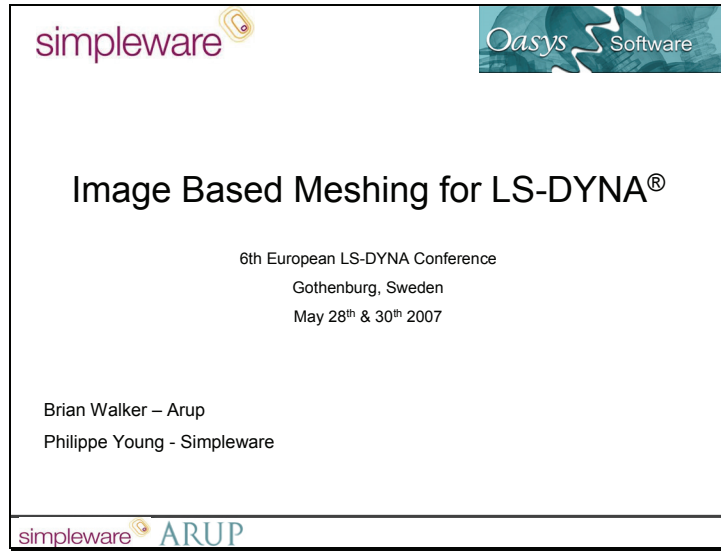
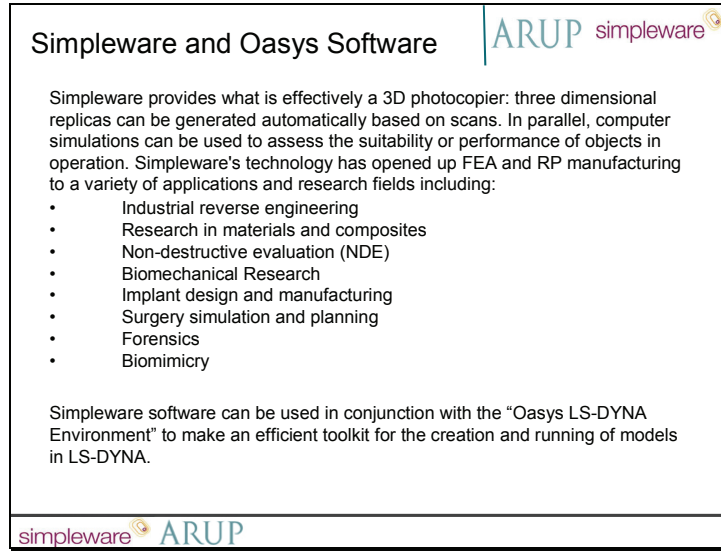

simpleware
Oasys Software
Image Based Meshing for LS-DYNA®
6th European LS-DYNA Conference
Gothenburg, Sweden
May 28th & 30th 2007
Brian Walker – Arup
Philippe Young - Simpleware
simpleware ARUP


