# Accelerating Product Lifecycle Management with 3D Scanning

Sumit Gahletia[1*], Ramesh Kumar Garg[1]

[1]Department of Mechanical Engineering, DCRUST, Murthal, 131039, Sonipat, Haryana, India

Corresponding author-sgahletia@gmail.com

**Abstract:**

Digital fabrication technologies like 3D Scanners & printers entails a radical shift in the traditional consumer-producer paradigm. Integrated with other recent technologies severalsophisticated and interactive technologies are developed that would otherwise never have existed.3D Scanning is emerged as a critical tool in all the stages of product lifecycle management by bridging the gap between the physical objects in real world and digital design environment. The sole purpose of the paper is to study the role of 3D scanning in the entire stages of product lifecycle including -concept, design, manufacturing & servicing. Interaction of this disruptive technology in accordance with Industry 4.0 will help in fostering the industries with enhanced quality, eliminating warehousing costs, faster time tomarket and better understanding of product performance. In this study a series of workshops, research explore the potential of 3D scanning where the development over the time also enables the beginning of Smart Product Service System (Smart PSS).

**Keywords:** 3D scanner &printerSmart Product Service System (SPSS).

## Introduction

3D Scanning is the fast, furious, and disruptive technology which involves analysing a real-world object or environment to collect data on its shape or form and possibly its appearance. As the mainstream media in today's scenario continue its obsession with 3D Printing, still another quiet, perhaps even more impactful, disruption is revolutionizing the way a product is designed, engineered,manufactured, and inspected, it is 3D Scanning technology which is the act of capturing data from objects in the real world and brings them to digital pipeline. As we capture the physical reality to use as a part of our digital design process in 3D scanning, we are engaged in reverse engineering. Digital 3d scanners captures the image of object and stored this digital data by converting surface image into billions of coordinate points.[1] 3D scanning is a modern approach to reverse engineering- backed by latest software and measurement technology captures accurately the complete geometry of virtually anything we can scan and yields editable, manufacturable 3D CAD models that meets the specific engineering and manufacturability requirements. 3D scanners are used to capture object in its digital form and manufactured the prototype with aid of Additive Manufacturing (AM) [2]. Digital data obtained is compatible with available design, testing & inspection software. However,the quality of data produced by a sensor is always governed by systematic and random errors inherent in its measurement.[3]

The quality of data produced by a sensor is governed by the systematic and random errors inherent in its measurements the 3D CAD data acts as a baseline for wear inspection, rework and redesign This 3D Scanning technology has become of vital importance over the past two decades due to its effective metrology technique that has been used in today's manufacturing measurement and inspection arsenals. This rapid non-contact measurement technology has become an essential component in various quality control strategies and is bridging the gap between physical and digital worlds. The three-dimensional scanning technology can be applied to almost every field to save time, money and material [4-7].3D scanning has emerged as a critical tool in every stage of product lifecycle management (PLM) process which involves managing the entire lifecycle of a product from inception, through engineering design & manufacturing, to service and disposal of finished products. The ideation model of 3D Scanning is shown in the figure (1)below [8]

