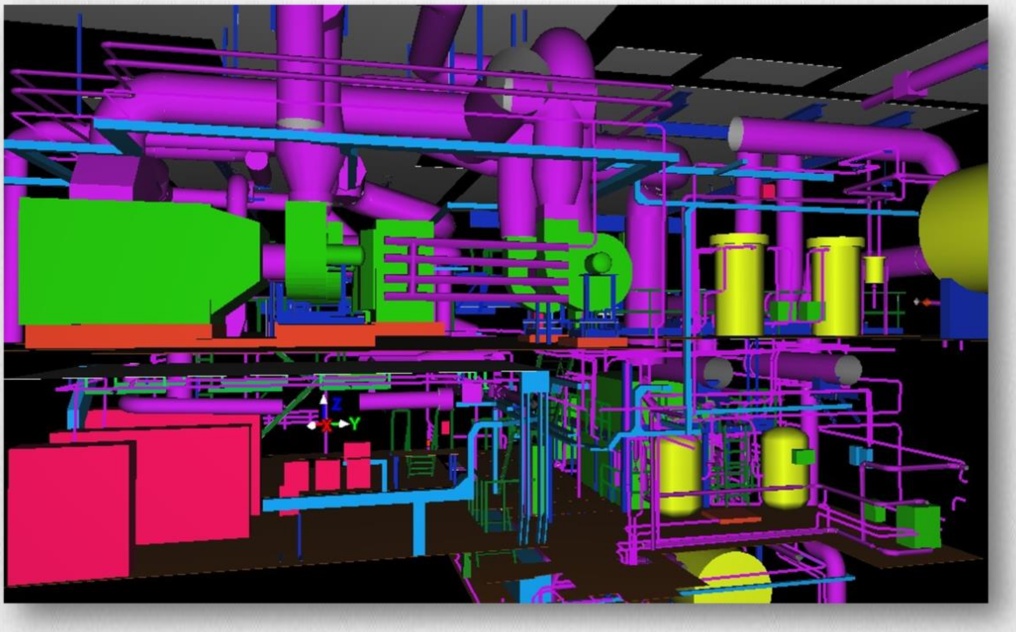
Nuclear 3D Scanning



Section One	Lesson Plan
Section Two	Module PPT
Section Three	Pre Assessment Test Pre Assessment Answer Key

RCNET
Regional Center for Nuclear Education & Training

RCNET Nuclear 3D Scanning Module

Topic

This module is an introduction to 3D scanning and its applications in the nuclear industry.

Module Introduction / Brief Lesson Description

This module will explain what 3D scanning is, how and where it can be applied in the nuclear classroom, the implications for nuclear technicians, and the future uses of 3D scanning in the industry.

Learning Objectives / Outcomes

Upon completion of this module, students will be able to:

1 Describe the basics components of a 3D scanner.
2 Identify the types of 3D scanning technology most often used in the nuclear industry.
3 Discuss the applications and limitations of 3D scanning as they pertain to the nuclear industry.
4 Identify and discuss the different types of software, inputs and outputs used for 3D scanning.
5 Recognize and discuss opportunities where 3D Scanning technologies would be applicable in a nuclear environment.

Procedure for Using the RCNET Module

This module was designed to be taught over a period of six lecture hours, as outlined below. However, the teacher may modify this curriculum, as needed, to fit into specific program allowances.

Prior to Starting:		Review module material included in this packet
		Gather module materials, included and not included in this packet (see the **List of Materials** section)
		If providing hard copies of the PPT, print class set to hand out after the pre-assessment.
Day One, Hours 1-2:	1	Introduce topic. Ask questions to generate discussion. (See Lecture Notes, included with PPT, for specific questions.)
	2	Start student presentation. Introduce the topic, module introduction, learning objectives, and module agenda.
	3	STOP the PPT.
	4	Administer Pre-Assessment. Explain to students that this assessment is to gauge their pre-existing knowledge of n3D Scanning and will not count as a grade in the course.
	5	Collect pre-assessments for grading.
	6	Hand out pre-printed student slides.
	7	If time permits, continue module, using PPT and lecture notes
	8	End day one of module.
Day Two, Hours 3-4:	9	Briefly review topics discussed on previous day.
	10	Review results of pre-assessment. Tests can be handed back to students for discussion, but should be re-collected at the end of the discussion.
	11	Continue module, using PPT and lecture notes. Engage students in module by asking questions in lecture notes and allowing open discussion.

	12	Demonstrate Hands-On Activity (see **Hands on Activity** section for specific details)
	13	End day two of module.
Day Three, Hours 5-6:	14	Briefly review topics discussed on previous days.
	15	Continue module, using PPT and lecture notes. Engage students in module by asking questions in lecture notes and allowing open discussion.
	16	Review takeaways and learning objectives to prepare students for post assessment.
	17	Administer Post-Assessment. The post-assessment can be administered by any of the following methods: -- Same day with open books/notes -- Same day without books/notes -- Next day to allow students time to study on their own -- At a later day in the campus assessment center
	18	Collect post-assessment, grade with provided key and provide feedback to students.

List of Materials

List all of the materials that will be needed for this module.

Required:	RCNET Nuclear 3D Scanning PPT with Lecture Notes
	AV equipment with connection to a computer equipped with Microsoft PowerPoint
Optional:	Printed class set of RCNET Nuclear 3D Scanning PPT student handout (master included in this packet)
	Printed class set of Pre -Assessment (master included in this packet)
	Printed class set of Post -Assessment (master included in this packet)
	A mobile device with *Autodesk's 123D Catch* application installed. (Please note that 123D Catch requires a login. It is best to register ahead of time. The process is quick and free.)
	An object to scan that has some depth and smaller features. For the purposes of this module, we found a common cake topper with stands, which can be purchased at the following link: *http://amzn.com/B008RPYWCM*

Lesson Plan & Scope of Work

This is the actual lesson plan and includes all your fundamental theory, description of relevant concepts, procedures, implications, scope, & lesson delivery. This is the part of the lesson plan that the teacher will be using to teach from.

Introduction, Learning Objectives, & Module Topics

Slide 1	Introduce the overall topic of the module: 3D Scanning in a Nuclear Environment. -- What do you know about 3D scanning? -- Why do we need 3D models? -- What can we do with them? -- What do you know about reverse engineering? -- What do you know about 3D printing? -- Why are we talking about 3D scanning in a nuclear class?

Slide 2	Suggested ACADs and sample Program Courses where this module may fit into your nuclear program.
Slide 3	Learning Objectives Understand and describe the basics of 3D scanning Identify what the common uses of 3D scanning are in a nuclear environment. Learn how and why to embed this into technician training in a nuclear environment Be able to identify the common CAD file types and their applications Describe how we can visualize 3D data Understand the process of making a digital object physical PAUSE THE PPT AND ADMINISTER THE PRE-ASSESSMENT
Slide 4	This module is broken down into five sections: 1. The Basics of 3D Scanning 2. Digital Modeling VS Reverse Engineering 3. Visualizing 3D Data 4. 3D Data in the Nuclear World 5. From Digital Model to Physical Object
The Basics of 3D Scanning	
Slide 5	**The Basics of 3D Scanning** In this section we will cover the following topics: 1. What is 3D Scanning? 2. Laser Scanning vs Digitization 3. Why do need 3D Models? 4. The Drawbacks of 3D Scanning
Slide 6	3D Scanning is a non-destructive technology that digitally captures the shape of physical objects using a line of laser light or a surface contact roller. There are multiple ways to capture or import 3D data, but the two main methods used are laser scanning and digitizing.

Slide 7	3D scanning was developed decades ago but was road blocked by slow transmission speeds and small storage capacities. The first handheld 3D scanners were developed in the 80s, used inaccurate contact probes, and took weeks to complete a simple scan. The 1990s brought about huge increases in storage space and higher speed Internet transmission. By then, the optical technology had caught up, allowing for the scanning of fragile objects and for color scans. With the advent of computers it was possible to build up a highly complex model, but the problem came with creating that model. Complex surfaces defied the tape measure. in the eighties the toolmaking industry developed a contact probe. this enabled a model to be created, however it was very slow. We needed a system that captured the same amount of data but at a much greater speed to be useful. Engineers began working on optical technology to bridge this gap. Three types of optical technology were available at the time; point, area, and stripe.
Slide 8	Optical point technology used a single point of reference and repeated it many times – it was the slowest form of scanning and involved lots of physical movement by the sensor. Optical area technology was technically difficult to configure and manage, and produced no more accurate results than optical point scanning. There’s a reason no optical area systems exist today. Optical stripe technology used a band consisting of many points to pass over the object at once. This proved to be the perfect mixture of speed and accuracy that the engineers were looking for. Stripe was clearly the way to go.
Slide 9	3D scanners create “point clouds” of data from the surface of an object. These point clouds are defined by X, Y, and Z coordinates and represent the external surface of an object. Point clouds are created by 3D scanning devices that measure a large number of points on the surface of an object. The output of the scan is a point cloud that is saved as a data file. The point cloud represents the set of points that the device has measured.
Slide 10	The process of 3D scanning breaks down into three basic steps. 1. First, you capture your 3D data. 3. Then we take that raw scan data and use it to digitally model or reverse engineer the object. 2. Finally, we send our model to third party applications to be used for archival, inspection, reproduction, or visualization.

Slide 11	During laser scanning, a laser line is passed over the surface of an object in order to record three-dimensional information. The surface data is captured by one or more camera sensors mounted in the laser scanner which records dense 3D points in space, allowing for very accurate data without ever touching the object. Laser scanning is: -- The most accurate method for scanning organic shapes. Generally, it is used in higher volume scanning projects (i.e. vehicles, large machinery, and buildings) -- Preferred for documentation of important artifacts or fragile components due to no-touch scanning
Slide 12	Laser scanning utilizes TOF technology. TOF technology is defined as: *Any number of methods that measure the time that it takes for an object, particle or acoustic, electromagnetic or other wave to travel a distance through a medium. In the case of 3D scanning, light travelling through air and bouncing off the object being scanned.* The simplest way to think about "time of flight" laser scanning is to approach it as nothing more than a laser range finder. A laser range finder measures a distance by shooting a laser beam out to an object and measuring how long it takes that laser beam to bounce back. By knowing the speed of light (laser beam) and measuring the time of travel of the laser beam, we can figure out the distance and depth of the object. As in surveying, in order to compute an x,y,z position, you need to know the distance to the object, the bearing (horizontal angle from a known line) to the object and the vertical angle (angle from gravity) to the object.
Slide 13	This slide features some common laser scanners that you will encounter out in the field. They include Portable CMM Arm-Based Scanning, 3D Laser Scanning Camera, Long-Range Laser Scanner, and Conventional CMM-Based Scanning. CMM stands for Coordinate Measuring Machine.
Slide 14	Digitizing is a contact based form of 3D data collection. It is done by touching a probe to various points on the surface of the object to record 3D information. Using a point or ball probe allows the user to collect individual 3D data points of an object in space rather than large swathes of points at a time, like laser scanning. This method of data collection is generally more accurate for defining the geometric form of an object rather than organic freeform shapes. About combining data sources: There are projects when it is more cost and time effective to use multiple methods of data collection. A good example is a cast part with geometric machined features. You might need a 3D model of the entire part and also need incredible accuracy on the machined features while the freeform cast surface itself is not as important. In such a case, it can be much more effective to laser scan the entire part and then digitize the geometric features.
Slide 15	Some common digitizers in the field include Portable CMM Arm-Based Scanning, Portable Laser Tracker, and Conventional CMM-Based Scanning.

Slide 16	In this section, we will explore the importance of 3D models. We will find out why we need 3D models, how 3D data is processed, and learn more about the two common applications of 3D scanning: Digital Modeling and Reverse Engineering. With proper training and preparations, 3D scanning can provide a significant advantage over traditional means to do design planning, documentation, and prototyping in a nuclear environment. A 3D model is a digital representation of a physical object. Physical objects can be captured and transformed into 3D digital models via 3D scanning equipment. This is done by processing the raw data the 3D scanner captures. 3D models are mostly used for quality control, failure analysis, animations, renderings, dimensional object analysis, reverse engineering, archival, restoration, and scaling of objects.
Slide 17	Point clouds can have full color image overlays, allowing precise optimization of work areas and machinery. The raw scan data can be mixed with real world imagery to give a more accurate depiction of systems and machinery. By combining both data sources, engineers and inspectors gain an in-depth understanding of their work areas.
Slide 18	Is there anything 3D scanning can't do? 3D scanning operates on line of sight for laser scanning and touch for digitization Holes or small internal features are typically not immediately discernable Commercial units are expensive and limited to servicing by a few private companies Because we are always trying to capture the most accurate data possible, there are a few other things to keep in mind. Bright light sources can severely alter the scan data. It is suggested to scan all outdoor objects at night if possible. Very reflective materials generally do not scan well. If you have an object with a high reflectivity, it is suggested to use some form of powder spray, such as athlete’s foot spray, to cover the object prior to scanning. Whether you are laser scanning or digitizing, it is important that your scan object will not move while you are collecting data. The tiniest shift will greatly alter scan data. Most professional setups will including a computerized rotational platform to place the object upon.
Slide 19	Now that we know how to capture 3D data and its importance, let’s explore what we can do with the data we have collected.
Slide 20	3D scanning is a faster, more distributable, and more affordable choice for design planning, parts inspection, and prototyping than traditional methods. We can measure 3D data via laser scanning or digitization.
Digital Modeling VS Reverse Engineering	

Slide 21	Digital Modeling Vs. Reverse Engineering What is Digital Modeling? Benefits of Digital Modeling What is Reverse Engineering? Benefits of Reverse Engineering To create a Digital Model or Reverse Engineer Design Intent & As-Built
Slide 22	Digital Modeling vs Reverse Engineering: The processing of collected data is divided into two main categories: digital modeling, and reverse engineering. These are generally based on shape and desired file output. Digital Modeling is the process of creating a computer model of an object that exactly replicates the form of the object. 3D scanners are used to capture the 3D data of the object, and this data is transferred to the computer where it is aligned, edited and finalized as a complete 3D model. Reverse engineering broadly refers to analyzing and dissecting something with the goal of recreating it. In 3D scanning, reverse engineering typically means the process of measuring an object using a 3D scanner and then creating CAD data that reflects its original design intent.
Slide 23	Digital modeling is the process of creating a computer model of an object using a 3D laser scanner that exactly replicates the form of the object.
Slide 24	When discussing Digital Modeling it is important to know the types of models that are available, and what each one is best used for. A Polygonal Model is a faceted (or tessellated) model consisting of many triangles. Facets are formed by connecting points within the point cloud. These models lack definition and are typically only used for capture verification and initial inspection. Polygonal models are mostly used for visualization, rapid prototyping, design, milling, and analysis software.
Slide 25	NURBS stands for Non-uniform rational Basis spline. A Rapid NURBS 'Dumb' Solid starts with the polygonal model. NURBS surfaces are wrapped over the polygonal wire frame. This wrapped surface model is smoother than a polygonal model. The NURBS model can be brought into parametric modelers such as SolidWorks (it is called "dumb" because it has no parametric history).
Slide 26	A Hybrid model is a polygonal model that has been converted in a rapid NURBS surface model and then also uses traditional solid modeling techniques. It is commonly used when basic geometric features, such as holes & edges, blend with complex organic contours, such as a machined casting. The bridge between Digital Modeling and Reverse Engineering is the Hybrid Model.

Slide 27

There can be a fine line between Digital Modeling and Reverse Engineering and sometimes both methods can be a valid solution to 3D problems.

Some advantages of Digital Modeling are:
--Faster and more cost effective than Reverse Engineering
--A great solution for creating solid models when an object has organic contours.
--Offers excellent dimensional accuracy and can be utilized for comparative analysis.
--Unlike raw point clouds, digital models can be visualized in rendering software as a solid object, which is great for seeing the overall shape and contour of the model.

Slide 28

Reverse Engineering is the process of measuring a part or object and then creating a CAD model of the part/object that reflects how it was to be designed originally.

The reverse engineering process needs hardware and software that work together. The hardware is used to measure an object, and the software reconstructs it as a 3D model. The physical object can be further measured using 3D scanning technologies like a coordinate measuring machine, structured light digitizer, or computed tomography.

Slide 29

Some of the benefits of Reverse Engineering are:

--Can be brought into Parametric Modeling Packages (solid modeling CAD software). Other than NURBS ‘dumb’ solids, reverse engineered models contain geometric features such as planes and radii making the models a better fit for designing and measuring.
--Reverse engineered models are great for analysis software such as for CFD and FEA.

The importance of Parametric Models is that they have a feature tree that is editable.

CFD – computational fluid dynamics - a branch of fluid mechanics that uses numerical analysis and algorithms to solve and analyze problems that involve fluid flows.
FEA – Finite element analysis - computerized method for predicting how a product reacts to real-world forces, vibration, heat, fluid flow, and other physical effects.

Slide 30

When does a project fall into the category of Reverse Engineering as opposed to Digital Modeling?

Why should I opt for Reverse Engineering when it sounds more time consuming and requires additional processing, and therefore is more expensive?

The answer generally depends on several factors including: shape (organic vs. geometric) and desired file output. If you want to make a Rapid Prototype of a hand-carved chair then going the digital modeling route is probably a fine option for you. If you want to scan a turbine to create an accurate model for CFD analysis, need a model of an impeller for flow analysis, or require a model of an engine casing for a redesign then you’ll probably want to spend the time and effort creating a fully reversed engineered model.

People that choose Digital Modeling generally will use the file for Rapid Prototyping or visualization purposes. When you need more than that, either for redesign purposes or for importing models into analysis programs, you generally choose to Reverse Engineer, which means bringing your files into parametric modeling software.

Slide 31	When choosing to reverse engineer a part, it is important to decide if the part should be reverse engineered as-built (or as-scanned, in its current state) or engineered with its design intent. Often the actual physical production parts are off just fractions of millimeters or sometimes the parts have worn down a bit from the original fabrication. Design Intent is the intended design of an as-built physical object. Every manufactured part or object varies from its original intended design by some factor. These imperfections can be identified, analyzed, and corrected during the reverse engineering process. As-built is modeling to captures the exact physical shape of an object as it actually is, including its imperfections.
Slide 32	Once the data has been captured, and the object has been modeled or reverse engineered; what happens with the 3D model?
Slide 33	Digital modeling is faster and more cost effective than reverse engineering. Reverse engineering models contain parametric values (features trees). Shape and desired file output dictate whether you want to digitally model something, or reverse engineer it. Design intent is the initial intended design of an object, as-built is how the object exists after production.
Visualizing 3D Data	
Slide 34	This next section focuses on Visualizing 3D data. In this section we will find out what types of things we can do with 3D models, and what types of files are most common. We will also utilize a mobile application to capture our own 3D data. What can we do with 3D models? Class activity The many flavors of CAD
Slide 35	Beyond converting 3d models to systems renderings, we can utilize these models during the Quality Assurance/Quality Control process, find damage caused by the manufacturing process, and test prototypes without the expense of producing physical examples of each variant.
Slide 36	3D scanning is very beneficial to QAQC technicians, as it enables you to: Verify the compliance of final manufactured and assembled products through sample check inspection using automated techniques. Monitor the production cycle by automatically measuring the wear of tools and quickly detecting any abrupt degradation in product quality. Use high-density point clouds and contact-probe datasets of digitized prototype parts & assemblies to quickly identify deformations and to fix problems in the early stage of the manufacturing process.
Slide 37	3D models are crucial to digitally repair damage to an object so that it can be reproduced in its proper form using rapid prototyping and milling technologies.
Slide 38	3D models can also be used to make and test changes to a product without the need and expense of producing a physical good with each variant.

Slide 39	Digitally fabricated objects are created with a variety of CAD software packages, using both 2D vector drawings, and 3D modeling. Types of 3D models include wireframe, solid, surface and mesh.
Slide 40	This is a depiction of a detailed scan of a plant. The ability to manipulate the models on all axis, as well as being able to color map specific systems, gives engineers and technicians a unique perspective into their plant operations.
Slide 41	3D data can also be converted to fully illustrated models used during design planning and marketing projects.
Slide 42	Stop the PowerPoint and ask students to get out their mobile devices and visit the displayed links to install 123D Catch by Autodesk. It is available in both the Android and iOS marketplaces for free. Due to the cloud-based nature of this application, students will need to create a login with Autodesk to process their data. Have the student set the object to be scanned on a flat surface. Make sure the object can be scanned from all sides and angles. If necessary, and to ensure the object does not move, use double sided tape to secure the object to the flat surface. Have the student open up 123D Catch and click the '+' sign in the top right hand corner to begin a new scan. Begin capturing images. When done, or when 123D Catch alerts that it has enough data, upload and process your 3D data by clicking 'Finish'. It can take up to 3 minutes for your data to be modeled through the cloud.
Slide 43	The image above shows how many images and the different angles used to capture the chair within 123D Catch. Some key tips are: 8 to 20 photos per revolution is optimal When capturing complex objects, multiple angles should be used Don’t move the object, instead move around the object.
Slide 44	CAD, or Computer Aided Design, is a standard term defining a group of software that aides in design. It is typically used in manufacturing or other engineering disciplines.
Slide 45	Here we discuss some of the most common file types you will encounter when utilizing 3D scanning. --ASCII - an X,Y,Z point cloud file in ascii text format. --DWG - a native AutoCAD drawing file. --SLDPRT - a native CAD format for SolidWorks. --STL - Standard Tessellation Language. STL is a special internationally recognized file format that stores XYZ coordinate measurements and their normal. STL is the standard file format for rapid prototyping, and is used in reverse engineering.
Slide 46	The term ‘CAD’ is universal. For example: An engineer designs in SolidWorks, Pro-E, AutoCAD, Catia, or Unigraphics; all of which are Computer Aided Design or Computer Aided Engineering programs.
Slide 47	Neutral types of CAD are files that are widely supported by various proprietary software and are designed to share data more easily amongst companies and institutions.

