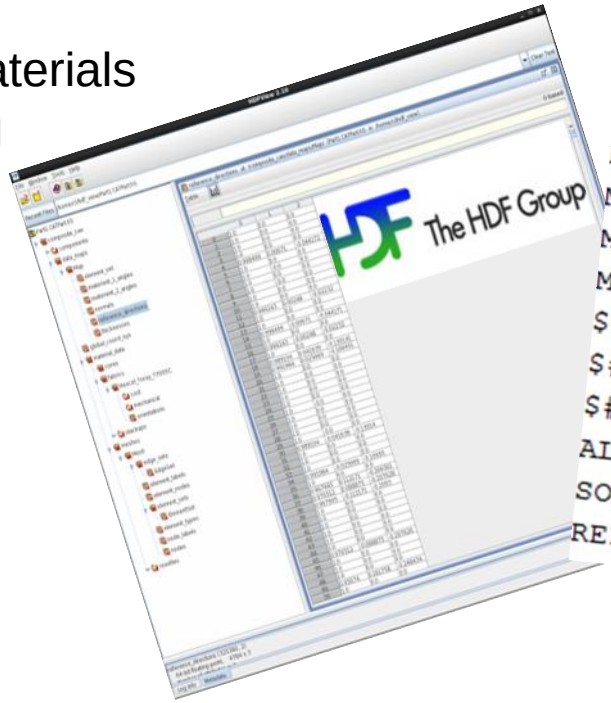
Point Cloud - Shell

- The most general mapping case
  - Reading arbitray csv data:
    - X, Y, Z, HISV#1, HISV#2,…
  - Points can be element centers, integration points, CT scan data,…



MOLDEX3D_MUCELL - SOLID

- Consider locally varying densities from foam filling analysis.
- User provides various materials models for part clustering
- HDF5 link necessary

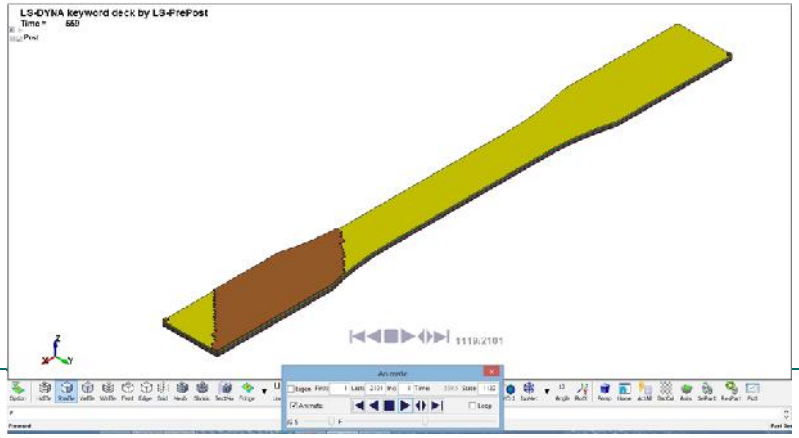


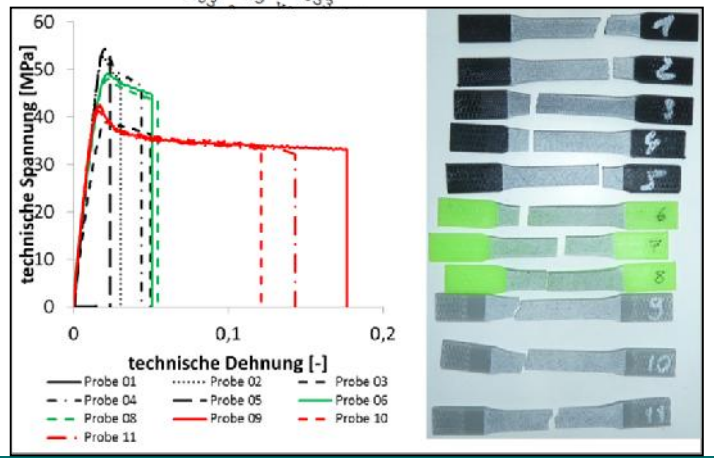

```
SG_3.0 30
SG_4.25 40
SG_12.0 50
SG_6.0 60
$#-------------------------
$# Target - PIDs
$#-------------------------
ETYP=2
MapStress=NO
MapWeldline=NO
MapMainDir=NO
$#-------------------------
$# Mapping-Options
$#-------------------------
ALGORITHM=ClosestPoint
SORT=BUCKET
REPEAT=YES
```