Simpleware and Oasys Software
ARUP simpleware
Simpleware provides what is effectively a 3D photocopier: three dimensional replicas can be generated automatically based on scans. In parallel, computer simulations can be used to assess the suitability or performance of objects in operation. Simpleware's technology has opened up FEA and RP manufacturing to a variety of applications and research fields including:
• Industrial reverse engineering
• Research in materials and composites
• Non-destructive evaluation (NDE)
• Biomechanical Research
• Implant design and manufacturing
• Surgery simulation and planning
• Forensics
• Biomimicry
Simpleware software can be used in conjunction with the "Oasys LS-DYNA Environment" to make an efficient toolkit for the creation and running of models in LS-DYNA.
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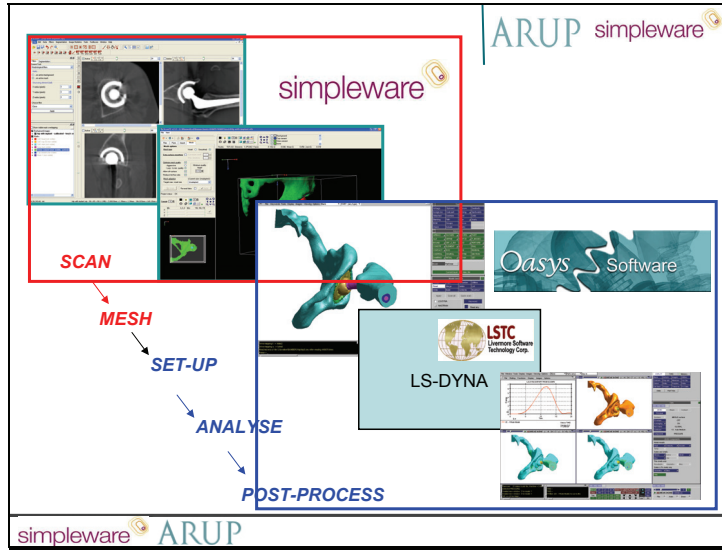
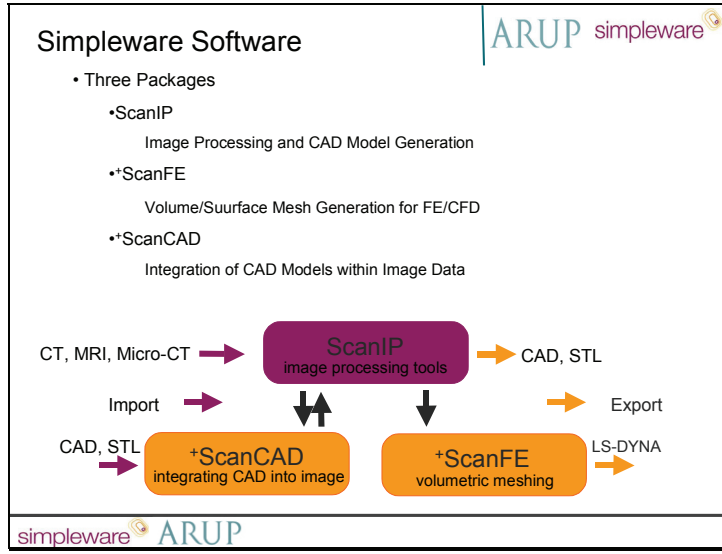

ARUP simpleware
simpleware
SCAN
MESH
SET-UP
ANALYSE
POST-PROCESS
Oasys Software
LSTC
Livermore Software Technology Corp.
LS-DYNA
simpleware ARUP


Simpleware Software
ARUP simpleware
• Three Packages
•ScanIP
Image Processing and CAD Model Generation
•+ScanFE
Volume/Suurface Mesh Generation for FE/CFD
•+ScanCAD
Integration of CAD Models within Image Data
CT, MRI, Micro-CT
ScanIP
image processing tools
CAD, STL
Import
Export
CAD, STL
+ScanCAD
integrating CAD into image
+ScanFE
volumetric meshing
LS-DYNA
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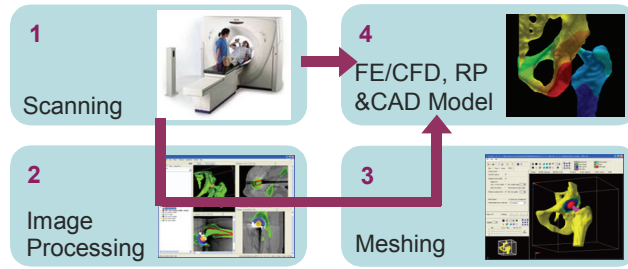
Process overview - from scan to model

ARUP simpleware



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ScanIP

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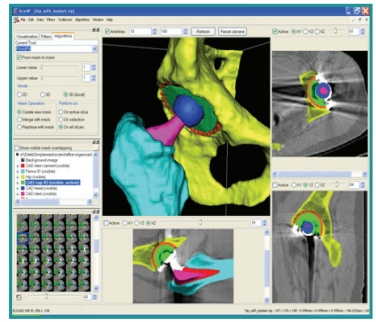

