

Manufacturing Insights

Reverse Engineering

<p>SCENE 1.</p> <p>CG: FBI warning white text centered on black to blue gradient</p>	<p><u>WARNING</u></p> <p>Federal law provides severe civil and criminal penalties for the unauthorized reproduction, distribution or exhibition of copyrighted video media</p> <p>© SME 2006</p>
<p>SCENE 2.</p> <p>SME logo with music</p>	
<p>SCENE 3.</p> <p>CG: Title of video</p> <p>CG; company logos fly in and hold</p>	<p>MUSIC UP AND UNDER</p> <p>Manufacturing Insights, Manufacturing Engineering Magazine's video series for process improvement. This program will explore the latest developments in reverse engineering and the role that it is playing in design, manufacturing and inspection.</p> <p>We traveled to Direct Dimensions, a full service 3D laser scanning and digital modeling firm. Founder and president, Michael Raphael, describes the process and applications for laser scanning and touch probe systems.</p> <p>We will also see how Realadi Inc. a provider of reverse engineering services, applies technology like white light scanning. Rick Baldini,</p>

president, shares his insights on the process, applications and the future.

Next we talked with Rick Moore, rapid technologies lab leader, and James Orndoff, engineering technician, about their experience in using the technology for design of new chemical and biological defense equipment within the U.S. Army's Advanced Design Manufacturing Team.

We also spoke with application engineer David Mann about the role reverse engineering plays in Roush Manufacturing's design, prototyping, and manufacturing services.

And finally, we went to GKS Inspection Services, a third party dimensional inspection company. Steve DeRemer, general manager, discusses the company's use of both coordinate measuring machines, commonly called "C - M - Ms", and laser scanning.

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	<p><u>NARRATION (VO):</u></p> <p>Reverse engineering is the process of capturing 3D, digital definitions of physical objects. It is a tool for design, visualization, documentation, analysis, manufacturing, tooling and inspection. It spans nearly every process in design and manufacturing of products.</p>
	<p>NARRATION (VO):</p> <p>“Reverse engineering,” {pause} “3D scanning,” {pause} “data capture,” {pause} “digitizing”; {pause} these terms are used interchangeably. While industry has not settled on a name for the technology, it is clear that reverse engineering is much more than the sole application of copying and interrogating an existing product’s design.</p>
	<p>NARRATION (VO):</p> <p>With the wide array of applications and the technological advances, the use of reverse engineering is expanding, but the industry has only scratched the surface.</p>

	<p>Rick Baldini (RB) (Ric Baldini.mp4 11:26:08-11:32:29) what we see needs to happen is a cultural change, that's the biggest obstacle right now. The technology is there.(12:28:22-12:36:13) It's a technology that people have to understand how to use and how it can apply to their own business.</p> <p style="text-align: center;">-- TOUCH TO BLACK --</p>
	<p>NARRATION (VO): There are nearly one hundred companies that offer reverse engineering technology, which can make the topic daunting. However, as the experts explain, starting with a general understanding of the differences and advantages—by category—can make the technology easier to understand.</p>
<p>Fly in of all three technologies. Hold and move to background as next flies in.</p> <p>Arm: Roush B-Roll ~2:14:34+</p> <p>White light: Realadi B-Roll ~7:53:44:00</p> <p>Laser: Realadi B-Roll ~8:19:25:25</p>	<p>RB (14:50:20-15:19:27) In today's marketplace there are a lot of options. We boil it down to three basic categories. The portable CMM machine, where you can physically contact the object with a rigid arm to get discrete points. Then there's the white light systems that can look at broad areas and give you very dense coordinate point clouds. Then there's the laser based systems that utilize reflective laser or time of flight to determine where the actual location of the surface is.</p>

