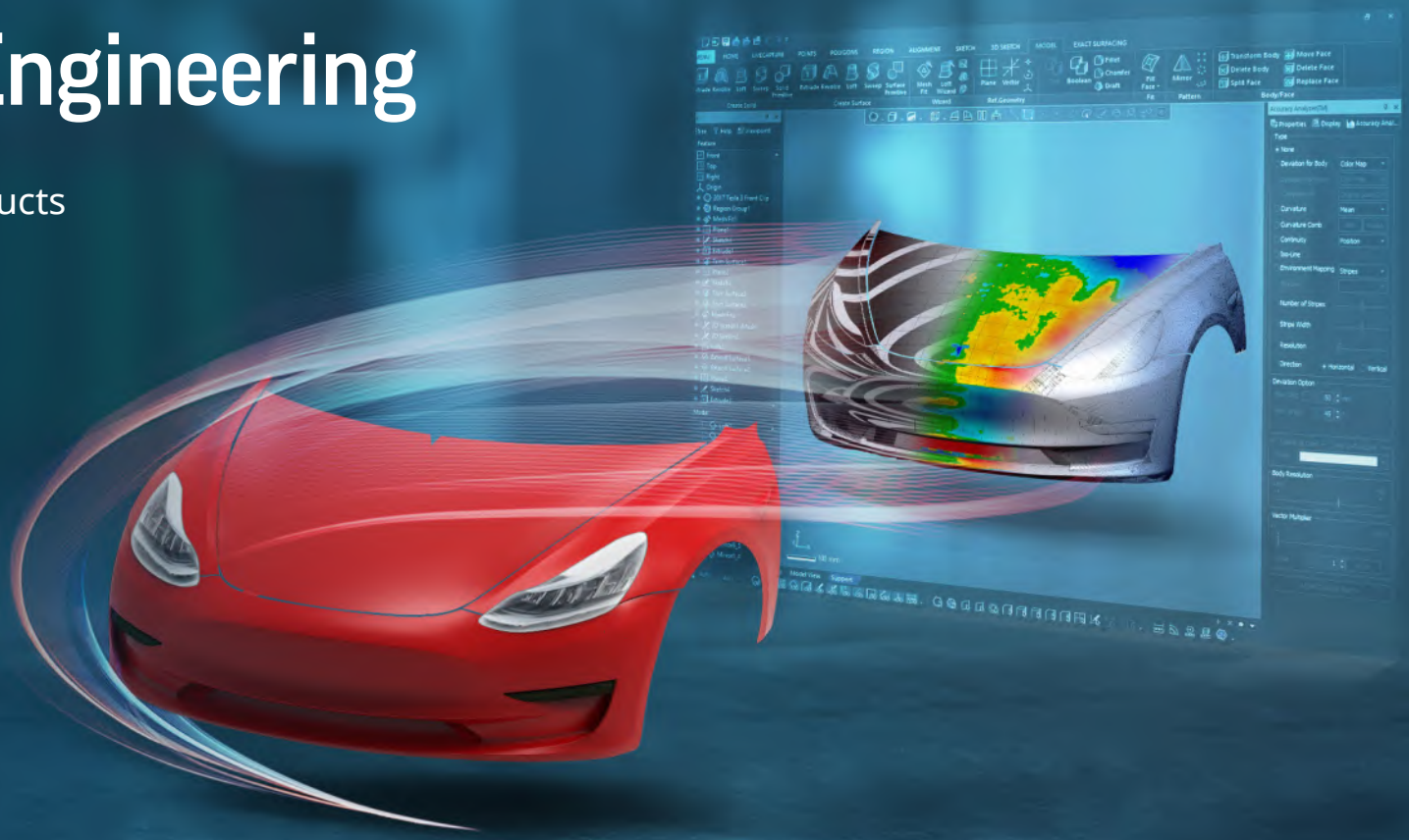
eBook

Drive Product Innovation with Reverse Engineering

Extract New Value from Old Products



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3D SYSTEMS

Contents

Defining Reverse Engineering

Every time you capture physical reality to use as part of your digital design process, you are engaging in reverse engineering.

