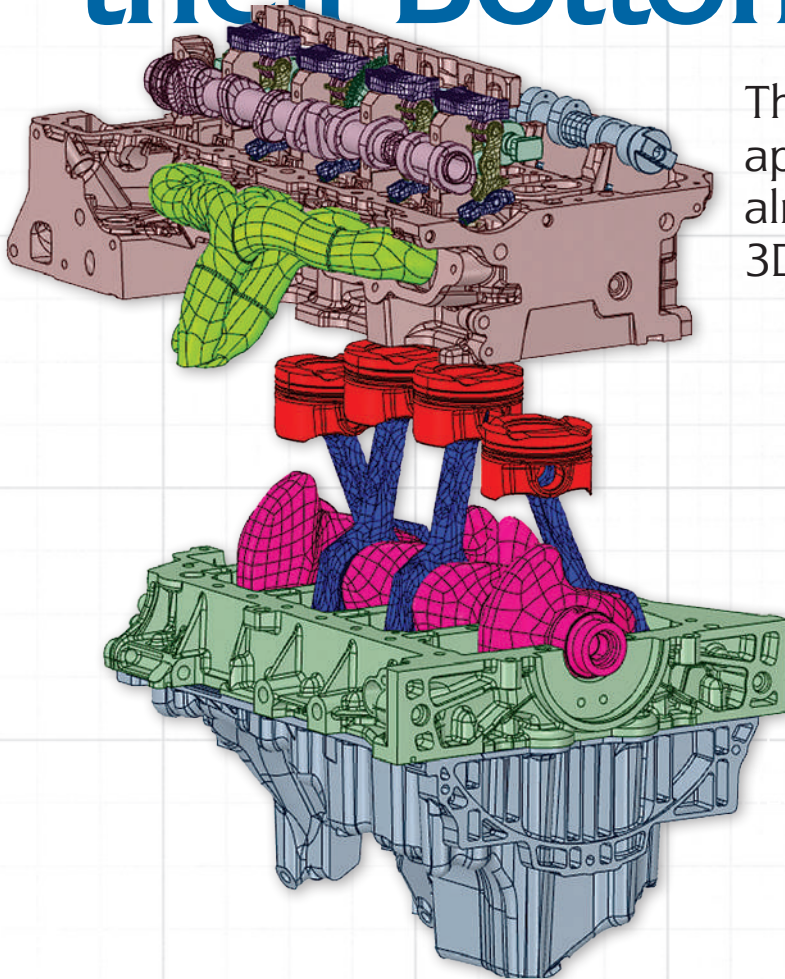# Smart 3D Software Helps Shops Boost their Bottom Line

The straightforward approach to CAD gives almost any user an efficient 3D engineering tool.

SPACECLAIM
CORPORATION

MACHINE
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BY ENGINEERS FOR ENGINEERS

Smart 3D Software Helps Shops Boost their Bottom Line

The straightforward approach to CAD gives almost any user an efficient 3D engineering tool.

Many large manufacturing OEMs manage their workflows by enforcing the use of a single feature-based CAD platform. But for machine shops and smaller companies, this approach is usually impractical because it requires keeping a team of extremely well-trained, full-time certified CAD experts on the payroll. This scenario is akin to that of everyday car owners hiring full-time racecar mechanics to work on their vehicles when all the cars need is maintenance twice a year. Shops that use feature-based CAD software and that don't invest in highly trained teams often have disastrous results and end up getting turned off to solid modeling in general.

A better approach for smaller shops is simply to use an appropriate tool for the job. So instead of necessarily relying on a feature-based system, companies might consider a new 3D modeling tool called SpaceClaim to build models, create concepts, reverse engineer parts, and win competitive bids.

SpaceClaim Engineer is based on technology called direct modeling that frees users from the frustration of dealing with other designers' models that may have been built using a different modeling practice. Designers need not be CAD specialists to use the program. What's more, unlike with feature-based systems, users don't have to understand underlying programming instructions or "recipes" to make changes to models. Instead, engineers use intuitive "pull," "move," "fill," and "combine" tools to work directly on parts.

SpaceClaim solves the problem of interoperability. It should be no surprise that industry often uses the term "dumb model" to describe what happens when models are moved from one feature-based CAD package to another. Because much of the model

What's up with feature-based, parametric, and direct modeling?

These common terms often cause confusion in industry. "Parametric" just means users can modify a design with parameters. The term can apply to either feature based or direct-modeling software. For example, users of the direct modeler can drive models with parameters. Let's say you have a block and use the pull tool in SpaceClaim to change the size of the block. The software can create annotations in which there are dimensions that, for instance, give the position of a hole and the size of the block. Engineers can then use those dimensions to edit the model. And simulation users often import models from any CAD system and then add whatever parameters they want to them. "Feature-based" modelers, on the other hand, work on a set of instructions or a recipe to build the model (kind of like programming).

So, what's the big difference between a feature-based and a direct modeler? Designs created in a direct modeler need not be held together by constraints (because otherwise the model will fall apart).

Feature-based modeling has its place in the creation of large complex designs such as complete airplanes. But for jobs typically found in smaller shops, the approach can be inefficient. Direct modeling eliminates a lot of problems associated with traditional feature-based tools. For example, engineers who might not use CAD on a daily basis can make changes to models without having to understand the recipe.

intelligence can get lost when this happens, designers must struggle with problems such as needing to rebuild a model so that they can edit it with the right design intent. In contrast, users of the direct modeler can easily edit models regardless of where they came from as needed.

