Multiphysics Software Applications in Reverse Engineering

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Reverse Engineering

- **"…. *reverse engineering*....starting with a finished product or process and working backward in logical fashion to discover the underlying new technology."**

  (Source: The Society of Manufacturing Engineers)

- **Reverse engineering is "a fair and honest means of starting with the known product and working backwards to divine the process which aided in its development or manufacture"**

  (Source: U.S. Supreme court)

Applications

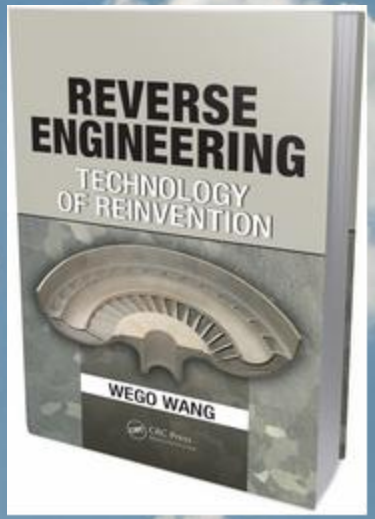
- Information technology (IT) industry
- Aviation industry
- Automotive industry
- Accident investigation/reconstruction
- Forensic analysis
- Legal analysis
- Academic research

Steps of Reverse Engineering

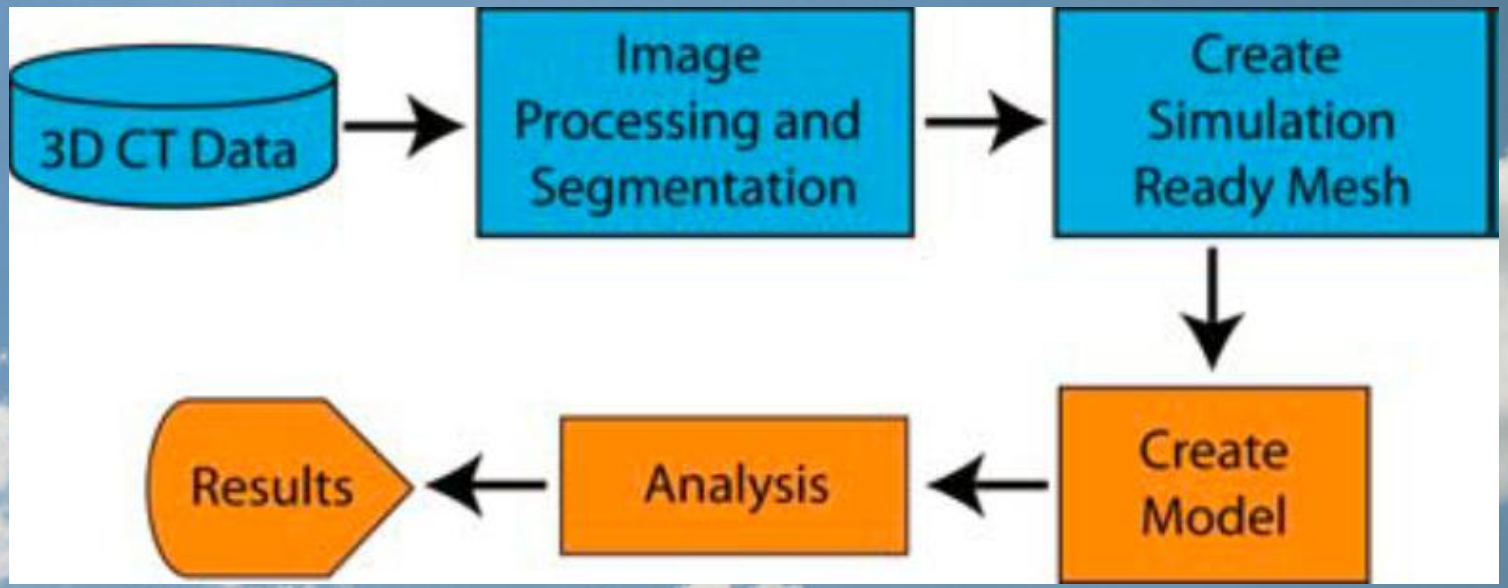
- Data Collection
- Verify form, fit, function, performance, and design details.
- Identify processing, manufacturing, material, tooling, fixturing and other requirements.
- Establish acceptance criteria for substantiation data and testing results
- Justify any modification of technical data