Whether you call it reverse engineering or something else, you are almost certainly measuring physical parts and using those dimensions to inform multiple aspects of your product designs. And you are probably doing this multiple times throughout each product lifecycle.

A modern approach to reverse engineering—backed by the latest measurement technology and software—can drive value throughout your business.

- Rebuild CAD data for legacy parts and tooling.
- Design new custom products that fit in, on, or around existing ones.
- Document changes made post-prototype or manufacture.
- Recreate non-existent or lost CAD data for parts and molds.
- Convert physical parts into CAD for new product designs.

As a practice, reverse engineering is as old as engineering itself. Thanks to continuing advances in hardware and software technology, reverse engineering is now so fast, accurate, and effective that it has become an integral part of modern product design.

> "The shift from 2D to 3D analyses has made a tremendous difference. It has enabled us to expand our analyses and generate replicable results."
>
> Dr. Robert Z. Selden, Jr., Center for Regional Heritage Research Associate, Stephen F. Austin State University, Nacogdoches, Texas, USA

Inspiring Great Design

Every great design is inspired by another.

Pioneering manufacturers are deploying modern reverse engineering to drive business value throughout the design, manufacture, and maintenance of their products.

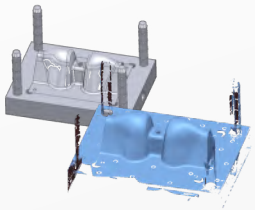
> "We've always built cool stuff. But now, with the added technology, we're building even cooler stuff—in a lot less time."
>
> Dave Kindig, Owner, Kindig-It Design, Salt Lake City, Utah, USA

Additive Manufacturing

Reapply design intent to generative mesh results from topologically-optimized parts and get feature-based results that you can edit and use within CAD.

Supply Chain Optimization

Reduce lead times and centralize your knowledge and manufacturing capability by creating a digital inventory for critical parts with high wear or parts that often fail.



Sheet Metal Stamping

Scan stamping dies that have been modified post production so that you can modify the original CAD designs to reflect real, as-built conditions.

Product Design

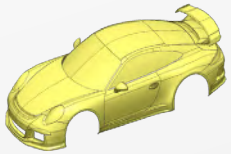
Significantly reduce time to market by using reverse engineering to combine off-the-shelf parts and assemblies with custom-designed parts.

Casting

Quickly create manufacturable digital models for broken castings with no design plans to rebuild and remanufacture critical components using 3D scanning and scan-based design.

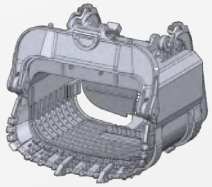
Redesign and Customization

Start with an existing part—like a vehicle, vehicle component, or product that precisely fits the human body—and use it as a reference to create brand new or custom-fit parts.



Prototyping

Create manufacturable designs faster by digitizing hand-built prototypes and prototypes typically fabricated with foam, cardboard, or modeling clay.