- Input data CT, MRI, Micro-CT
- Image Processing
- Segmentation
- CAD Export

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ScanIP

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ScanIP is used to import 3D imaging data from MRI, CT, Micro CT and Ultrasound scans. It provides a series of image processing and segmentation tools which allow the user to define areas of interest in the image based on grey scale values. The smoothing algorithms used by ScanIP are volume, topology and geometry preserving. This ensures the accuracy of both the generated surface reconstructions and mesh models is based on image accuracy alone. The segmented areas can then be exported as a 3D stereo lithography file or exported into +ScanFE for meshing. The stereo lithography files can either be used directly for producing rapid prototype parts or imported into CAD software.

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ScanIP – Input Data

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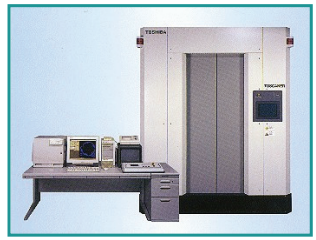

- Scans can be carried out in hospitals or at specialist industrial companies
- Cost of Industrial CT Scanner, £100,000
- Cost of individual scan £500-£1000
- Normal CT scans pick up 0.5 – 1mm

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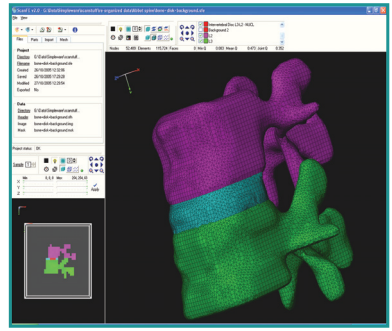
+ScanFE

ARUP simpleware



- Single-step conversion to multi-part volumetric mesh
- Assignment of complex material properties based on signal strength
- Direct export to LS-DYNA®, (no re-meshing necessary)
- FE model is exact replica of the STL

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+ScanFE Features

ARUP simpleware

- Robust, automated and accurate surface and volume reconstruction (STL and FE)
- Multiple structures meshed simultaneously
- Adaptive meshing
- Generation of models for multi-physics simulations
- Volume and topology preserving smoothing: morphological accuracy contingent only on image quality
- RP models are exact geometric replica of FE mesh
- Generation of material properties based on signal strength
- No intermediary steps necessary (which would reduce quality and take more time)

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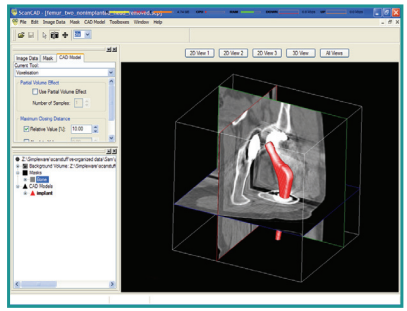
+ScanCAD

ARUP simpleware



- Import of CAD data into 3D image
- Interactive positioning, e.g. for pre-operative planning
- Export as multi-part CAD/STL or volumetric mesh (FE/CFD)

ScanCAD allows you to import a CAD model, position it interactively within the 3D imaging data and then generate a Scan IP mask. Scan CAD can be used to obtain patient specific models by positioning CAD models of different implants within a pre-operative scan. Post-operative performance can be simulated using the combined models and multiple scenarios can be tested easily.