Reverse Engineering Mechanical Parts

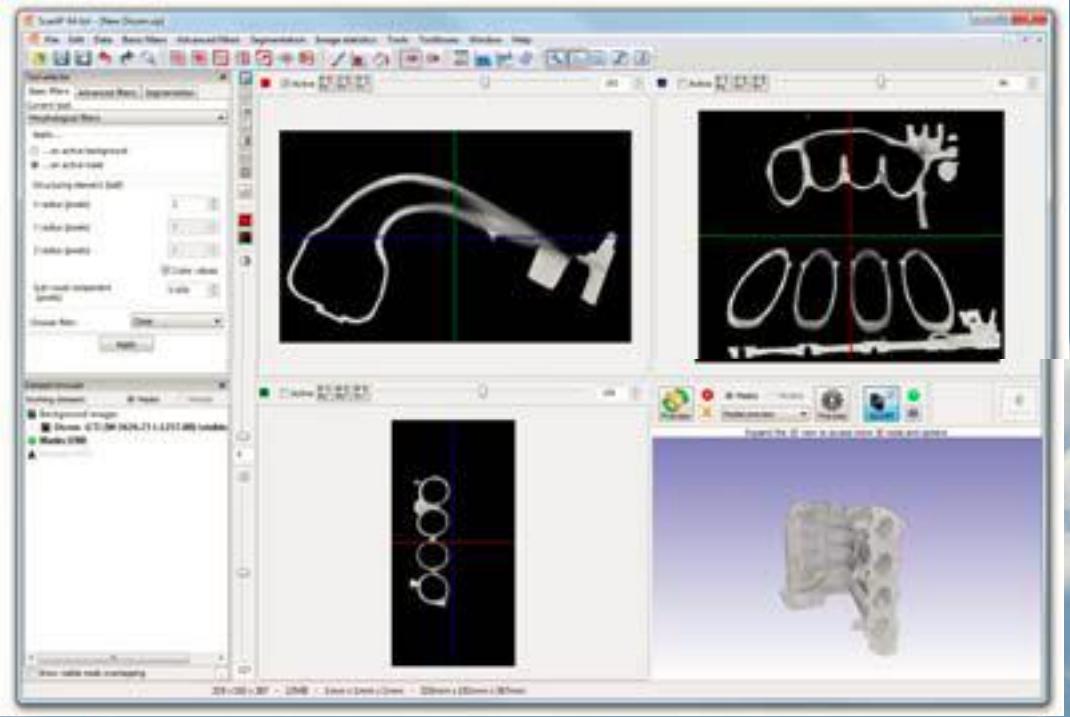
- **Reverse engineering enables the replication or repair of an existing mechanical part/component/assembly by duplicating or restoring its characteristics**
  - **Physical features**
  - **Dimensional tolerances**
  - **Materials**
  - **Manufacturing process**
  - **Surface finishes**
  - **Design function**