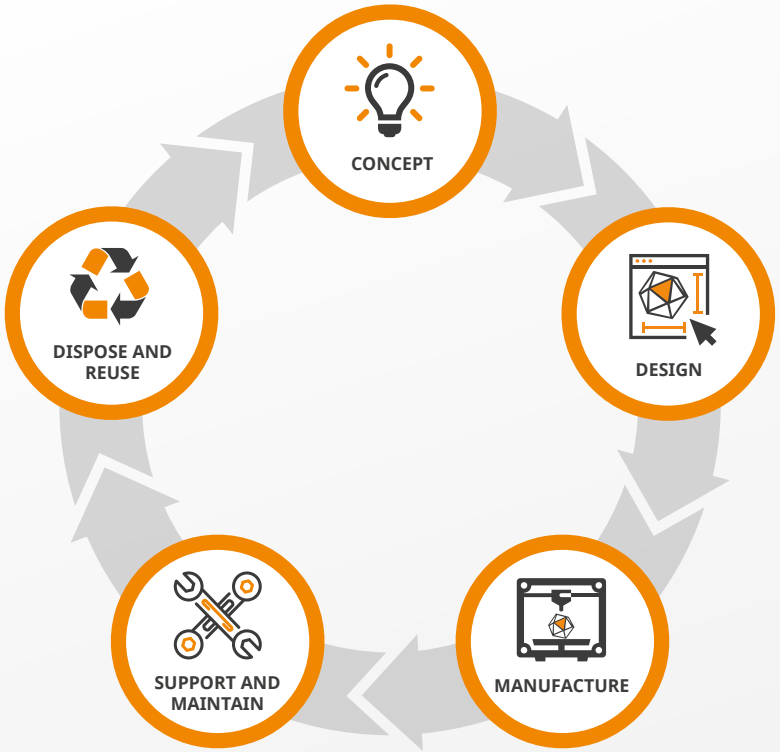
Remanufacturing and Maintenance

Protect expensive heavy equipment from emergencies and keep it running efficiently by using 3D scan data to create spare and replacement parts.

Adding Value to the Product Lifecycle

Reverse engineering adds value at every step of the product lifecycle.

To create and sustain long-term value, manufacturers know that they need to take a holistic view of the entire product lifecycle. The best-performing companies have mastered the ability to move seamlessly from digital, to physical, and back to digital throughout the product lifecycle using technology like 3D scanning, reverse-engineering software, digital metrology software, and 3D printing.



> "The 3D CAD data provides a baseline for wear inspection, rework, and redesign. Without it, changes and repair can be a nightmare."
>
> Dave Chrisman, Process Engineer, B&J Specialty, Inc., Wawaka, Indiana, USA

CONCEPT

- Start from existing products.
- Benchmark your competitors.

DESIGN

- Ensure designs will interface with existing products.
- Capture changes made to physical prototypes.

MANUFACTURE

- Speed up tooling development.
- Compensate design files to reflect as-manufactured state.

SUPPORT AND MAINTAIN

- Manufacture replacement parts.
- Create tooling digital archives.

DISPOSE AND REUSE

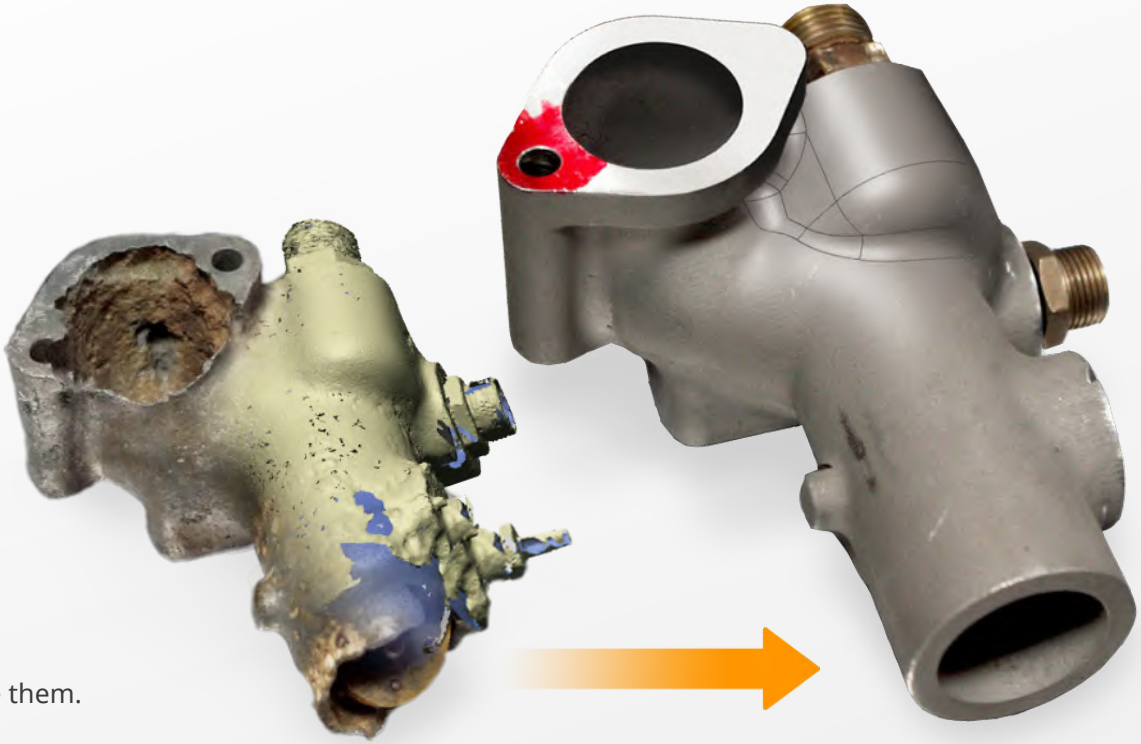
- Leverage intellectual property locked up in physical parts.
- Document as-manufactured parts in CAD.