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EXAMPLES

- Detailed Examples
  - Human Eye
  - Hip Implant
- Summary Examples
  - Auxetic Foam
  - Glass Fibre In Matrix

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Ex. 1. Human Eye

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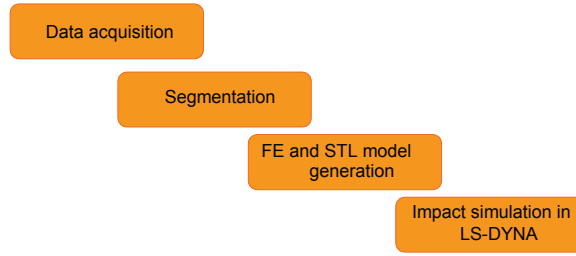
- Patient specific computer models of the human eye based on *in vivo* MRI acquisitions were constructed.
- Bio-fidelic three dimensional numerical meshes of the orbital area including the eye and surrounding soft and hard tissues generated.
- Impact with projectile modelled using LS-DYNA



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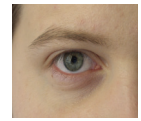
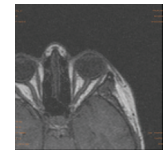
Ex. 1. Human Eye (Data Acquisition)

ARUP simpleware

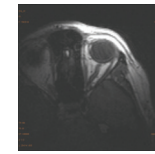
- A 29 year Caucasian female



- Models constructed based on two high resolution MRI scans of the right orbital area (using head coil and surface coil).
- In-plane and out-of-plane resolution of 1mm. The data consisted of 50 slices, each at a pixel resolution of 128x128.



Head Coil



Surface coil

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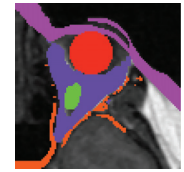
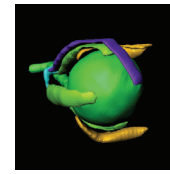
Ex. 1. Human Eye (segmentation)

ARUP simpleware

- Segmentation within ScanIP
- 6 different segmented structures
  - Globe and optic nerve
  - Bony orbit
  - Eyelids
  - Fat
  - Facial soft tissues
  - Extra-ocular muscles





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Ex. 1. Human Eye (STL Model Generation)

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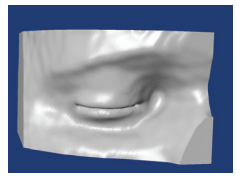
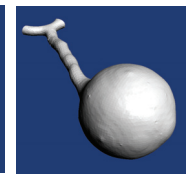
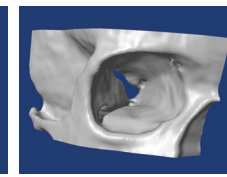
- STL models of all the segmented structures were generated using proprietary multi-part anti-aliasing scheme available with ScanIP
- STL models are suitable for importing into third party CAD software







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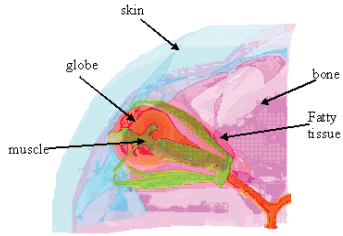
Ex. 1. Human Eye (FE Model)

ARUP simpleware

- Transparent top view of model showing each mask including bone, skin, globe, fatty tissue and muscles



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Ex. 1. Human Eye (FE Model)

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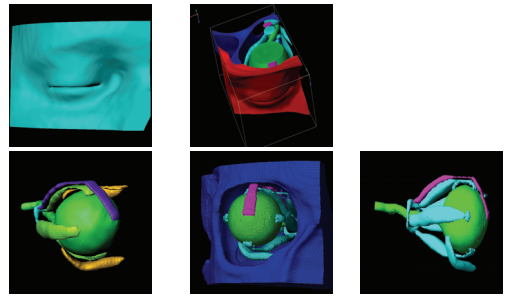
- Volume mesh: mixed hex/tet elements or pure tet.
- Structures/parts modelled either as volumetric meshes or as surface meshes as required (e.g. the bony orbit modelled as a rigid structure defined by surface shells).
- Model Completed in Oasys PRIMER



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Ex. 1. Human Eye (LS-DYNA)

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- Impact with golf ball (42 mm diameter, 45g mass)
- Impact Velocity 4.47 m/s
- Single surface contact
- Material Models
  - Skin: Mooner-Rivlin material model
  - Bone: Rigid
  - Globe and fat: Elastic
  - Ball: Rigid