For example, a machine shop might have customers using SolidWorks, Pro/Engineer, and Catia. Shop personnel can import the customer's models from these programs into SpaceClaim, combine them, make changes, mark up the resulting design, send it back to the customer, and even say something like, "this part would cost half as much with these changes."

Many smaller shops also find that SpaceClaim reduces wasted time in engineering because the software facilitates the use of 3D in concept modeling. This is unlike traditional CAD, which can stifle innovation because users tend to lock down designs too early in the design cycle. In contrast, SpaceClaim direct modeling lets users create new concept models quickly and easily to share with customers and manufacturing. Because the software allows for fast concept iteration and real-time collaborative work with prospects, it helps shops win more competitive bids.

Need a part but lack a print?

One machine shop that finds the software useful as a concept modeler, especially in reverse engineering applications, is **Eureka Tooling** in Nettleton, Miss. "We use SpaceClaim as a separate tool," says shop owner Roger Hester. "We do have a traditional CAD package, but hardly ever use it because most of the work we do is conceptual. Customers typically have an idea of what they want—situations where they like something about one machine, for example a jig, fixture, or die, but want to morph the part into another component for a different machine. During most projects, it's not unusual for customers to want concepts from two or three machines, which means customers must shut down the machines while we laser scan the components. Needless to say, we must work in a hurry. Other times though, the customer gives us the CAD data so we have the part. We then basically just start building around it in the software."
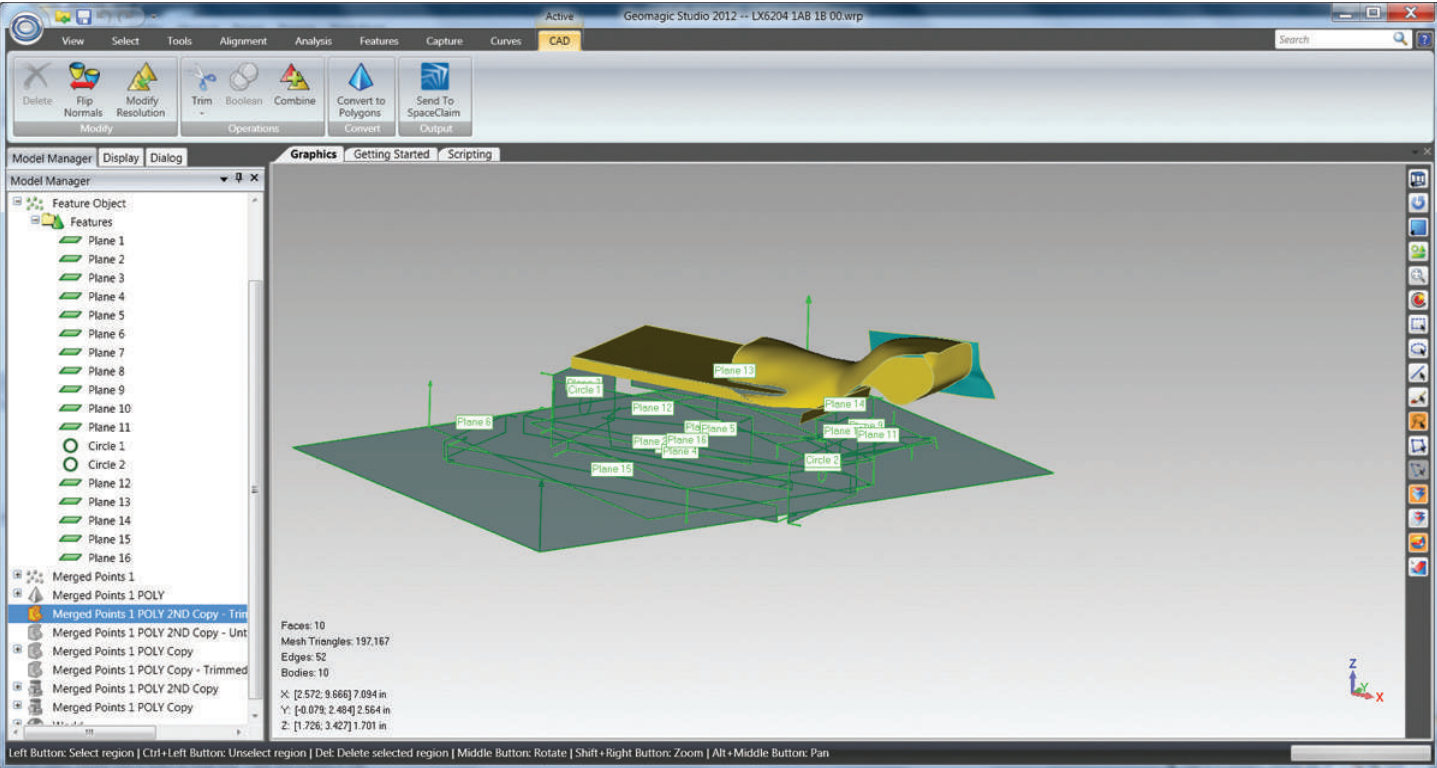
🔺 A Geomagic screen shot shows the scanned data. The surface data was output to SpaceClaim. The planes and other features were saved to an IGS file and imported into the direct modeler.

🔺 Eureka Tooling scanned this fixture to reverse-engineer it.

