SYSTEMS 3D

innovation in 3D solutions

Understanding 3D Scanning

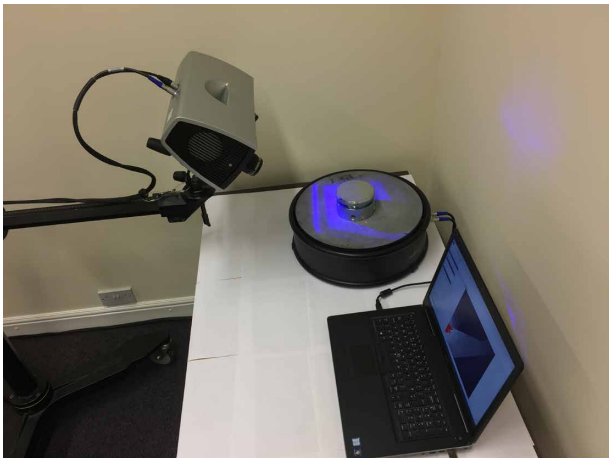
What is 3D Scanning?

3D digital is are the process of analising real-world objects and collecting data on its shape and appearance. The collected data is then used in the construction of digital 3D models. A 3D scanner can be based on many different technologies, each with its own limitations, advantages and costs.

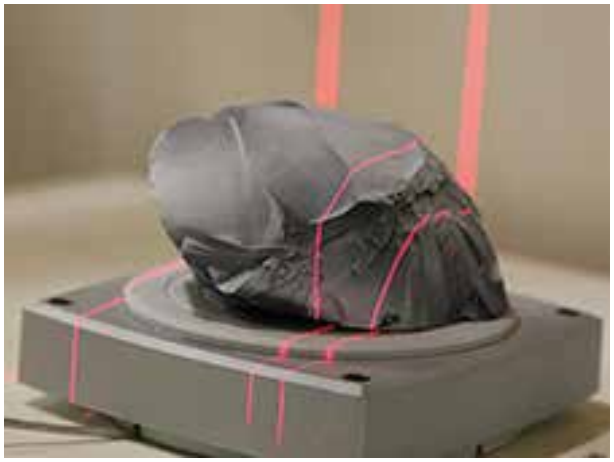
3D Digital Scanning expands and enhances what can be done with design processes and also 3D Printing and CNC Machining. 3D Scanning allows you to replicate the shape of any object and can often replace the need to build a 3D model from scratch.

Digital High-Resolution 3D Scanning technologies and are known by many different names such as:

- Structured Light Scanning (Blue Light)
- Laser Triangulation
- Photogrammetry
- Contact Bases Scanning
- Laser Pulse Scanning
- CT Scanning (Computer Tomography)



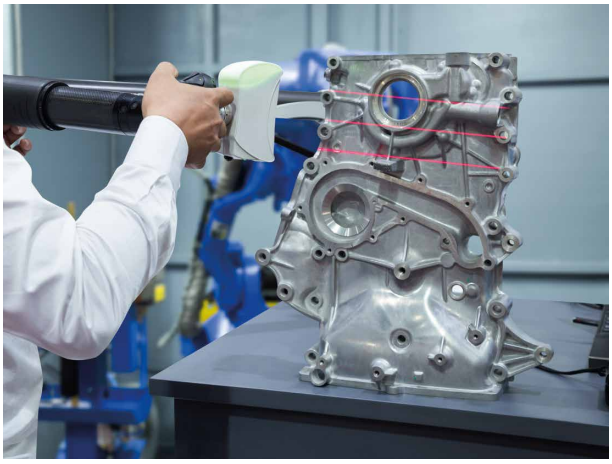
Structured Light (Blue Light)