Slide 48	IGES was created in 1979 by a group of users (including Boeing and GE) with support from the Department of Defense (DoD) and NIST. Since the late 80's the DoD has required that all Digital Project Manufacturing Data (PMI) be deliverable in IGES format.
Slide 49	By sending our completed 3D models to other applications, we can easily create multiple uses for the same data. The models can be used for archival, re-engineering, inspection, reproduction, and visualization.
Slide 50	3D models can be used for archival, re-engineering, inspection, and visualization. 'CAD' is a standard term defining a group of software that aides in design. The IGES file type is the only acceptable format for DoD/NIST brownfield projects.
3D Data in the Nuclear World	
Slide 51	3D data to the Nuclear World What are the advantages of 3D scanning in a Nuclear environment? 3D Scanning to the rescue!
Slide 52	Design planning in Nuclear Power Plants is long term and driven by certification and design reviews. The average Nuclear plant design planning is done based on a period of 30 years. Requirements for nuclear safety are intended to ensure the highest level of safety that can reasonably be achieved for the protection of workers, the public and the environment from harmful effects of ionizing radiation arising from nuclear power plants and other nuclear facilities. It is recognized that technology and scientific knowledge advance, and that nuclear safety and the adequacy of protection against radiation risks need to be considered in the context of the present state of knowledge. Safety requirements will change over time. The design of new nuclear power plants now explicitly includes the consideration of severe accident scenarios and strategies for their management.
Slide 53	Radiation exposure is deadly, nuclear plants must practice ALARA. A.L.A.R.A. – as low as reasonably achievable. The NRC breaks nuclear safety down into three major points: (a) To control the radiation exposure of people and the release of radioactive material to the environment during operational states; (b) To restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source, spent nuclear fuel, radioactive waste or any other source of radiation at a nuclear power plant; (c) To mitigate the consequences of such events, were they to occur.
Slide 54	Chart showing the NRC's radiation dose limits. Describe the doses and limits from the chart. Ask questions such as : "What is your biggest exposure factor?", "How does your plant deal with exposure during downtime and refueling periods?"

Slide 55	Nuclear power plants are a restrictive access environment. Most maintenance can only be performed during a planned shutdown. Infrequent maintenance windows are typical (usually just once per 18 months). Requires employees to work a very tight schedule for all planned maintenance. Refueling periods during the outage restrict access and movement within the containment area.
Slide 56	3D Scanning tremendously reduces exposure time when gathering design data. It also reduces the number of personnel who need to access the radiation or contaminated areas. Documentation is accurate and can be reviewed long after the plant is back in operation. Can be used for historical data for 'as-built' configurations. Data can be shared amongst departments to ensure maximum collaboration.
Slide 57	Laser scanning has reduced total installed cost for brownfield projects by 5-7% and has reduced contingencies for rework to less than 2% compared to traditional survey methods. Plant operators report that the speed of laser scanning allows them to attain the needed measurements inside containment structures and other areas within tight shutdown or 'outage' schedules-often times up to 10% less time than traditional methods. These results are remarkable not only for the magnitude but for their consistency across a wide variety of projects. Achievement of these cost savings sometimes requires higher initial investment in 3D data capture solutions than traditional methods (total station, piano wire, spirit level, plumb bob and tape measure). Schedule compression of as much as 10% has been reported when 3D laser scanning has been deployed. Such savings dwarf the cost of data capture and modeling in applications such as nuclear power generation where outage time costs $1 million/day and offshore platform revamp production values can exceed $500,000 per day.
Slide 58	Real world examples of 3D scanning in the nuclear industry: Rostov nuclear power plant needed a platform to fit one of its turbines. The team had to complete the scan within a 4 hour window, in heat in excess of 100 degrees Fahrenheit, and in an access controlled area. The area was also designated FME and they had to use caution because of fall hazards. The team was able to use 3D scanning to complete the project within the specified timeline.
Slide 59	Real world examples of 3D scanning in the nuclear industry: Sellafield is in the process of cleaning up its 60-year-old Pile Fuel Storage Pond (PFSP). To transfer the radioactive sludge from the pond to a waste encapsulation plant, the company was implementing a 40 ton stainless steel Solid Waste Export Flask; however, Sellafield will need to create a new lid for the existing container. Utilizing 3D blue-LED scanning, the team was able to create a model of the lid more quickly and affordably than by other methods.

Slide 60	Real world examples of 3D scanning in the nuclear industry: In 2011, at the Fukushima Daiichi power plant, reactors 1 through 3 experienced full meltdown followed by a series of hydrogen-air chemical explosions. During the early days of the accident, workers had to be evacuated for radiation safety reasons, leading to unfinished work and much misplaced information. Japanese officials classified the accident as a level 7, the highest scale value. TEPCO, the Tokyo Electric Power Company, recently dispatched a smartphone-carrying robot encased by a 3D printed shell, to capture images and data from the Unit 3 Reactor, which was destroyed during the Fukushima Nuclear Disaster in 2011. The resulting information is hoped to provide valuable insights into the state of the PCV hatch, which is unreachable by humans due to strong levels of radiation.
Slide 61	In short, using 3D scanning technology in a Nuclear environment is faster, more efficient, more accurate, and more reliable than traditional methods. It also provides data that is easily shared and manipulated.
Slide 62	3D scanning is a faster way to measure objects in a nuclear environment. It enables maximum efficiency during scheduled downtime and refueling periods. Utilizing 3D scanning reduces workers’ exposure time. The documentation from 3D scanning is highly accurate and very reliable. The data can be easily shared amongst departments, ensuring maximum collaboration.
From Digital Model to Physical Object	
Slide 63	From Digital Model to Physical Object Scaling Restoration Additive Manufacturing Milling What the future hold
Slide 64	3D models can be made into real products through the use of 3D printers, CNC milling, or additive manufacturing.
Slide 65	Entire systems can be reverse engineered on a part-by-part basis. This allows a much more in-depth understanding of the system and provides advanced problem solving and analysis applications.
Slide 66	3D models can also be scaled to enable a more micro or macro view of the system and allow for enlargements, reductions, or exact size replicas from the same data.
Slide 67	3D data can be used to replicate or restore damaged objects as well. By using 3D data within manufacturing, we can completely restore any object that has been damaged by weather, neglect, natural disasters, etc.
Slide 68	Manufacturing prototypes are when we create a physical prototype that can be used for testing or to manufacture final pieces from 3D data.

Slide 69	Additive Manufacturing There are a variety of additive manufacturing equipment manufacturers and processes on the market. The software within these machines generates the layering instructions and directs the deposition of successive layers of material needed to build up the physical part. Regardless of the type of AM, the various machines read the 3D data most typically in an STL file format. Essentially this part is created from cross sectional layers. The layers are fused together automatically and ultimately create the final shape, an exact physical replica of the 3D model.
Slide 70	In comparison with traditional subtractive manufacturing methods in which a block of finished material is machined down to make a product, additive manufacturing methods are fast, use less energy, and generate less waste material.
Slide 71	Most often used in the creation of metal production parts, tools, and molds for virtually any industry, an engineer, or even an artist, counts this as a well-tested valuable method. More advanced Computer Numerical Control (CNC) milling machines, like the various additive manufacturing machines, use a 3D CAD file to create a physical reproduction of the digital model. Unlike AM, CNC milling machines can utilize an extremely diverse range of materials including Metals, Stones, Woods Waxes, Plastics.
Slide 72	The future of 3D scanning is exciting. Let's look at some of the milestones of 3D Scanning: in 2015: Sub Millimeter scanning is perfected, bringing with it endless possibilities. In 2017: The US Army launches the Expeditionary Warrior program, providing 3D scanned and printed drones and equipment to deployed soldiers. in 2022: 3D scanning market hits peak, with more than 60% of all companies using the technology, creating a $15 billion industry. In 2029: The first mass produced 3D captured and printed vehicles are released for sale.
Slide 73	3D models can be made into real products through the use of 3D printers, CNC milling, or additive manufacturing. 3D printing and additive manufacturing use source materials more efficiently than CNC milling. Unlike A.M., CNC milling machines can utilize an extremely diverse range of materials including metals, stones, woods waxes, plastics.
Slide 74	Nuclear 3D Scanning Takeaways

Hands-On Activity

1	Stop the PowerPoint and ask students to get out their mobile devices and visit the displayed links (on slide 43) to install 123D Catch by Autodesk. (It is available in both the Android and iOS marketplaces for free; due to the cloud-based nature of this application, students will need to create an Autodesk login).
2	Have the student set the object to be scanned on a flat surface. Make sure the object can be scanned from all sides and angles. If necessary, and to ensure the object does not move, use double sided tape to secure the object to the flat surface.
3	Have the student open up 123D Catch and click the '+' sign in the top right hand corner to begin a new scan.

4 Begin capturing images. Use slide 43 for tips on photographing the object.

5 When done, or when 123D Catch alerts that it has enough data, upload and process your 3D data by clicking 'Finish'. (It can take up to 3 minutes for your data to be modeled through the cloud).

6 Use the students processes and outcomes to generate an opn discussion about the process of 3D scanning, the limitaitons of the App and how they may overcome them in-situ.

Takeaways

The Basics of 3D Scanning

3D scanning is a faster, more distributable, and more affordable choice for design planning's, parts inspection, and prototyping than traditional methods.

We can measure 3D data via laser scanning or digitization.

Digital Modeling VS Reverse Engineering

Raw point cloud data is processed into 3D models to allow for multiple downstream applications.

3D models can be used for digital modeling or reverse engineering.

Visualizing 3D Data

QA\QC technicians can use 3D scanning to greatly increase the efficiency of their analysis and inspection reports.

Autodesk's 123D Catch is a mobile application that you can use to test small scale 3D scanning in your current environment at no cost.

The DoD and NIST require all brownfield projects be output in the IGES format.

3D Data in the Nuclear World

3D laser scanning can reduce downtime costs by 5-7%.

From Digital Model to Physical Object

When 'printing' a 3D object, we can choose to make it a scaled object, a replica, a new prototype, or a restoration.

Both milling and additive manufacturing are methods used to develop a physical object from a 3D model. The big difference is that milling can use many more materials, including metals, woods, stones, and plastics.

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Assessments

Pre-Assessment (Answer Key Included)

Post-Assessment (Answer Key Included)

Supplemental & Enrichment Material

Student enrichment resources

The Future of manufacturing (a 3D scanning/printing primer) - *https://www.youtube.com/watch?v=IYTobOMuMEM -*

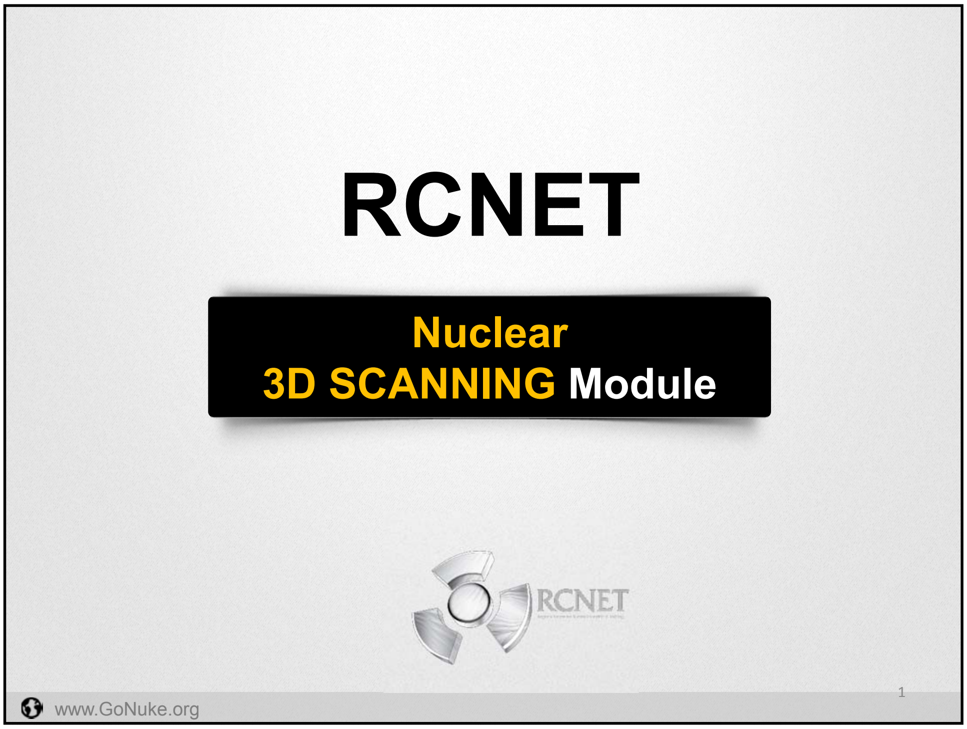
How metal 3D printing works - *https://www.youtube.com/watch?v=da5IsmZZ-tw*

3D Scanning Artifacts for Digital History - *https://www.lib.ncsu.edu/stories/3d-scanning-artifacts-digital-history*

Lynda.com course on Solidworks (membership required) - *https://www.lynda.com/SOLIDWORKS-tutorials/Learn-SOLIDWORKS-Basics/443026-2.html*

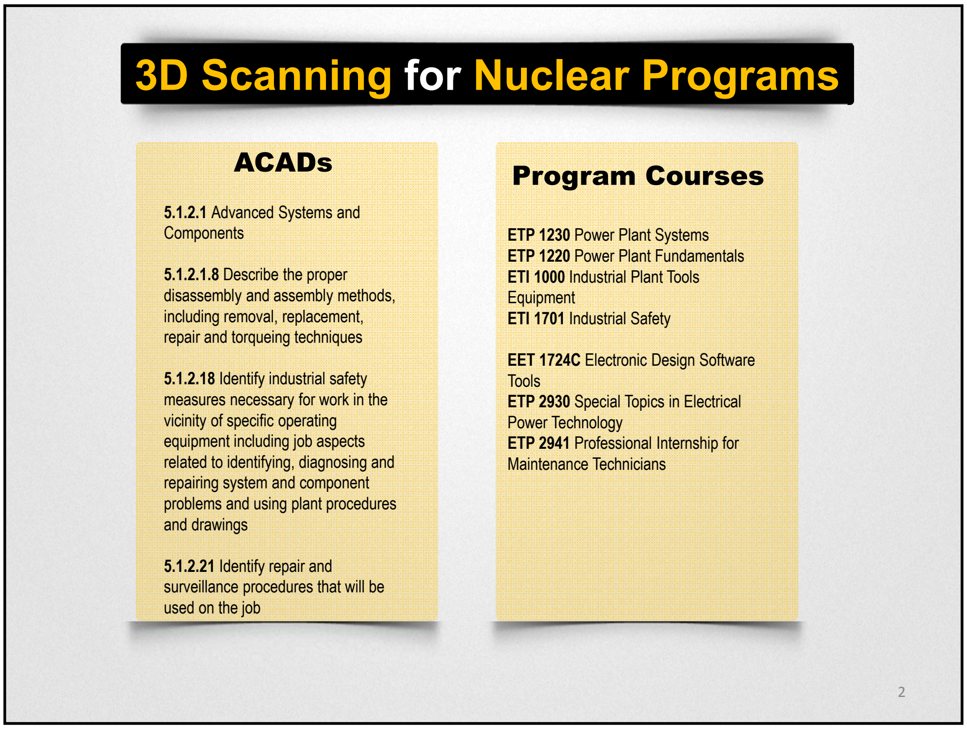
QA/QC Webinar - Conducting statistical analysis on a 3D scanned object- *https://www.youtube.com/watch?v=TC6gzIp8BII*

	tutorVista demo of a 3D nuclear reactor animation *https://www.youtube.com/watch?v=ueainTAy7G0*
	Teacher enrichment resources
	3d printing changing the way STEM students are taught *http://www.techrepublic.com/article/how-pitscos-3d-printing-curriculum-is-changing-the-way-stem-is-taught-in-the-classroom/*
	Full benchmark test of 3D scanning and 3D printing *https://www.youtube.com/watch?v=sZXlwxAe9co*
	Dremel's DREAMS program to bring 3D scanning and printing into classrooms - *https://3dprinter.dremel.com/3d-dreams*
	Information on the education partnership between MyStemKits and FSU, and the dramatic influence 3D scanning and printing has had - *https://3dprint.com/96094/mystemkits-partners-dremel/*
	Edutopia's article on how to understand and integrate advanced technological topics into your curriculum - *http://www.edutopia.org/discussion/i-dont-have-time-finish-my-curriculum-and-now-you-want-me-learn-what-3d-printing*



RCNET

Nuclear
3D SCANNING Module



3D Scanning for Nuclear Programs

ACADs

5.1.2.1 Advanced Systems and Components

5.1.2.1.8 Describe the proper disassembly and assembly methods, including removal, replacement, repair and torqueing techniques

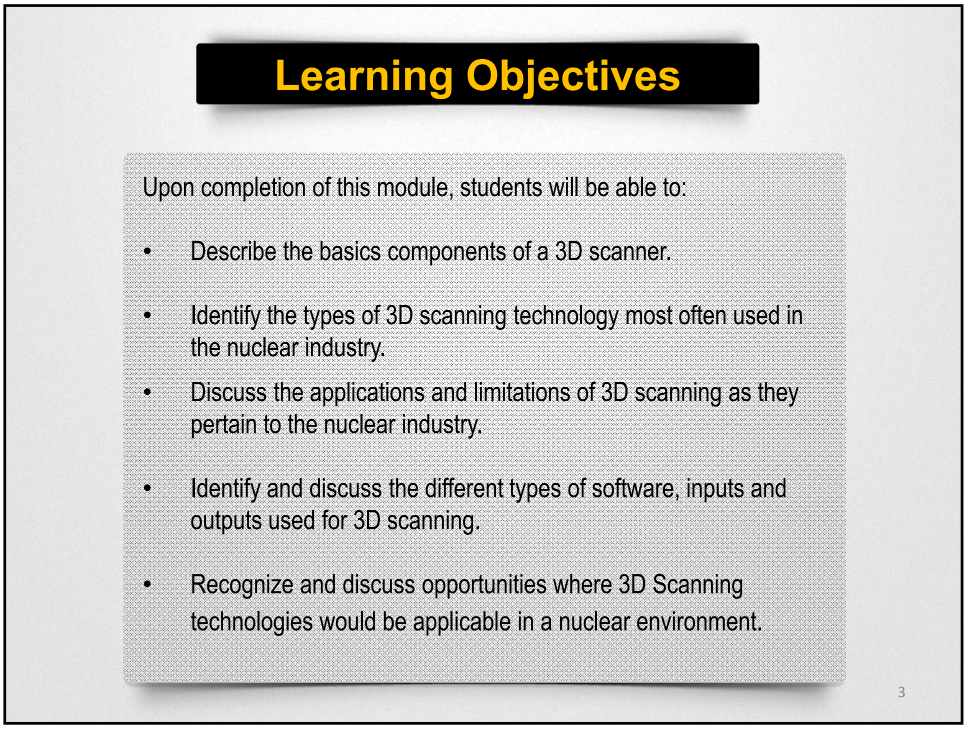
5.1.2.18 Identify industrial safety measures necessary for work in the vicinity of specific operating equipment including job aspects related to identifying, diagnosing and repairing system and component problems and using plant procedures and drawings

5.1.2.21 Identify repair and surveillance procedures that will be used on the job

Program Courses

ETP 1230 Power Plant Systems
ETP 1220 Power Plant Fundamentals
ETI 1000 Industrial Plant Tools Equipment
ETI 1701 Industrial Safety

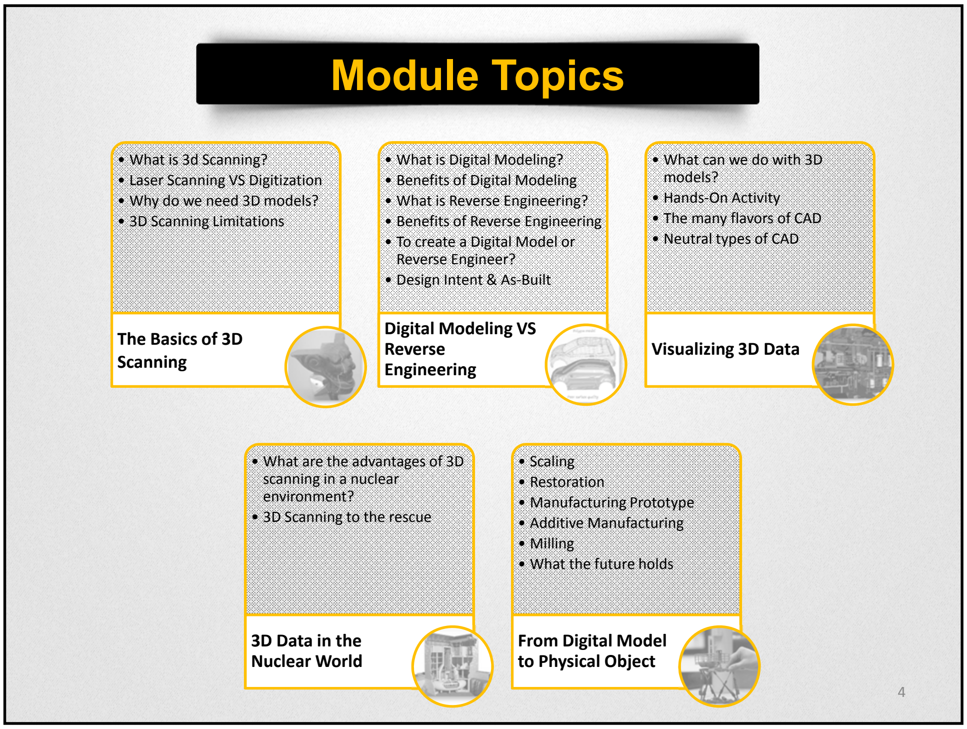
EET 1724C Electronic Design Software Tools
ETP 2930 Special Topics in Electrical Power Technology
ETP 2941 Professional Internship for Maintenance Technicians



Learning Objectives

Upon completion of this module, students will be able to:

- Describe the basics components of a 3D scanner.
- Identify the types of 3D scanning technology most often used in the nuclear industry.
- Discuss the applications and limitations of 3D scanning as they pertain to the nuclear industry.
- Identify and discuss the different types of software, inputs and outputs used for 3D scanning.
- Recognize and discuss opportunities where 3D Scanning technologies would be applicable in a nuclear environment.