Most often, customers need a component, but lack a print, says Hester. "That's because the supplier went out of business and took the information with it," he says. "Or companies bought parts new from a manufacturer or die shop, and the die shop won't supply prints because it wants to force customers to return to buy replacement parts."

After Eureka Tooling scans a component, it imports the point-cloud data from a program such as Geomagic as an STL or IGES file into SpaceClaim for cleanup. Geomagic is software that uses scan data to recreate organic or freeform surfaces. "Whether we clean up models in the shop or in front of a customer depends on the shape of the part," says Hester. "Sometimes the scanner creates 'echoes' in 90 degree corners. Or it might bounce off a shiny surface and create stragglers. We clean up that data to make a solid and combine it with the rest of the machine model at the shop. Then we go back to the customer, tweaking the model in front of it to get input. We talk
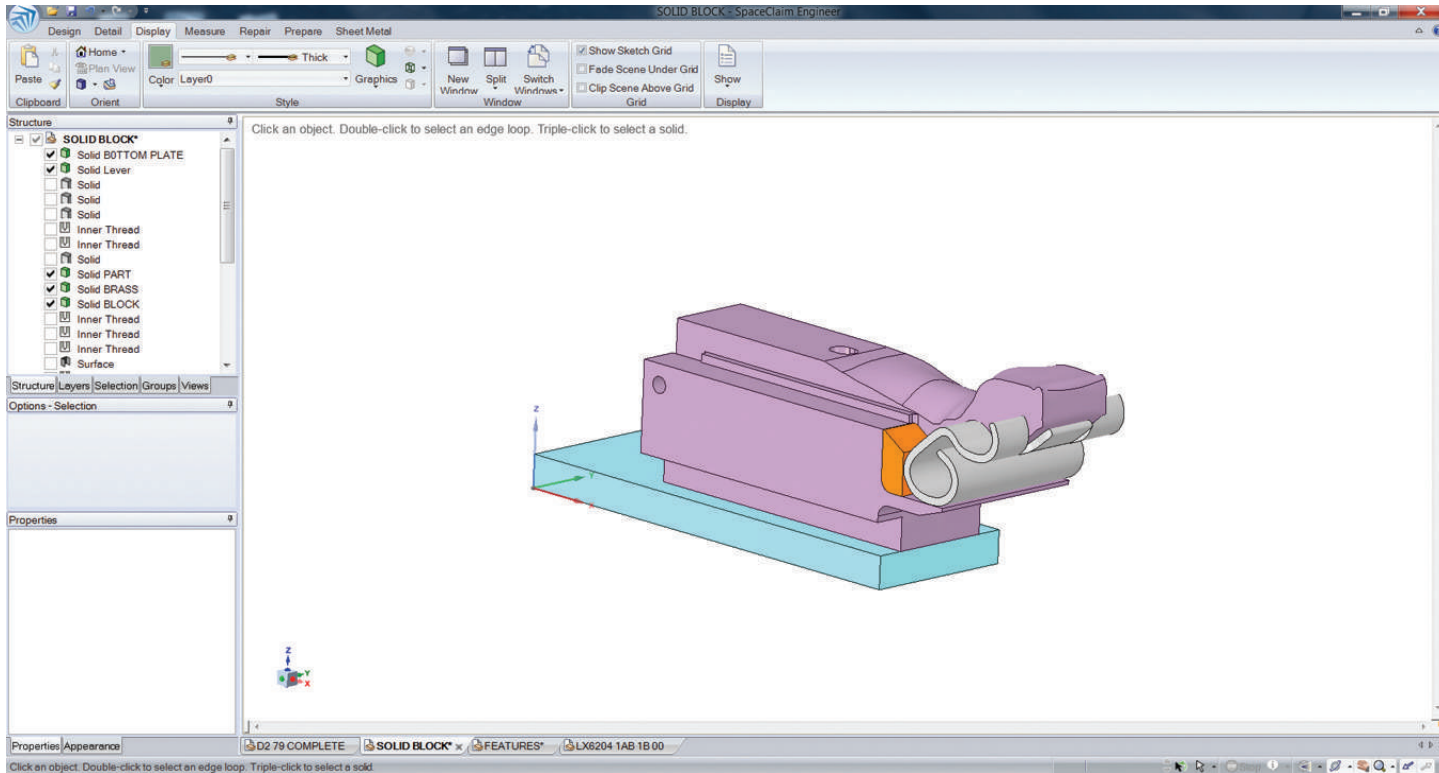
🔵 The SpaceClaim screen shot shows the completed drawing. The silver solid is the part that is being held. The rust-colored solid is a brass insert that was added.

to whoever is running the program, whether it's a tooling, a press, or a maintenance job. This approach lets us tackle any problems that might arise before building a component such as a fixture. The software makes it easy to clean up simpler rectangular, square, or triangular pieces, letting us immediately tweak these shapes while in front of customers."

Hester explains that Eureka first got into laser scanning and reverse engineering because engineering firms couldn't provide the necessary accuracy. "They were using CMM arms and a traditional CAD system, running around trying to measure parts with hard probes," he says. "Then one of the engineers would often make a wrong decision and we would end up building the block—which took two or three days of pretty complicated machine time—that basically could only be used as a paperweight. We finally figured out it's foolish to use firms that don't actually build parts because they don't know when they make mistakes. So we brought the processes in-house and use SpaceClaim to handle model cleanup and concept modeling. The program is easier to use than traditional CAD and most of our customers prefer to see the sometimes complicated components as solids, not wireframes."

