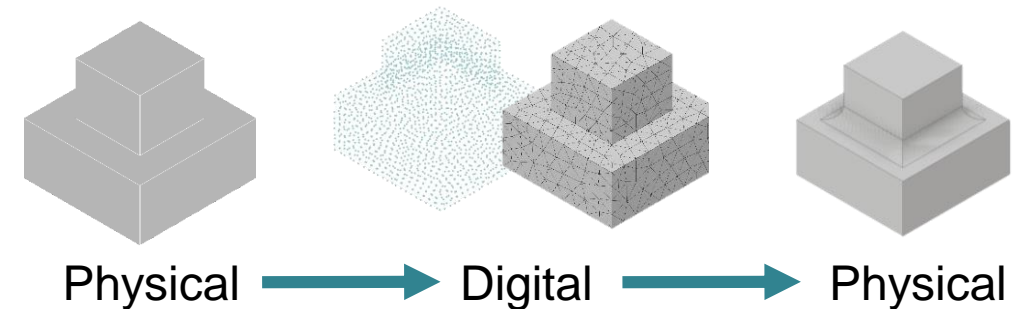


# Reverse Engineering

# What is Reverse Engineering?

- Reverse engineering is the process of inspecting an object in order to reconstruct it as digital model.
- It assumes no knowledge of the original product definitions nor manufacturing processes used to make it.
- Depending upon the application, the reverse engineering process will usually attempt to determine the design intent (i.e. functionality) of the object.



# Inspection Systems for Reverse Engineering

- Measurement capability required dependent upon final application.
- Optical / non-contact systems common.
- Dense measurement points in the form of 'point clouds'.
- May also want a system that can capture colour for visualisation.
- Possible to use a combination of systems to improve accuracy.



# Laser Scanning

- Laser line illuminates surface, which is captured by photosensor, and used to triangulate distance.

Advantages	Limitations
<ul style="list-style-type: none"> <li>• Can be mounted on coordinate measuring machine (CMM) or articulated arm CMM</li> </ul>	<ul style="list-style-type: none"> <li>• Requires line of sight</li> <li>• Difficult to inspect holes, slots, and high aspect ratio features</li> <li>• Difficult to inspect very rough surfaces</li> <li>• Developer spray required for reflective surfaces</li> </ul>



FARO

# Structured Light

- Projection of a known image onto part, which is captured by cameras and compared to a flat reference image.

Advantages	Limitations
<ul style="list-style-type: none"> <li>• Portable</li> <li>• Designed for dimensional inspection</li> <li>• Works well on very rough AM surfaces</li> </ul>	<ul style="list-style-type: none"> <li>• Requires line of sight</li> <li>• Difficult to scan holes and slots</li> </ul>



GF Messtechnik

# Photogrammetry

- Images captured from a number of angles, and fed into software which stitches the images into a 3D scene.

Advantages	Limitations
<ul style="list-style-type: none"> <li>Non-contact</li> <li>Possible to make use of low cost cameras</li> <li>Can be used for dimensional measurement</li> <li>Can be geared toward visualisation with colour photo overlay</li> </ul>	<ul style="list-style-type: none"> <li>Line of sight required</li> <li>Need to ensure full coverage</li> <li>Targets often need to be stuck to the surface</li> </ul>