Module Topics

The Basics of 3D Scanning

- What is 3d Scanning?
- Laser Scanning VS Digitization
- Why do we need 3D models?
- 3D Scanning Limitations

Digital Modeling VS Reverse Engineering

- What is Digital Modeling?
- Benefits of Digital Modeling
- What is Reverse Engineering?
- Benefits of Reverse Engineering
- To create a Digital Model or Reverse Engineer?
- Design Intent & As-Built

Visualizing 3D Data

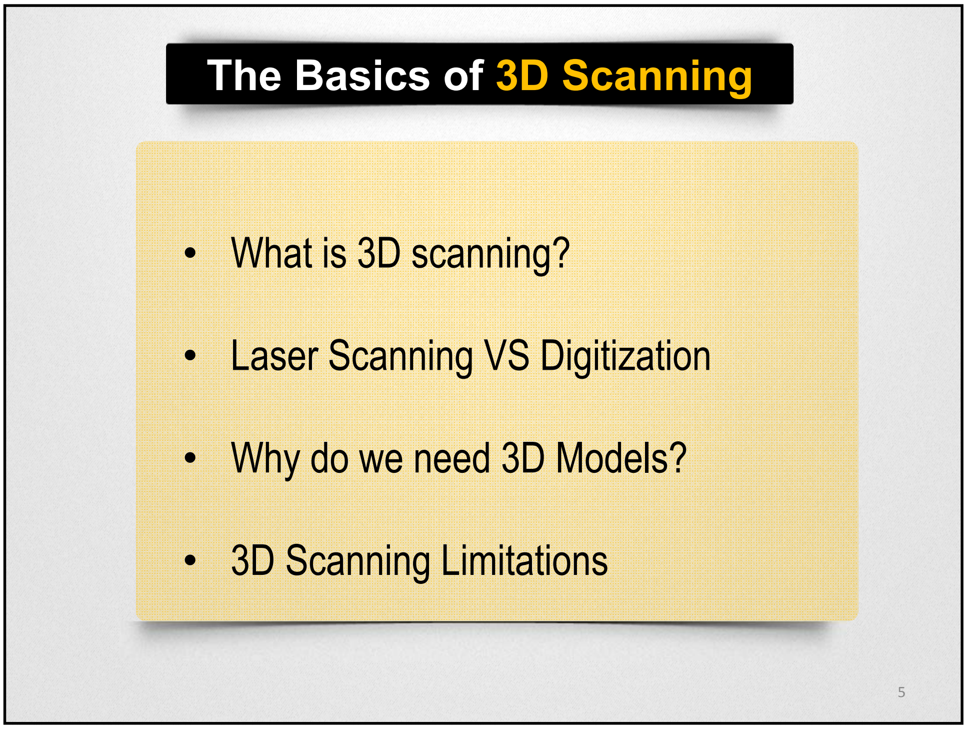
- What can we do with 3D models?
- Hands-On Activity
- The many flavors of CAD
- Neutral types of CAD

3D Data in the Nuclear World

- What are the advantages of 3D scanning in a nuclear environment?
- 3D Scanning to the rescue

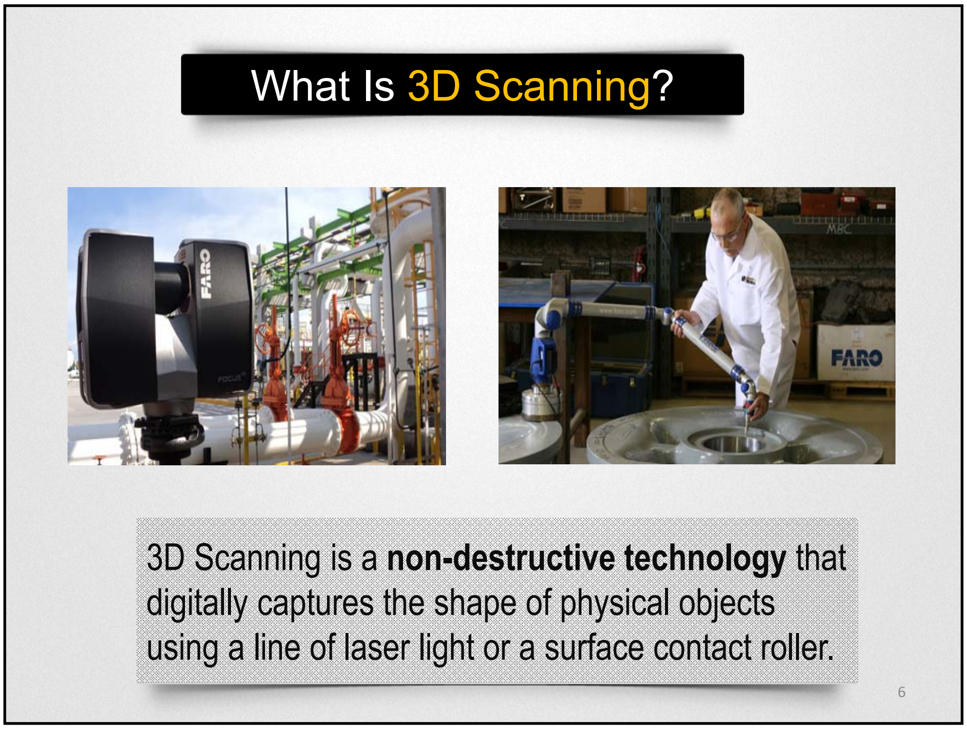
From Digital Model to Physical Object

- Scaling
- Restoration
- Manufacturing Prototype
- Additive Manufacturing
- Milling
- What the future holds



The Basics of 3D Scanning

- What is 3D scanning?
- Laser Scanning VS Digitization
- Why do we need 3D Models?
- 3D Scanning Limitations

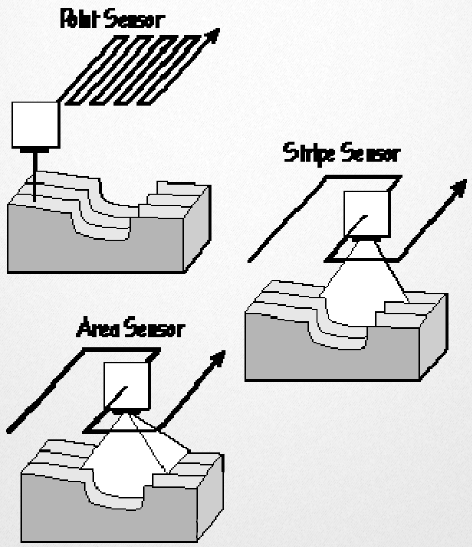


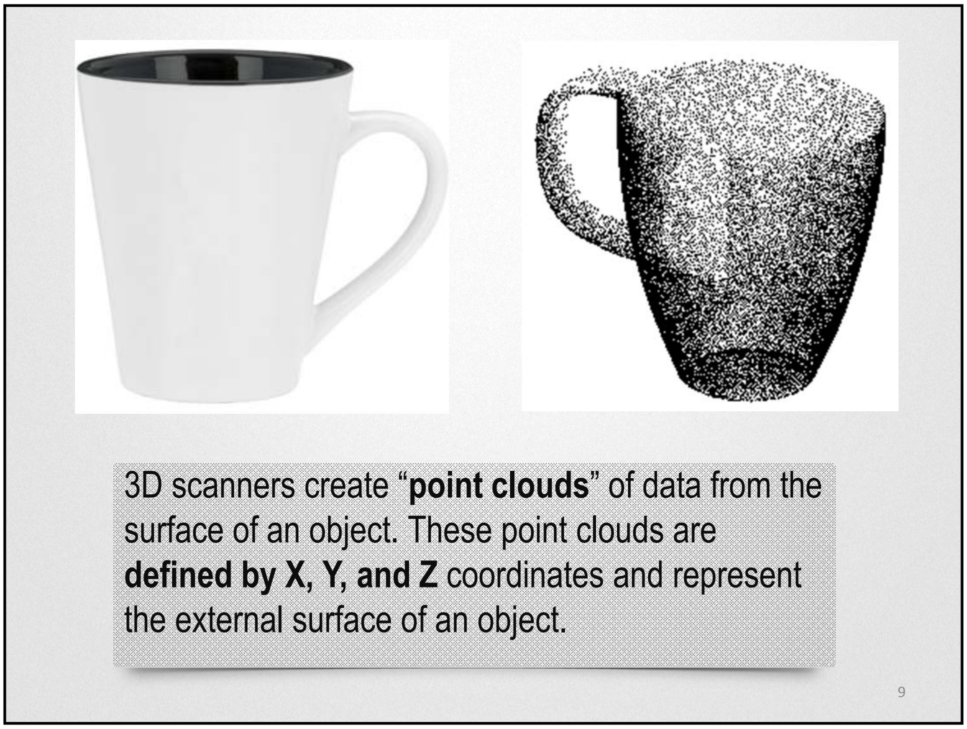
What Is 3D Scanning?

FARO
FOCUS
FARO

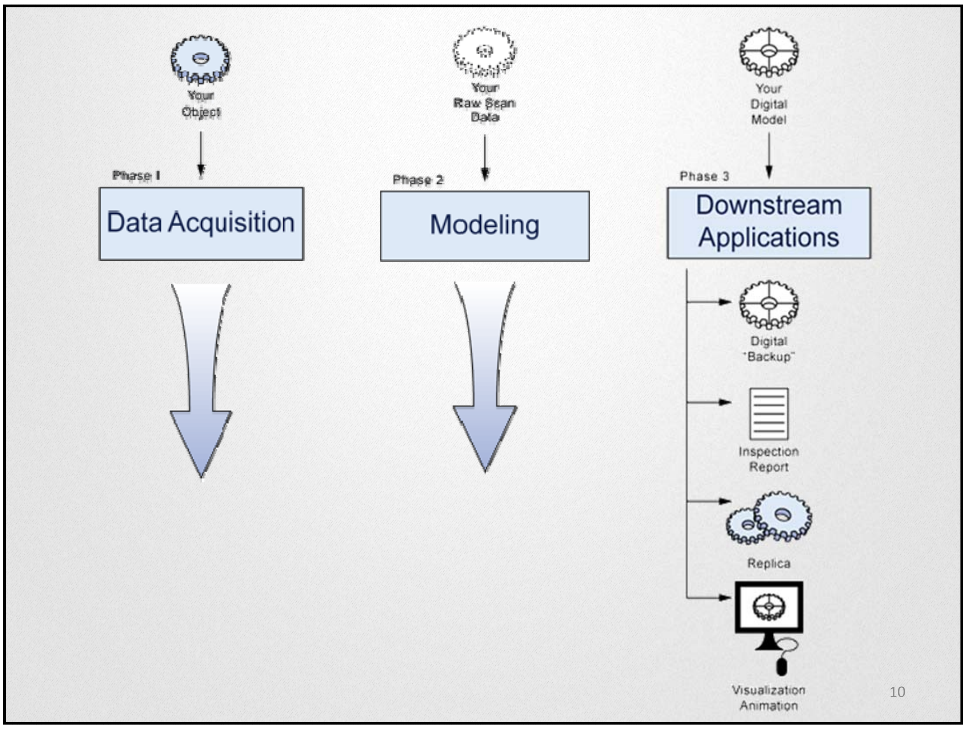
3D Scanning is a **non-destructive technology** that digitally captures the shape of physical objects using a line of laser light or a surface contact roller.

- 3D scanning was developed decades ago but was **road blocked by slow transmission speeds** and **small storage capacities**.
- The first handheld 3D scanners were developed in the 80s, used **inaccurate** contact probes, and took weeks to complete a simple scan.
- The 1990s brought about huge **increases in storage space** and **higher speed Internet transmission**. By then, the optical technology had caught up, allowing for the scanning of fragile objects and for color scans.





3D scanners create “**point clouds**” of data from the surface of an object. These point clouds are **defined by X, Y, and Z** coordinates and represent the external surface of an object.



Your Object

Phase I

Data Acquisition

Your Raw Scan Data

Phase 2

Modeling

Your Digital Model

Phase 3

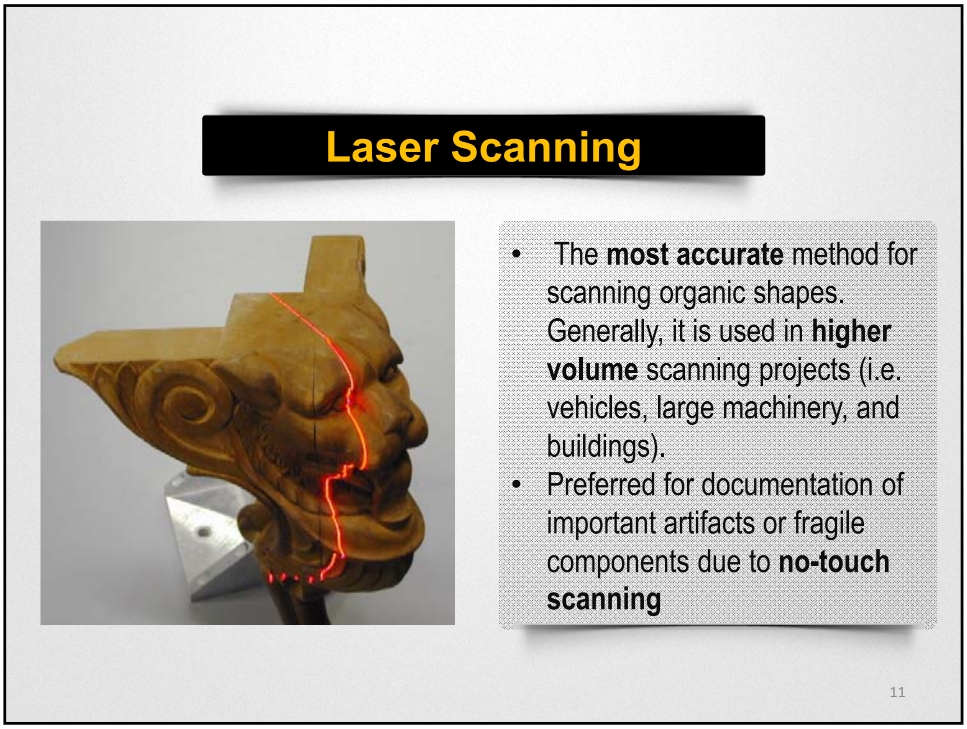
Downstream Applications

Digital "Backup"

Inspection Report

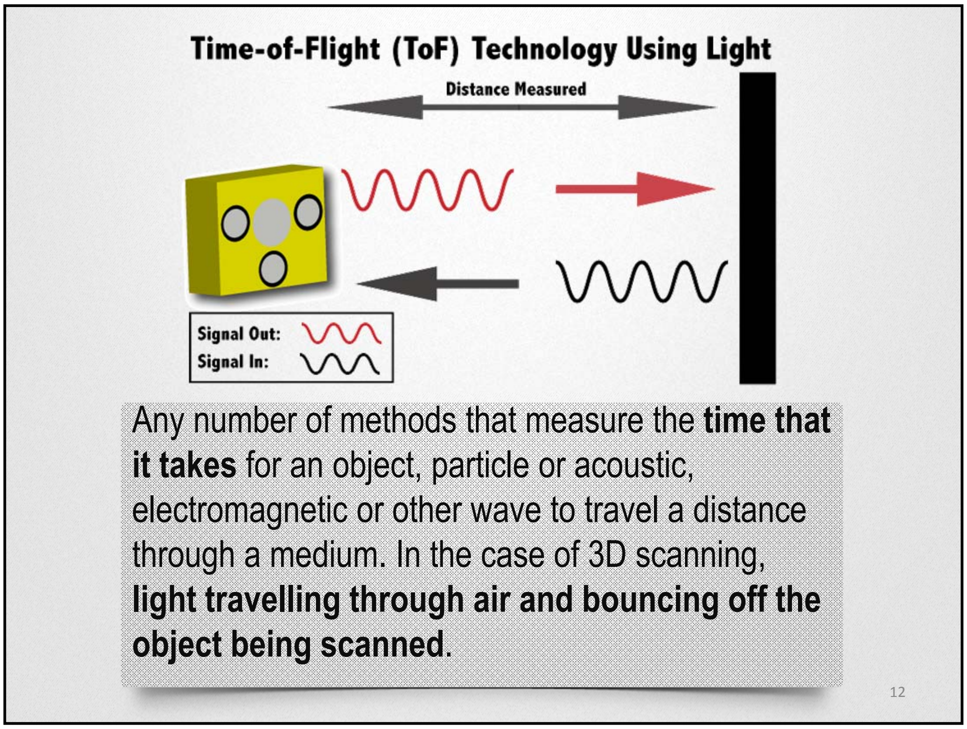
Replica

Visualization Animation



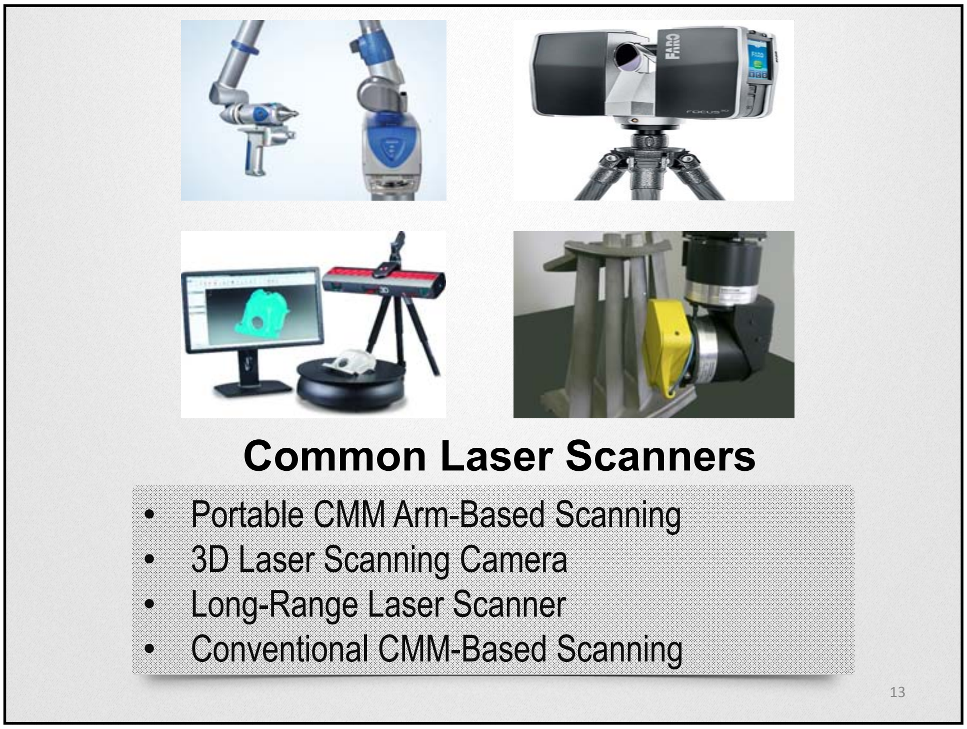
Laser Scanning

- The **most accurate** method for scanning organic shapes. Generally, it is used in **higher volume** scanning projects (i.e. vehicles, large machinery, and buildings).
- Preferred for documentation of important artifacts or fragile components due to **no-touch scanning**



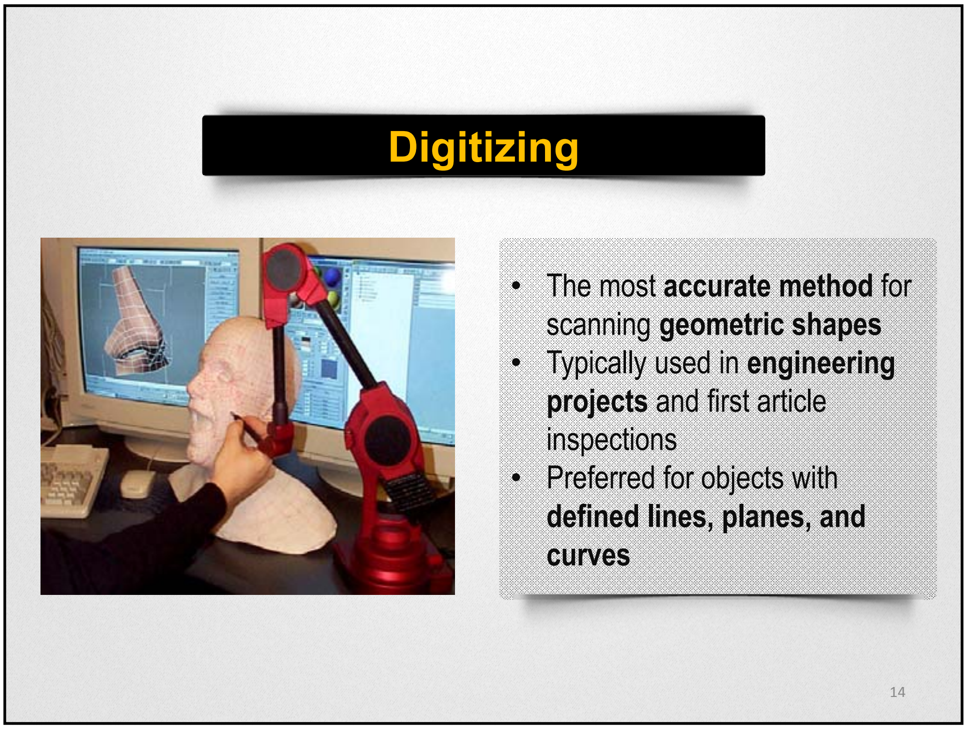
Time-of-Flight (ToF) Technology Using Light

Any number of methods that measure the **time that it takes** for an object, particle or acoustic, electromagnetic or other wave to travel a distance through a medium. In the case of 3D scanning, **light travelling through air and bouncing off the object being scanned**.