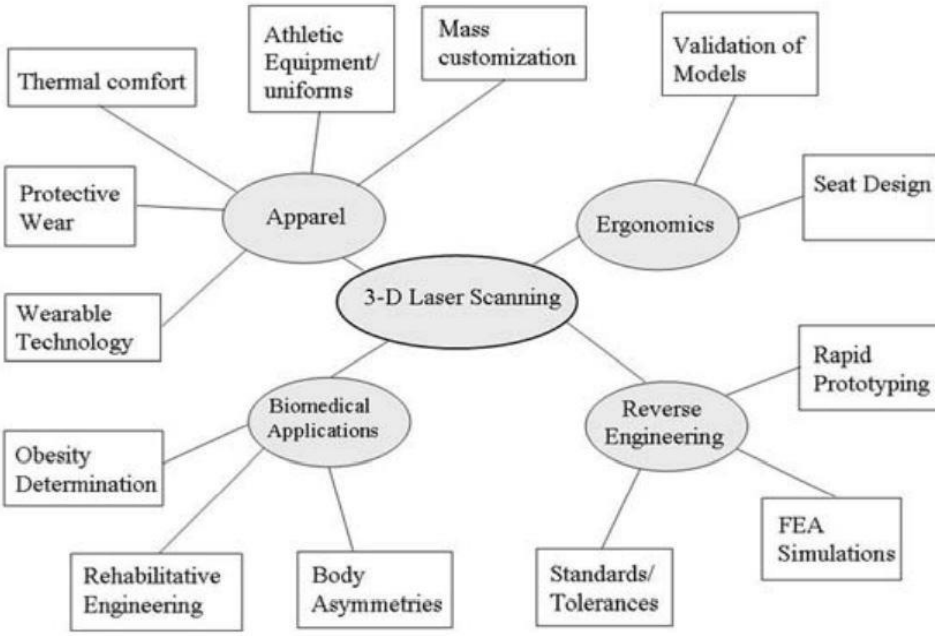


**Fig1:3D laser scanning Ideation model (Source- Journal of Textile and Apparel, Technology and Management · September 2007)**

3D scanning as it measures every surface at millions of points will lead to measurement of more complex parts and the soft parts on other hand which can be easily deflected or deformed on touch can be easily measured with this reverse engineering technology in quick succession of time.3D Scanning being exponentially fast in collecting measurements as compared to contact-based measurements and hence can be used for parts that take much measurement time. The digital data recorded during the scanning can be used anytime for measuring the object itself for analysis and documentation. This is done for applications like Computer Aided Inspection (CAI), digital archiving and Computer –aided engineering analysis (CAE)3D scanning can drive value throughout almost in all the fields ranging from Biomechanics in medical industry, Aerodynamics in space sector to the Automation sector which is tremendously making a great difference by expanding, analyzing, and generating replicable results. All the applications of 3D Scanning requires precision and accuracy at micrometer scale. [9-11]

Several of those applications for 3D scanning require precision and accuracy at micrometer scale3D scanning is also used in customized manufacturing which enables nearly infinite variations on basic design of existing consumer products for instance the customization extends to capturing human body for individualized medical equipment and for fit-to-body design.

The portable 3D laser scanning technology id fueling the movement from the laboratories to front line of factories and fields due to below mentioned factors:

(1) Convenience and flexibility associated with huge rage of applications including all the aspects of product life cycle management (PLM)

(2) Simplicity and automation promote the use of technology beyond specialists into mainstream engineering.

(3) Lower costs, greateraccuracy, speed, and reliability also broadens the market.

**3D scanners**

Within industrial contexts, tools used for 3D scanning are generallytermed as 'metrology tools' but are more casually referred to as 3D scanner.[12]3D scanners are the tri-dimensional measurement device used in bridging the physical and digital worlds simply by capturing the real-world object so that they can be remodeled or analyzed in digital world. These can be used to obtain complete or partial 3d measurement of any physical object. Most of such devices either generate points or measure extremely high density when compared to the conventional "point-by point" measurement devices.3D Scanners are therefore supporting technology that offers high level flexibility to create designs for ergonomic tooling, rapidprototyping, and biocompatible surgical guides.[13]. Generally, a wide variety of scanners use either led -based projectors or lasers as illumination source, led projectors on contrary provide more uniform illumination and sharper edges, however due to size and cost constraints, a class of non-contact scanners that uses laser a light source for projection pattern on geometry is widely used. [14-15]

**Objectives of 3D Laser Scanning Technology**

The scanners are used to scan an object usually for the purposes.

(1) For the extraction of dimensions to reconstruct a CAD file either for reverse engineering or rapid prototyping,

(2) Scanners are also used for the measurements of object for analysis and documentation.