Steps of Reverse Engineering for Mechanical Parts

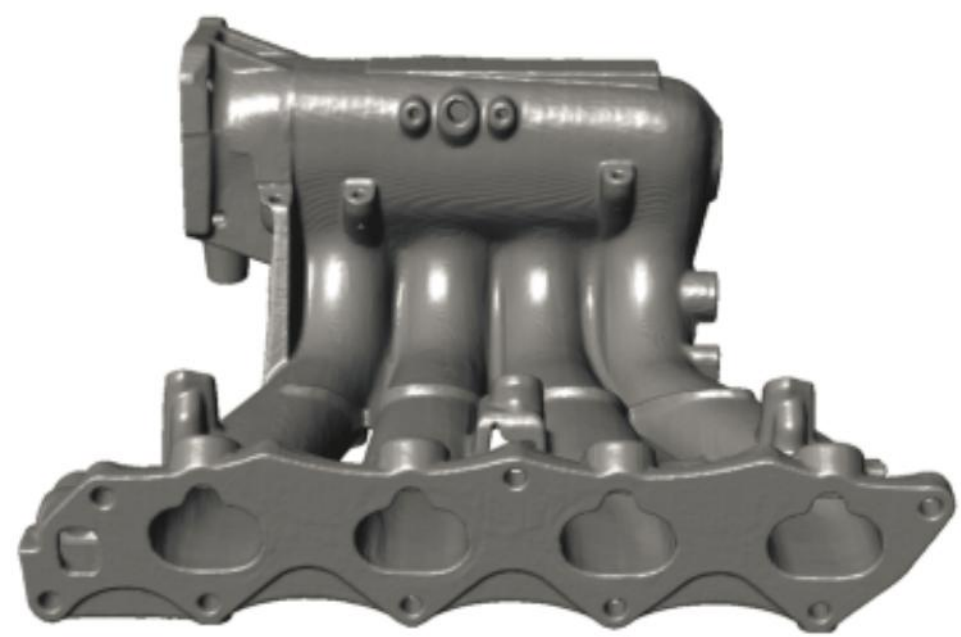


Object Scanning and Image Processing



The ScanIP software environment showing three orthogonal views of the scanned 3D image data (grey images with black background), with a volume rendering of the entire data set (bottom right)

Segmentation and Aligning the Solid Structure

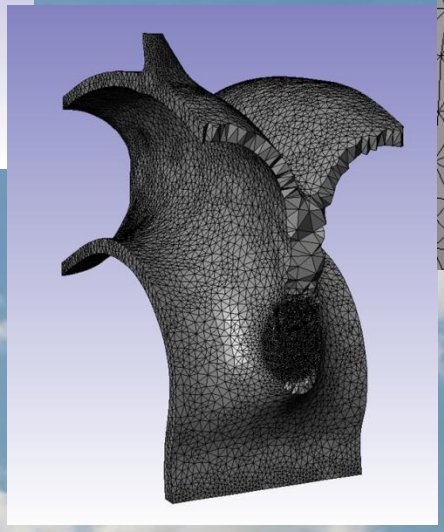


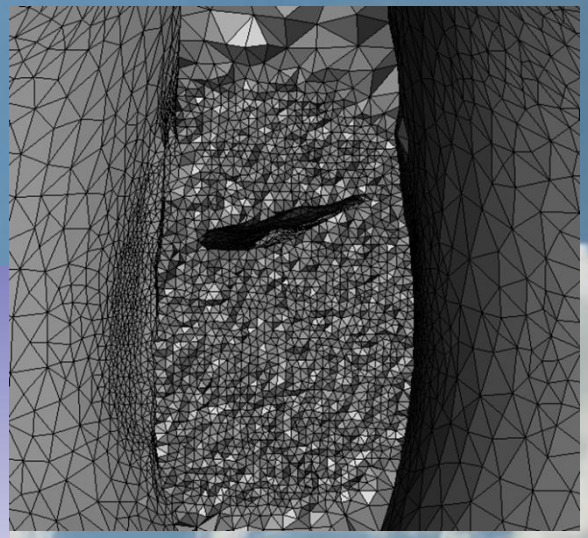
Segmented geometry of the solid structure of the engine manifold from the 3D CT data

Meshing the Manifold Geometries

Segmented geometry of the internal fluid structures (blue) within the engine manifold (transparent grey).