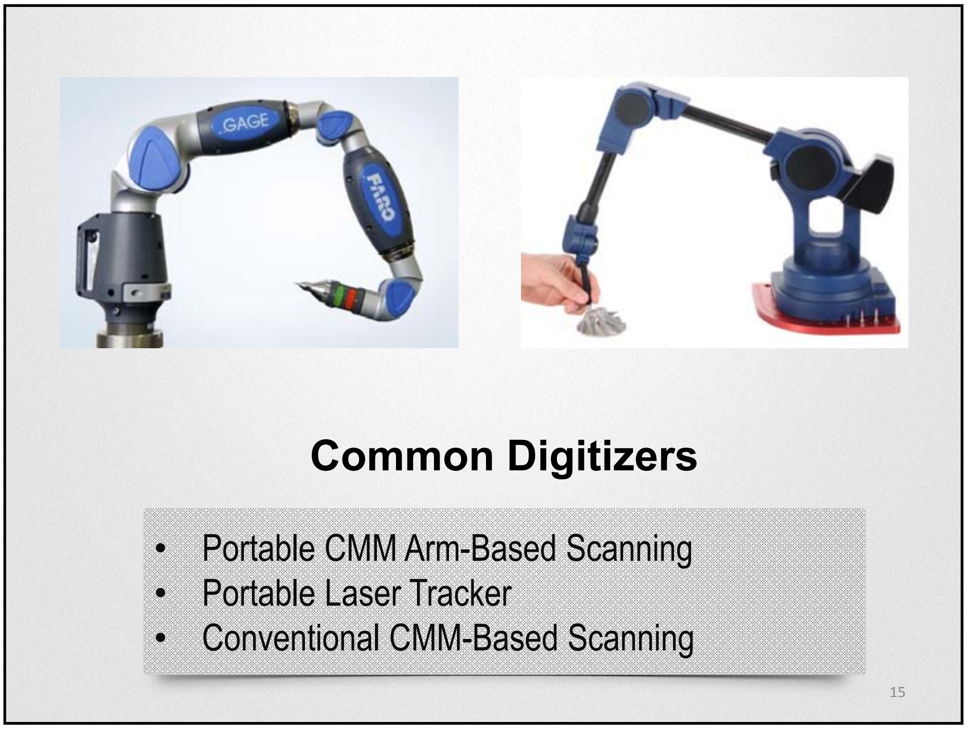
Common Laser Scanners

- Portable CMM Arm-Based Scanning
- 3D Laser Scanning Camera
- Long-Range Laser Scanner
- Conventional CMM-Based Scanning



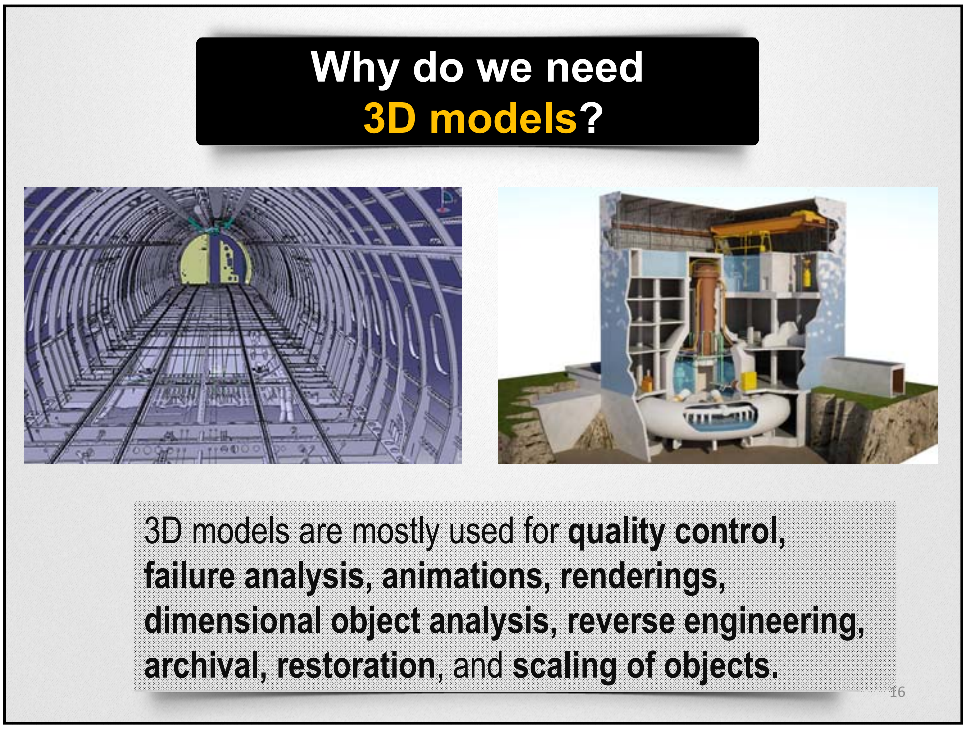
Digitizing

- The most **accurate method** for scanning **geometric shapes**
- Typically used in **engineering projects** and first article inspections
- Preferred for objects with **defined lines, planes, and curves**



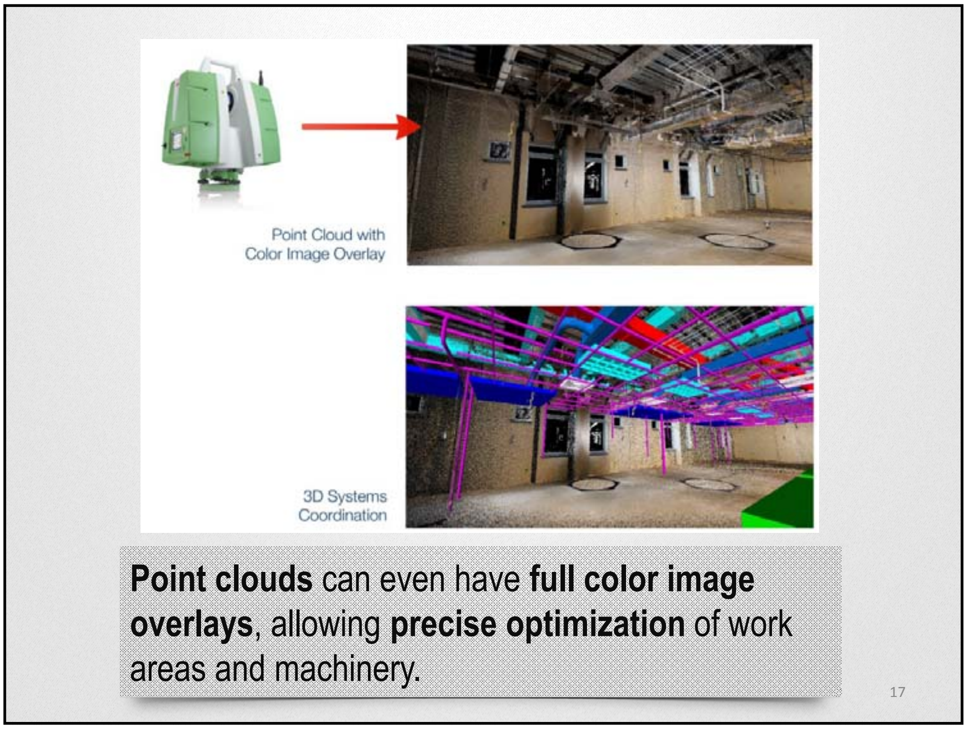
Common Digitizers

- Portable CMM Arm-Based Scanning
- Portable Laser Tracker
- Conventional CMM-Based Scanning

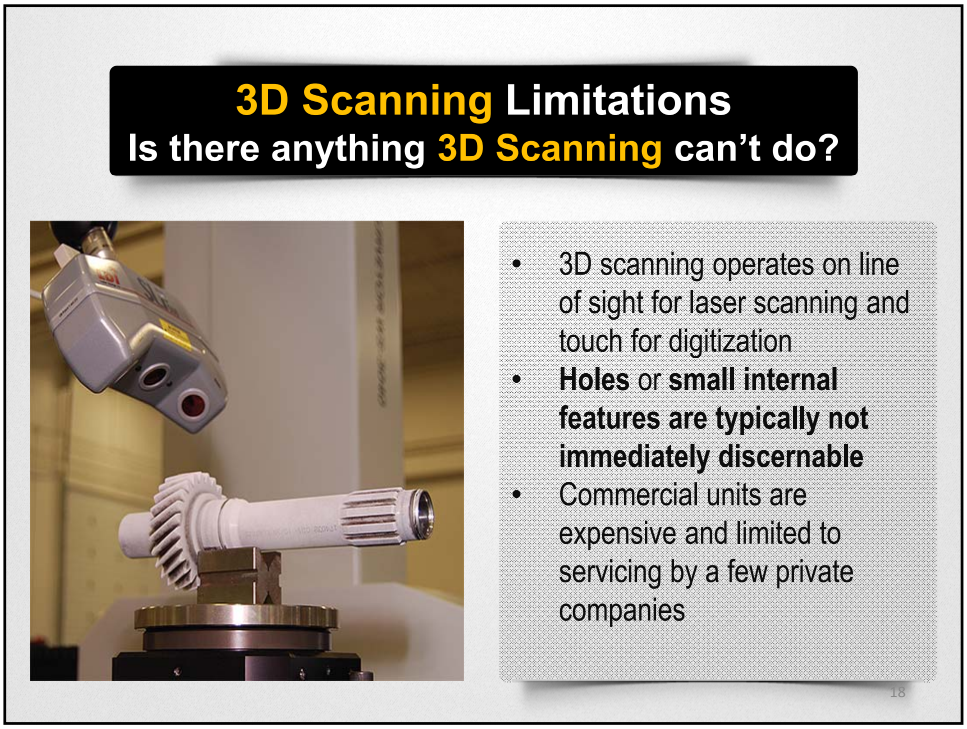


Why do we need 3D models?

3D models are mostly used for **quality control, failure analysis, animations, renderings, dimensional object analysis, reverse engineering, archival, restoration**, and **scaling of objects.**

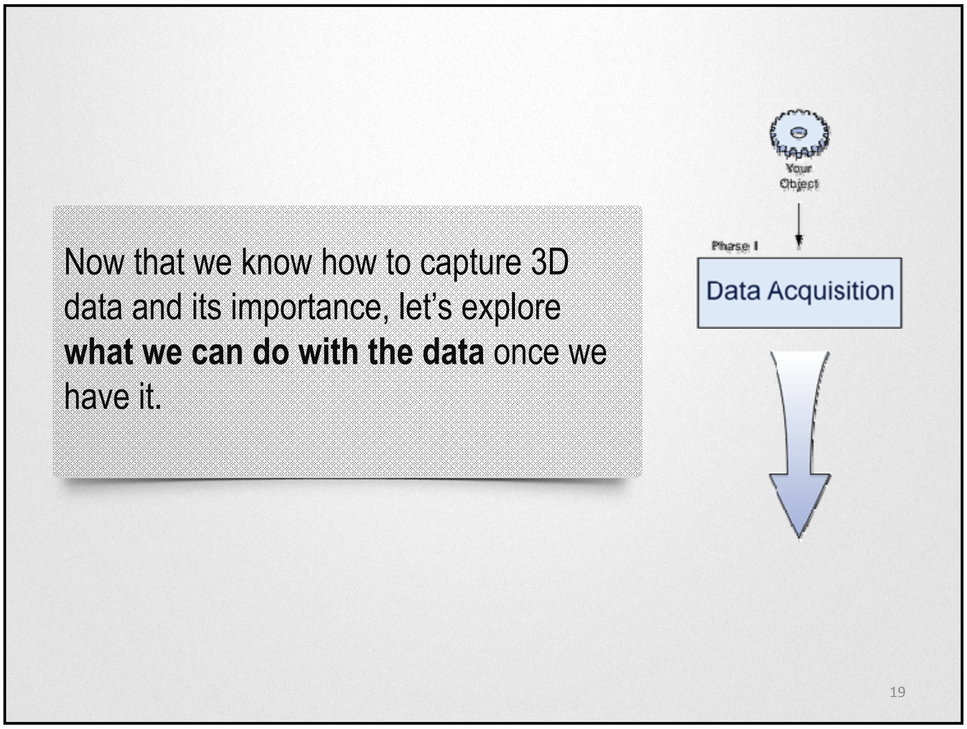


Point clouds can even have **full color image overlays**, allowing **precise optimization** of work areas and machinery.



3D Scanning Limitations
Is there anything 3D Scanning can't do?

- 3D scanning operates on line of sight for laser scanning and touch for digitization
- **Holes** or **small internal features are typically not immediately discernable**
- Commercial units are expensive and limited to servicing by a few private companies

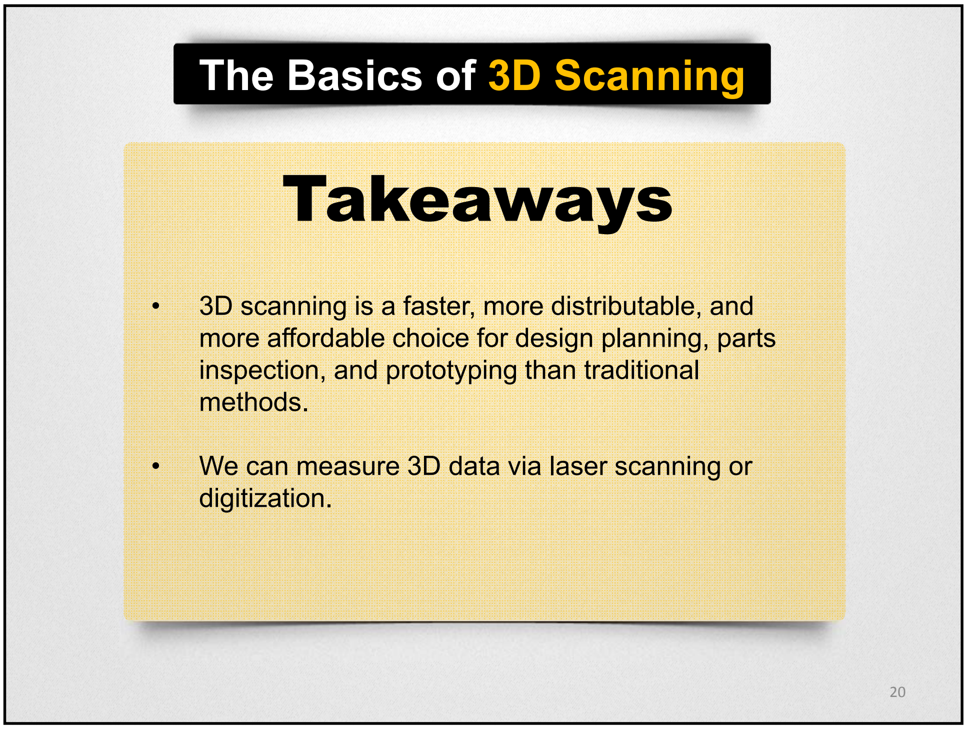


Now that we know how to capture 3D data and its importance, let's explore **what we can do with the data** once we have it.

Your Object

Phase I

Data Acquisition



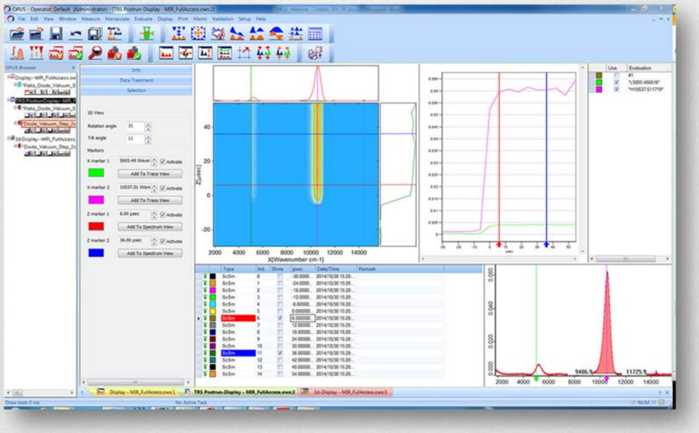
The Basics of 3D Scanning

Takeaways

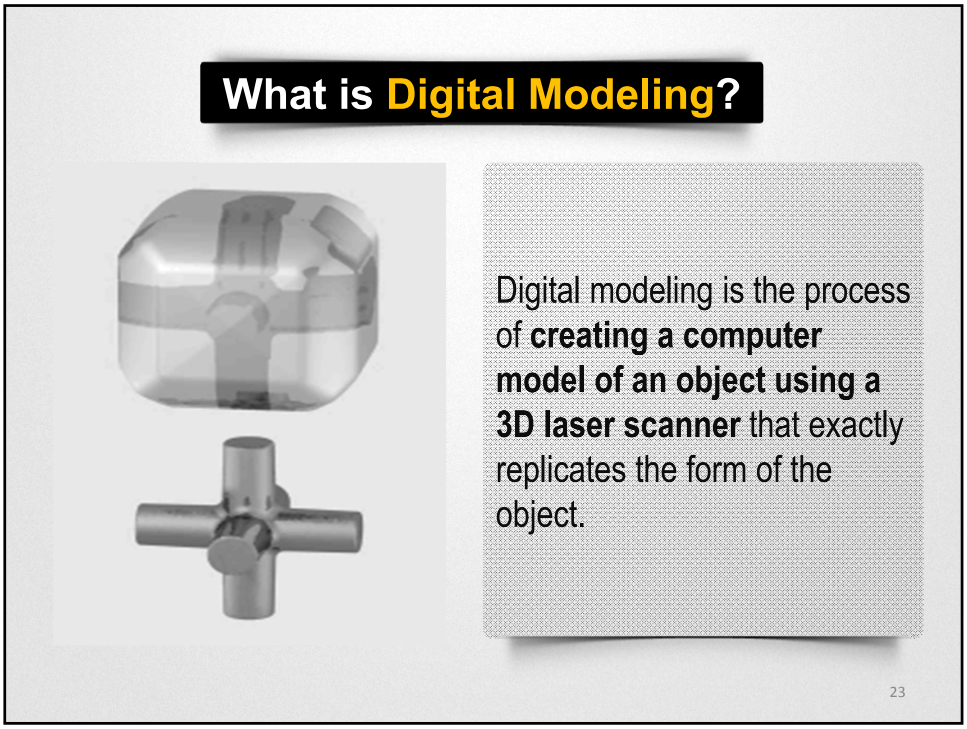
- 3D scanning is a faster, more distributable, and more affordable choice for design planning, parts inspection, and prototyping than traditional methods.
- We can measure 3D data via laser scanning or digitization.