GCODE - PATH

- Considering the manufacturing process of 3D – printed parts, reading gcode data and preparing the path of the printer source
- Next step includes mapping of warpage onto the target mesh
- Enhance computed source paths

```
G21 ;metric values
G90 ;absolute positioning
M82 ;set extruder to absolute mode
M107 ;start with the fan off
G28 X0 Y0 ;move X/Y to min endstops
G28 Z0 ;move Z to min endstops
G1 Z15.0 F9000 ;move the platform down 15mm
G92 E0 ;zero the extruded length
G1 F200 E6 ;extrude 6 mm of feed stock
G92 E0 ;zero the extruded length again
G1 F9000
;Put printing message on LCD screen
M117 Printing...
;LAYER_COUNT:8
;LAYER:0
M107
G1 F1500 E-6.5
G0 F3600 X12.7 Y93.2 Z.4
;TYPE:WALL-OUTER
G1 F1500 E0
G1 F1800 X52.833
G1 X58.009
G1 X63
```





Summary

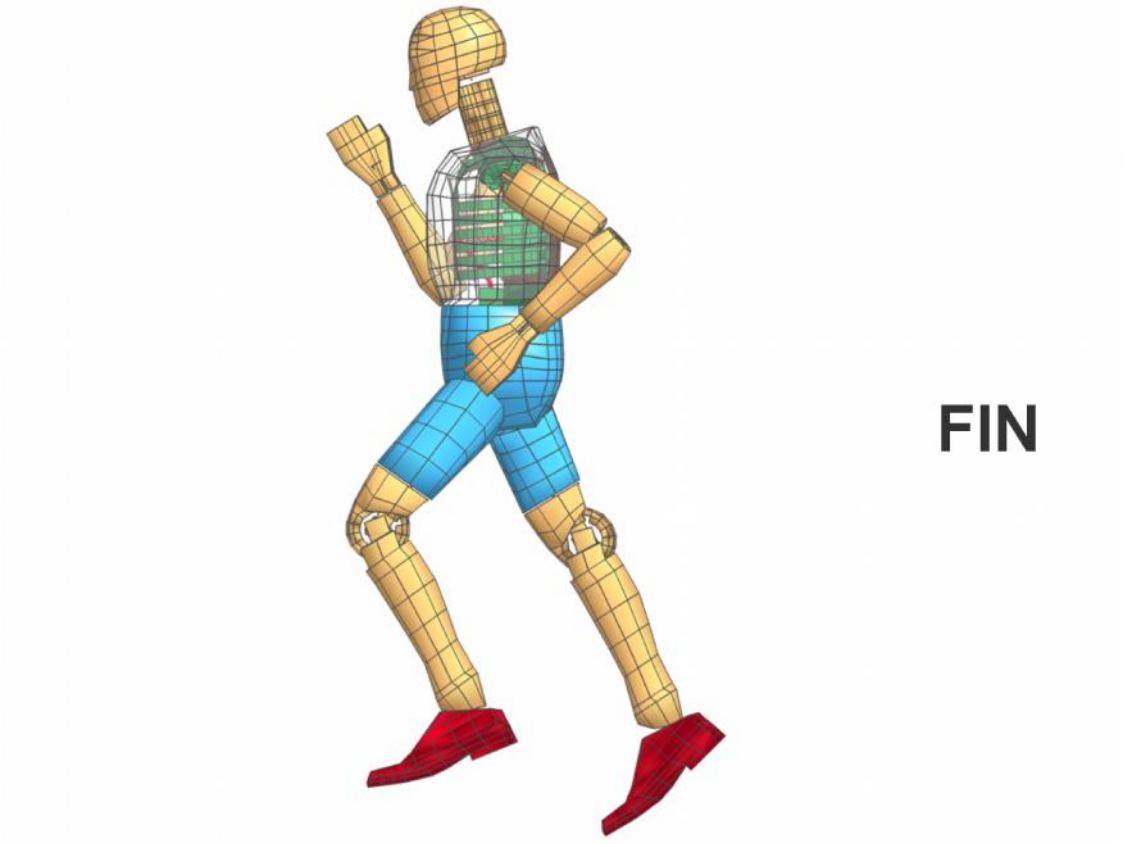
- ENVYO® is available for both, windows and linux operating systems
- Test versions can be requested @ DYNAmore, preferrably with a small application example
- After a successful testing period it is thought to distribute Envyo® commercially. Details will follow in due time.

Remark:

- The quality and the capability of the program are highly dependent on its usage. Feedback is highly appreciated!

Acknowledgement

- The mapping tool ENVYO® is and has been developed in the following research projects and with the following partners:
  - ARENA2036
  - TPult
  - Swim-RTM



FIN

C. Liebold[1]

[1]DYNAmore GmbH
Industriestraße 2
70565 Stuttgart

cl@dynamore.de