And when it comes to creating models for bidding on jobs, an approach sometimes called "bid modeling," Hester says the shop previously used feature-based CAD. "But that method didn't make sense from a time-frame point-of-view," he says. "We would work two or three days trying to build a 3D model, something that SpaceClaim lets users do in a matter of hours. This modeling speed lets us respond to more proposals in less time and thereby win more business. Speed is critical to us because we have no salespeople. Usually, our designer just handles the bid modeling."

Win more competitive bids

Also using the software as a concept modeler, for reverse engineering, and to win competitive bids is three-dimensional measurement company **Physical**
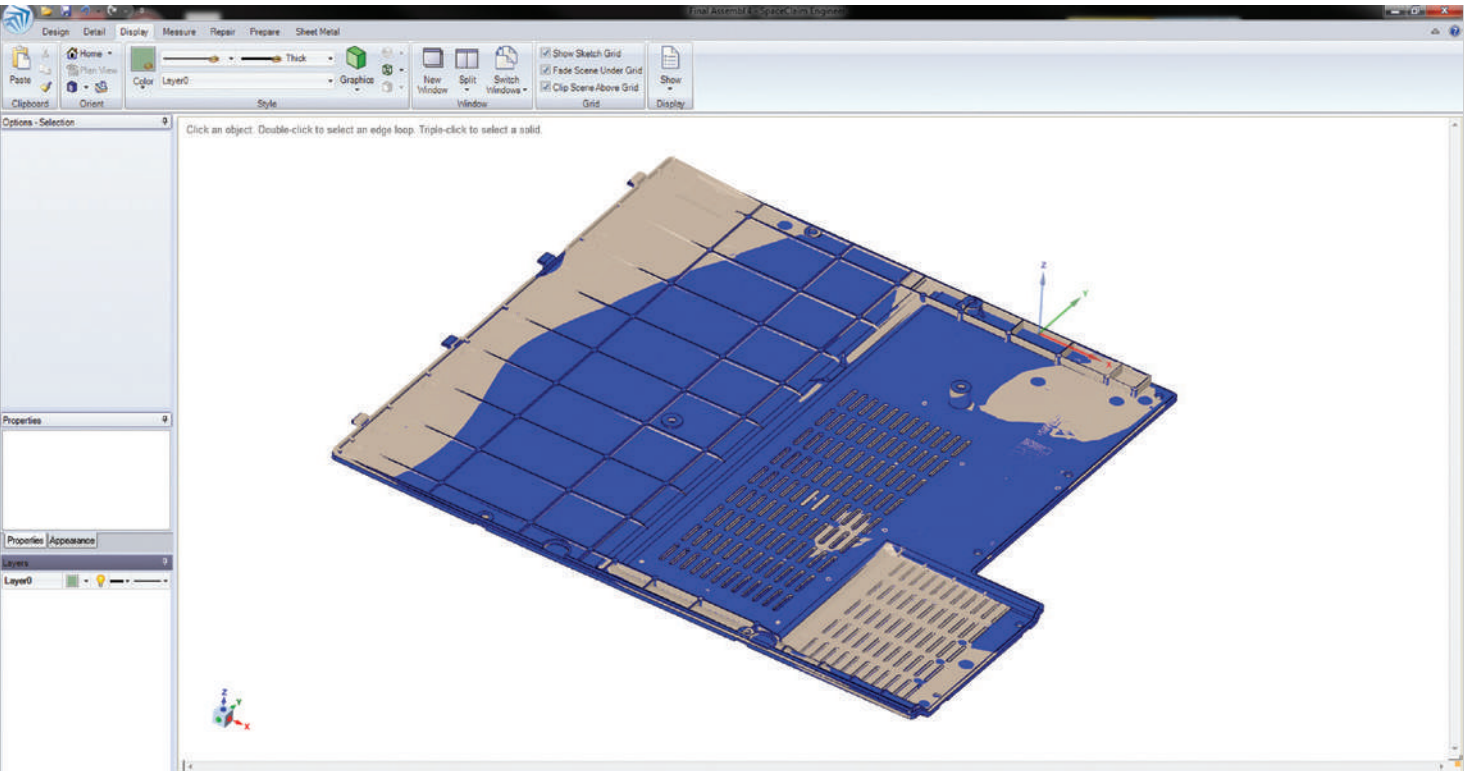
▼ Physical Digital created this model when bidding for a contract to scan and reverse-engineer injection molded electrical components where parts were no longer available.

Digital Ltd., (www.physicaldigital.com) in England. The company reverse-engineers everything from whole aircrafts to toilet seats and medical devices—anything a customer doesn't have CAD data for. "When you have a component that is old, broken, or worn out, and you want to remanufacture it, we can accurately scan it and create the model using SpaceClaim," says Daniel Lainchbury, applications engineer at the shop.

The main reason the shop purchased the direct modeler in the first place was because the company was getting a lot more requests to reverse-engineer CAD models from scan data, says Lainchbury. "We were outsourcing so much work that purchasing the software made sense. In fact, the costs were absorbed in the first couple of jobs, which is probably unheard of in any other CAD world."

To reverse-engineer components, the shop uses a structured white light scanner, which projects a pattern across the surface of objects using stereo cameras to accurately map the surface. The method is more ac-

curate than laser scanning because it does not measure a reflected beam but rather it measures the pattern on a surface, so there is a lot less digital noise.