Digital Modeling Vs. Reverse Engineering

- What is Digital Modeling?
- Benefits of Digital Modeling
- What is Reverse Engineering?
- Benefits of Reverse Engineering
- To create a Digital Model or Reverse Engineer
- Design Intent & As-Built

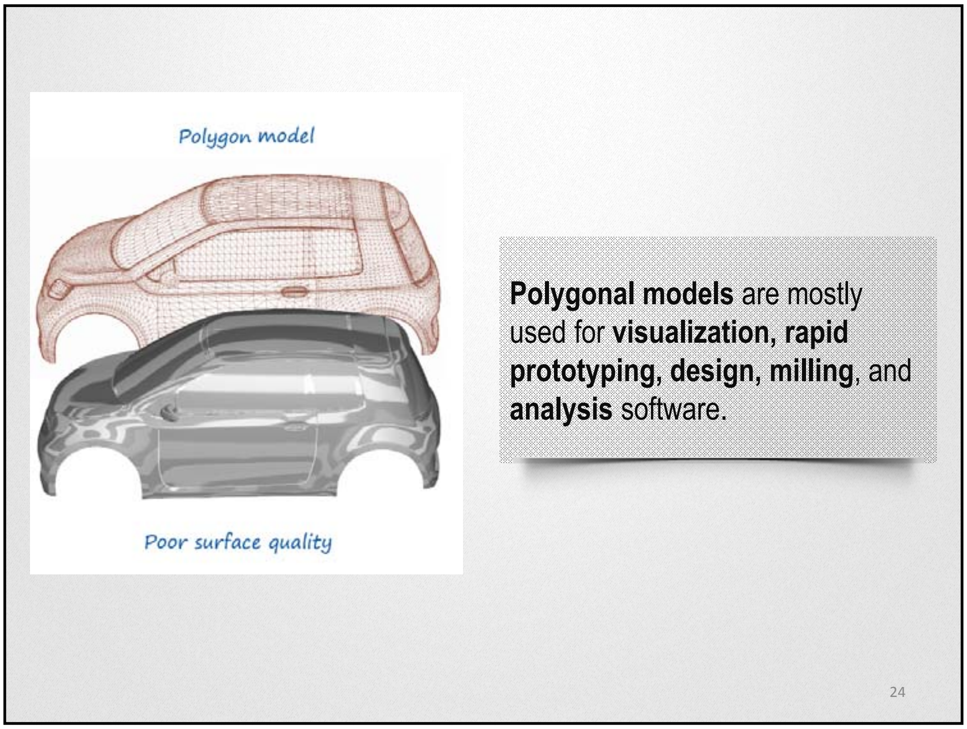


The processing of collected data is divided into two main categories: **digital modeling** and **reverse engineering**. These are generally based on shape and desired file output.



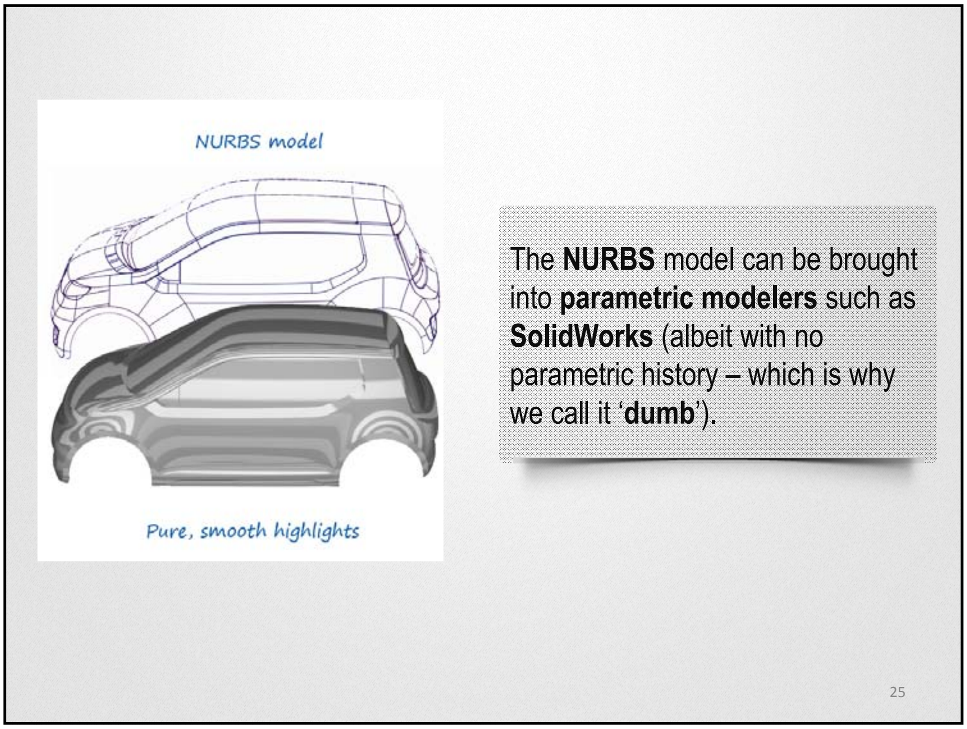
What is Digital Modeling?

Digital modeling is the process of **creating a computer model of an object using a 3D laser scanner** that exactly replicates the form of the object.

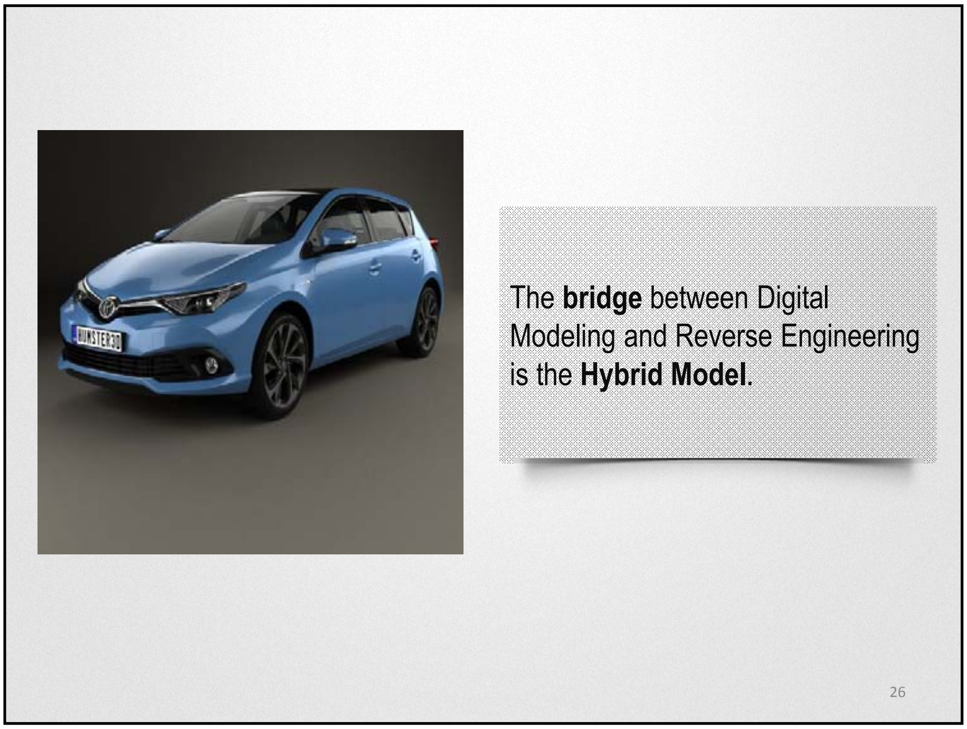


Polygon model
Poor surface quality

Polygonal models are mostly used for **visualization, rapid prototyping, design, milling**, and **analysis** software.



The **NURBS** model can be brought into **parametric modelers** such as **SolidWorks** (albeit with no parametric history – which is why we call it '**dumb**').

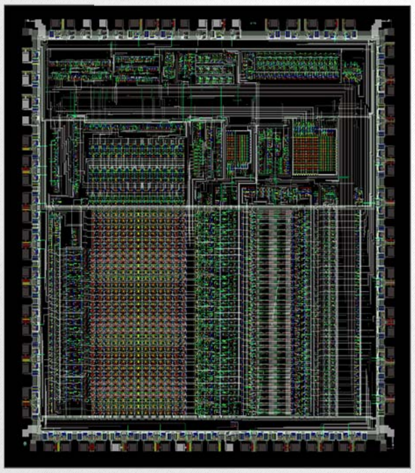


The **bridge** between Digital Modeling and Reverse Engineering is the **Hybrid Model**.

Benefits of Digital Modeling

- **Faster** and **more cost effective** than Reverse Engineering
- A great solution for **creating solid models** when an object has organic contours.
- Offers **excellent dimensional accuracy** and can be utilized for comparative analysis.
- Unlike raw point clouds, digital models can be **visualized in rendering software** as a solid object, which is great for seeing the overall shape and contour of the model.

What is Reverse Engineering?



Reverse Engineering is the process of **measuring a part or object and then creating a CAD model** of the part/object that reflects how it was originally .

Benefits of Reverse Engineering

- Can be brought into **Parametric Modeling Packages** (solid modeling CAD software)
- Other than NURBS ‘dumb’ solids, reverse engineered models **contain geometric features such as planes and radii** making the models a better fit for designing and measuring.
- Reverse engineered models are **great for analysis software** such as for CFD and FEA

To create a Digital Model or Reverse Engineer?

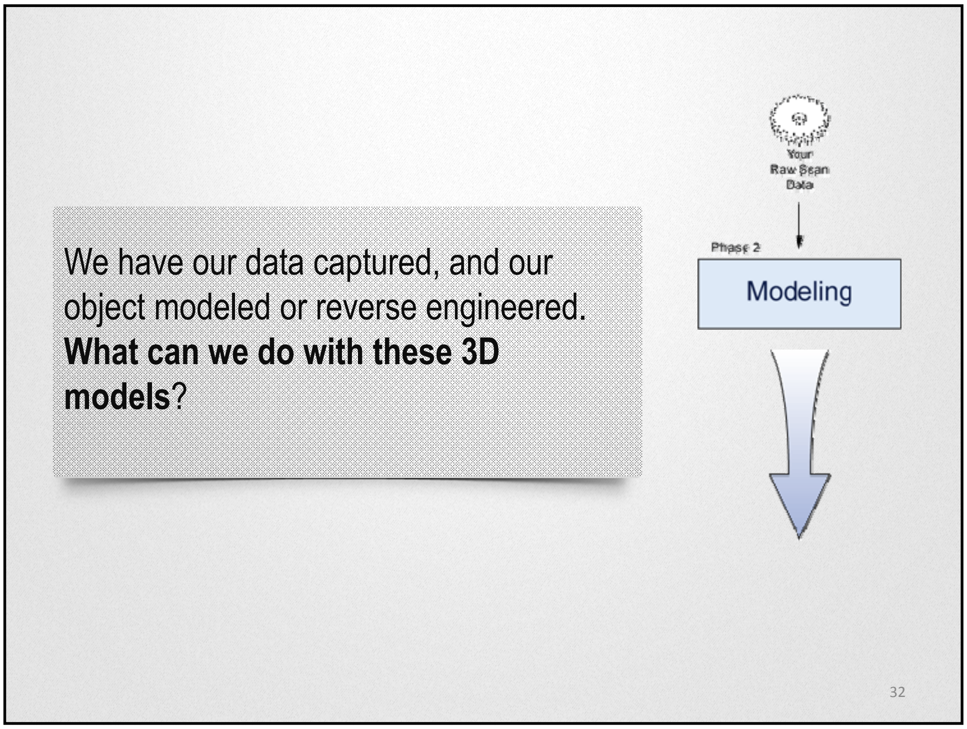
People that choose **Digital Modeling** generally will use the file for **Rapid Prototyping or visualization purposes**. When you need more than that, either for redesign purposes or for importing models into analysis programs, you generally choose to **Reverse Engineer**, **which means bringing your files into parametric modeling software**.

Design Intent

As-Built

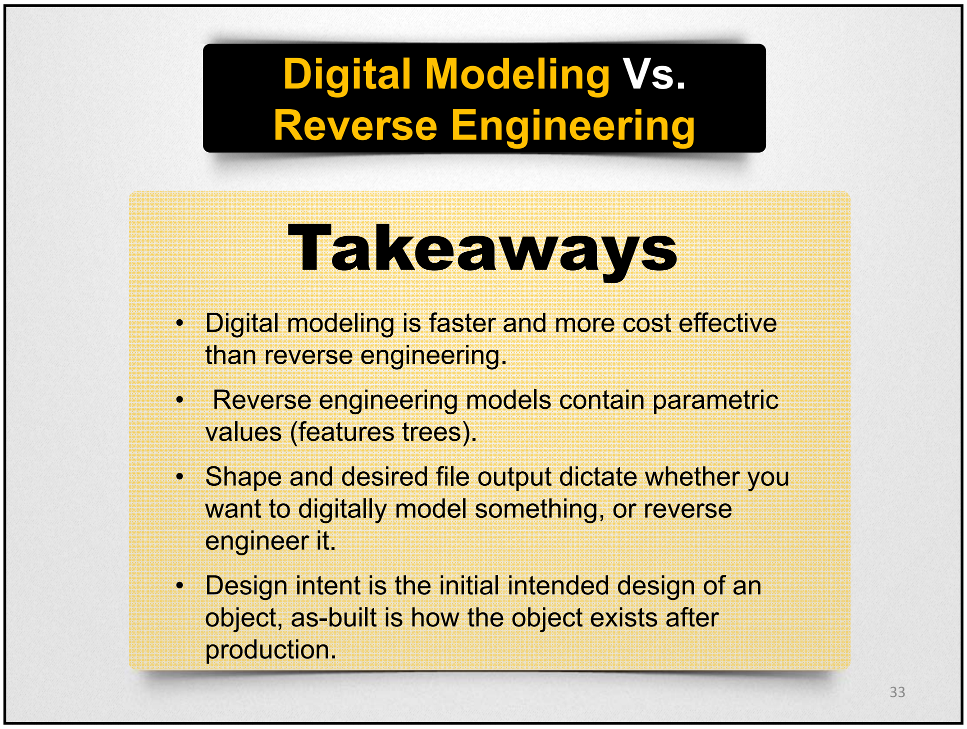
Design Intent - **the intended design of an as-built physical object**. Every manufactured part or object varies from its original intended design by some factor.

As-built - modeling which captures the **exact physical shape of an object as it actually is,** with its imperfections.



We have our data captured, and our object modeled or reverse engineered. **What can we do with these 3D models**?

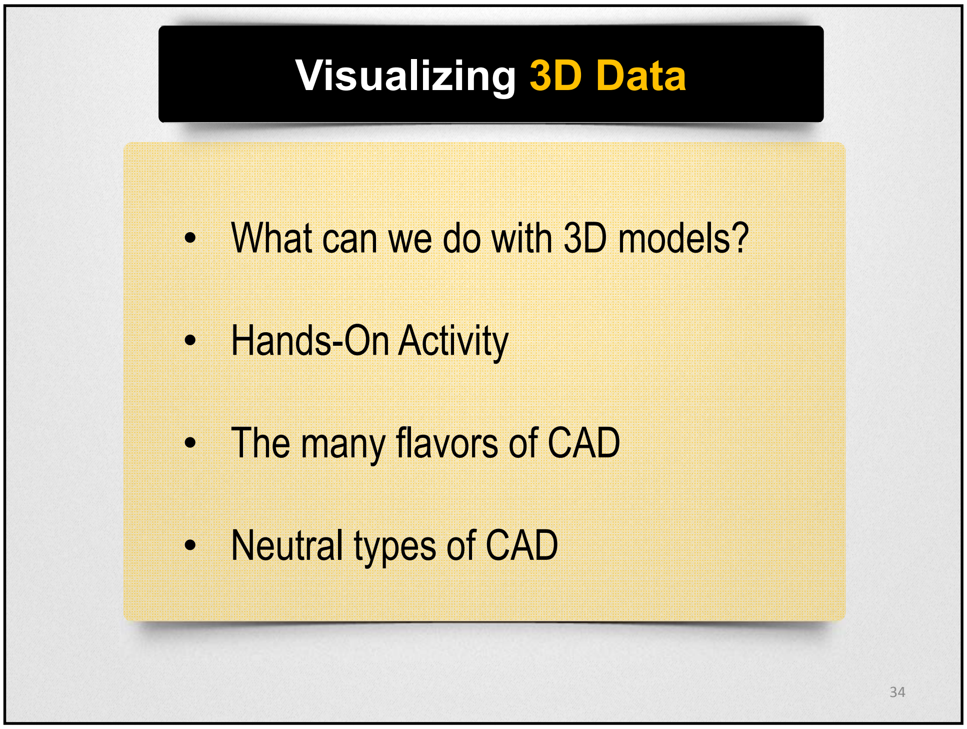
Your
Raw Scan
Data
Phase 2
Modeling



Digital Modeling Vs. Reverse Engineering

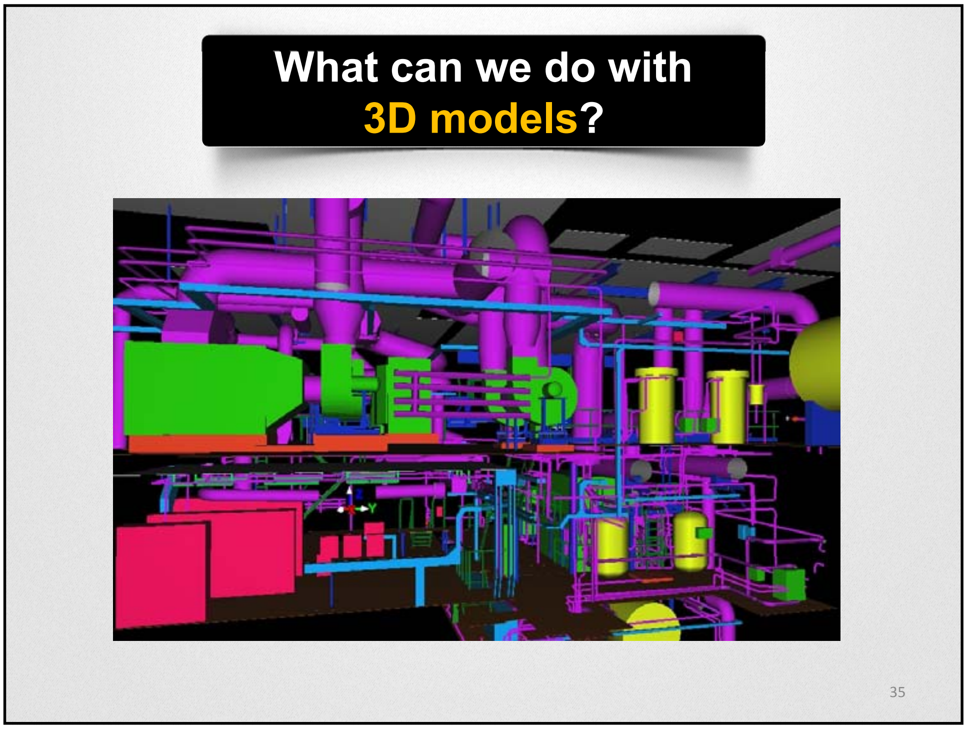
Takeaways

- Digital modeling is faster and more cost effective than reverse engineering.
- Reverse engineering models contain parametric values (features trees).
- Shape and desired file output dictate whether you want to digitally model something, or reverse engineer it.
- Design intent is the initial intended design of an object, as-built is how the object exists after production.

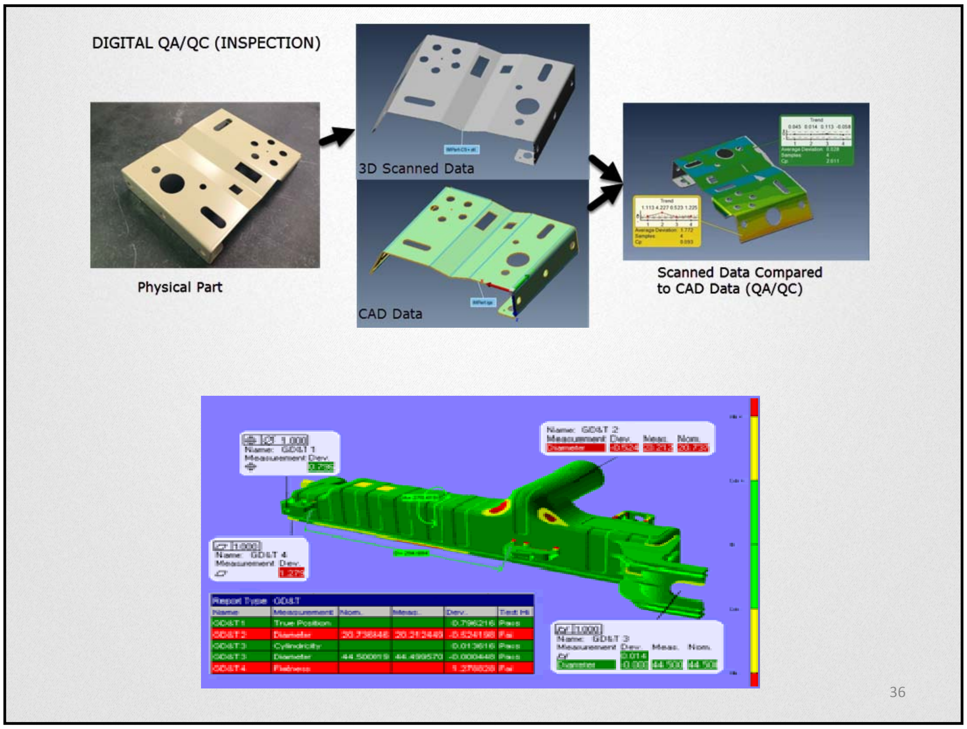


Visualizing 3D Data

- What can we do with 3D models?
- Hands-On Activity
- The many flavors of CAD
- Neutral types of CAD

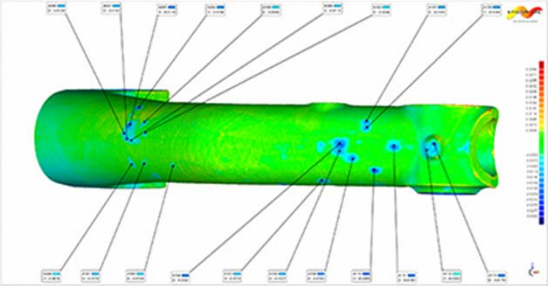


What can we do with 3D models?