<p>Hold previous shots and fly in a stationary CMM shot GKS b-roll ~4;06:21:00</p>	<p>NARRATION (VO):</p> <p>While primarily used as a touch probe method for inspection and quality control, the stationary CMMs also fit in a discussion of reverse engineering.</p> <p>Additionally, both the portable CMMs, which are articulated arms, and the stationary CMMs can be fitted with laser scanning technology, which turns them into non-contact scanning systems.</p> <p>{pause}</p>
	<p>NARRATION (VO):</p> <p>When starting a reverse engineering project the first decision to be made is whether to use contact or non-contact processes. Then, you must consider other requirements such as: the number of points needed, desired precision, system portability and the time for the process.</p>
<p>Side by side shots: touch arm and laser arm Direct Dimension b-Roll ~ 6:19:28:29 and ~5:58:30:00</p>	<p>Michael Raphael (MR) (Tape DD - Mike Raphael.mp4 19:46:22- 19:56:05) The contact systems we use provide the ability to collect geometric information very rapidly and accurately on a touch basis that's very deliberate. (20:04:11-20:14:02)The scanning technologies we offer provide the ability to scan very organic and naturally flowing surfaces very rapidly to capture all the surface.</p>

<p>Same as above, two new clips</p> <p>Roush B-Roll ~2;16:09</p> <p>Realadi B-roll scene of scanning with aircraft prominently in background</p>	<p>RB (16:13:03-16:28:03) For instance, we might use a discrete touch probe to get a hole pattern or a fastener pattern. If we need to look at global surfaces or something as large as a fuselage, we'll put white light systems there to capture the entire area.</p>
<p>GKS B-roll ~3:43:40:00</p>	<p>Steve DeRemer (SD) (Steve_DeRemer.mp4 2:42:15-3:01:10) We decided to add laser scanning because we observed sort of a void in the market for free form surface measurement. There really, at that time, wasn't a lot of technology out there for measuring free form geometry, other than CMM's taking discrete points</p>
<p>CMM shot</p> <p>GKS B-roll ~4:06:21:00</p>	<p>SD (11:01:05-11:18:15) The advantages of CMM are that it is really good for exact, precise measurements. CMM can take prismatic features, prismatic being planes, cylinders, holes, things of that nature, and the CMM is very good at getting down inside those features and taking those measurements.</p>
<p>GKS B-Roll ~3:49:00:00</p>	<p>SD (11:18:08-11:33:12) A laser scanner, the only limitation between it and a CMM is a laser scanner is based on line of sight. It's a light-based system, so it's not going to get down inside holes and crevices very well.</p>

	<p>SD (3:41:18-3:54:01) The line is drawn really non-contact vs. contact measurement. The contact, the older style, which is a CMM, relies on a touch probe actually touching the part, physically touching it. (4:06:25-4:12:28)Laser scanning is good because it doesn't do either one. It doesn't touch, it doesn't deform the part</p>
	<p>NARRATION (VO):</p> <p>In some cases electing to use non-contact scanning systems may be based on the object being pliable or soft; or specifications that an object may not be touched, as is common with antiquities.</p>
	<p>NARRATION (VO):</p> <p>It is important to note that the technologies are complementary. Many companies have both contact and non-contact systems, and for non-contact scanners, most have access to multiple technologies.</p> <p>Rick Moore explains..</p>
<p>Army B-Roll ~5:06:44:19 & 4:55:48:14</p>	<p>Rick Moore (RM((Army - Rick Moore.mp4 26:35:10-27:02:00) It basically gives us more tools, because no two jobs are the same. We use laser scanning for the complex shapes, complex geometries such as a protective mask or head form. We use the point probe with revworks to basically capture prismatic geometry, geometry that we can keep in our native CAD environment</p>