The figure 2 clearly illustrates the need of 3D laser scanning for the use of reverse engineering and part inspection.

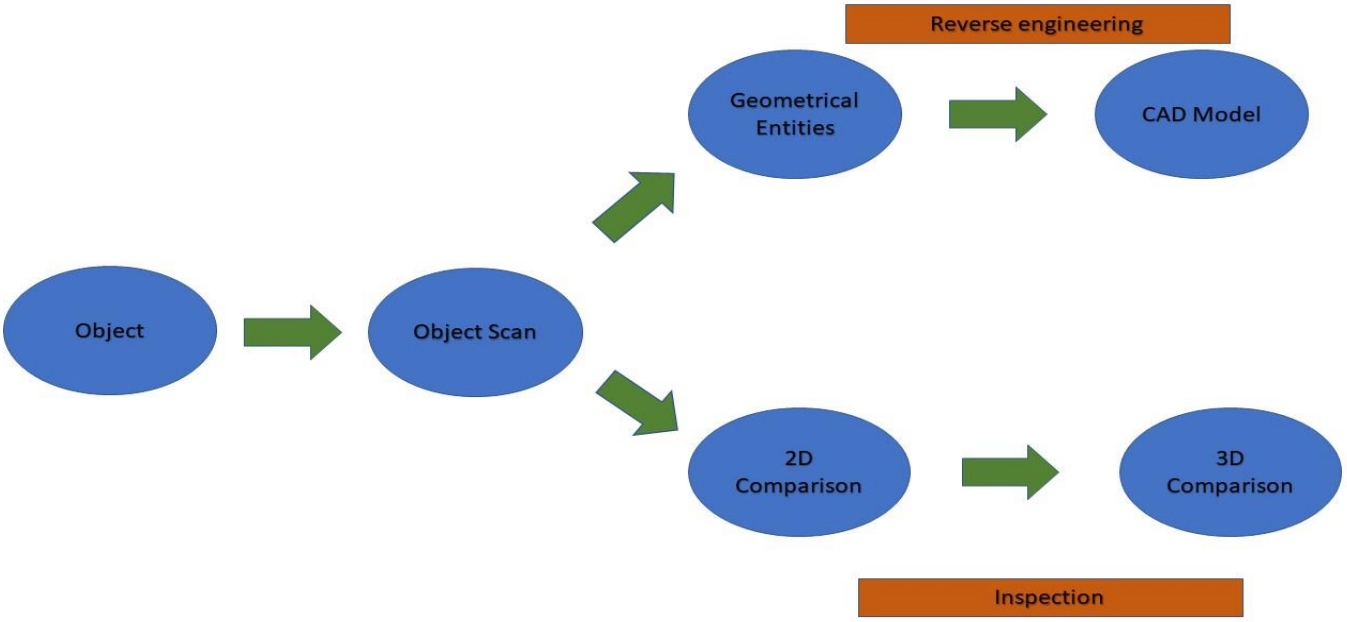


**Fig 2- Role of 3D Scanning**

## Research Methodology:

### Steps involved in 3D Laser Scanning process

The problem of 3D Scanning of any object is multistep complex process from beginning to the end which can be broken down into steps as shown in figure 2.[16]

(1) **Data Acquisition**

It includes capturing of depth data from all around an object and performing the necessary operations for preparation of the captured data for storage.

(2) **Storage**

This stage predominately determines how the data can be stored and deals with retrieval and manipulation of data by proceeding stages.

(3) **Registration**

This stage intends to align the overlapping data acquired and stored on top of each other for formation of final shape of the object.

(4) **Post -Processing**

As the depth data collected from sensor consists a considerable amount of noise coming from large uncertainty around the voxels, some techniques are implemented to reduce the noise and remove fluctuations around the surfaces.

(5) **Results**

The stage consists of providing visual as well as binary form of generated and processed model for further processing and use to the user.