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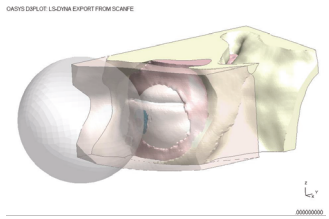
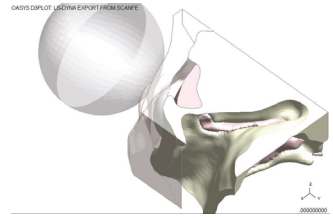
Ex. 1. Human Eye (LS-DYNA)

ARUP simpleware





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Ex. 2. Hip Implant

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- Hip Implant model obtained from *in vivo* MRI scan data.
- Impact under impulse loading LS-DYNA

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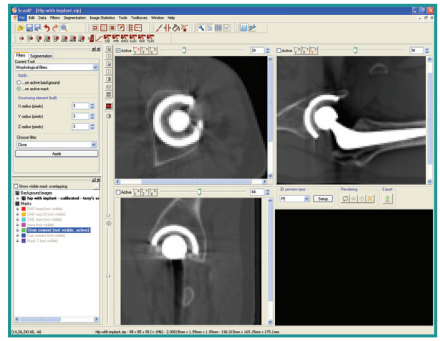
Ex. 2. Hip Implant (ScanIP)

ARUP simpleware



- Import MRI data
- Several different materials can be seen in the scan due to their different densities.

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Ex. 2. Hip Implant (ScanIP)

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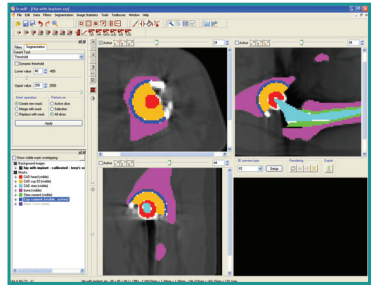

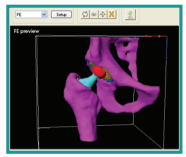

3D – View of Masks

- Filter the image data
- Reduces noise and holes in structure
- Segment the data to determine different objects
- Tools determine different objects based on greyscale threshold values
- A series of masks are created which identify each object of interest.

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Ex. 2. Hip Implant (+ScanFE)

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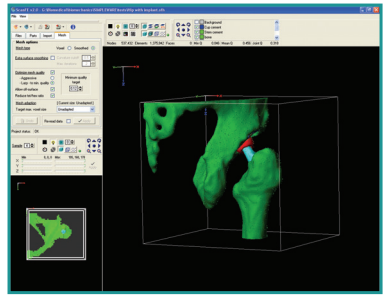

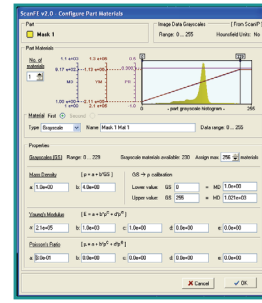

- Import data into ScanFE
- Adapt mesh to reduce number of elements
- Optimise mesh quality
- Material properties can be assigned to the elements based upon their greyscale value
- Export model to Oasys PRIMER

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Ex. 2. Hip Implant (Oasys PRIMER)

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- Complete Model in PRIMER
- Create
  - Boundary Conditions
  - Contact Surfaces
  - Control Cards
  - etc, etc ……
- Check Model
- Write out complete LS-DYNA keyword input deck.