Identifying Common Product Development Challenges

Designers and engineers often encounter product development challenges.

> "That's the great thing about this kind of technology. Parts are no longer lost to time. We're ready to go for another hundred years."
>
> Jay Leno, Owner, Jay Leno's Garage, Burbank, California, USA

- Missing CAD files
- Archaic, ad hoc reverse-engineering techniques
- Inability to extract design intent
- Inadequate software
- Adoption barriers



Read on to learn more about these challenges and how to overcome them.

Missing CAD Files

Very rarely does design work occur in a vacuum. New products usually rely on existing components, interface with other products, or are inspired by existing designs.

The idea that you can design a manufacturable part with a blank screen and creativity is somewhat of a myth. You must design all products within certain constraints, and many of these constraints are dimensional.

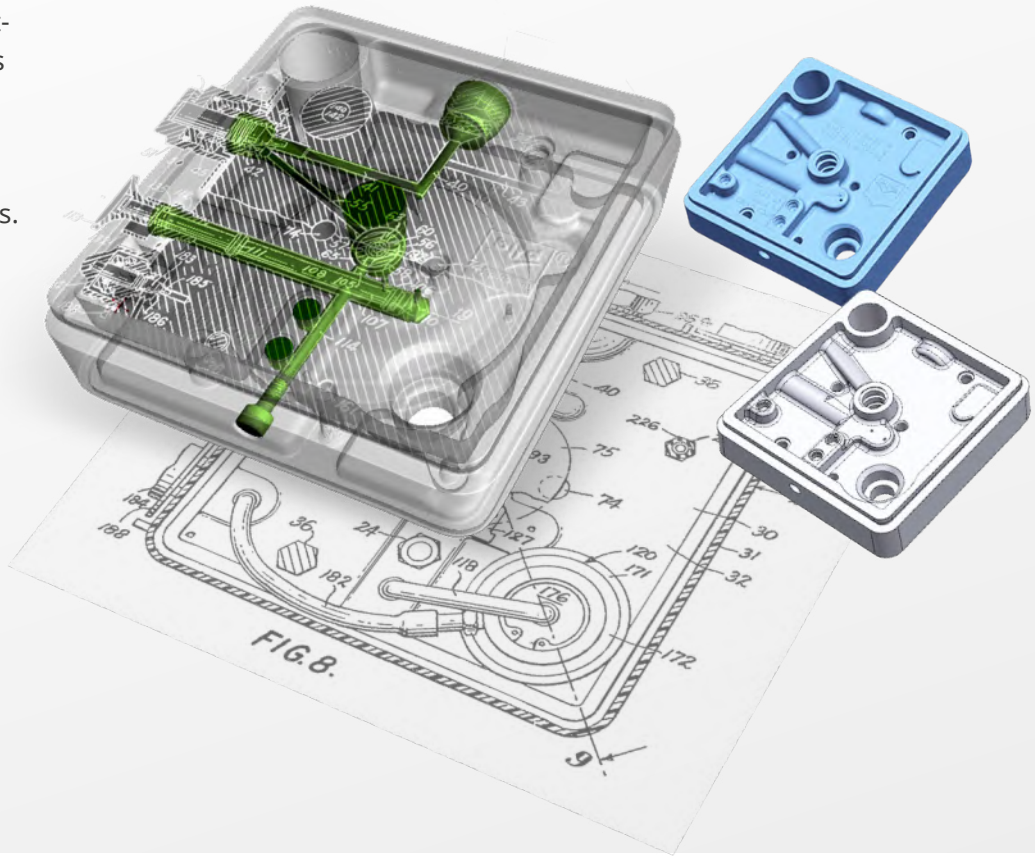
With a world quite literally full of objects to leverage, it is much more efficient to start with existing products that you know already perform well.