"It's helpful that SpaceClaim and Geomagic have what's called parametric exchange, which lets users create freeform surfaces in Geomagic and transfer them directly into CAD models, without having to save surfaces, re-import them, and stitch them," says Lainchbury. "Building a freeform surface, such as an arm, in traditional CAD would take hours and hours. The parametric exchange helps speed up our workflows."

In one case, the shop won a job to reverse-engineer some components. "The customer wanted to continue to use our services and asked if we were interested," says Lainchbury. "We sat down next to the shop engineers, and, with the computer screen in front of us, quickly came up with several concepts, all while we were sitting there. This would have been impossible to do using traditional CAD. And before

we purchased SpaceClaim, we had to put a lot of formal thought into targeting a project because we were outsourcing all the CAD work, which got expensive. We use the direct modeler to rapidly iterate on concepts, giving us the capability to put in bids we otherwise wouldn't have been able to."

The direct modeler also makes it easy to work on projects that are similar to ones the shop has had in the past, says Lainchbury. "We can drag CAD models into the software from any system and manipulate designs quickly to make relevant examples to bid. Previously, we would have had to start from the ground up and build complete models, a time-consuming task."

Lainchbury says concepts the shop has come up with include changing aspects of a design to see the outcome. "For instance, a change as simple as moving a pivot point quickly showed us a design's movement limitation," he says. "After the customer gave its input, I could quickly drag the pivot toward the specified direction. This quickly gave us the boundaries in which to design the final concept."

According to Lainchbury, designers at the shop include proficient NX and Catia users. "But for what we needed, SpaceClaim is the best tool because almost anyone can easily learn how to use it," he says. "This ease-of-use lets us sit in meetings and make design changes quickly. Everybody can volunteer their input and understand the modeling processes without having to start from the beginning, should something prove incorrect."

Previously, the shop would get models from outside and view them in free viewing software. But this approach did not let engineers manipulate models, make notes, or check dimensions. "Now though, even when we outsource work and get models in, the direct modeler lets us tweak them for our customers' needs rather than going back to the beginning just to change something basic and having to update the history tree," says Lainchbury. "SpaceClaim eliminates this problem."

