About Scanning Based Shape Capture and Reverse Engineering

There are a number of parameters to consider when using scanning to capture legacy design information. These parameters can significantly impact the cost of the project and the quality of the results. The following describes some of the parameters and their effects.

Model Type

There are several types of CAD models available and the difference between them can significantly affect the overall cost of the project and the usefulness of the results. The available CAD models are:

- STL Mesh
    - STL isn't really a type of model so much as it is a 3D dataset. Most CAD and CAD/CAM software can't utilize STL very well (or at all), but sometimes STL is all that is required.
    - Raw STL is the least expensive deliverable. Raw STL is output by the scanners and is not processed further. It is usually comprised of multiple scans that may or may not share a common coordinate system i.e. the scans may or may not line up with each other. Raw STL will also have some small amount of 'noise', which is incorrect data. Customers almost never select this type of deliverable.
    - Manifold Solid STL (Watertight STL) starts as raw STL, but is processed using specialized software. Multiple scans are aligned and merged into a single coherent dataset and the noise is significantly reduced or even eliminated. Although greatly improved over raw STL, Manifold Solid STL is still not very useful to most customers and is seldom selected.
- Vector Graphics (DXF, DWG)
    - Two dimensional CAD files typically used for fabricating flat parts using CNC waterjets, plasma cutters or lasers. This is the least expensive true CAD file.
    - Created by cleaning, aligning and merging the STL and then using specialized software to extract profile data (outlines).

- Surface Quilt (Autosurf) based Solids
    - Three dimensional CAD model suitable for CNC machining and creating simple molds and fixtures.
    - Created using many, sometimes thousands, of surface patches. As the name implies, the patchwork is created semi automatically using specialized software and is the least expensive 'solid' CAD model.
    - Accurately reproduces the scanned part, but may include some noise in the scan data. Especially useful for objects that are created or finished by hand such as gun stocks, sculptures, furniture, etc.
    - Difficult to edit (modify) and may be difficult to tool path (CAD/CAM).
- Parametric Solids
    - Created using sketches and features to create extrusions, revolves, sweeps, lofts, etc. Specialized software is used to extract sketches and features from STL mesh.
    - Easy to edit.
    - May be output as SolidWorks® models with feature tree and all requisite sketches.
    - Most expensive CAD output.
    - Best used for machined parts, molded parts, castings, etc.
- Hybrid Solids
    - Contain both parametric solids and surface quilt solids.
    - Are often used for mixed form objects like boat propellers where the blades are finished by hand, but the mounting system (tapered hole and key) is machined.

Model Extent (How Much)

The extent of the model is determined by the intended use. For example, if engineering an exact replacement part, the entire part will be scanned and modeled, but if engineering a mating part, perhaps only the mating/interfering features need to be scanned and modeled.

Feature Size (Scan Resolution)

Feature size affects scanning time and may dictate the scanning technology to be used. It is important to identify the smallest dimension of the smallest feature to be captured (resolved).

- Cutting the feature size in half will more than quadruple the scanning time.
- Features smaller than 1mm are difficult to resolve using lasers.
- X-ray CT can fully resolve features as small as .06mm.

Accuracy

Accuracy may dictate scanning methods/equipment.

- Laser scanning is accurate to the larger of ±.04mm **or** ±(.02mm + L/10000).
- Hybrid scanning using a combination of laser scanning and tactile CMM scanning can achieve accuracies of +/-.003mm.
- X-ray CT scanning is accurate to ±.0045mm.

Surface

An important consideration is part finish; color, translucency and specularity affect scanning time. Lasers don't work well with translucent or specular surfaces and don't work well with very dark surfaces. While it is sometimes possible to scan a specular or dark surface, the additional scanning time may be cost prohibitive. It may be more cost effective to treat the surface with aerosol paint or Magnaflux® developer even if it means ruining the part. Without surface treatment, a translucent material must be scanned using X-ray CT.

And probably the most important consideration is scanning technology. The two available technologies are laser scanning and X-ray CT scanning.

- Laser scanning
    - Less expensive (10X)
    - Less accurate (10X)
    - Requires larger features (up to 16X)
    - Can only scan line-of-sight
    - Can scan very large parts
    - Works best with light colored matte finished surfaces
    - Works with any material
- X-ray CT scanning
    - More expensive (10X)
    - More accurate (10X)
    - Can scan smaller features (up to 16X)
    - Can scan all surfaces, inside and out
    - Can only scan parts smaller than 350mm
    - Works well with any surface
    - Works best with low density materials such as plastic and aluminum

Careful identification and selection of the above parameters will insure a successful scanning project.