However, 90 percent or more products do not have existing CAD files. When CAD design files actually do exist, they may be 2D drawings or plans or out-of-date 3D files that do not reflect the as-manufactured product. Designers end up having to reinvent the wheel and spend significant time and effort recreating the designs from scratch.

Reverse engineering enables you to recreate CAD files for existing products.

"We needed a 3D model of the 1960s-era Bird Mark 7 ventilator as-built, but the molds and drawings had been lost. So we used non-destructive CT scans and reverse-engineering software to interpret those scans into native CAD files in only 24 hours."

David P. Fergenson, Ph.D., CEO, Livermore Instruments, Inc., Oakland, California, USA



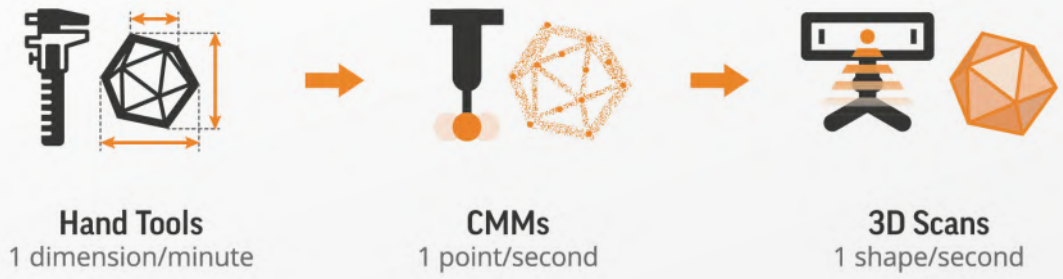
Archaic, Ad Hoc Reverse-Engineering Techniques

Teams often struggle with archaic, ad hoc approaches to reverse engineering. Although you may not think of it as such, the use of even limited measurements in new product design is a form of reverse engineering.

Measuring parts with basic hand tools—including micrometers, calipers, and even rulers—for use in CAD models to inform design is slow, tedious, error-prone, and difficult to verify for accuracy.

Coordinate-measuring machines (CMMs) or portable arms can measure more accurately in 3D space than hand tools. However, not only are these options time-consuming, they also only provide a few dimensions, don't provide the full picture or capture the full shape for indefinite storage and reference, and potentially miss important details. Resolution matters.

With 3D scanning and scan-based reverse engineering, you get full data capture fast—at a speed and resolution that's impossible with simpler measurement tools. For example, 3D scanning is at least 2,500 times faster than probing.



"The entire project took us 50 hours instead of 500, allowing us to achieve success in only 10% of the time it would have taken us compared to using conventional means."

Bobby Machinski, Owner, MACH-T3 Engineering, Campbell, California, USA

Inability to Extract Design Intent

There is a big difference between manufacturing a model and manufacturing a good, useable model. When you redesign an existing part, you need tools that enable you to make the same or similar compromises and design-intent decisions in the redesign process as the original designer. Just capturing its shape or components doesn't really help solve real problems, with quality.

Every mechanical part contains design intent—like the revolving axis of a wheel or gear, a specific dimension of a feature, or the constraint that a series of holes should be of the same radius and depth—hidden within scanned parts. Extracting the design intent during the 3D scan-to-CAD conversion process enables you to edit that data, use it directly for new design and manufacture, and greatly increases the value of the reverse-engineering process.

The measure of success for reverse engineering is an accurate, useable part that delivers significantly more value downstream. More than 90 percent of scan-based reverse engineering focuses on creating a CAD model with a history-based feature tree and editable dimensions and constraints that you can transfer, intact, to mainstream CAD applications.

Inadequate Software

Even if you have a high-quality 3D scanner and already use CAD software for design that can import STL files, you may find that you struggle to get accurate 3D models or spend too much time and effort to create the right 3D model.

Most CAD software programs cannot handle 3D scans of even moderately-sized measured data sets, and are therefore slow, cumbersome, and inefficient to use for real-world reverse-engineering tasks on a regular basis—even with optional reverse-engineering modules.

For real engineering challenges where quality and accuracy matter, you need dedicated, scan-based software.