The pull, fill, and combine tools are easy-to-use, says Lainchbury. "Also, the software is 'intelligent' in that when users select a face, for instance, it only displays the command relevant to moving or altering a
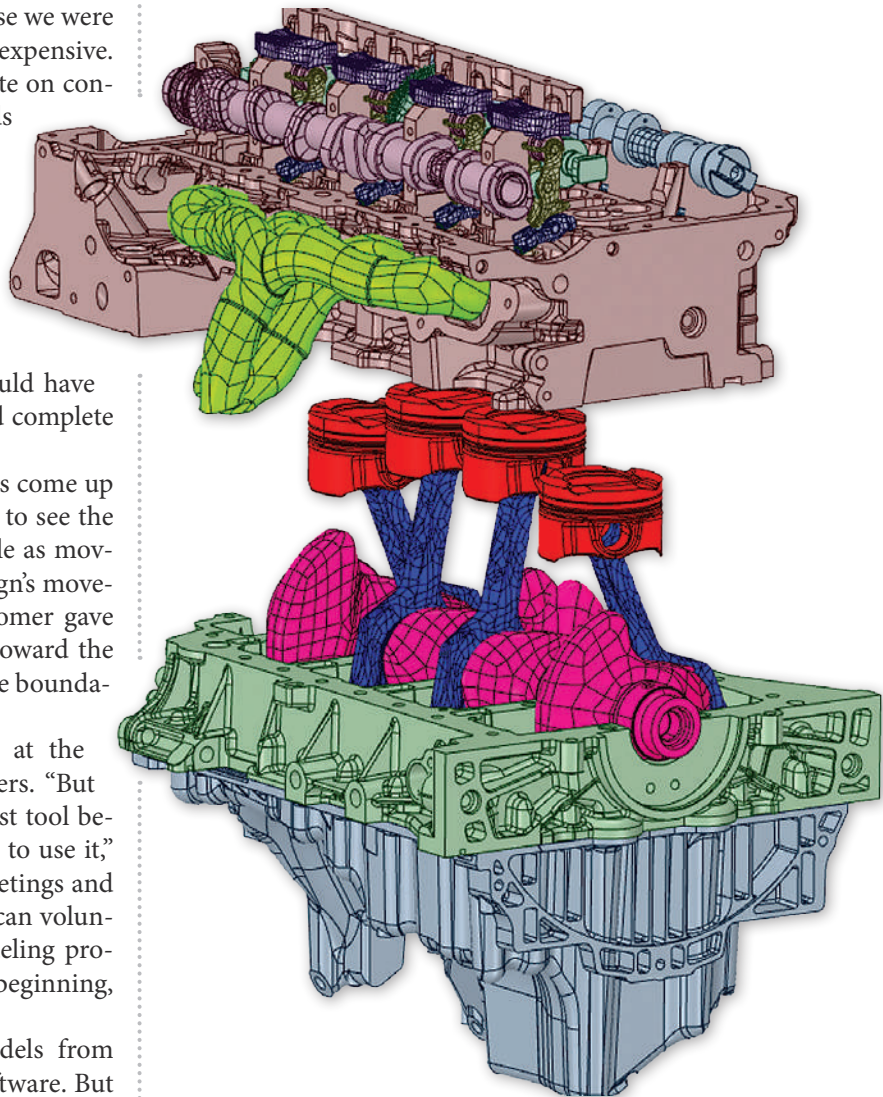
The shop scanned an entire engine and reverse-engineered it using different software packages (SpaceClaim, Catia, NX, and Geomagic). The moving, functioning assembly was created in the direct modeler.
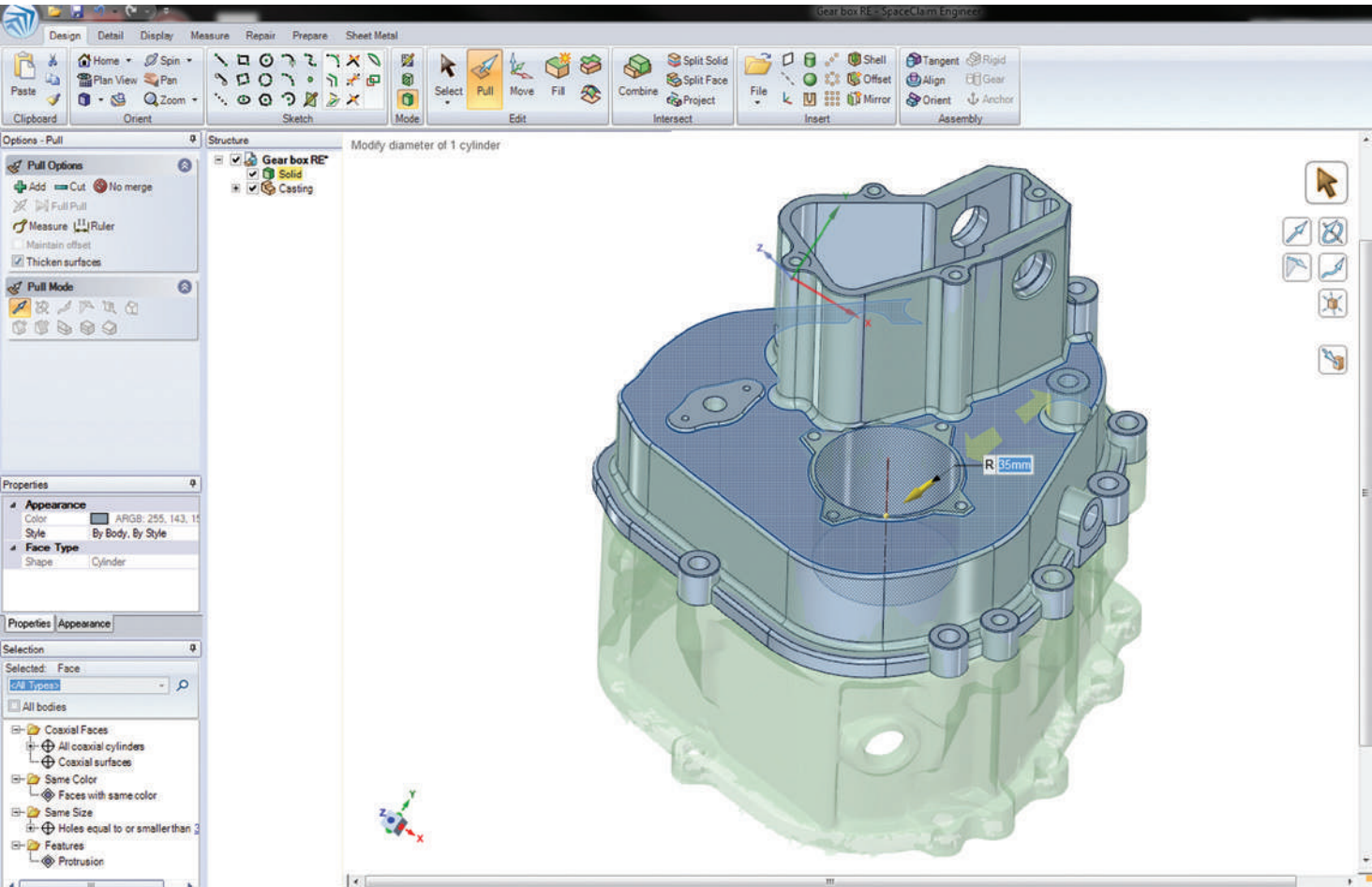
🔵 The gearbox was reverse-engineered and the data imported into SpaceClaim. The green area represents the scan data.

face," he says. "Once users wrap their heads around pulling and moving things rather than creating a sketch and then extruding it, for instance, modeling becomes a lot easier. Users can just manipulate models right in front of their faces, so to speak. This capability comes in handy for bid modeling or concept modeling because users can see the effects of changes instantly."

But even though the software supports a quick modeling approach, this is not to say that it lacks a way for users to keep control of models. According to Lainchbury, it all comes down to the idea that function drives form. Thus, users can "lock" features so that the distance between two holes remains the same. Users can also specify that a part must not interfere. In other words, users can set limitations. "But you can then quickly manipulate all the geometry surrounding those bits," he says. "So when you have functionality built into key features—say something has to be on a flat plane—you can maintain that and work around it without having to go back and update everything as you go along. Again, an example of that from our point of view would be reverse engineering the inside of an engine and then being able to put a component within the inflow of that engine."

Also important to the shop is using SpaceClaim to collaborate internally. "Sometimes this is faster than sketching a design in two dimensions on paper, and it is a good way to hone-in on a project plan," says Lainchbury. "The approach lets lots of user input and

🔺 Shop personnel are scanning the last remaining WWII Spitfire that saw active service in the battle of Britain, for historical reasons and reverse engineering.

experiences go into designs. Contrast that to traditional methods where designers leave, make a model, and then come back. Only then are changes made. SpaceClaim, on the other hand, speeds the design loop because users can make changes on-the-fly."