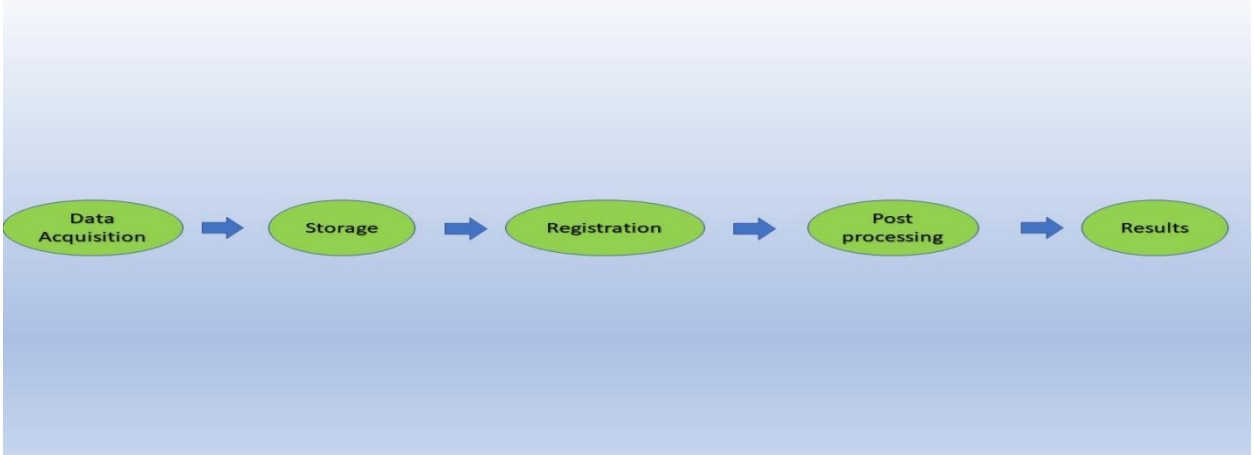


**Fig3-3D object scanning process steps**

Scanning results are represented by using free form, unstructured 3D data, generally in form of a point cloud or triangle while certain type of scanners also acquire the respectivecolor information for applications wherever required. These scans are brought together into a common reference system to merge the data into a complete model. Computer software are used for cleaning the scan data, filling of holes, correction of errors and improving data quality. The resulting triangle mesh is either exported as STL(Stereolithography) file or converted to Non uniform Rational B-spline (NURBS) for CAD modelling. (17)

**Accelerating the Product Lifecycle Management (PLM) process**

3D scanning is used in almost every aspect of product lifecycle management process ranging from Concept,design,Manufacturing to servicing and industries are benefited from faster time to market, enhancedquality, decreased cost associated with warehousing and better understanding of product performance.[18]

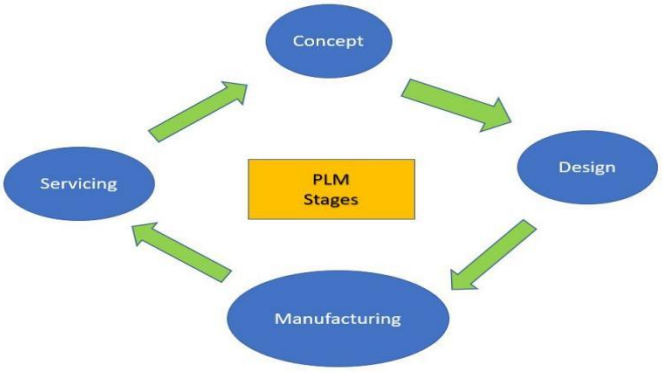


**Fig4: Different stages of PLM**

## 3D Scanning in PLM: concept

It is used in concept stage of PLM for a wide variety of processes that involves determination of requirements and specifications, concept design (including reverse engineering) and concept prototyping's detailed 3D scans and models permits user to accurately design and integrate the product and provides an imaginary visualization of the design before final approval and production.