Adoption Barriers

Barriers to adopting reverse-engineering methods can lead to missed opportunities and benefits.

Many teams avoid reverse engineering because they do not have the right tools to do it quickly, accurately, and cost-effectively. But, with the right 3D scanner and reverse-engineering software, you can take any physical part and bring it into your digital design environment, speed your product development time, and leverage existing parts instead of designing from scratch.

Implementing Modern Reverse Engineering

> "Using a 3D laser scanner and software, we can reverse engineer equipment in a fraction of the time it takes to manually accomplish this task."
>
> Bobby Machinski, Owner, MACH-T3 Engineering, Campbell, California, USA

Fortunately, there is a better way. Replacing your existing CAD software with dedicated reverse-engineering software for 3D scan-based design has many benefits.

A modern reverse-engineering approach accurately captures the complete geometry of virtually anything that you can scan and yields editable, manufacturable 3D CAD models that meet specific engineering and manufacturability requirements. In addition, this process is faster, less expensive, and easier than ever before.

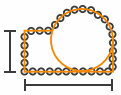
Some of the many benefits of modern reverse engineering include:

- Broadening your design capabilities
- Enhancing your CAD environment
- Accelerating time to market
- Leveraging existing assets
- Reducing costs
- Doing the impossible

Top 5 Key Features of Dedicated Reverse-Engineering Software

When shopping for dedicated reverse-engineering software, look for five key features.

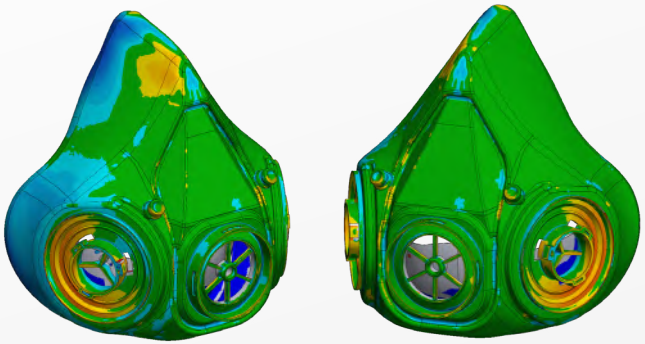
> "The accuracy analyzer feature calculates the spatial distance between the mesh and the generated surface and then assigns a color to the distance. It shows you how accurate your model is compared to the mesh that is based on the actual scan data."
>
> Christian Stark, Engineer, Bellingham, Washington, USA



Automated sketching increases accuracy by removing the need to estimate. With many CAD programs, you typically have to hand-select points to form sketches or, worse, rely on visual approximations to guess where the sketches should go. You should be able to fit sketch lines, arcs, and curves onto scanned parts more accurately by best fitting to tens of thousands of points on a model automatically.

Automated feature creation speeds up modeling. CAD models have hundreds or thousands of features describing every aspect of a given part. Saving just one minute when modeling each feature can add up to hundreds or thousands of minutes. Common feature modeling operations that you should be able to perform automatically in seconds include 2D and 3D sketch, revolve, extrude, fillet, shell/thicken, and pipe.

Fitted NURBS surfacing makes it easy to capture complex, freeform geometry. Some part regions such as rough, unmachined casting portions do not require design intent extraction. Where appropriate, you should be able to capture as-built NURBS geometry automatically to blend automatic surfaces with solid-modeled features seamlessly.



Real-time accuracy analysis helps ensure models are correct and true. With mainstream CAD programs, you often have to stop modeling and export the CAD file to another application to check deviation. Real-time feedback is the only way to analyze the accuracy of your CAD model on the fly during every step of the reverse-engineering process.

Seamless data exchange to multiple CAD applications for a native, editable CAD file. CAD models created in standalone software sometimes have compatibility issues with CAD software. You should be able to connect directly to most CAD software programs and transfer each feature automatically, which yields a parametric model with complete modeling history in your CAD software as though you created it there originally.

Proven Reverse-Engineering Solution

One software program brings this all together: Geomagic® Design X™ by 3D Systems.

