SPS Pilot

Case 3: Prothesis Adapter

CIRCULATION
all

VERSION

DATE
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QUALITY CONTROLLER
SPS
Agenda

• SPS Pilot Outline
• Digitalization : Assessment
• SPS Product Development Cycle
• Main Challenges and Solution Providers
• Pilot Schedule
• Pilot Execution Steps
• Enabling Technologies Used
• Current Status
Pilot: Prosthesis Adapter Design

Main aim:
- Lighter adapter
- Improved design and analysis loop
- Production through additive manufacturing
- Proper tracking of changes in requirements and design during development
SPS Assessment: Results

The main technologies identified to be implemented are:

- QRM / MDE
- ERP / CRM
- Digital Twin
Asset Selection

Main Digital Twin Application Product:
Prosthesis Adapter

Enhancing the digital twin to map the vibration / thermal test data => Improve Digital Twin:
Sandwich Panel
Prothesis Adapter: Product Development

- Requirements
- Design and Analysis
- Production
- Testing and Release

Initial SPS Design → Digital / Virtual Twin → Product

Digital Twin

HORIZON 2020
SPACE STRUCTURES
Digital Twin: Challenges

Main Challenges to be considered:

- Faster Data Exchange, Common Data Exchange formats
- Reliability: Enrichment of the Digital Twin with Test Data
- Rework time: Consideration of Product Manufacturing Information during Design Phase
- Data Interoperability of 3D models with Complex Geometries
- Improve Reaction Time to Requirements Change
- Data Storage and Archiving
- Product Development: First Time Right
- Computing Time

Requirements → Design → Analysis → Production → Testing and Release
Solution Providers and Pilot Application

Solution Providers:
- Data Exchange
- Data Storage and Archiving
- Multidisciplinary data management
- Computing Performance on Demand
- Enrichment of the Digital Twin with Test Data: Photogrammetry

Solution Providers:
- Product Manufacturing Information, Design checking for manufacturing
- Production: 3D Metal printing
## SPS Pilot: KPIs

<table>
<thead>
<tr>
<th>Process / Topic</th>
<th>KPI</th>
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</thead>
<tbody>
<tr>
<td>Data exchange</td>
<td>• Time of the data exchange operation</td>
</tr>
<tr>
<td></td>
<td>• Number of iterations required until exchange is successful</td>
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<tr>
<td>Computing performance on demand</td>
<td>• Time from job submit until the results are received</td>
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<td></td>
<td>• Infrastructure costs</td>
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<tr>
<td>Product manufacturing information</td>
<td>• Number of documents and revisions</td>
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<tr>
<td></td>
<td>• Non-recurring setup cost</td>
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<tr>
<td></td>
<td>• Machine parameters and behaviour</td>
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<tr>
<td>Enrichment of the digital twin with test data</td>
<td>• Non-recurring installation cost</td>
</tr>
<tr>
<td></td>
<td>• Correlation time</td>
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<tr>
<td></td>
<td>• Accuracy increase</td>
</tr>
<tr>
<td>Data storage and archiving</td>
<td>• File size</td>
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<tr>
<td></td>
<td>• Access time</td>
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<td></td>
<td>• Long-term accessibility</td>
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</tbody>
</table>
## Pilot Schedule

### Model Update – Done

- **Task 1**: Review objectives and requirements
  - Review and up-issue of requirements document

### Manufacturing engineering - Ongoing

- **Task 2**: Initialise software tools and cloud-computing environment
  - Readiness of SPS-in-house design softwares
  - Cloud-computing
  - PLM
  - SimDB

- **Task 3**: Prepare data/environment for pilot execution “prosthesis adapter”
  - Envelope previous geometry as topology draft version for FEM
  - Optimisation runs
  - Analysis & Geometry checking (incl. compatibility with other softwares)
  - STL (or similar) generation and model checking

- **Interim Report**

- **Task 4**: Manufacture physical realizations of prosthesis adapters
  - Manufacturing engineering
  - 3D metal printing
  - Post processing of printed parts

- **Task 5**: Enrichment with physical test data
  - Photogrammetry
  - TNO feasibility study
  - Correlation with current analysis results
  - Photogrammetry on new prosthesis
  - Static & Fatigue testing
  - Process test data

- **Task 6**: Populate SimDB system
  - Sandwich panel data
  - Prosthesis adapter

### Feedback and Report Generation

### Continuous Tasks

- Populate PLM system
- Task 1: Review objectives and requirements
- Task 2: Initialise software tools and cloud-computing environment
- Task 3: Prepare data/environment for pilot execution “prosthesis adapter”
- Task 4: Manufacture physical realizations of prosthesis adapters
- Task 5: Enrichment with physical test data
- Task 6: Populate SimDB system