	<p>NARRATION (VO): {delivered as an "aside"}</p> <p>Revworks is a software application that uses a touch probe system as an input device for SolidWorks solid modeling software.</p>
<p>Roush B-Roll~2:01:50 & 2:25:07:09</p>	<p>Dave Mann (DM) (Dave_Mann_Interview.mp4 13:30:03-13:54:19) We would use the CMM on fixtures and tooling that the customer is only requiring a few points, geometric measurements, holes, slots. One of the advantages of the ATOS is that it records up to 1.5 million points per shot</p>
	<p>NARRATION (VO): {delivered as an "aside"}</p> <p>ATOS is a white light scanner from GOM</p>
<p>Roush B-Roll~2:01:50 & 2:25:07:09</p>	<p>DM (6:48:20-7:09:09) We have multiple technologies in order to give the customer what he wants. If he is looking for a full surface scan, we'll use the ATOS Two. If he's looking for just some geometric measurements on the underneath of a vehicle, we'll use a Roamer. If we're measuring fixturing and tooling, we'll use the stationeries.</p>
	<p>NARRATION (VO): {delivered as an "aside"}</p> <p>Romer/Cimore offers articulated arms with both touch probe and laser scanning.</p>
	<p>NARRATION (VO):</p> <p>Precision and accuracy are imperative in most applications. However, the distinction between contact an non-contact processes is blurring.</p>

	<p>DM (22:56:26-22:06:17) One of the most common misconceptions I would say, is that the technology isn't advanced enough to produce extremely accurate results</p>
	<p>SD (9:53:25-10:06:22) The accuracy of the laser scanner is getting better as time goes on, they're getting closer and closer to that of a CMM. In fact, depending on the manufacturer that you ask, they're right in line with what a CMM can do.</p>
	<p>NARRATION (VO): Often, downtime or transportation cost can influence technology selection.</p>
<p>GKS B-Roll ~4:01:03:00</p>	<p>SD (5:21:04-5:39:11) An ARM system enables us to go out into the field and take measurements on site, the benefit of that being the customer doesn't have to ship either their parts or their molds or tools to our facility. A lot of times that's beneficial because their molds and tools don't have to be pulled out of production,</p>
	<p>NARRATION (VO): The advantages of portability are also available from many of the laser and white light systems. In-situ measurement offers the convenience of have the technology come to the part to minimize operational downtime or transportation challenges.</p>

	<p>NARRATION (VO):</p> <p>There are many different types of scanning technology. And while there is a lot of similarity, there can be considerable difference.</p>
<p>Direct Dim b-Roll ~6:07:03:26 to 6:13:18:21 {Show full scanner shot, close up of scanner head and scanning of coin}</p>	<p>MR (23:58:10-24:33:01) One of our technologies is the CMM or coordinate measuring machine based laser line scanner. This is a laser head mounted to the bottom quill of a CMM. It's computer controlled, motorized and joystick driven, where we can in a very controlled fashion scan over small objects and capture literally micron-level detail. In this case we have creon technology mounted on a very accurate CMM, and we can capture within a one-line scan, 600 points per line at 34 lines per second as we move across the object.</p>
<p>Dir Dim B-Roll ~6:04:58:23</p>	<p>MR (24:47:00-25:00:05) Moving up the ladder in terms of scale, the next technology we operate with typically is an arm-based laser scanner. This provides us with portability and manual articulation so that we can move about the surface of the object.</p>

<p>Dir dim B-Roll ~6:15:13:00</p>	<p>MR (25:56:00-26:14:06) Another scanner technology we use frequently is a patch-based scanner. This is essentially a 3D laser scanning camera. Within seconds it scans a patch of maybe up to 3 foot by 3 foot. We can capture something like the side of a car very quickly and very accurately by moving the patch based scanner about the object.</p>
	<p>NARRATION (VO): 3D scanning technologies are also used for long range data capture for architecture, civil engineering, surveying and mapping.</p>
	<p>NARRATION (VO): The technologies use many methods for calculating 3D spatial data, but the most common is triangulation.</p>
<p>GKS B-Roll ~3:48:05:00</p>	<p>SD (7:28:10-744:04) Laser scanning is based on a triangulation principle, where a beam of light is projected down, sort of a slice of light if you want to call it that. There are two CCD cameras that look at the shape of that line once it's projected onto the part</p>