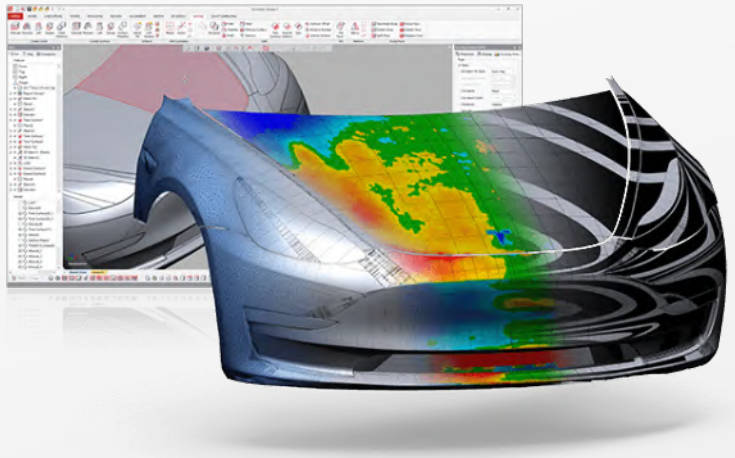
Geomagic Design X reverse-engineering software makes it easy to extract new value from existing products by creating CAD models from 3D scans faster, more accurately, and more reliably than any other reverse-engineering method. It connects directly to your existing CAD environment and creates native files that you can use the same way as any other model—except that it accurately represents a scanned object.

> "Geomagic Design X is the best reverse-engineering software, providing a great feature balance and easily handling huge point clouds. Its flexible modeling methods make it the ideal tool for a wide range of challenges."
>
> Norimichi Abe, Group Leader of General Control Group for CAD Machine Processing, Asano Co., Ltd., Isesaki, Gunma, Japan

Geomagic Design X checks all the boxes:

- ☑ 3–10X faster time to CAD
- ☑ Handles large scan data sets faster than any other software
- ☑ Mesh editing and point-cloud processing
- ☑ Automatic, guided solid-model extraction
- ☑ Accurate surface fitting to organic 3D scans
- ☑ Automated feature creation and sketching
- ☑ Proven and trusted since 1998
- ☑ 14,500+ licenses in use
- ☑ Real-time feedback with patented accuracy analyzer
- ☑ Seamless live data transfer to most CAD software
- ☑ Only software that combines scan processing and CAD
- ☑ Easy to learn and use
- ☑ Regular updates
- ☑ WW local sales, training, and support
- ☑ Vast network of scanner partnerships