Laser Triangulation

Photogrammetry

Contact Based



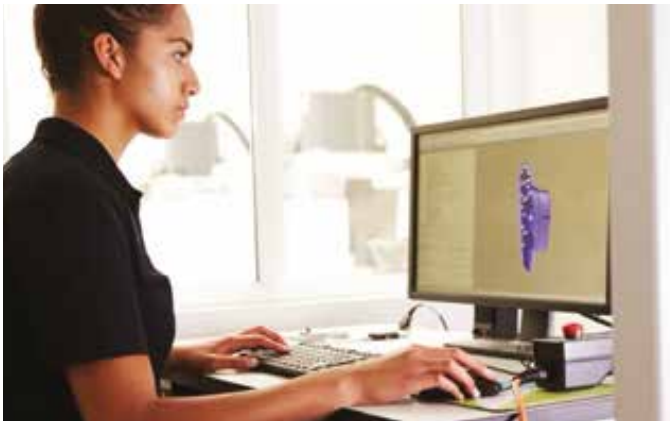
Laser Pulse

Computer Tomography (CT)

- **Structured Light Scanning (Blue Light Scanning)** – this process projects a pattern onto an object and then measures the relative deformation of the pattern.
- **Laser Triangulation** – a laser beam is projected onto the surface of the object and the deformation of the laser beam is then measured.
- **Photogrammetry** – 3D models are generated from from 2D photos based on computational geometry algorithms. This process is also referred to as 3D scan from phototaghraphies.
- **Contact-Based Scanning** – points on the surface of an object are measured by the deformation of a probe.
- **Laser Pulse 3D Scanning** – this technology is based on the time of flight of a laser beam. The laser beam is projected onto the surface of an object and the time of travel between emission and reception. The elapsed time is then reported back to a sensor and is computed into geometrical surace information.
- **CT Scanning (Computer Tomography)** – this technology enables the complete capture of an object's complex surface structures no matter internal, external, or occluded or not. Line of sight or visual access to a surface is not a requirement.

The accuracy of the different scanning technologies varies greatly, and there is a direct relationship between cost and accuracy.

At Systems 3D Group we use a Zeiss Comet L3D Blue Light Scanner with a rotary table that has a capacity of 100 Kg. This scanner has a 5 megapixel camera, and we have a variety of lenses that can accommodate a wide range of object sizes.



3D Scanning Basics

Many different things can be accomplished with 3D Scanning

- **Reverse Engineering** – scan data is used to reconstruct an object based on the data acquired from the scanning process. The scan data acts as a geometrical guide for the designer.
- **Quality Control and Inspection** – scanned components are compared against another set of data such as a CAD file or other scan data to determine the variations between the two models.
- **Archaeology & Historic Preservation** – precious artefacts are scanned in order save their actual physical form, features, and physical properties in a digital format.

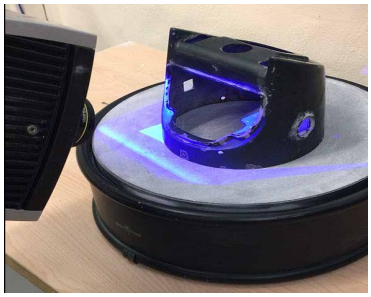
3D Scanning offers a wide variety of possible end-results. These are determined by the customer's goals and needs. Please contact Systems 3D Group to discuss your require-ments.

3D Scanning Process

The scanning process works by projecting calibrated grids onto the viewable surfaces of the object. At the same time, an industrial camera takes thousands of photos per second. Each projected pattern and photograph captures a different grid trajectory.

The thousands of photos are sent to the back-end software which references a table holding the calibrations for the projection patterns. It then translates the captured photos into a digital format.

The result of the scan data collected by a 3D Scanner is a collection of triangles (tessellations) connected at the edges and representing the surface of an object.



File Resolution

The density of the triangles varies based on the chosen scanning parameters. Using a higher scanning resolution will produce a model with smaller triangles and an overall larger quanitiy of tesselations. The inverse is true for lower resolution scans which will produce the same model with fewer triangles.

The more triangles within the model the larger the resulting scan file will be. Once again the inverse is true for low-resolution scans. Low-resolution scans will have fewer triangles. and can lead to the potential of loss of detail.

High-resolution files are typically very large files that have more detail, and they take more computer power to manipulate them through design processes. The trick is to find a happy medium where there is sufficient detail, and the resulting file is not too large.