<p>Roush b-Roll ~1:47:16:29</p>	<p>DM (7:38:00-7:59:25) The ATOS Two is a white light scanning system. It works by projecting a contrasting white and dark pattern on your part. There are two high resolution video cameras that see that pattern at different angles, and calculates points at that contrast of light and dark.</p>
<p>Realadi B-Roll ~7:53:44:00</p>	<p>RB (18:39:08-19:06:08) With all the options out there, many times it comes down to precision vs. data acquisition speed. The white light systems like the ATOS and the I-Metric will acquire huge amounts of data in a measurement volume that's roughly a meter. But the acquisition time may take as much as 20-30 seconds. The laser based systems may acquire data much faster, but they'll use a smaller volume,</p>
	<p>NARRATION (VO): CMM technology captures a few points per minute, versus the thousands of points per second when using scanning technology.</p>
	<p>NARRATION (VO): Another major aspect of the Reverse Engineering process is software. As with the scanning systems, there are many options for processing the 3D scanner data, and each has its own advantages.</p>

	<p>SD (21:27:18-21:39:19) We use a variety of softwares. It depends on whether we're trying to do a product comparison to a CAD model, or a complete reverse engineering job.</p> <p style="text-align: center;">-- TOUCH TO BLACK --</p>
<p>Note For following Scenes, maybe use some of the still we have of representative parts</p>	<p>NARRATION (VO):</p> <p>Applications for reverse engineering are as diverse as the companies that benefit from the technology.</p>
	<p>RB (24:37:17-25:08:24) Reverse engineering has the ability to connect the imagination to a computer driven world, so it's the best of both world. That application space affects mature products or legacy products that were developed and designed and manufactured before the age of computers, and it also helps with the creative process today. We see application space both in existing hardware like old airplanes, or new things like animation for Walt Disney.</p>
	<p>MR (15:04:10-15:16:11) We have seen in our history such a wide range of applications. We go from art to sculpture to industrial to medical to aerospace to automotive.</p>
	<p>MR (30:46:12-30:58:02) we tend to find a great deal of work in the military and defense contracting areas, where folks are trying to keep airplanes and military assets going longer</p>

	<p>MR (32:07:20-32:39:27) These technologies are excellent for solving problems related to aging components within the helicopters, airplanes, that the military tries to keep flying longer. As components wear out, as these components are very old, the suppliers are no longer available, the suppliers may have gone out of business, the tooling is gone, the drawings may not exist any more. We're able to capture these components very accurately, create CAD models, such that these parts can be remanufactured.</p>
	<p>RB (23:41:00-23:51:08) We have focused on a lot of design and manufacturing applications as small as a keypad for a car key, or as large as an entire fuselage for an airplane. (23:56:00-24:07:18) We've looked at things like tooling for hot tubs, modifying custom cars, and we actually know what the next generation of NASCAR vehicle is going to look like before anyone else does.</p>
	<p>RM (24:34:29-24:53:13) The primary reasons and applications are to extract 3D data from physical objects, and to bring that data back into a virtual environment, such as CAD, as quickly and accurately as possible, to basically design, develop and improve our chemical and biological defense equipment</p>

	<p>NARRATION (VO):</p> <p>Design, documentation, visualization, documentation, analysis, manufacturing and inspection...this is the broad range of 3D scanning applications. And, this is the reason that industry resists the term reverse engineering.</p>
<p>Army B-Roll Robot shot ~4:33:40:05 & Software processing shot ~4:48:47:13</p>	<p>RM (30:46:15-31:17:03) Some of the applications we've done recently, we've gotten into unmanned ground vehicles, UGV's or robotics. That basically allows a soldier to send a robot into dangerous situations. We've taken commercial off-the-shelf robots, reverse engineered or got data from the cargo base, so we can basically outfit the robots with our chem bio detection equipment...(31:41:03-31:55:01)so rather than retrieving technical data packages or drawings, we're able to take that existing object and then basically recreate it in our environment.</p>
	<p>NARRATION (VO):</p> <p>Joel Semanski, a senior engineer at Georgian Aerospace Group, explains how Realadi helped them modify an aircraft component.</p>