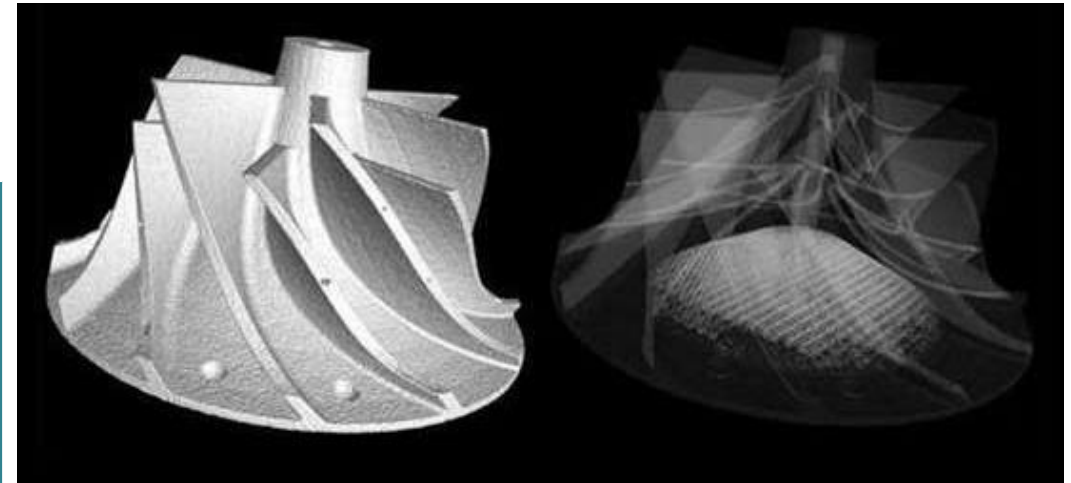
itSeez3D



# X-Ray Computed Tomography (XCT)

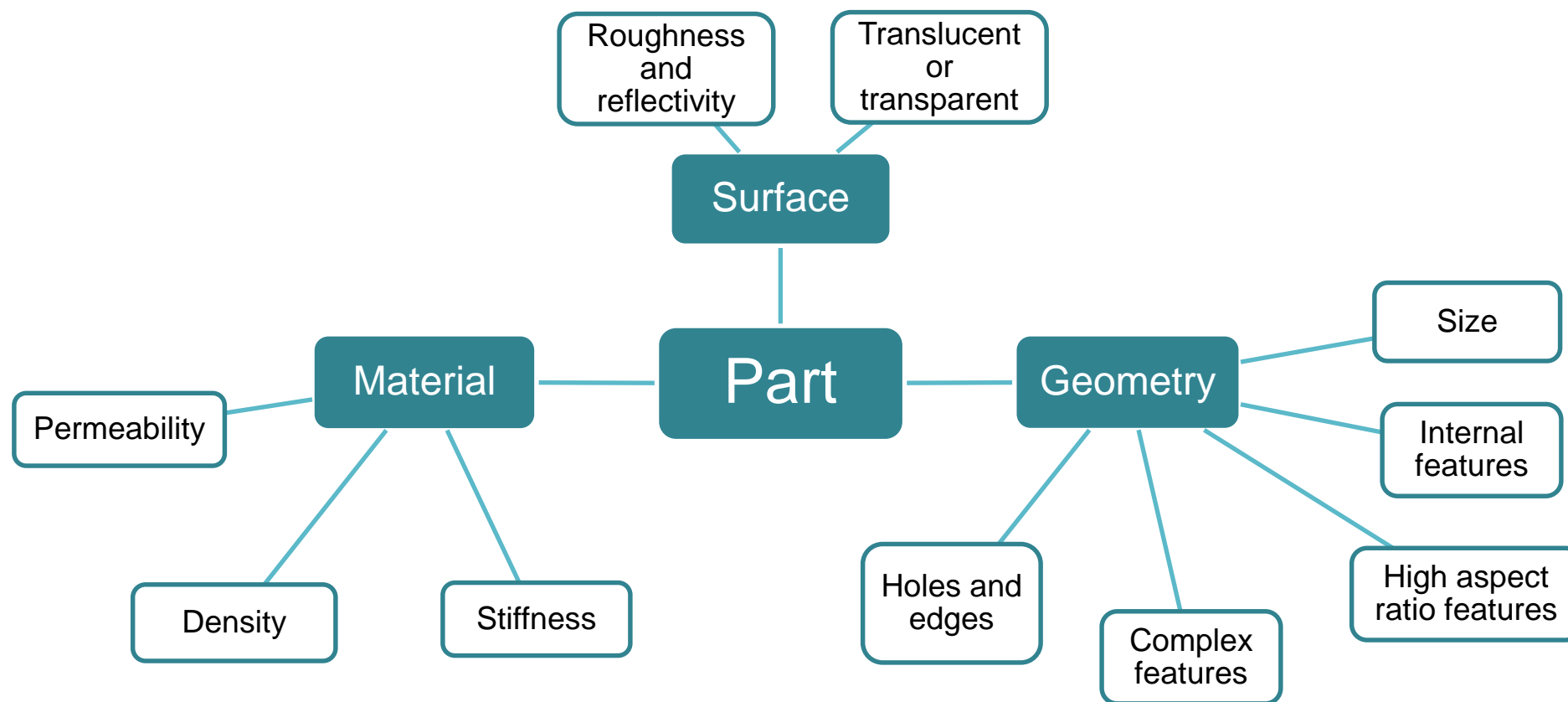
- X-rays transmitted through part to create a series of 2D images through a number of rotations to digitally reconstruct a volume with the intensity used to represent density.