Meshing the Solid Structure





Fe-Free + mesh refinement

Meshing the Internal Fluid Structure

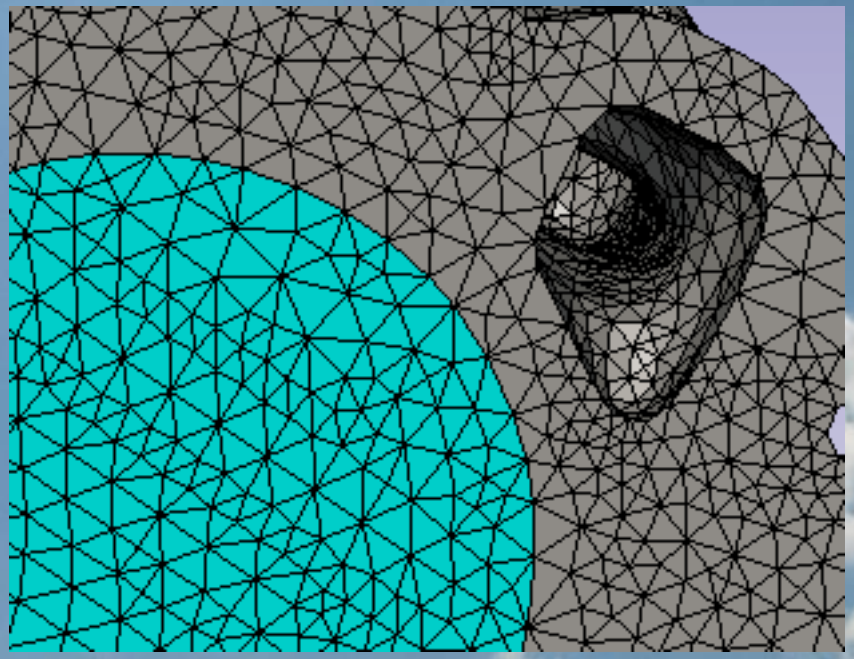
CFD mesh internal fluid structures (blue) within the engine manifold (transparent grey)

Highlighted pressure outlet and multiple velocity inlet BCs

Analysis and Simulation

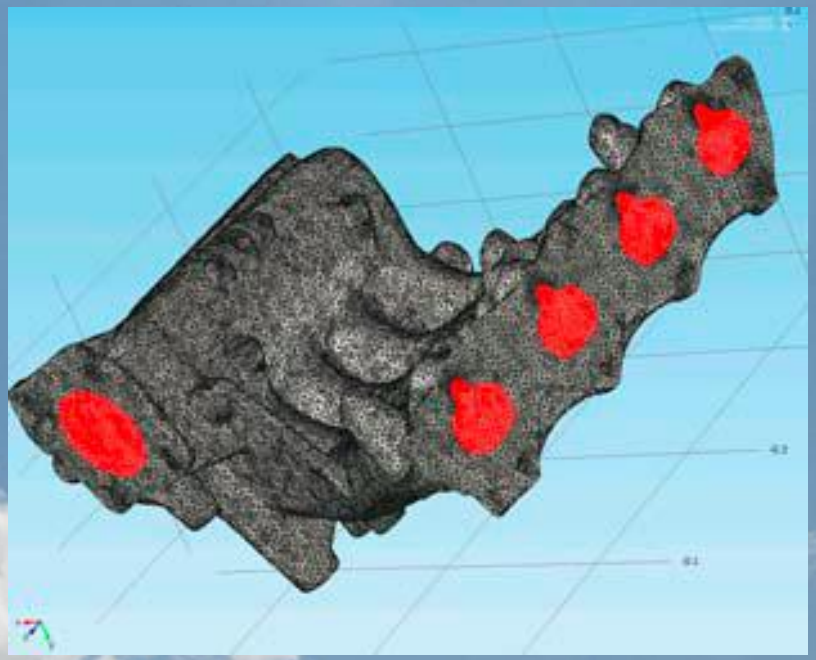
- Verify form, fit, function, performance, and design details
- Identify processing, manufacturing, material, and other requirements
- Justify any modification, such as design change/improvement for product