Lainchbury adds that smaller shops don't have the financial power to buy high-end CAD software and employ someone with decades of experience to run it. "But almost anyone can pick up SpaceClaim and within a week be able to design 95% of all the components and assemblies they will need to design," he says. "And lots of bigger companies are using the program as a separate tool for bid modeling because it is hundreds of times faster than designing with traditional CAD."

Machining and rapid prototyping, anyone?

Waylan Elmenhurst, principal of a new company called **Relic Engineering** in Seattle (www.relicengineering.com), says the firm purchased the software primarily as a concept modeler but also because the program comes in handy for machining and rapid prototyping. "We wanted to take ideas that had been on paper and digitize them so they could communicate directly to machines," he says. "I used to hire someone outside to create drawings. But I can get a lot more done when I do the modeling myself. Instead of wasting a lot of time trying to explain things, I just do it. I either export files to a 3D printer (STL) or CAM (IGES or STP). My partner owns a CAM package, which he uses to draw the tool paths and create the code for the CNC."
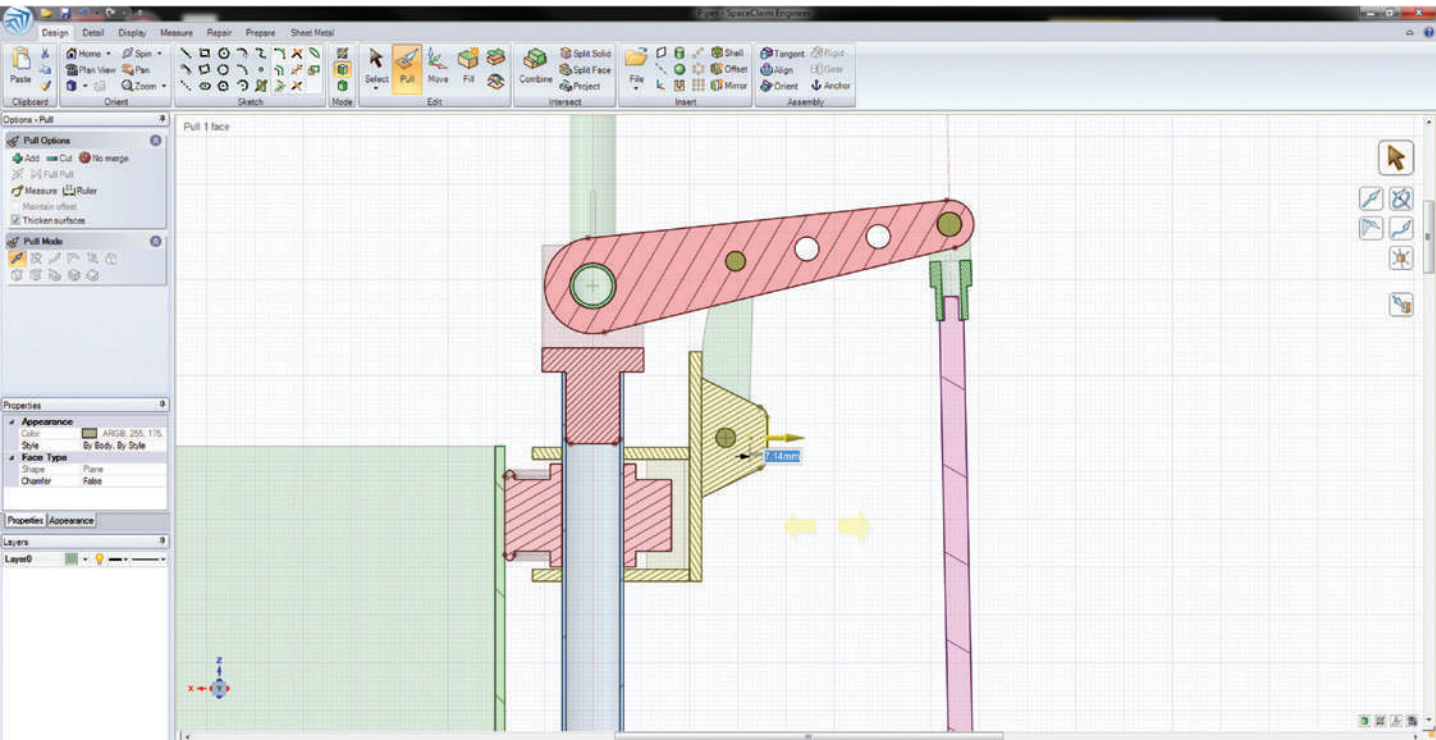
🔺 Physical Digital completed the design using SpaceClaim as a bid modeler. The company continued the project entirely using the direct modeler for the finished product.

The direct modeler helps foster collaboration in the sense that sometimes Elmenhurst sends his partner a file that needs a change. "My partner is my number one manufacturing consultant," he says. "As a machinist, he has been invaluable to me for suggestions regarding models. Often, designers put in too much detail. My partner says when I need a threaded hole, just draw the hole and specify the threads—don't draw in the threads. This would make his job as a CAM operator much more complicated and limit his options to approaching a machining challenge."