Choosing a resolution depends on the desired and required end-result from the customer. Applications with boxy, square, smooth models can often be scanned in lower resolutions. Items such as sculptures require greater detail to be retained and accurately portrayed.

Data Acquisition

The first step of 3D Scanning is the data acquisition process which entails capturing the model in digital format.

- **Rotary Table** – involves placing the scan-object onto the table and taking a series or collection of photos from a 360-degree spectrum while the projector and camera remain static.
- **Static Scanning** – involves the object remaining static while the camera is manually moved around the object. This is usually done with large objects such as motorbikes, cars, statues, and engines.

It is very rare that an object can be scanned and the data then be used for production purposes without post-processing of the data.

Here is a piece that we scanned for an artist using the rotary table. After the model was scanned the file was immediately exported and sent to production.

Surface Features and Defects

Due to the extreme accuracy of the L3D Comet minute surface features such as scratches, knicks, dents, chips in painted surfaces, engravings and letterings, will be captured as part of the finished model.

Occluded Features

Occluded areas such as deep recesses, holes, and pockets, normally cannot be collected as part of the scan dataset because the scanner can only scan what it can project a pattern onto. Internal cavities also cannot be collected, and there will be a gap in the model in these respective areas.

When a model has deep recesses, holes, or internal cavities, the scanner captures these features to the extent that it can project a pattern into the area and take a corresponding picture. The recesses, holes, and cavities will be portrayed as part of the surface geometry but will not be portrayed in their entirety. These areas will be portrayed as holes or as partial surface geometry.

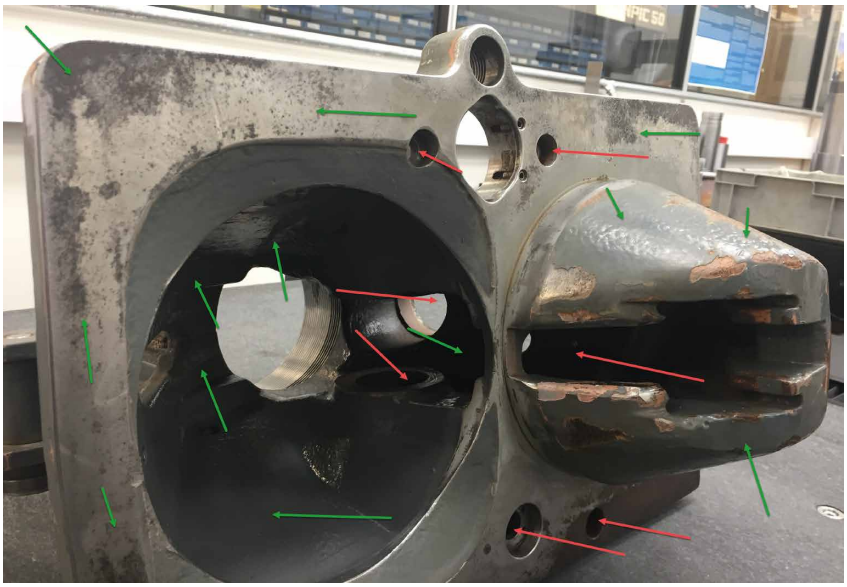
The missing gaps can be interpolated and filled in by the scanner software, but the filled and repaired features will only be the best estimation of the original feature.