| Requirements & Specifications | Concept design | Concept prototyping |
|---|---|---|
| 1. Competitive analysis of product | 1. Reverse Engineering | 1. Ergonomic prototypes |
| 2.Measurement of product environment or connected parts | 2. Model measurement | 2.Integration of prototype modifications into CAD file |
| 3.Measurement of existing parts | 3.Styling and aesthetics | 3.Form study, proof of concept prototypes |

**Fig5: Role of 3D Scanning in concept stage**

## 3D Scanning in PLM: Design

3D laser scanning is used at the design stage of PLM for various purposes such as computer aided design (CAD), rapid prototyping and for testing, simulation& analysis applications like Computational Fluid Dynamics(CFD), Finite Element Analysis (FEA)3D scanning makes it possible to rapidly obtain the accurate 3D images of the assembly and all other existing parts which eliminates the laborious time invested in CAD drawings and have an efficient return on investment (ROI).

| CAD Design | Prototyping | Testing ,simulation & analysis |
|---|---|---|
| 1. 3D scan to CAD | 1. Rapid Prototyping/Manufacturing | 1. Finite Element Analysis(FEA) |
| 2.Packaging design | 2. Integration of prototype modifications into CAD file | 2.Interference analysis |
| 3. Extracting design –intent (Reverse Engineering) | 3. Prototype Inspection | 3. Deformation,geometry analysis |

**Fig6-Role of 3D Scanning in Design stage of PLM**

## 3D Scanning in PLM: Manufacturing

3D scanning at this stage primarily deals with the manufacturing operations such as tooling design, assembly, production, and quality control. The quick set up and acquisition, easy to operate, measurement performance for several surfaces and portability of the Scanner enables to scan the manufacturing parts and record the accurate measurement.

| Tooling Design | Prototyping | Quality Control |
|---|---|---|
| 1. Tooling validation and inspection | 1. Virtual assembly | 1. First Article Inspection(FAI) |
| 2.Updating CAD files to reflect as built tooling measurements | 2. Tool/Robot path programming | 2.Part to CAD inspection |
| 3. Reverse engineering of dies ,molds,jigs and fixtures | 3. Part assessment before machining | 3. Supplier quality inspection |

**Fig7: Role of 3D Scanning in manufacturing stage of PLM**

## 3D Scanning in PLM: Servicing

3D Scanning is also used at the service stage of PLM for various applications including documentation, maintenance repair and overhaul, and replacement, recycling band restoration of the parts

| Documentation | Maintenance, Repair and Overhaul(MRO) | Replacement/Recycling |
|---|---|---|
| 1. Digital archiving | 1. Wear and tear analysis | 1.Reverse engineering for developing replacement/restpration parts |
| 2.Marketing presentations,3D training systems | 2. Custom repairs,modifications | 2.Planning complex assemblies |
| 3. As -built documentation of parts/tooling | 3. . As -built documentation of parts/tooling before maintenance | 3. Dismantling of parts planning |

**Fig8: Role of 3D Scanning in Service stage of PLM**

## Conclusion

3D Scanners have become a complementary scanning tool with other scanning technologies being used in product life cycle management. Researchers& technologists can take advantage of improving the existing applications of product life cycle integrated with 3D scanning. This paper analyses the requirements of 3D scanning in manufacturing applications and this technology has made a significant impact on the product lifecycle of any product. Parts or products which are scanned by this technology can have improved quality of pre-operative planning &diagnosis with enhanced team communication and enables researcher to contribute to development of tooling design, rapidprototyping, and inspection of the parts. It also helps in solving the problems arises in manufacturing equipment such as jigs &fixtures, clamps,die manufacturing.3D scanning technologies design diverse range of manufacturing equipment and tools according to the requirement with high level of precision. Effective utilization of 3D scanners however can be taken into consideration in the complex cases, where need of customized parts with effective quality control is required. Hence there is extensive scope for research & development.

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