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Ex. 2. Hip Implant (LS-DYNA)

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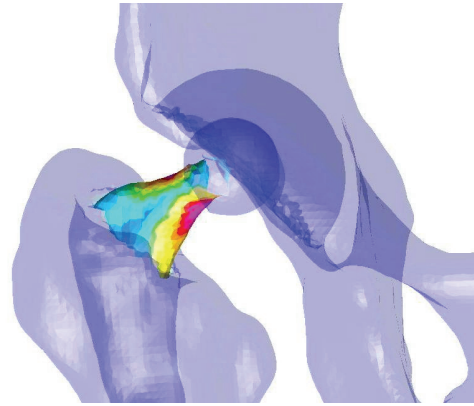

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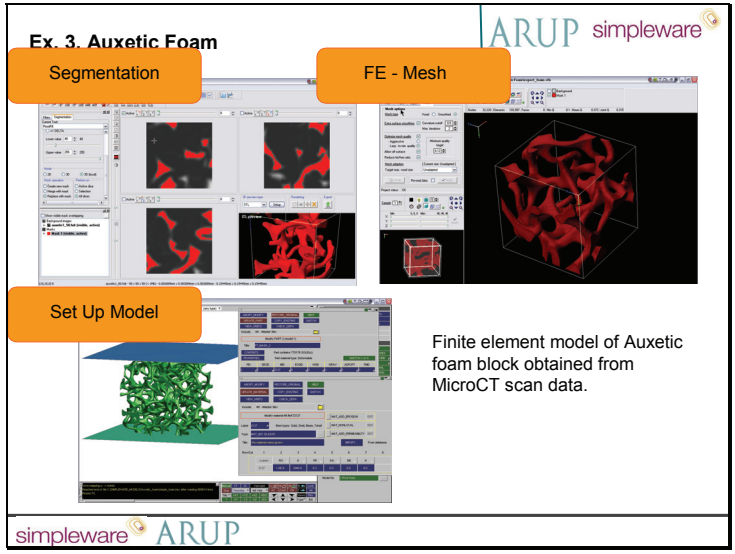
Ex. 3. Auxetic Foam
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Segmentation
FE - Mesh
Set Up Model
Finite element model of Auxetic foam block obtained from MicroCT scan data.
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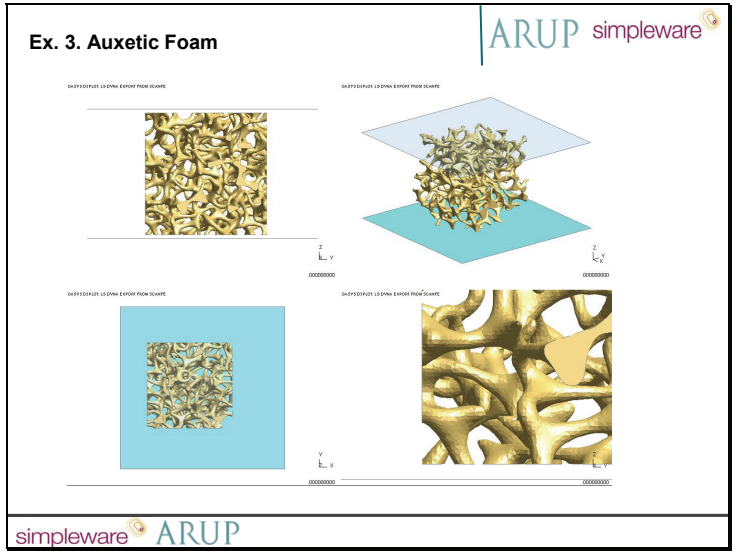
Ex. 3. Auxetic Foam
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Ex. 4. Glass Fibre in Matrix

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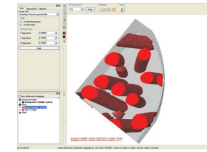
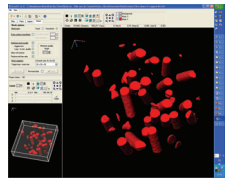
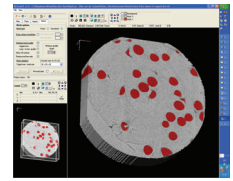
Glass fibres in a matrix

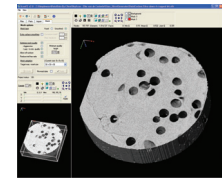
Data from microCT (Courtesy of Skyscan)

Work in progress









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Further Details.

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