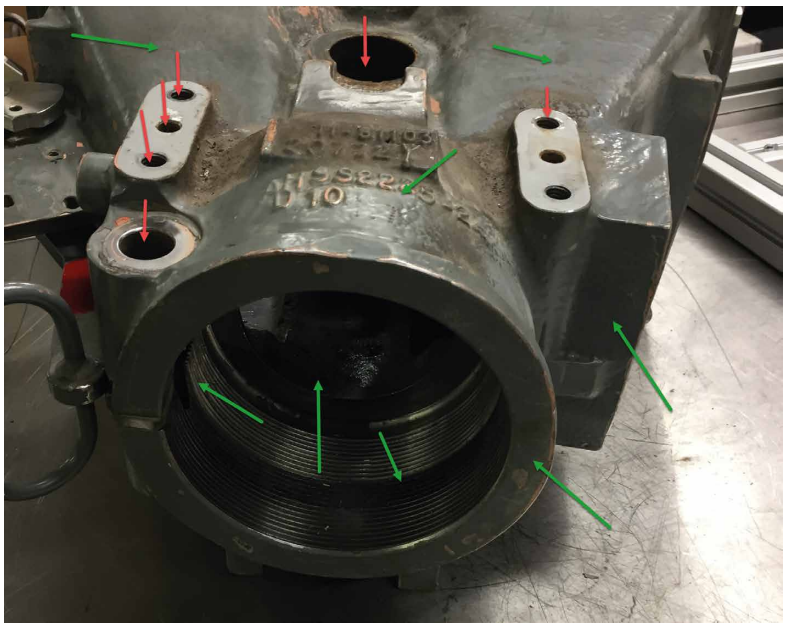
The scanner software can effectively patch, heal, and interpolate holes in the acquired surface data but it cannot interpolate the depth of the holes and cavities.

Scanning objects with deep holes, overhangs, underhangs, recesses, and internal cavities require secondary operations in order to produce a file that can be used for design or manufacturing purposes.

Secondary operations include healing surface holes, removing surface flaws, and interpolating curved and geometrical surfaces that could not be collected.

Within the photos below the surfaces that are most likely will be successfully collected are indicated with green arrows. The areas that most likely will not be successfully collected are indicated with red arrows.





Shiny Objects

Shiny surfaces are difficult to scan and need to be coated to avoid the reflection of the scanner's projected patterns. When an item is not precious flaw detector spray is used because it is easy, efficient, and effective. When working with precious items other methods to cut reflections are used, and the safest method to be used for coating precious items is determined by our in house curatorial staff. Every precaution is taken by Systems 3D Group staff when handling precious items.

Unsprayed Chrome Skull

Sprayed Chrome Skull

Skull Scan Data

Skull 3D Printed

End Results of 3D Scanning

3D Scanning is used for a variety of purposes. The end-results of the 3D Scanning process typically are:

- **3D Printing Project**
    - **STL File**
- **CNC Machining or Routing Project**
- **Digital 3D Design Project**
- **Reverse Engineering Project**
    - **STL File**
    - **IGES File**
    - **STEP File**
- **Quality Control and Inspection Reports**
    - **Scan data to CAD data comparison**
    - **Scan data to can data Comparison**

File Types Available

STL – is an abbreviation for Stereolithography File but people also purport it to be "Standard Tessellation Language"or "Standard Triangle Language". The STL file format is the de-facto standard file format for 3D Printing. An STL file is a system of triangles that are knitted together by their edges to create surface geometry. There are two types of STL Files: ASCII and Binary.

STEP – is the most widely used data exchange format in CAD design work. It has an ASCII structure and is easily read by all prominent CAD software. The current ISO standard is ISO 10303-21.

IGES – is an acronym for Initial Graphics Exchange Specification and it is a vendor-neutral file format used for the digital exchange of information among CAD systems. It was the first interchange protocol on the scene. Today most CAD designers use STEP.