### Tasks by Month:

- September 2020
- October 2020
- November 2020
- December 2020
- January 2021
- February 2021
- March 2021
- April 2021
- May 2021
- June 2021
- July 2021
- August 2021
- September 2021
- October 2021
- November 2021
## Twin Building: Steps

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Review Objective and Requirements</td>
</tr>
<tr>
<td></td>
<td>• Main Requirements for Design Update</td>
</tr>
<tr>
<td></td>
<td>• Review current design</td>
</tr>
<tr>
<td></td>
<td>• Identify software requirements</td>
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<tr>
<td>2.</td>
<td>Initialise software tools and cloud computing</td>
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<tr>
<td></td>
<td>• Deploy required softwares</td>
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<tr>
<td></td>
<td>• Employ cloud computing environment</td>
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<tr>
<td>3.</td>
<td>Optimization of prosthesis design and model analyses</td>
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<td></td>
<td>• Recalculation of load environments</td>
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<td></td>
<td>• Design optimization and analysis update of the prosthesis adapter</td>
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<td></td>
<td>• Model checking for data interoperability</td>
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<tr>
<td>4.</td>
<td>Manufacturing of prosthesis adapter</td>
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<tr>
<td></td>
<td>• 3D Metal printing</td>
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<tr>
<td></td>
<td>• Post processing of the product</td>
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<tr>
<td>5.</td>
<td>Enrichment of the test data with photogrammetry</td>
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<tr>
<td></td>
<td>• Feasibility study for using photogrammetry to enrich prosthesis test data</td>
</tr>
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<td></td>
<td>• Employment of the technology during test phase (TBD)</td>
</tr>
<tr>
<td>6.</td>
<td>SimDM and Test data correlation</td>
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<tr>
<td></td>
<td>• Correlation of prosthesis mechanical test data with the analysis model</td>
</tr>
<tr>
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<td>• Correlation of mechanical and thermal test data of sandwich panel</td>
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Design Optimization and Analysis

- Optimization Loops
- Design Update
- Mechanical Analysis

- Minimum Mass
- Maximum Stiffness
- Maximum Stress
- Maximum Displacement
Enabling Technology – PLM Software

truePLM – Jotne

- End-user application for standards based (ISO 10303-239) Product Lifecycle Management (PLM).
- Structures a product or project by breakdown elements.
- A Reference Data Library (RDL) enables extensive adaptation to use cases by the end user herself (the application semantics are not hard-coded).
- Interoperability with other engineering tools is provided via ISO 10303, STEP, that is, data exchange by AP239 and AP242

➢ Implemented to efficiently store data and to track changes at all phases of the product development
Enabling Technology – Cloud Computing

CloudBroker

• High performance cloud space access for computing

➢ Deployment of Altair software on cloud and access for model analyses

➢ truePLM access through Windows based virtual machine on the cloud

Home page

https://c2t.cloudbroker.com/
Enabling Technology - Design for Manufacturing

Additive Industries

- Best practices for additive manufacturing

- Design checking using commercially available Build Manager Software

- Assessment of the printability of the geometry and suggestions for build orientation
SimDM - Jotne

- ISO 10303-209 (AP209) repository and application for managing multidisciplinary analysis, design and test data
- Imports data by AP209, AP242, NASTRAN, Abaqus, Ansys and csv-formats (test data) and combined into a federated model via cross domain correlations
- Possible extension of the application by a 3D viewer (VCollab)
- Enables correlation of the test data with the analysis models, thus improve the analysis models (virtual twins)
Enabling Technology – 3D Metal Printing

3D printing and post processing - Additive Industries

➢ Prosthesis adapter manufacturing using Metal Fab 1
➢ Post-production heat treatment
➢ Post processing of the component

https://www.additiveindustries.com/systems/metalfab
Enabling Technology – Photogrammetry

Optical fringe projection scanner - TNO

• 3D imaging technique to analyse the adapter and store data as Stanford Triangle Format for 3D point clouds

• Prosthesis adapter scanned without stress and with applied stress

• Geometry of both states are registered with respect to the M10-interface plane and deformation can be established by estimating shift of the surface

• The component geometry (STEP AP214) is split into components and registered individually to establish internal deformation of the component under stress
Current Status

1. Review Objective and Requirements
2. Initialise software tools and cloud computing
3. Optimization of prosthesis design and model analyses
   - Design update completed
   - Final checks ongoing
4. Manufacturing of prosthesis adapter
   - 3D Metal printing
   - Post processing of the product
5. Enrichment of the test data with photogrammetry
   - Feasibility study for using photogrammetry completed ➔ Positive results
   - Employment of the technology during test phase (TBD)
6. SimDM and Test data correlation
   - Correlation of prosthesis mechanical test data with the analysis model
   - Correlation of mechanical and thermal test data of sandwich panel

PLM Implementation and Use

Completed | Ongoing | To be done