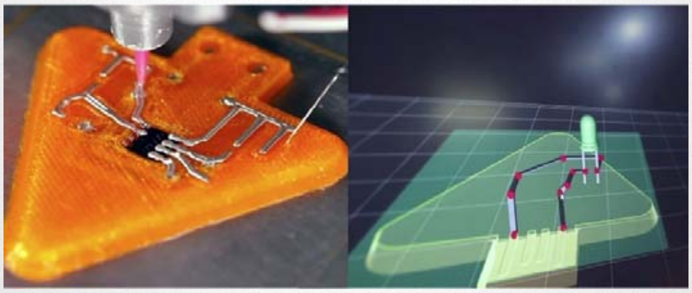


DIGITAL QA/QC (INSPECTION)

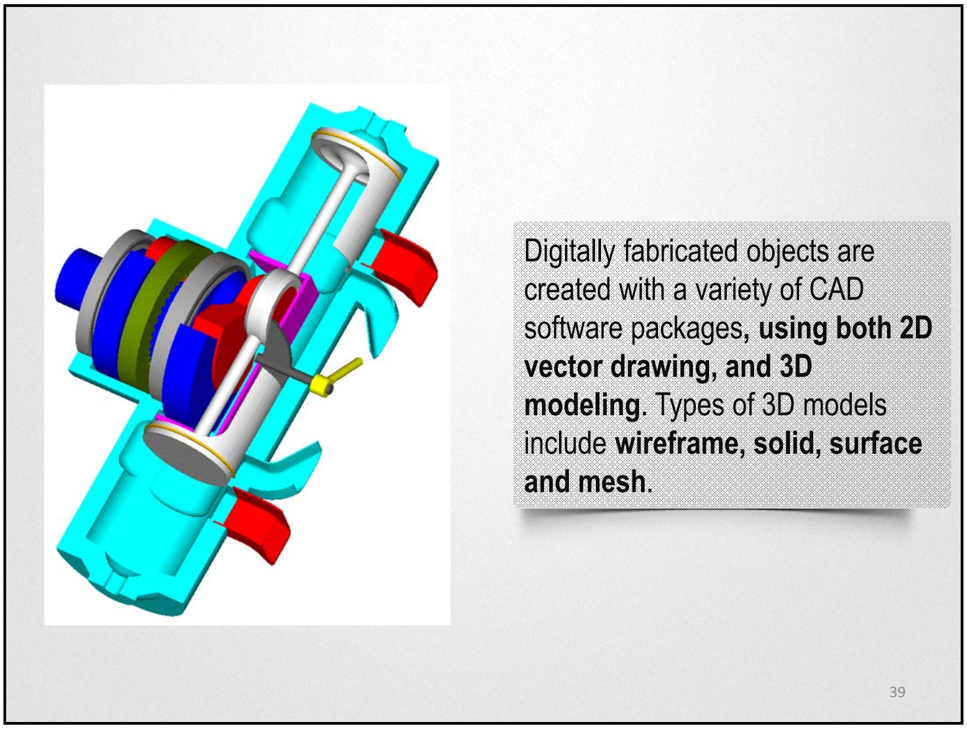
Report Type	GD&T				
Name	Measurement	Nom.	Meas.	Dev.	Test Hi
GD&T 1	True Position			0.796216	Pass
GD&T 2	Diameter	20.736846	20.212449	-0.524198	Fail
GD&T 3	Cylindricity			0.013616	Pass
GD&T 3	Diameter	44.500019	44.499570	-0.000448	Pass
GD&T 4	Flatness			1.276828	Fail



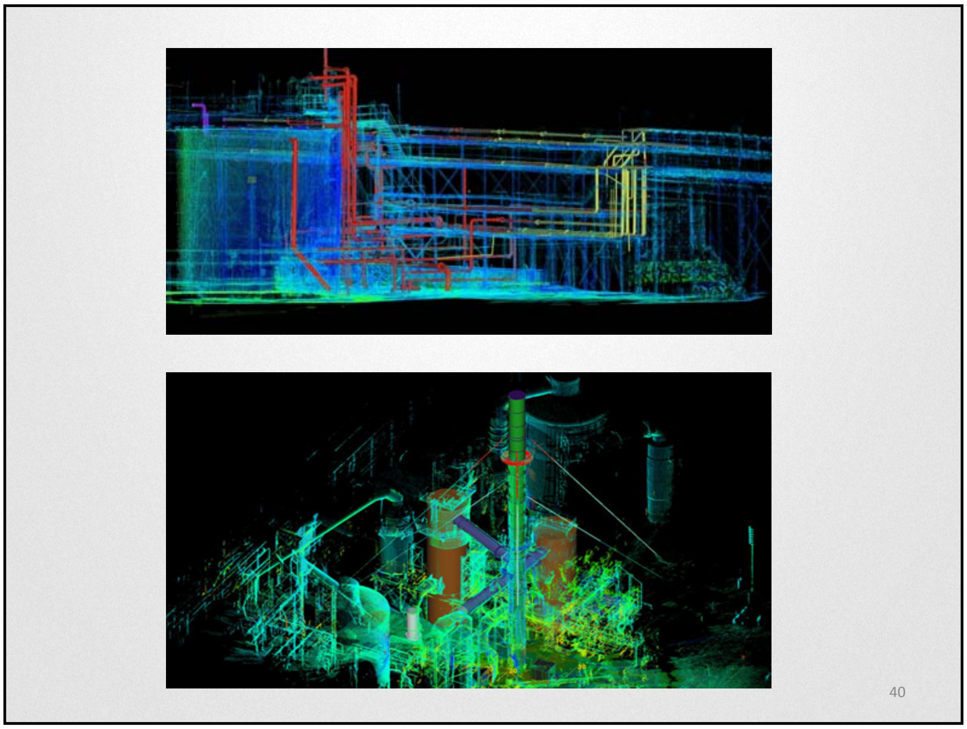
3D models are **crucial** when used to **digitally repair** damage that has been done to an object which can then reproduce that object in its proper form using rapid prototyping and milling technologies.

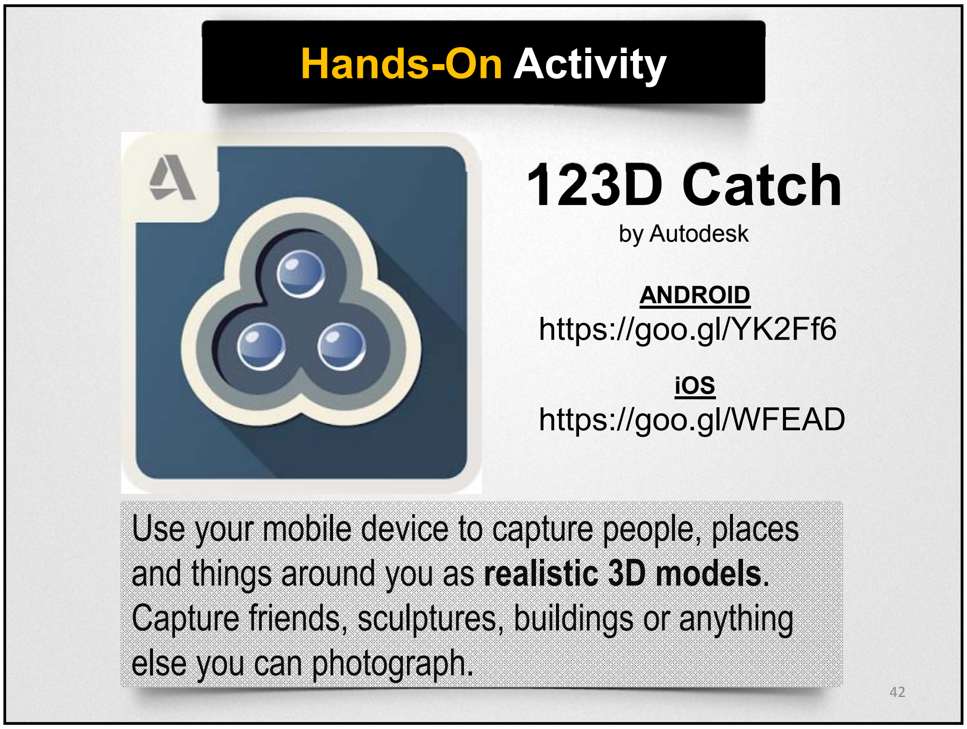


3D models can also be used to **make and test changes** to a product without the need and expense of producing a physical good with each variant.



Digitally fabricated objects are created with a variety of CAD software packages**, using both 2D vector drawing, and 3D modeling**. Types of 3D models include **wireframe, solid, surface and mesh**.





Hands-On Activity

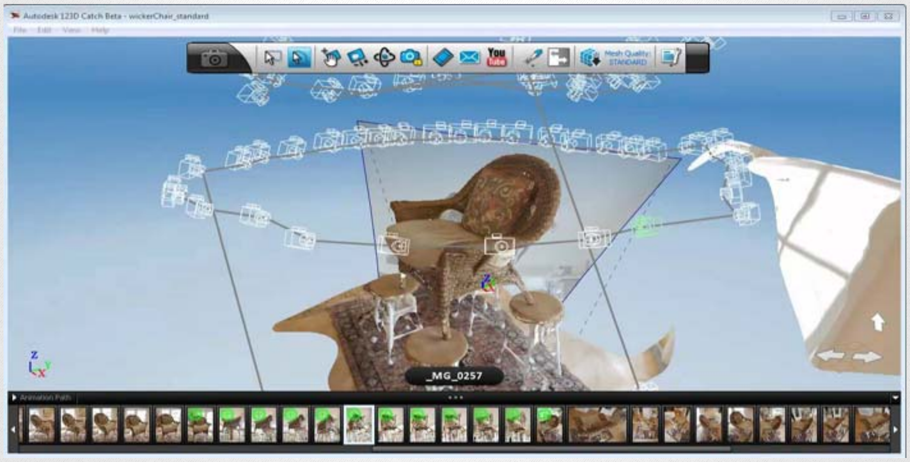
123D Catch

by Autodesk

ANDROID
https://goo.gl/YK2Ff6

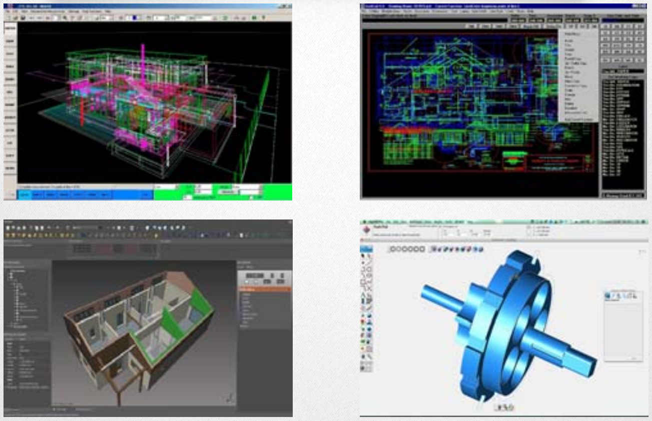
iOS
https://goo.gl/WFEAD

Use your mobile device to capture people, places and things around you as **realistic 3D models**. Capture friends, sculptures, buildings or anything else you can photograph.



- **8 to 20 photos per revolution** is optimal
- When capturing complex objects, **multiple angles** should be used
- Don’t move the object, instead **move around the object**.

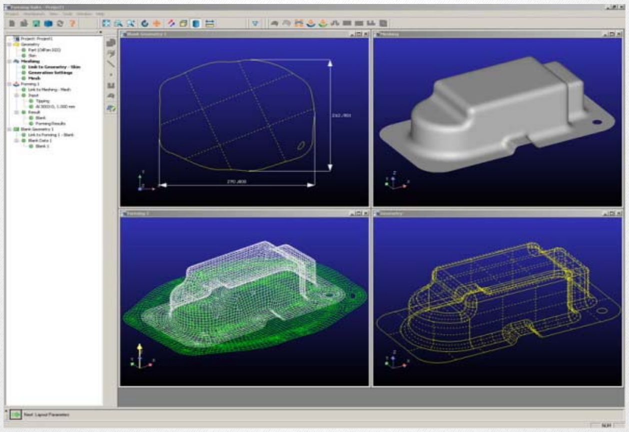
The many flavors of CAD



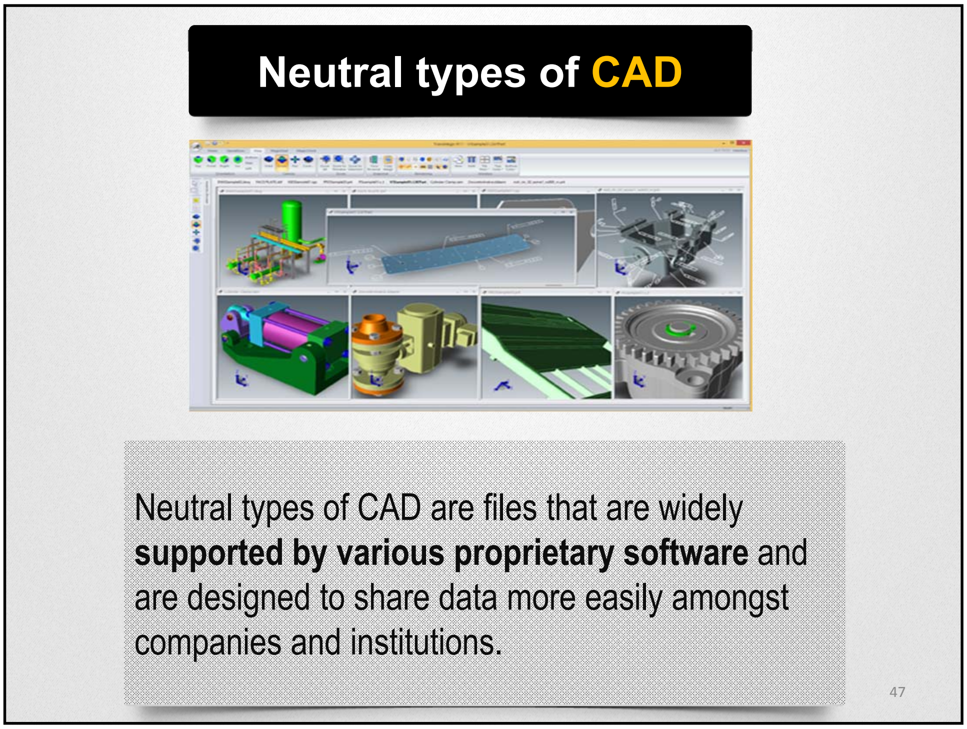
CAD is a **standard term** defining a group of software that aides in design. It is typically **used in manufacturing** or other **engineering disciplines**.

CAD File Types

- ASCII - an **X,Y,Z point cloud** file in ascii text format.
- DWG - a native AutoCad drawing file.
- SLDPRT - a native CAD format for SolidWorks.
- STL - **Standard Tessellation Language**. STL is a special internationally recognized file format that **stores XYZ coordinate measurements** and their normals.

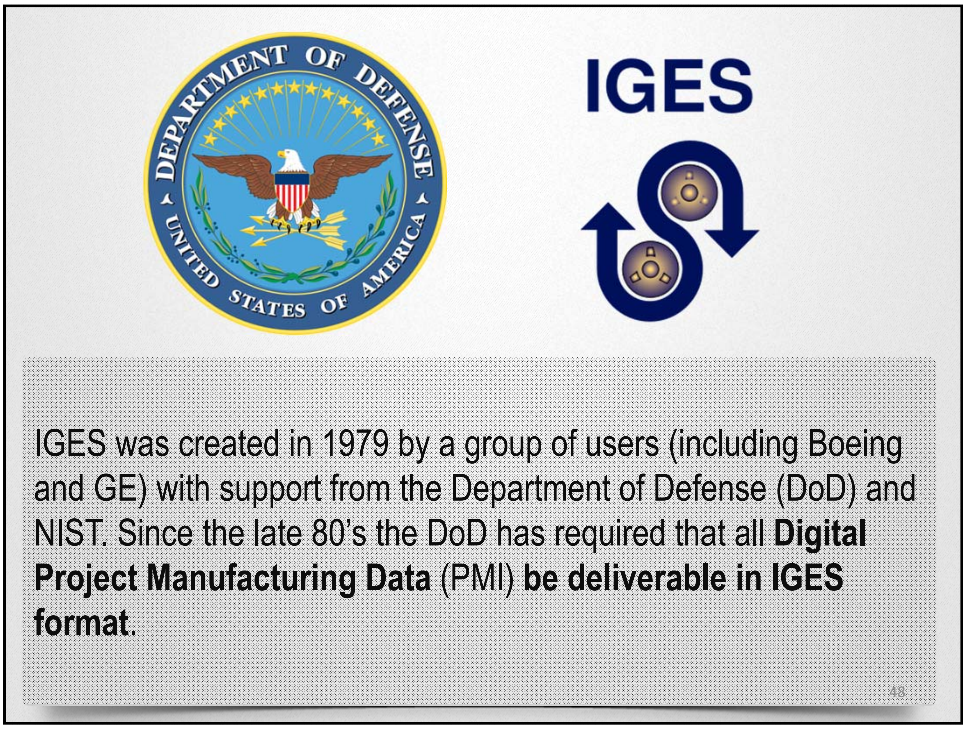


The term ‘**CAD’ is universal.** For example: An engineer designs in SolidWorks, Pro-E, AutoCAD, Catia, or Unigraphics; **all** of which are **Computer Aided Design** or **Computer Aided Engineering programs**.



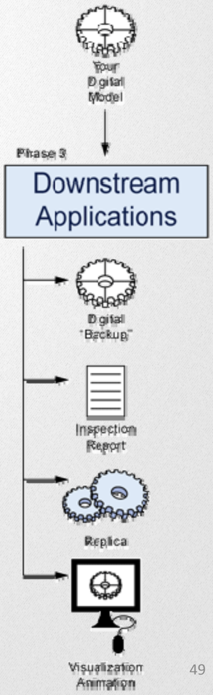
Neutral types of CAD

Neutral types of CAD are files that are widely **supported by various proprietary software** and are designed to share data more easily amongst companies and institutions.



IGES was created in 1979 by a group of users (including Boeing and GE) with support from the Department of Defense (DoD) and NIST. Since the late 80's the DoD has required that all **Digital Project Manufacturing Data** (PMI) **be deliverable in IGES format**.

By sending our completed 3D models to other applications, we can easily **create multiple uses for the same data**. The models can be used for **archival, re-engineering, inspection, reproduction,** and **visualization**.



Visualizing 3D Data

Takeaways

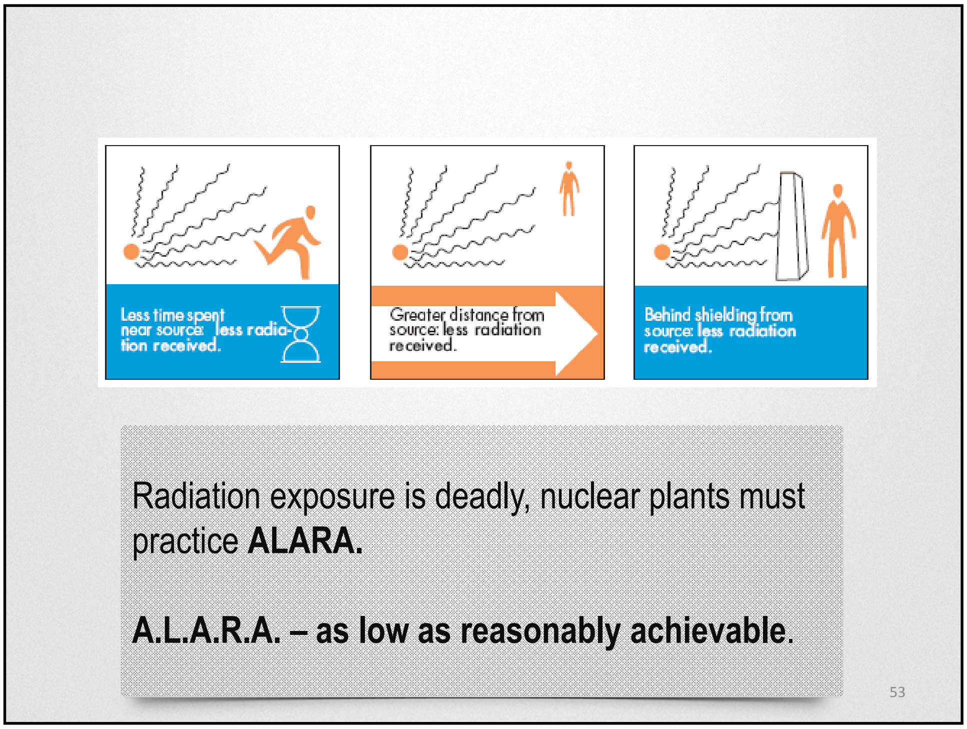
- 3D models can be used for archival, re-engineering, inspection, and visualization.
- ‘CAD’ is a standard term defining a group of software that aides in design.
- The IGES file type is the only acceptable format for DoD/NIST brownfield projects.