Advantages	Limitations
<ul style="list-style-type: none"> <li>• Volumetric and internal inspection</li> <li>• Enables a detailed analysis of 3D locations, shapes and sizes of defects present</li> </ul>	<ul style="list-style-type: none"> <li>• Cost, given hardware required &amp; cycle time</li> <li>• Penetration &amp; rotation requirements in relation to machine power &amp; enclosure size limit maximum component size</li> </ul>



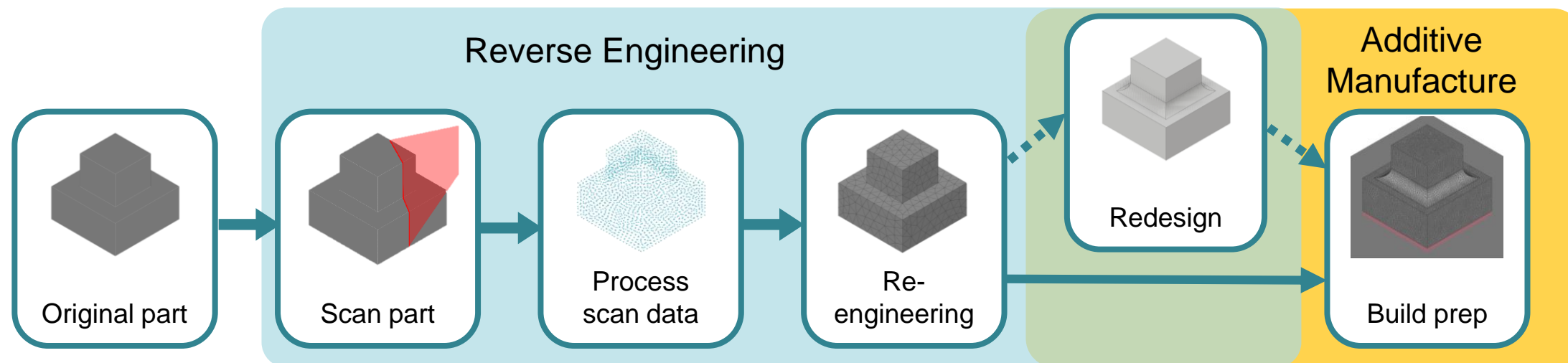
additivemanufacturing.media

# Part Considerations

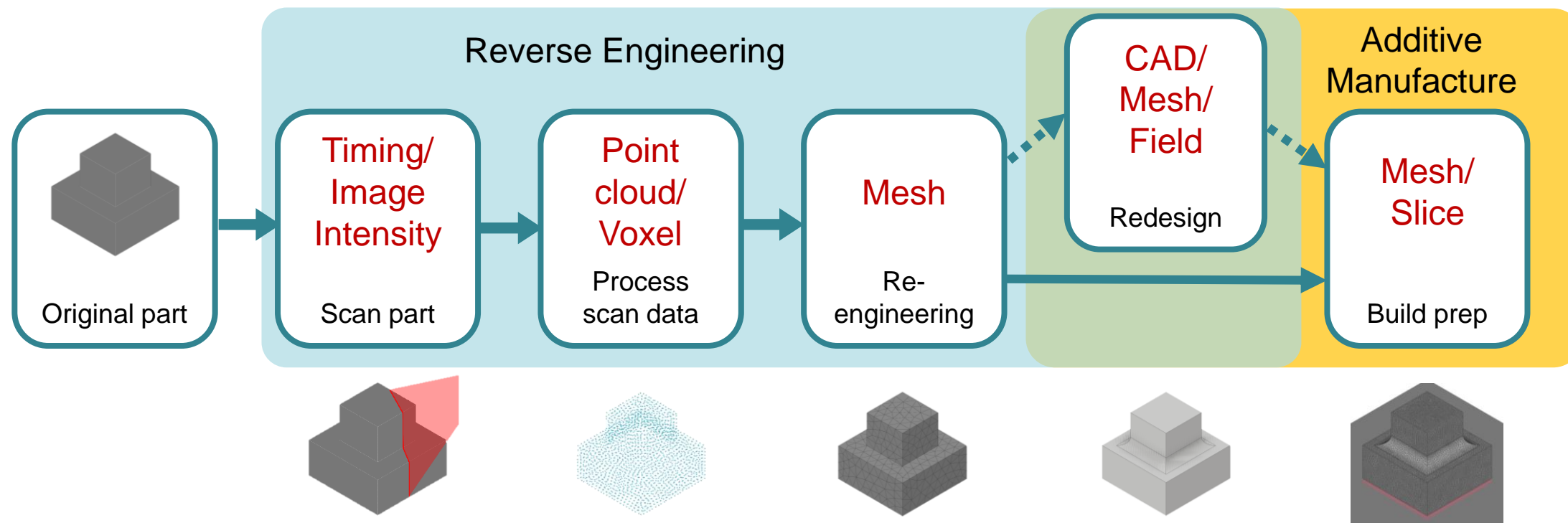




# Reverse Engineering Workflow



# Reverse Engineering Workflow



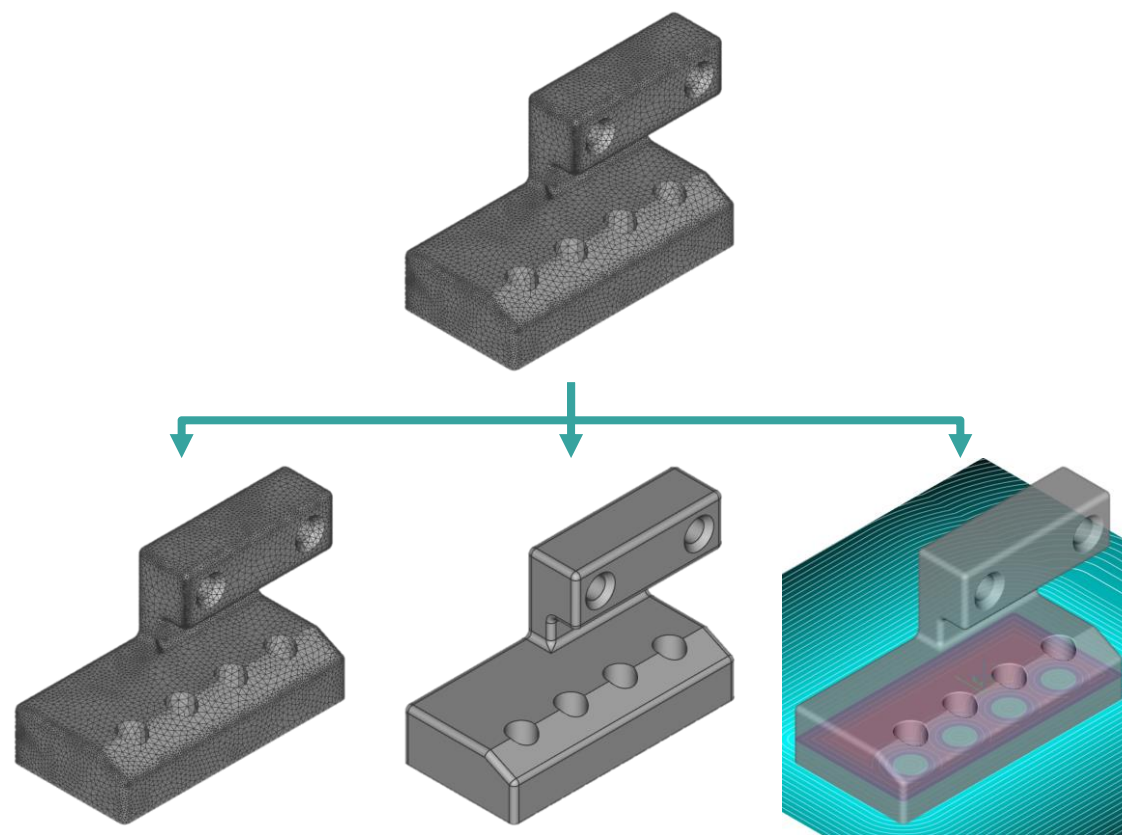
# Processing the Scan Data

- Scan data can have a lot of noise and inaccuracies in it:
  - Background inclusions
  - Inaccurate scanning due to difficult features.
  - Low resolution data.
- These need to be removed, often manually.
- Once the data has been cleaned up it can be turned into a mesh.



# Re-engineering

- If modifications are required to the part it can be done through one of 3 routes:
  - Mesh/STL modelling
    - Directly edit the mesh from the scans.
    - No file conversion required.
    - Difficult to make changes.
  - Brep modelling
    - Requires feature recognition to convert file.
    - Easy to modify geometry.
    - Fits in with conventional design workflow.
  - Implicit
    - Direct slicing possible.
    - Lattice capabilities.



# Intellectual Property

## Formal Definition

“Creations of the mind for which exclusive rights are recognised and which can be treated as an asset”

## Forms of IP protection

- Copyright
- **Patents**
- **Design rights**
- Database rights
- Trademarks

## In a business:

IP can be owned by the customer, or the provider of the service (e.g. developer, manufacturer), or an employee.