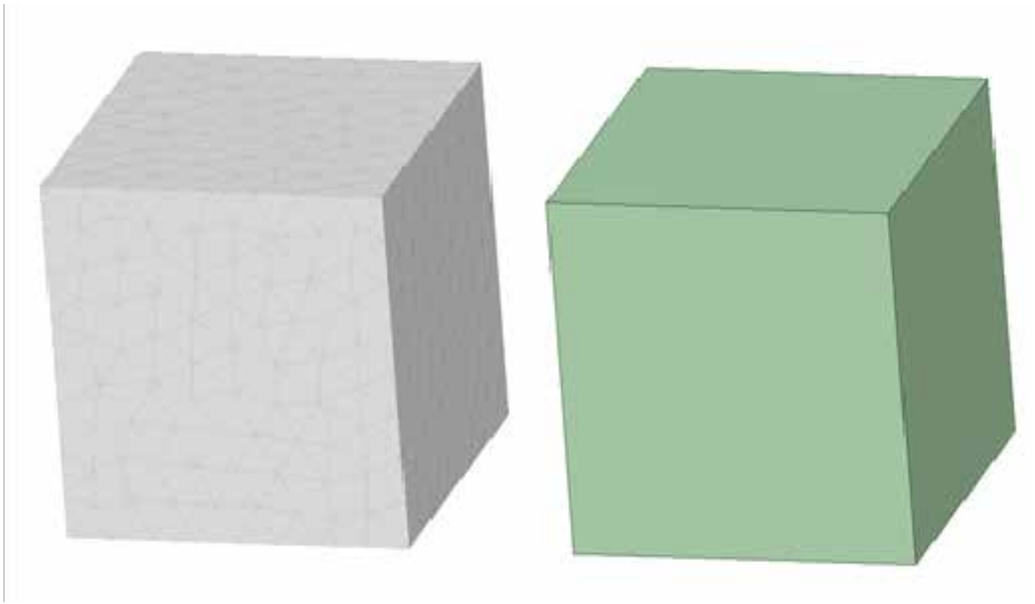
During the scanning process, the picture pattern data is collected and then translated into a tessellated format. The produced model will be a tessellated format no matter to what format the data is output. Even if the output of the scan data is thereafter translated to STEP or IGES it will still be a tessellated model.

To get a solid model with surfaces, planes, spheres, and objects it is required that the tessellated model is used as based data to create a new solid model.

Comparison of an STL File and a Solid Model File

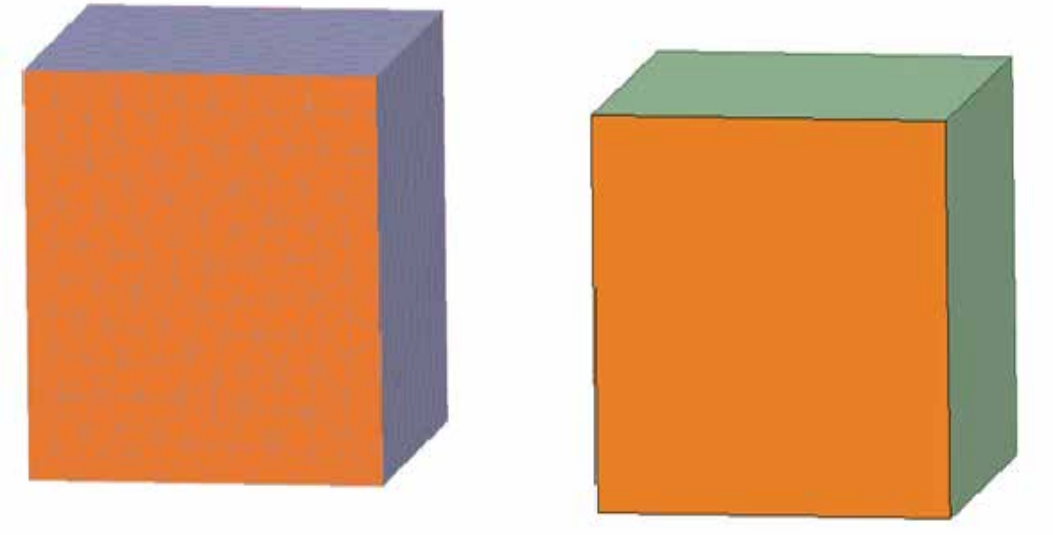
STL files are files where features and surfaces are made up of a grouping of triangles whose edges are stitched together. These triangles are also called tessellations.

Solid models will have the same features and surfaces, but these surfaces are made up of one component versus a grouping of triangles.



STL Model **Solid Model**

When modifying a surface on the block of the STL file you will need to select all of the triangles to be able to manipulate the whole surface of the square. On the other hand with the solid model, there is only the surface to manipulate. Certain issues are presented when attempting to manipulate an STL for design purposes and generally the process is much more complex.



Conclusion

3D Scanning provides flexibility to a wide variety of manufacturing, design, and reverse engineering processes. It can also be used for metrology purposes or as a preservation tool no matter if the object it is a precious artefact or an engineering component. Talk to one of our technicians to discuss the wide range of options and benefits 3D scanning can provide to your organisation.

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