	<p>Joel Semanski(JS) (Joel Simanski.mp4 1:26:28-1:32:20) We had a job where we wanted to replace some windows in a Saber Liner.</p> <p>(1:53:27-2:00:02)we don't have any original data on the windows for shape or fit. (3:24:09-3:37:07)Where it goes in the airplane, it's contoured in all different directions, and it would be very difficult to hand-generate a drawing to make a part to fit where the window goes</p>
	<p>RB (26:03:00-26:23:19) for Columbia Aircraft, we've looked at the entire fuselage and done a complete surfacing on their fuselage to verify their tooling. We've also looked at a Corvette customization project, where we took a 1962 Corvette body style and transitioned that so it would fit on a brand new C5 chassis,</p>
	<p>DM (11:34:04-12:20:22) When Roush was developing the Roush Mustang, the rear spoiler was designed on a vehicle that wasn't available yet. When the vehicle finally became available, they found it wasn't exactly fitting correctly, there were some gaps in the mounting surfaces. We took some deck lids and we scanned them, and discovered the sheet metal had a crown in it. So the designers, the tool designers made some adjustments based on that scan data on an actual part.</p>

<p>Dir dim B-roll ~5:49:55:25</p>	<p>MR (46:04:14-46:16:07) Probably the most special was the scanning of the Liberty Bell in Philadelphia. We were asked to create a digital model of the Liberty Bell, ultimately for a fabrication of a new Liberty Bell from this information.</p> <p style="text-align: center;">-- TOUCH TO BLACK --</p>
	<p>NARRATION (VO):</p> <p>Reverse engineering starts with preparation and it progresses through a work flow that includes scanning, data processing and file generation.</p>
	<p>SD (16:52:10-17:16:29) The idea of setting a part down and just scanning it without any user interaction, is just an old wives tale. There is nothing out there that I'm aware of that can do it. I commonly get questions from people referring to the "Big Red Button." You set a part down and you simply push a button and it simply does everything for you. To my knowledge, that is not out there.</p>
	<p>James Orndoff (JO) (Army - James Orndoff.mp4 15:56:24-16:11:02) When we scan a part, the first thing we look at is the geometry of the part, which geometry we want to capture, what features or things we want to look at.</p> <p>(16:34:27-16:42:07)But usually it's about 75% setup and 25% percent actual scanning.</p>

	<p>NARRATION (VO):</p> <p>While the scanning may take only a few minutes, as James Orndoff stated, preparation can take time. Preparing for scanning begins with a surface that the scanner can "see."</p>
<p>GKS B-Roll ~3:46:46:24</p>	<p>SD (17:39:23-18:10:27) There are machined parts or chromed parts, that are problematic from using a light based measurement system like a laser scanner or white light system, because the laser or white light goes onto the surface and it's just reflected away into a non-usable source of information. What we do to work around that is we use a developer spray that is sort of like a talcum powder or chalky spray.</p>
<p>Roush b-roll ~1:28:33:04</p>	<p>DM (14:27:02-14:43:03) The scanner needs to see an even contract surface. Because it is a white light scanner it depends on that white-dark contrast. (14:52:13-14:58:16)Anything that's reflective or transparent, the scanner won't see it.</p>