3D Data in the Nuclear World

- What are the advantages of 3D scanning in a nuclear environment?
- 3D Scanning to the rescue!

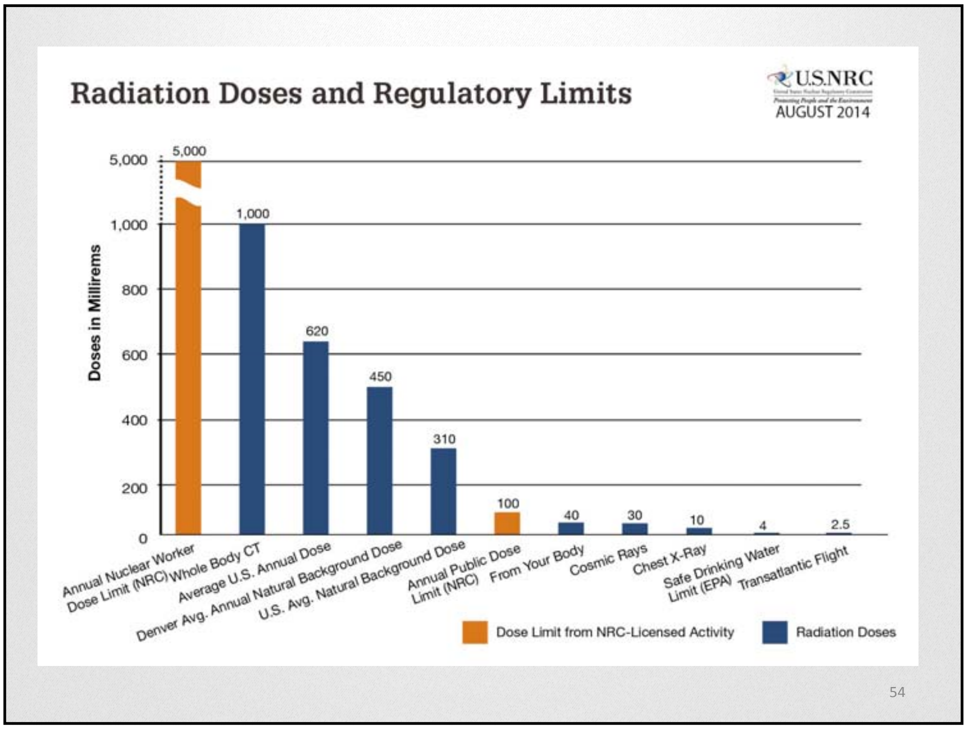
The Advantages of 3D Scanning in a Nuclear environment

Design planning in **Nuclear Power Plants** is long term and driven by certification and design reviews.

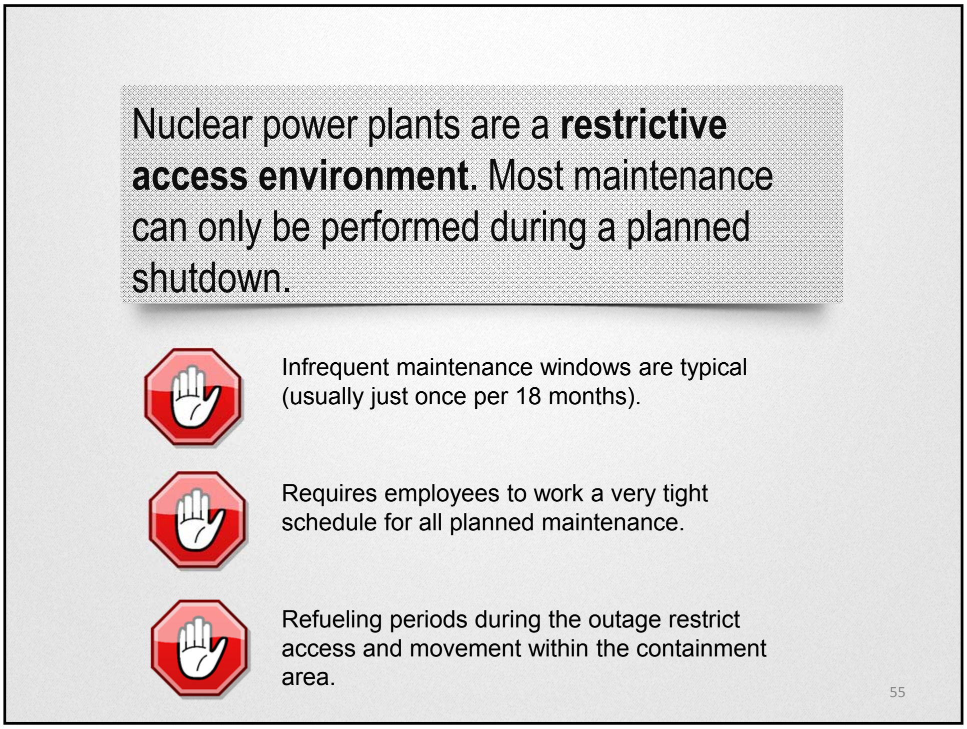

Less time spent near source: less radiation received.
Greater distance from source: less radiation received.
Behind shielding from source: less radiation received.

Radiation exposure is deadly, nuclear plants must practice **ALARA.**

A.L.A.R.A. – as low as reasonably achievable.

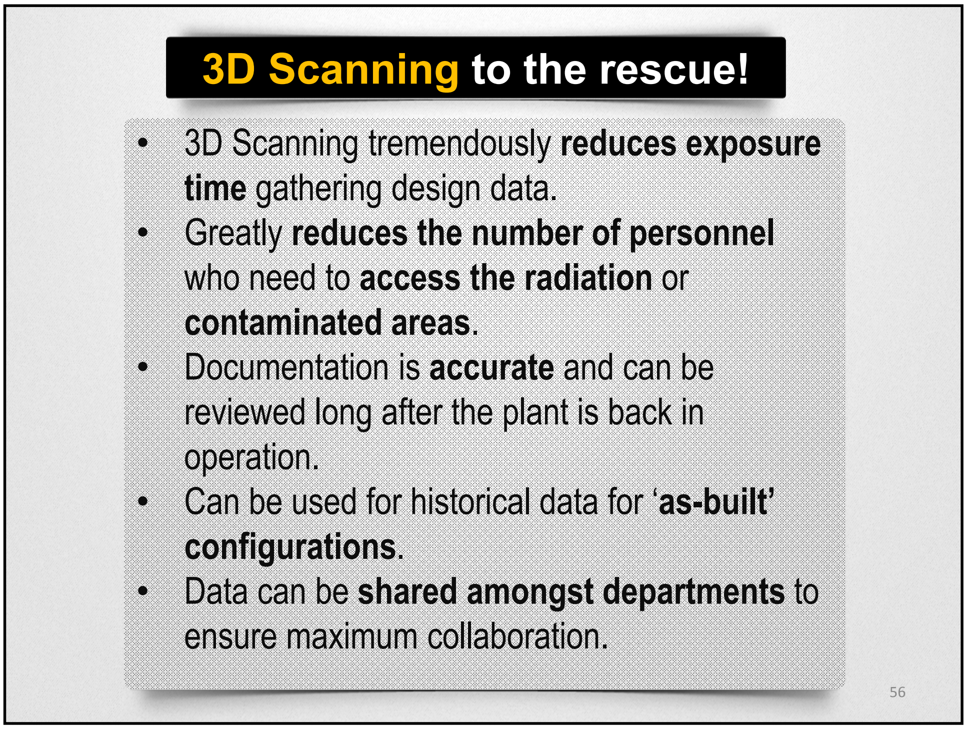


Radiation Doses and Regulatory Limits



Nuclear power plants are a **restrictive access environment**. Most maintenance can only be performed during a planned shutdown.

- Infrequent maintenance windows are typical (usually just once per 18 months).
- Requires employees to work a very tight schedule for all planned maintenance.
- Refueling periods during the outage restrict access and movement within the containment area.



3D Scanning to the rescue!

- 3D Scanning tremendously **reduces exposure time** gathering design data.
- Greatly **reduces the number of personnel** who need to **access the radiation** or **contaminated areas**.
- Documentation is **accurate** and can be reviewed long after the plant is back in operation.
- Can be used for historical data for **'as-built' configurations**.
- Data can be **shared amongst departments** to ensure maximum collaboration.

Laser scanning has **reduced total installed cost** for **brownfield projects by 5-7%** and has reduced **contingencies for rework to less than 2%** compared to traditional survey methods.

Plant operators report that the speed of laser scanning allows them **to attain the needed measurements inside containment structures** and other areas within tight shutdown or ’outage‘ schedules-often times **up to 10% less time** than traditional methods.

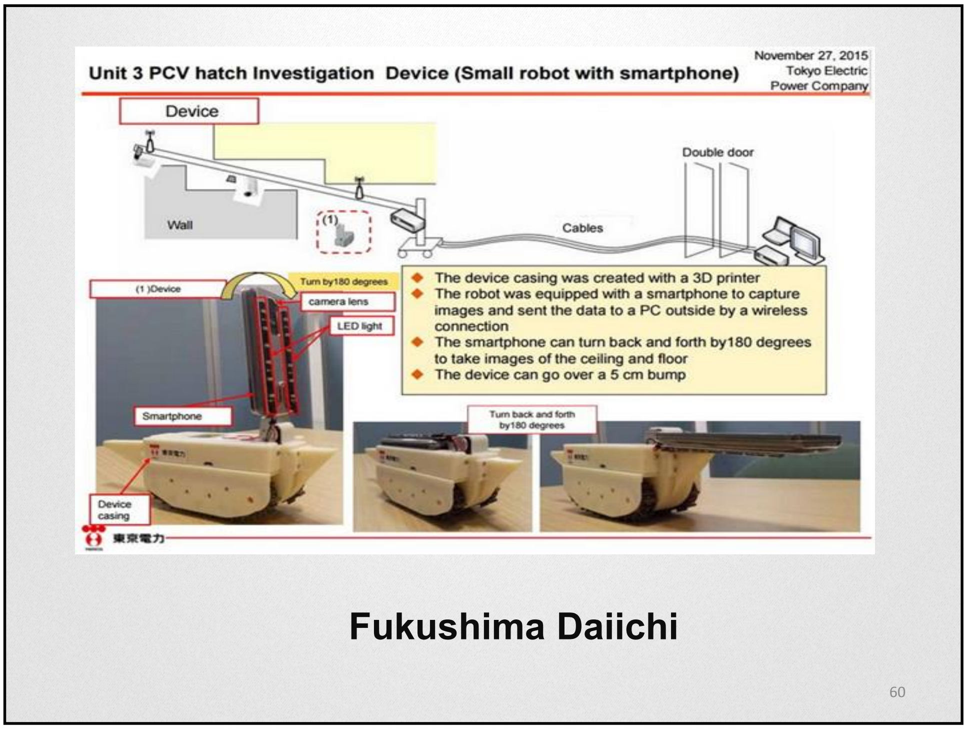
Rostov Nuclear Power Plant – Volgodonsk, Russia

Scope: Design a work platform to fit the opening.

- 4 hour window
- 100+ degree F heat
- Access controlled area
- Foreign Material Exclusion area
- Fall hazard

Sellafield Nuclear Power Plant – Cumbria, England

- 60-year-old Pile Fuel Storage Pond
- 40 ton stainless steel Solid Waste Export Flask
- Needed a new lid for the container

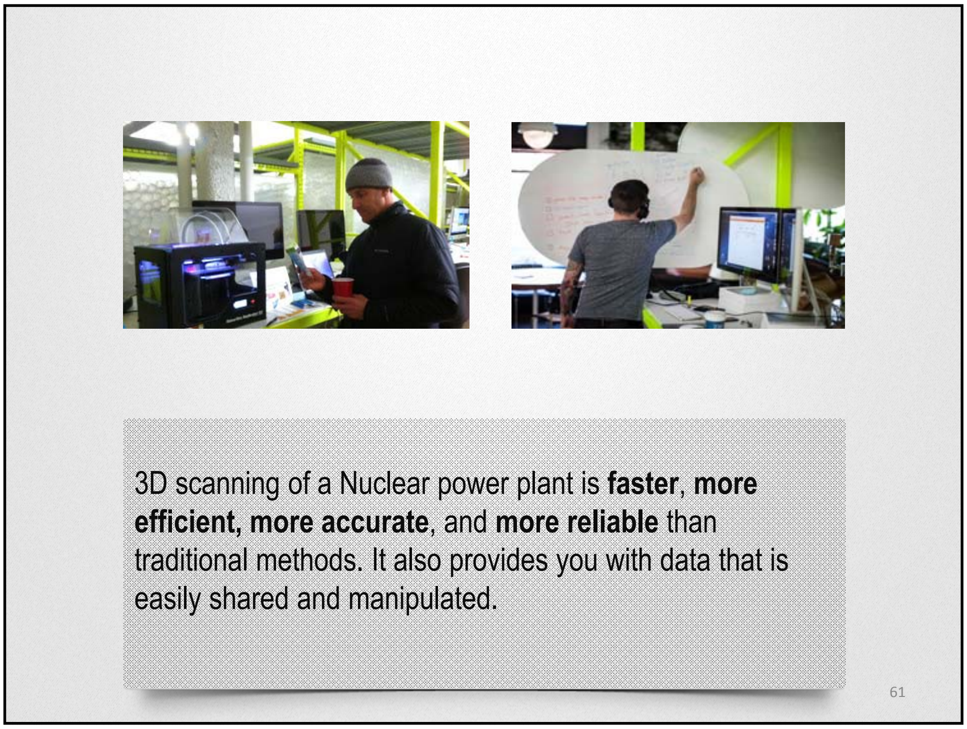


Unit 3 PCV hatch Investigation Device (Small robot with smartphone)

November 27, 2015
Tokyo Electric
Power Company

- The device casing was created with a 3D printer
- The robot was equipped with a smartphone to capture images and sent the data to a PC outside by a wireless connection
- The smartphone can turn back and forth by180 degrees to take images of the ceiling and floor
- The device can go over a 5 cm bump

Fukushima Daiichi



3D scanning of a Nuclear power plant is **faster**, **more efficient, more accurate**, and **more reliable** than traditional methods. It also provides you with data that is easily shared and manipulated.

3D Data in the Nuclear World

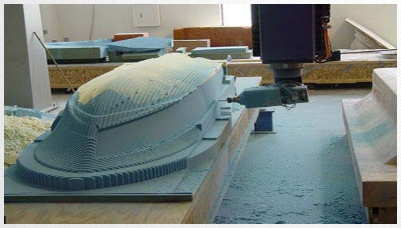
Takeaways

- 3D scanning is a faster way to measure objects in a nuclear environment. It enables maximum efficiency during scheduled downtime and refueling periods.
- Utilizing 3D scanning reduces workers’ exposure time.
- The documentation from 3D scanning is highly accurate and very reliable.
- The data can be easily shared amongst departments, ensuring maximum collaboration.

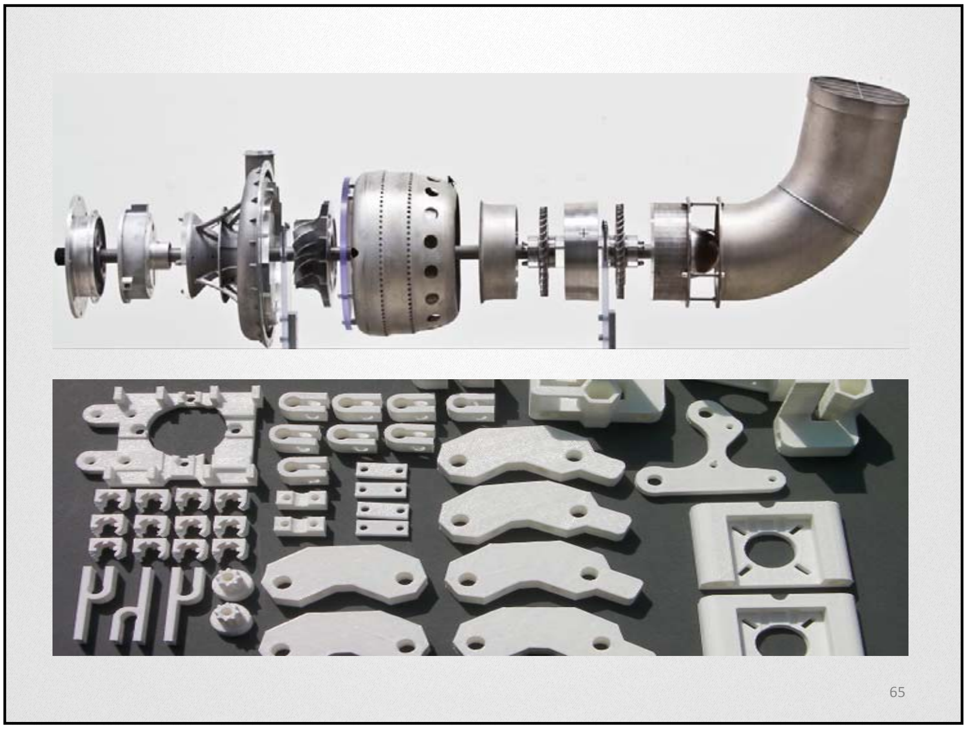
From Digital Model to Physical Object

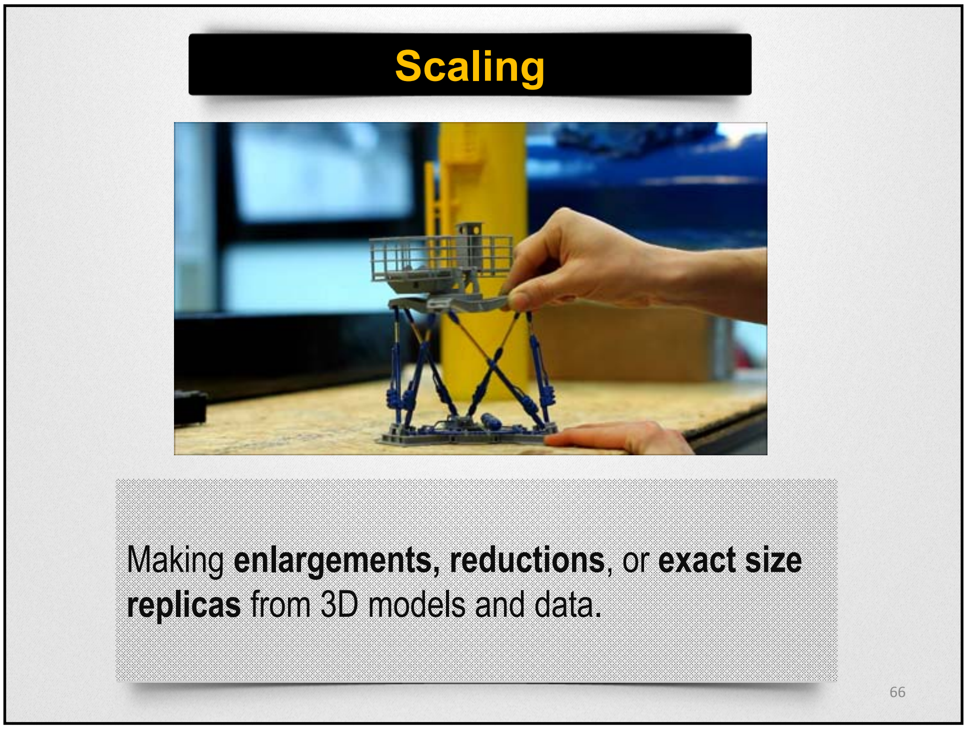
- Scaling
- Restoration
- Additive Manufacturing
- Milling
- What the future holds

From Digital Model to Physical Object



3D models can be made into real products through the use of **3D printers, CNC milling**, or **additive manufacturing**.



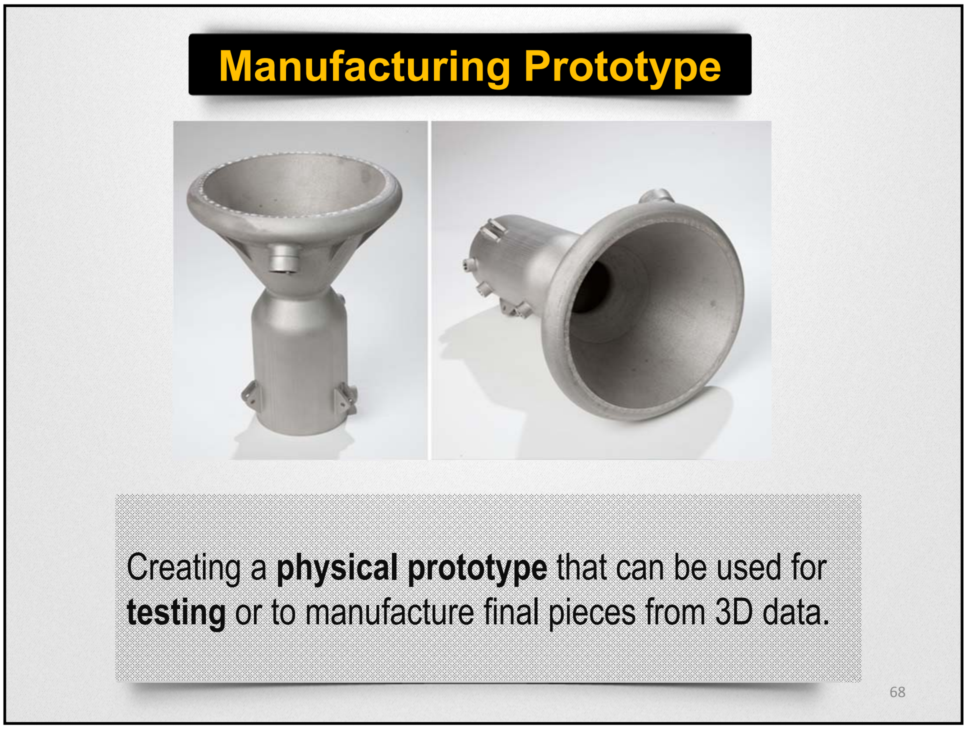


Scaling

Making **enlargements, reductions**, or **exact size replicas** from 3D models and data.