Dx Geomagic Design X



Speed Comparison

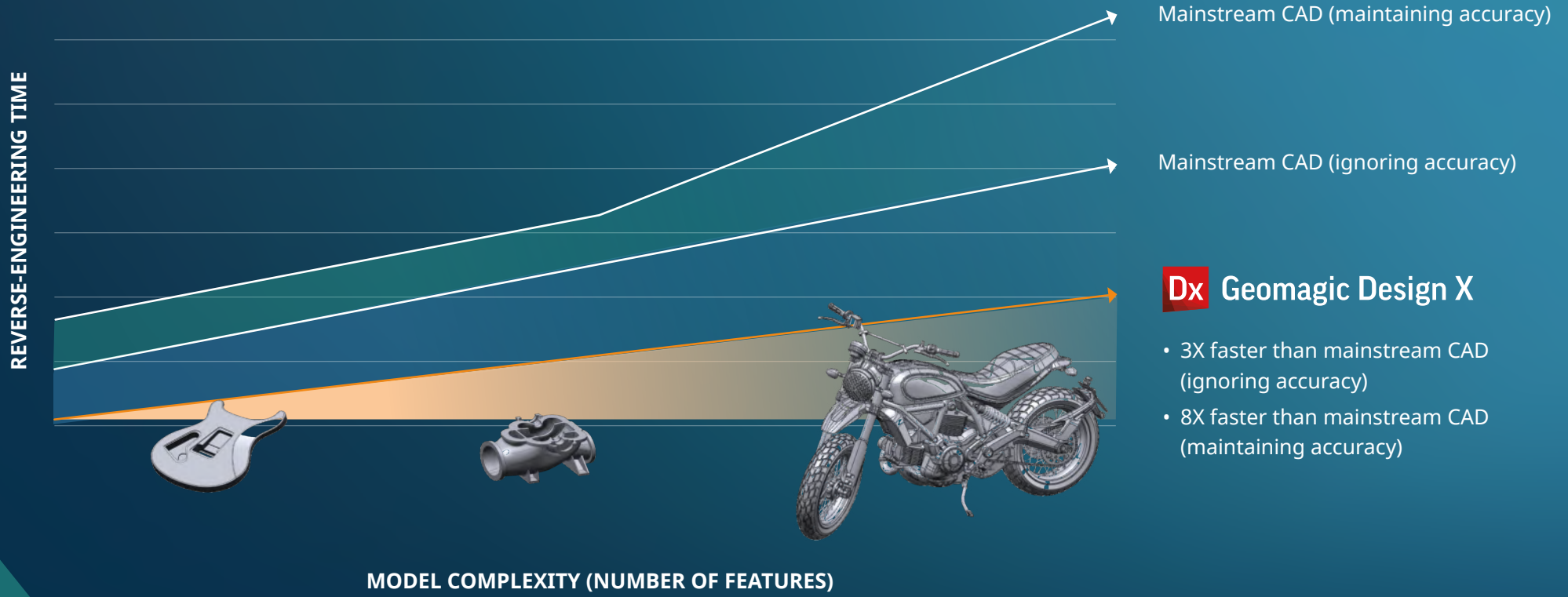
Let's look at the facts. 3D Systems regularly receives feedback from its customers about mainstream CAD software scan-to-CAD workflows. Customer feedback indicates that on very simple models like what you may see in a software demo, it takes an experienced user three to eight times longer to create an accurate, high-quality CAD model from a 3D scan using mainstream CAD software compared to Geomagic Design X.

As model complexity and feature count increase, reverse-engineering time increases at an even faster rate. This can add up to hours' or even days' worth of additional time spent on reverse engineering. It is no wonder that those who regularly reverse engineer objects rely on Geomagic Design X software to do it.

UP TO
10X FASTER
TIME TO CAD

"We're saving hundreds of man hours/year using a 3D scanner and Geomagic Design X to scan and design directly from the scan data—more precisely, with higher customer satisfaction. Getting the fit right the first time resulted in a 100% ROI in the first year."

Antonio Capristo, Owner, Capristo Exhaust Systems GmbH, Sundern, Germany



Top 5 Reverse-Engineering Implementation Checklist

Check out five key tips to adopt reverse engineering inside your organization successfully.

- **Break down the barriers between measurement and design.** Directly involve designers in the scanning and scan-based CAD modeling process by having product development and engineering departments operate scanners directly or work closely with inspection/quality departments that operate scanners.
- **Identify multiple applications for 3D scanning and reverse engineering.** Wherever possible, leverage reverse-engineering expertise and build stakeholder support across your organization to maximize your return on investment (ROI) and business impact.
- **Select the right 3D scanner.** Carefully select the 3D scanner that covers most, if not all, of your measurement needs and work with trusted outside service bureaus for the rest.
- **Don't use measurement software for design.** Most bundled scanner software focuses on taking great scans—not on applying design principles to extract the underlying functional intent of a part. Instead, use dedicated reverse-engineering software like Geomagic Design X for design.
- **Don't use design software for measurement.** Although it is tempting to use your existing CAD software to create CAD models from 3D scans, it is slow, cumbersome, and inefficient for regular use in reverse engineering. Specialized scan-to-CAD software like Geomagic Design X and inspection software like Geomagic Control X™ are must-haves for anyone serious about reverse engineering.

"With a background in CAD, Geomagic Design X is rather intuitive. I found it very easy to learn and it does everything I need it to do."

John Anastos, Aerospace Engineer, Advanced Vehicle Research, Greenville, South Carolina, USA

Free Trial and Consultation

Try Geomagic Design X for yourself with a 15-day free trial.

Request Free Trial

Where could you envision deploying modern reverse engineering in your company?

3D Systems is here to help. We believe in a collaborative, customer-centric approach where we begin by understanding your priorities, challenges, needs, and desired outcomes.

Contact our reverse-engineering experts to discuss your specific applications.

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