<p>Next 3 scenes Roush from 1:29:47:01 through 1:38:35:00</p>	<p>DM (15:01:00-15:07:18) After we paint it, we target it with an uncoated target. (15:29:09-...)After we put the targets on, (15:51:02-16:18:20)we do a photogrammetry session, which is taking digital images around the part, with a coated target and a known distance in the scale bar. The computer will then assemble all those images into one three-dimensional image, and triangulate the positions of all the black and white uncoated targets.</p>
	<p>DM (16:45:00-16:58:12) the scanner sees those black and white targets and recognizes where it is on the part based on the distance of the targets from each other. It uses those as a reference point.</p>
	<p>RB (19:27:24-19:42:23) each of the snapshots from the metrology, the white light system if you will, is one patch of the quilt. The photogrammetry provides a grid on which to hang all of those patches so they seam together perfectly.</p>
	<p>NARRATION (VO): Photogrammetry is one method for referencing individual scans. It can also be used as standalone data capture technology. In nearly all cases, multiple scans are needed to capture a complete geometric definition.</p>

	<p>SD (20:20:00-20:42:01) The number of scans we implement on any particular part depends a lot on the geometry of the part that we're trying to scan. If you give me a bowling ball, I can probably scan that in two or three or four scans. If you give me a really intricate transmission component that has lots of ribs and features that are difficult to describe, that may entail numerous scans.</p>
	<p>NARRATION (VO):</p> <p>Scanning the part is just the beginning. After a part is scanned, the raw data—the point cloud—must be processed with specialized software. Contrary to some perceptions, data processing is not, in most cases, an automated process that is completed in a few minutes.</p>
	<p>JO (22:01:04-22:20:05) Basically the major steps that we perform is we capture the raw 3D point data. We eliminate the outliers, which is the scatter data, the data that's not relevant to the part. We align the raw scans. (22:24:27-22:38:20)Once we align it, then we polygonize it, that's when we merge all the parts together and basically combine them with triangles. Then once we merge it, we surface it, we nerve surface it from there</p>

	<p>DM (19:59:12-20:37:18) When you scan there could be anywhere from five to 150 different individual scan shots. Some of the point clouds may overlap with others. You'll have points on top of points. When it's doing the postprocessing, the computer is going to align all those individual scan shots, it's going to mesh them together, delete the overlap, and then triangulate into one large point cloud.</p>
	<p>RB (26:51:11-27:29:13) There is a chain that connects the original data acquisition to the final CAD model, and each one of these links are important and potentially a product unto itself. The first thing that's done is to clean up the data. There's usually scatter in the data, and some outliers, so that's the first thing that's done. Then there are surfaces that are put onto it, and smoothing and filling holes in the data, places where the metrology didn't quite capture enough data for you. After that it's transitioned into a three-dimensional CAD package for full solid modeling</p>
	<p>NARRATION (VO):</p> <p>The time needed to output a file for design, analysis or inspection is dependent on several factors. The two most important are the desired data state and the file format, both of which are dictated by the intended application.</p>

	<p>NARRATION (VO):</p> <p>The data state is either as-built or as-designed. An as-built condition uses 3D data that reflects the part as it was manufactured. The as-designed state reflects the original design intent without variances induced by the manufacturing process.</p>
	<p>NARRATION (VO):</p> <p>The other factor is the file format. The simplest and fastest is the polygonal model, or STL file. As the data progresses further towards native 3D CAD data, more work is needed.</p>
	<p>NARRATION (VO):</p> <p>Not every job requires a 3D CAD model, so it is important to be realistic when defining your file format requirements.</p>
	<p>MR (44:50:19-45:00:02) The choice of output format depends on the customer's requirements, what their end use for the data is, what their software capability is, what packages they have on their end.</p>

	<p>MR (44:04:14-44:29:10) The raw data would be delivered as ASCII format, it's literally just X-Y-Z point clouds just in a text listing. The next is a polygonal format, which is the STL format commonly used for rapid prototyping, and we like to deliver typically watertight STL files. The next format would be nerves files, which allows us to translate directly into a CAD package. (44:33:20-44:40:25) The final solution would be a parametric model within a STEP format that allows you to take from one CAD package to another CAD package.</p>
	<p>RB (27:47:29-27:53:14) The amount of work that we actually have to do is driven by the requirements of our customer. (27:57:29-28:28:27)The original processing of the data results in a polymesh file or an STL file, and that can typically take anywhere from minutes to hours. After that, there's surfacing that takes place, and that usually takes somewhere between hours and days. If you need to go to a full solid model, that can take, depending on the complexity, a day to several days or a week.</p>
	<p>NARRATION (VO): When specifying CAD data, it is important to note that without additional work, the resulting 3D CAD file is only a dumb solid.</p>