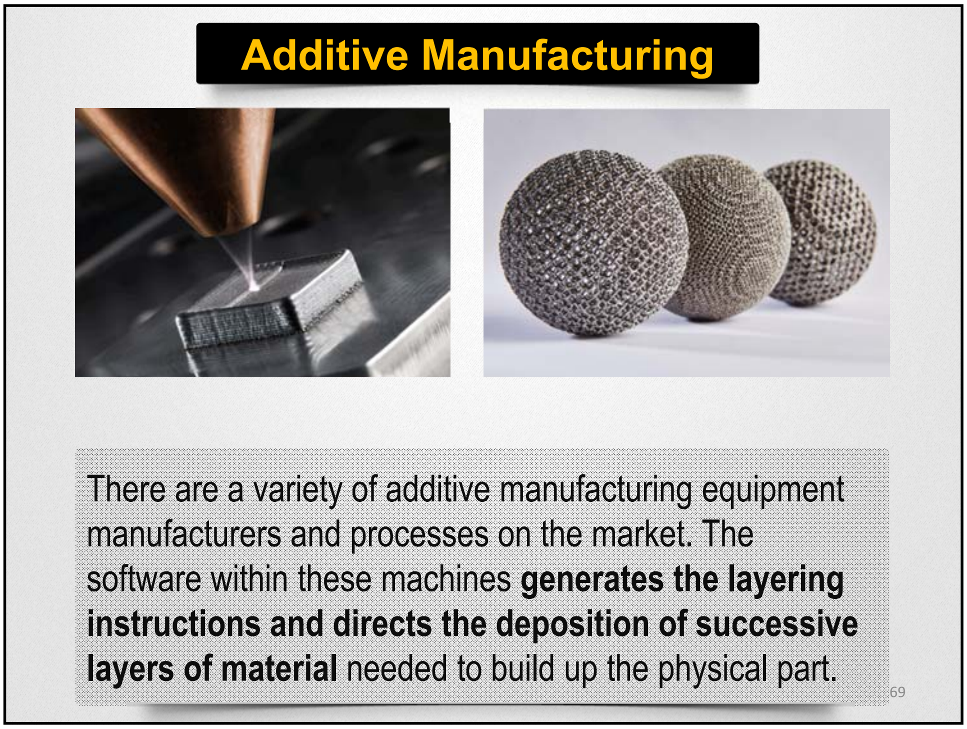
Restoration

Using 3D data for manufacturing to **completely restore any object** that has been damaged by weather, neglect, natural disasters, etc.



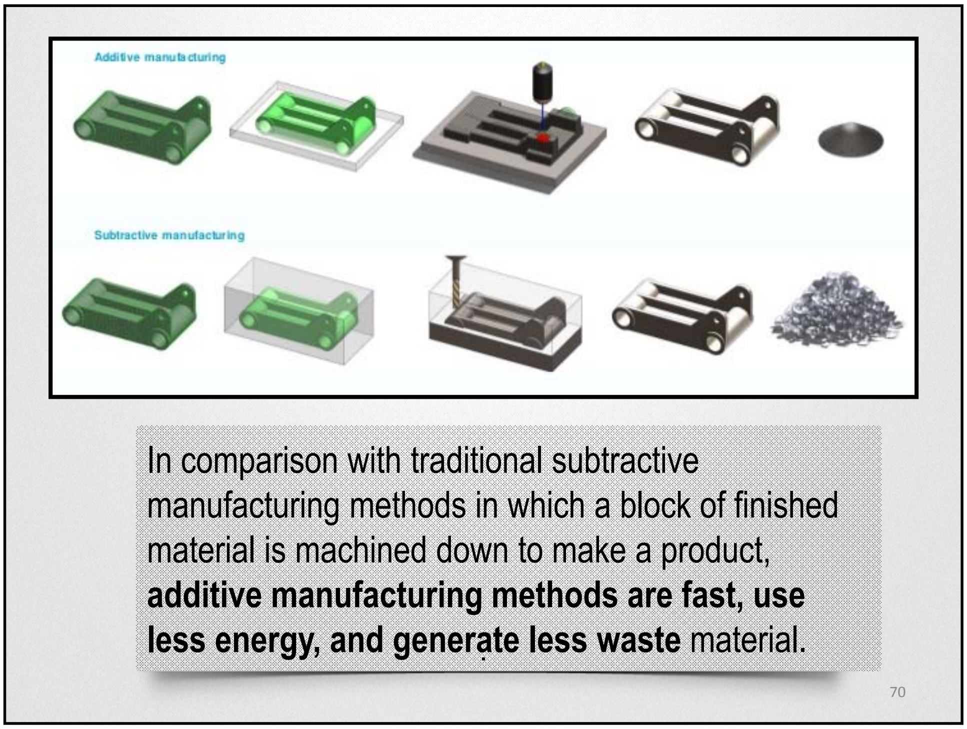
Manufacturing Prototype

Creating a **physical prototype** that can be used for **testing** or to manufacture final pieces from 3D data.

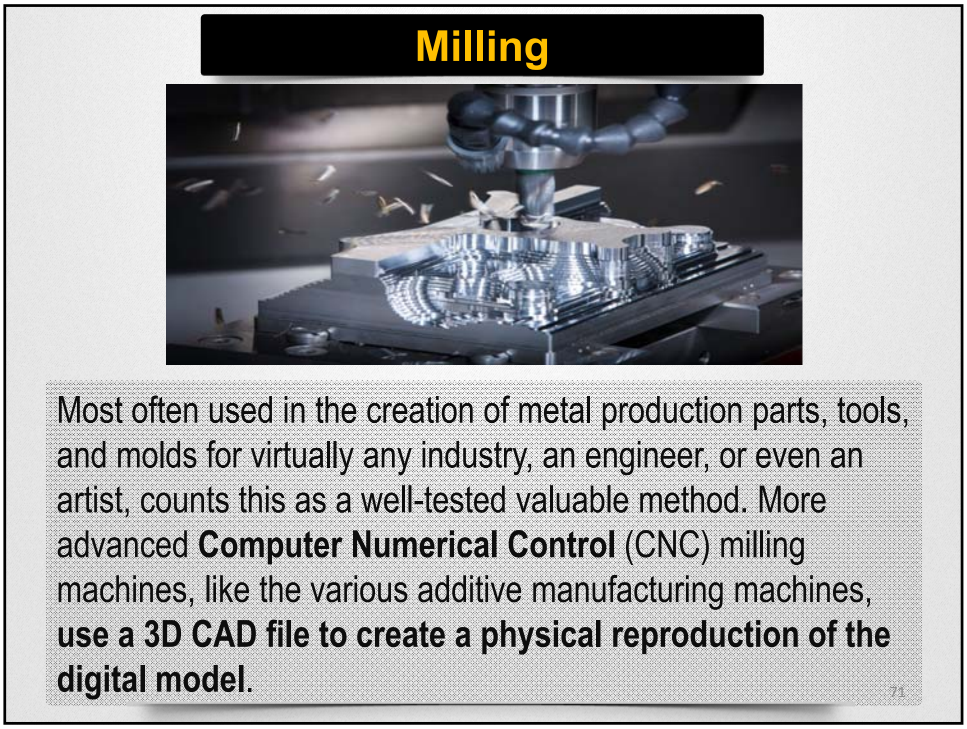


Additive Manufacturing

There are a variety of additive manufacturing equipment manufacturers and processes on the market. The software within these machines **generates the layering instructions and directs the deposition of successive layers of material** needed to build up the physical part.

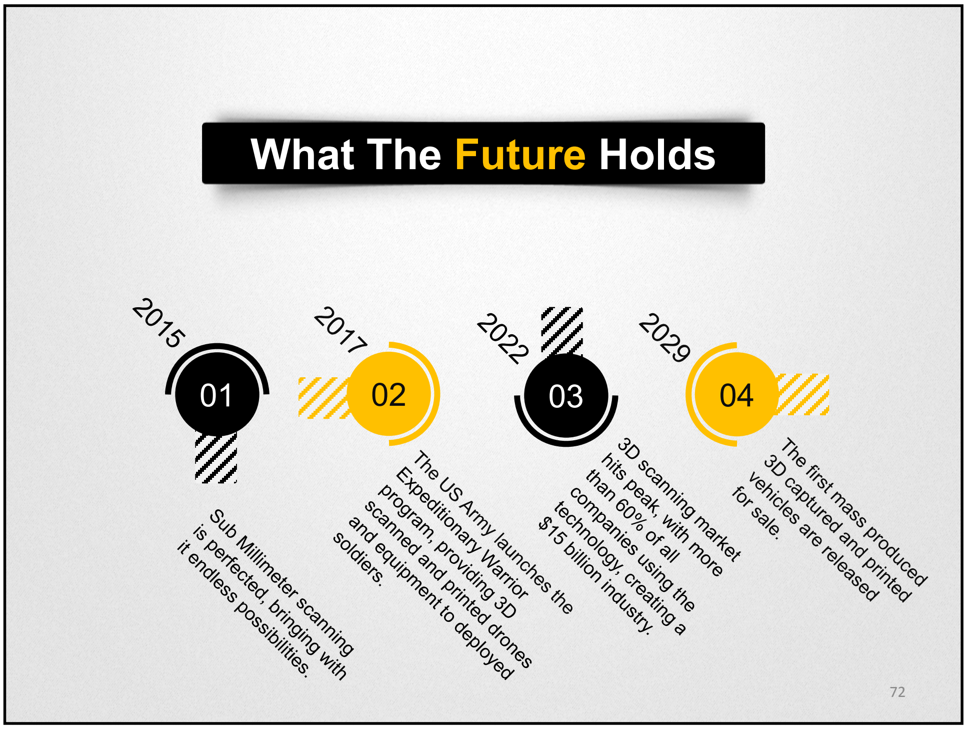

Additive manufacturing
Subtractive manufacturing

In comparison with traditional subtractive manufacturing methods in which a block of finished material is machined down to make a product, **additive manufacturing methods are fast, use less energy, and generate less waste** material.



Milling

Most often used in the creation of metal production parts, tools, and molds for virtually any industry, an engineer, or even an artist, counts this as a well-tested valuable method. More advanced **Computer Numerical Control** (CNC) milling machines, like the various additive manufacturing machines, **use a 3D CAD file to create a physical reproduction of the digital model**.



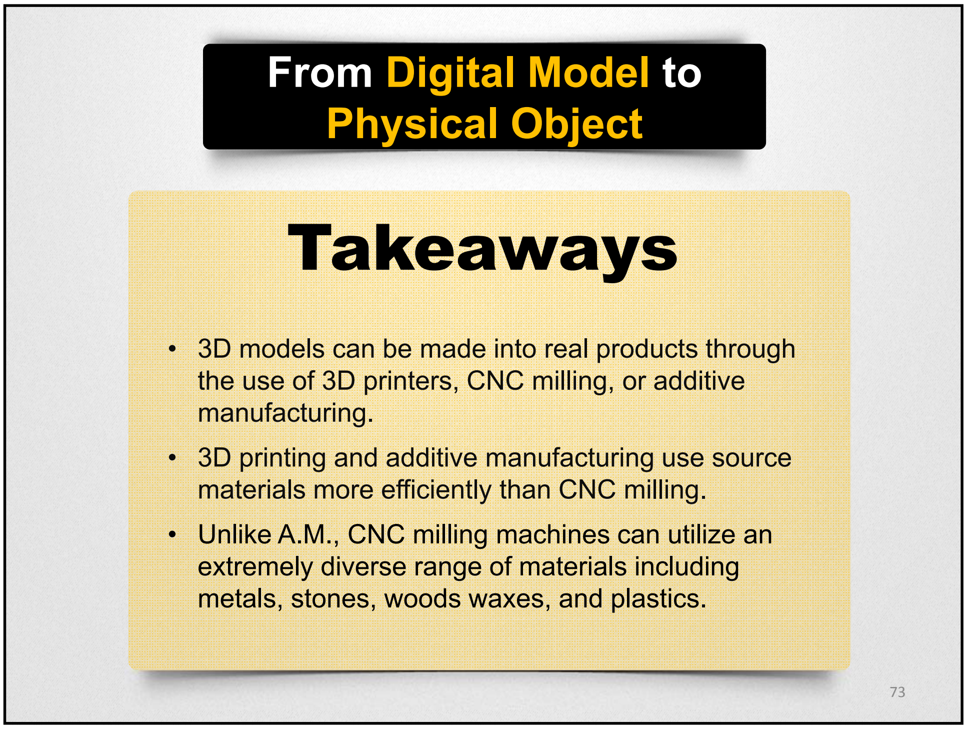
What The Future Holds

2015 — 01: Sub Millimeter scanning is perfected, bringing with it endless possibilities.

2017 — 02: The US Army launches the Expeditionary Warrior program, providing 3D scanned and printed drones and equipment to deployed soldiers.

2022 — 03: 3D scanning market hits peak, with more than 60% of all companies using the technology, creating a $15 billion industry.

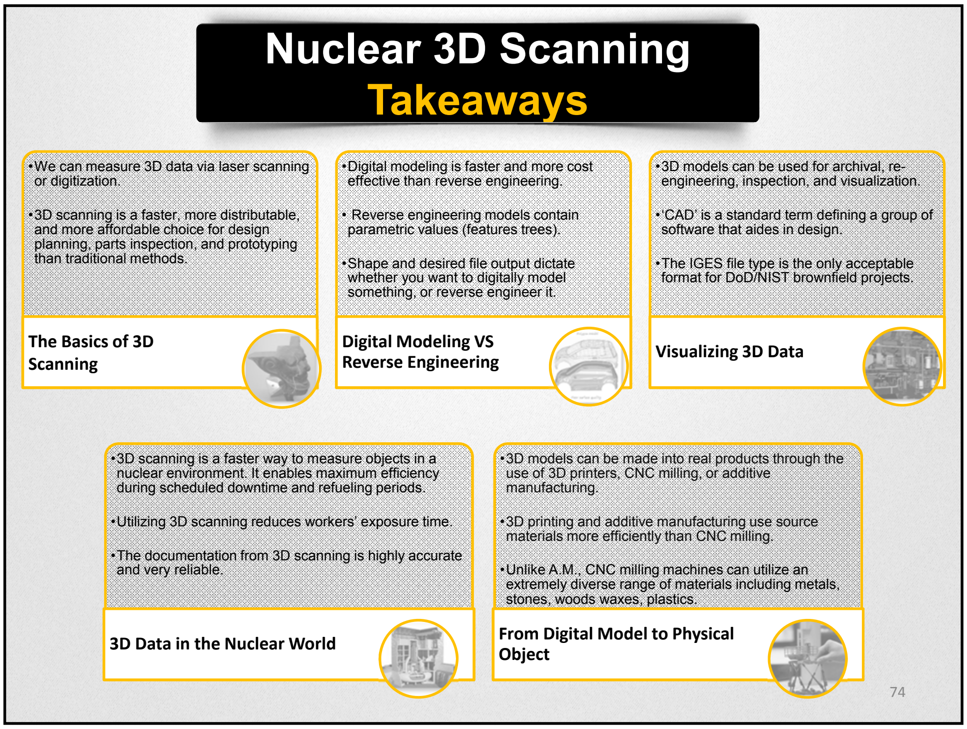
2029 — 04: The first mass produced 3D captured and printed vehicles are released for sale.



From Digital Model to Physical Object

Takeaways

- 3D models can be made into real products through the use of 3D printers, CNC milling, or additive manufacturing.
- 3D printing and additive manufacturing use source materials more efficiently than CNC milling.
- Unlike A.M., CNC milling machines can utilize an extremely diverse range of materials including metals, stones, woods waxes, and plastics.



Nuclear 3D Scanning Takeaways

- We can measure 3D data via laser scanning or digitization.
- 3D scanning is a faster, more distributable, and more affordable choice for design planning, parts inspection, and prototyping than traditional methods.

The Basics of 3D Scanning

- Digital modeling is faster and more cost effective than reverse engineering.
- Reverse engineering models contain parametric values (features trees).
- Shape and desired file output dictate whether you want to digitally model something, or reverse engineer it.

Digital Modeling VS Reverse Engineering

- 3D models can be used for archival, re-engineering, inspection, and visualization.
- 'CAD' is a standard term defining a group of software that aides in design.
- The IGES file type is the only acceptable format for DoD/NIST brownfield projects.

Visualizing 3D Data

- 3D scanning is a faster way to measure objects in a nuclear environment. It enables maximum efficiency during scheduled downtime and refueling periods.
- Utilizing 3D scanning reduces workers' exposure time.
- The documentation from 3D scanning is highly accurate and very reliable.

3D Data in the Nuclear World

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From Digital Model to Physical Object

THANK YOU

RCNET 3D Scanning Module Name:_________________

PRE Assessment ***TEST*** Date:_________________

This assessment is designed to determine your pre-existing knowledge about 3D Scanning technology and its nuclear applications. This assessment should be taken prior to starting the ***RCNET Nuclear 3D Scanning Module*** *and will not count as a grade.*

Please circle the correct answer.

1. What is 3D scanning?
   a) A non-destructive technology used to digitally capture a physical object in 3D space.
   b) A method for archiving letters of the alphabet.
   c) A destructive technology that digitally measures an object before completely destroying it.
   d) None of the above

2. What were the obstacles to 3D scanning during its early years?
   a) Small storage space
   b) Slow data transmission
   c) Lack of optical sensors
   d) All of the above

3. What type of optical technology does 3D scanning use?
   a) Slant
   b) Stripe
   c) Silhouette
   d) Sequential

4. How is 3D data obtained?
   a) Laser scanning
   b) Digitization
   c) CMMs
   d) All of the above

5. What is the main difference between laser scanning and digitizing?
   a) Laser scanning is non-contact, while digitization requires contact to measure data.
   b) The power of the laser beam.
   c) Lack of 3D sensors.
   d) They are essentially the same.

6. How does laser scanning measure the surface of an object?
   a) By projecting a 3D ruler onto the surface of the object.
   b) Virtual contact probes.
   c) The user inputs the object's measurements before scanning.
   d) By using the TOF (Time of Flight) method

7. 3D scanners create _______________ of data from the surface of an object.
   a) Data clouds
   b) Point clouds
   c) Partial clouds
   d) Cloud vectors

8. What do we do with the raw 3D data once we capture it?
   a) Turn it into 3D models
   b) Archive it for 'As-Built' purposes
   c) Use it to restore or replicate a damaged object
   d) All of the above

9. What can 3D models be used for in a nuclear environment?
   a) Quality control
   b) Reverse engineering
   c) Dimensional object analysis
   d) All of the above

10. What two factors help the user decide if they need to perform digital modeling or reverse engineering?
    a) The type and size of scanner used
    b) The shape of the object being scanned and the desired file type
    c) The time of the year and location of the object
    d) None of the above

11. The importance of parametric models in reverse engineering is that they have ____________ that are fully editable.
    a) Feature trees
    b) Model trees
    c) 3D trees
    d) None of the above

12. The three main types of models used in 3D scanning are polygonal, hybrid, and __________.
    a) Vector
    b) NURDS
    c) NURBS
    d) Point

13. What is one of the drawbacks of using 3D scanning?
    a) Holes and internal parts require additional scanning to capture

b) It generates a large amount of heat
c) It takes more time to complete than traditional measurement methods
d) It is noisy.

14. How can 3D scanning benefit a nuclear environment?
a) Saves time
b) Cuts costs
c) Data is more reliable
d) Collaboration is greatly increased
e) All of the above

15. Converting to 3D scanning saves the average nuclear plant how much each year?
a) 25%
b) 5-7%
c) 1%
d) 50%

16. What does CAD stand for?
a) Computer Aided Design
b) Calculated Air Dosimeter
c) Coordinate Accelerated Divide
d) None of the above

17. What CAD file type does the DoD and NIST require for all brownfield projects?
a) SEGI
b) STL
c) IGES
d) SLDPRT

18. Completed 3D models can be sent to downstream applications for digital backups, inspection reports, reproduction, and ______________.
a) Virtualization
b) Rescanning
c) Visualization
d) None of the above

19. Digital models converted to physical objects for prototyping are known as _________________.
a) On demand products
b) Rapid devices

c) The T1000
d) Manufacturing prototypes

20. The difference between additive manufacturing and subtractive manufacturing is:
    a) The type of material used
    b) The method of production
    c) Both A and B are correct
    d) Neither A nor B are correct

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POST Assessment ***TEST*** Date:__________________

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