Multi-Part Mesh

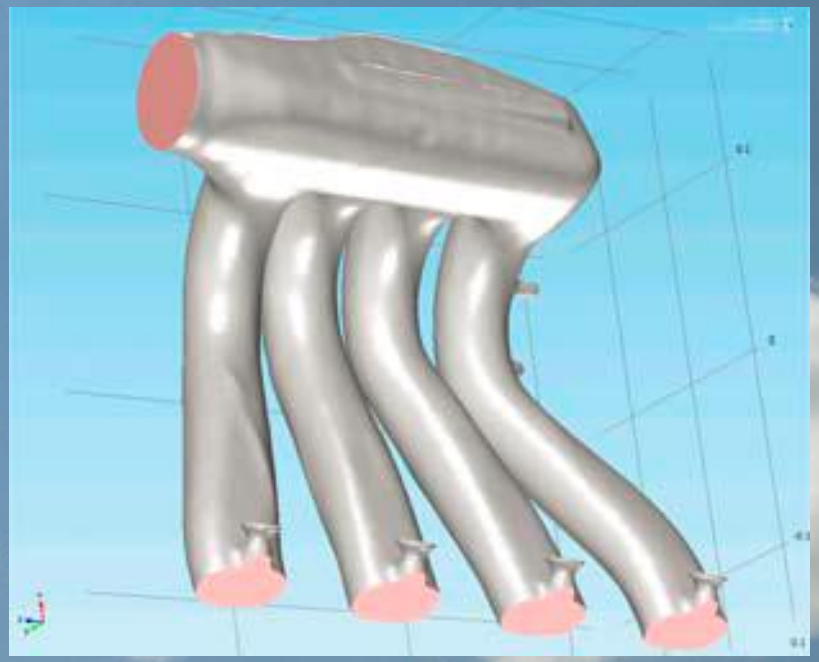


Coincident nodes defined at interface between solid (grey) and fluid (blue) structure

Export Model to COMSOL



Within the COMSOL environment, the mesh of the solid (black) and fluid (red)



CFD mesh of the fluid (grey) with the BCs highlighted (pink)

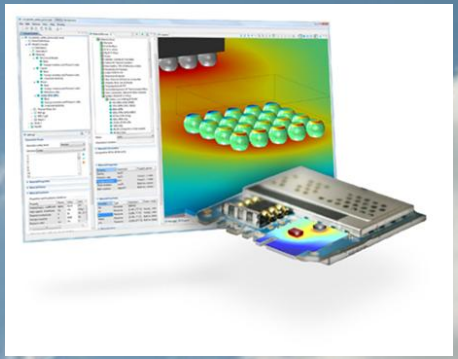
COMSOL CAD Import

- Simpleware
- SolidWorks
- Pro/ENGINEER
- Audodesk Inventor
- DXF
- Parasolid
- ACIS
- STEP
- IGES
- CATIAVS
- VRML
- STL

(SourceCOMSOL)

COMSOL Material Library

- Engineering data for 2500 materials
- Up to 24 key material properties
- Property vs temperature curves
- Customized material data base



(SourceCOMSOL)

COMSOL Applications in Reverse Engineering

- Multiphysical interactions
- Nonlinear structural mechanics
- Materials module
- Time-dependent solver
- Fatigue module
- Complex arithmetic calculation

Conclusions

- **The Simpleware software environment provides distinctive features and unique advantages allowing the reconstruction of a solid 3D model with fine precision of the scanned engine part, including its internal features.**
- **The utilization of COMSOL multiphysics software for further physics simulation and structure analysis will assure the functionality and performance of the reverse engineered part comparable to the original part.**

Questions