	<p>RB (32:41:12-33:10:28) The industry likes to classify solid models into two different categories, parametric solids and dumb solids. The parametric solids carry with it the history used to create it in the native CAD package, so if any changes need to happen in that model—change of thickness, change of hole size—you simply go back to where that was created, change a few parameters, and boom, the thing regenerates. Dumb solids, on the other hand, don't have the luxury of that history</p>
	<p>NARRATION (VO):</p> <p>Therefore, the dumb solid from the scanning process is reference data that is used to construct a parametric solid from scratch.</p> <p>-- TOUCH TO BLACK --</p>
	<p>NARRATION (VO):</p> <p>Companies who own several different systems have also seen the benefits of using multiple technologies on a single project.</p>

	<p>SD (8:52:10-8:59:26) We select between the two approaches based on the goal of what the customer is asking for, what they're trying to get to. (9:15:13-9:27:23)Occasionally the two overlap. We actually have some occasions where we will laser scan an object, then physically lift it up, carry it over to a CMM, and then measure the same part on a CMM for certain features.</p>
	<p>SD (11:52:19-12:02:06) The benefits of that is that you can measure machined faces or machine features using a CMM much more accurately than you can scan them. (12:18:10-12:26:23)So we incorporate the scanning with the CMM when we need very good definition of exact features like planar faces and holes.</p>
	<p>MR (26:59:10-27:26:22) No one tool solves all problems on all projects. We have a wide variety of tools because we have a wide variety of problems that come at us, and a wide variety of industries we work in. We frequently will intermingle these various tools on any one project, because every project has different aspects to it. Most projects have at least geometric components or feature-based measurements that need to be captured, and/or complex shapes and surfaces that need to be captured.</p>

	<p>NARRATION (VO):</p> <p>Likewise, companies may use more than one software application to get the job done.</p>
	<p>MR (37:09:06-37:26:27) Just like the scanner tools, where we have a wide array of scanner tools, we have a wide array of software tools. No one software tool seems, for us, to have all the tools and all the functions and features we need to do all the projects we do within all the industries we work in.</p> <p style="text-align: center;">-- TOUCH TO BLACK --</p>
	<p>NARRATION (VO):</p> <p>Reverse engineering is rapidly growing. Since its inception, it has moved from a novel idea to a practical solution for many types of businesses in many industries. This has been fueled by both advances in technology and a growing willingness to adopt it.</p>
	<p>SD (12:34:14-12:40:27) I think quality professionals are beginning to accept scanning as a normal process</p>
	<p>SD (14:24:05-14:43:02) I think now people are seeing the cost benefits of scanning vs. the old style measurement. It's a lot cheaper now than it used to be to take a part, scan it, and obtain a CAD model on the back end, both from the scanning time, the data processing time, and the modeling time on the back end.</p>

	<p>SD (13:09:00-13:29:25) Another big benefit in scanning today is that it's a lot more accepted because the computing power that's out there today is a lot more powerful than it used to be. Ten years ago it could take hours or a day or two of computational time on a system to derive tool paths. Now it can take minutes to do the same thing</p>
	<p>MR (14:13:27-14:28:08) The technology has improved greatly in the last 11 years that we've been in business. One of the most important factors has been the improvement in computers. The speed of computers is just tremendous advancements every year. (14:41:20-14:51:19)The others are of course the advancements in lasers and laser technology, the portability and the weight of these pieces of equipment, and I think the pricing is coming down a great deal as well over the years.</p>
	<p>RB (8:52:15-9:03:19) We've seen advancements in both metrology and in software. On the metrology side, portability has been a tremendous advancement, it provides great access to a variety of markets.</p>

	<p>NARRATION (VO):</p> <p>The technology has matured and adoption has increased, but there are still many advances that industry is anxiously awaiting. One of the highest on any user's list is feature recognition.</p>
	<p>RM (32:17:02-32:39:01) we're looking for a way to take laser scanning, or getting data through laser scanning, and having the software be able to process some sort of feature recognition to turn the data from just point cloud data into some kind of intelligent data where you can control dimensions and tolerances like we like to do in our CAD environment.</p>
	<p>NARRATION (VO): With feature recognition, the software would recognize cylinders, spheres and planes and build in intelligence that eliminates the issues created by dumb solids.</p> <p>-- TOUCH TO BLACK --</p>
	<p>NARRATION (VO): While adoption is growing, the industry has only scratched the surface.</p> <p>Hardware and software advances will help to increase adoption, but there is still a need for information and understanding, and there may still be resistance to change.</p>
	<p>MR (19:01:26-19:08:28) One of the challenges that we see with our industry and our customer base is the lack of understanding of these deliverables and these output formats.</p>

	<p>RB (11:26:05-12:00:11) what we see needs to happen is a cultural change, that's the biggest obstacle right now. The technology is there. We see a threat factor as being a constraint with our customers. It's a two-edged sword actually. On the one side you see people who are afraid that their job is going away or it's going to have to dramatically change in order to adopt this technology. On the other hand you get people who think, my heavens, this is a magic, push-button technology, and it's going to work perfectly. That's not true either.</p>
	<p>NARRATION (VO):</p> <p>One area of advancement that can ignite industry growth is in low cost systems with automated processes. There are several companies that offer affordable, easy to use systems. As costs decline and automation increases, the experts agree that the industry will see increasingly strong growth.</p>
	<p>NARRATION (VO):</p> <p>Whatever you call it, reverse engineering, 3D scanning or 3D data capture, the technology is advancing, application breadth is growing and user ranks are swelling.</p>

	<p>SD (27:14:21-28:08:11) the advantages of reverse engineering and scanning, at least over the old methodology, it gives you a much more thorough feel for the geometry of the part that you have been tasked with measuring. For example, in using the older CMM approach, it may have been easier or more prone to missing areas of the part that were not to design, simply because the density of the points that were measured on the part were not dense enough to pick up these features that could later prove to be problems. A scanning approach to it, using either a white light or a laser, it will pick up almost every feature on that part, and it's really hard to have anything slip through the cracks when you're picking up the full 3D geometry of the part.</p>
	<p>SD (15:53:24-16:04:02) probably within 10 years almost every company will have scanning of some sort or another, whether they use it in house or they seek outside services.</p>
	<p>RM (32:43:22-33:13:07) the advantage is back to the readiness and quick turnaround of extracting data from something that exists, to not have to retrieve or have access to drawings or technical data packages, to be able to take items that are usually developed in house by us and either improve or redesign those objects, it gives us an advantage to do that quickly.</p>

	<p>MR (17:18:29-17:43:02) We see the capability to integrate these reverse engineering practices deeper into the manufacturing of more common place objects. I think more and more manufacturing companies, product design companies, industrial design companies, anybody making virtually anything, will adopt these technologies more rapidly in the near future because of the speed at which the technology is advancing.</p>
	<p>NARRATION (VO):</p> <p>When designing, manufacturing or inspecting complex parts or organic shapes, 3D scanning is an ideal complement to traditional technologies. In the coming years, it will be a commonly used input device in companies of all sizes and industries of all types.</p> <p>Reverse engineering is a complementary tool for designers, engineers, machinists, molders and quality inspectors that need to convert physical objects into 3D digital product definitions.</p>