Another important job Elmenhurst uses Space-Claim for is creating 3D models to take to the patent office. "I just designed a new vacuum cleaner attachment and am in the process of patenting it," says Elmenhurst. "I use the models to communicate with my lawyer and investors. The software also works well for making models I can export directly to STL and then send out for 3D printing. This frees me from having to go through ordinary machining processes for quick prototypes. I drew the vacuum cleaner attachment prototype in SpaceClaim and then had it 3D printed out of ABS. The attachment came right off the machine, ready to use."

Elmenhurst agrees the software supports the idea that function drives form. "I first put a part together so I know it will perform as expected. Then I start cleaning up the model to make it more attractive. The direct modeler makes this endeavor easy because users don't have to go back and redesign everything. Should you want to remove a corner, just click on it and remove the corner. You don't have to go through the tree and rearrange the whole history on the part."

Also helpful to the shop is that the direct modeler supports assemblies. "You can pull a part off an assembly, work on the part, put it back in the assembly, and then test the part for fit," says Elmenhurst. "The software includes a set of tools that shows users any interferences. When two different solids occupy the same space, the software highlights them. In addition, users can assign constraints to different
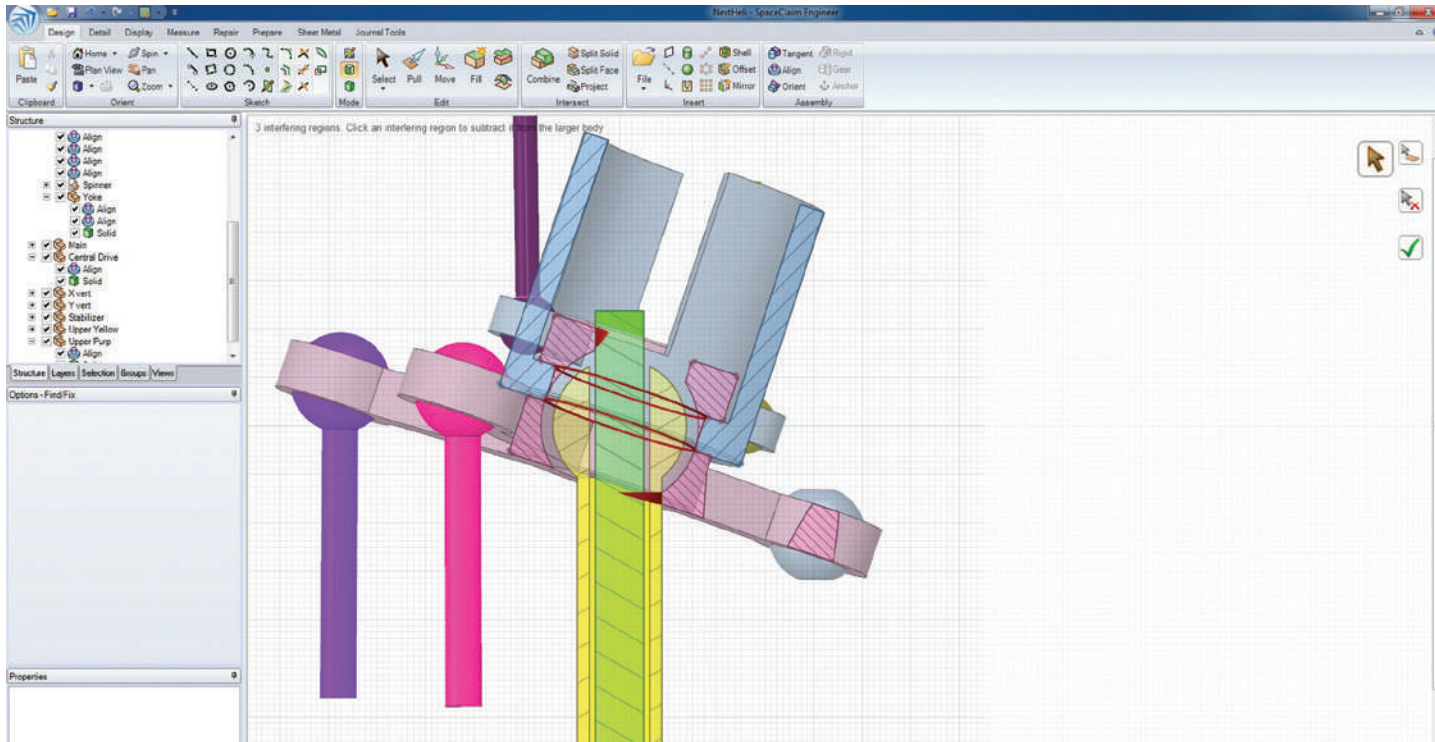
🔺 The screen shot shows Relic Engineering's yoke assembly. SpaceClaim highlights the areas in red where components are contacting each other.

parts, including ball-joint-like constraints. For instance, users can specify that a particular part will pivot off of a certain point. One of the drawings I made just to see how much I could do with assemblies was that of a yoke for controlling blade pitch on a helicopter. The component was really complex, with several ball joints and interconnected moving parts. I was able to put everything together and run the assembly through its motions and drag it around to the breaking point. As I made modifications, parts stopped fitting quite right and the software immediately let me identify where a ball joint had shifted out of alignment."

Conclusion

SpaceClaim's direct modeling approach lets shops quickly iterate on concepts, which helps them win more competitive bids. Traditional CAD often gets in the way when companies are conceptualizing new ideas in response to RFQs. In contrast, SpaceClaim lets non-expert CAD personnel use a 3D engineer-
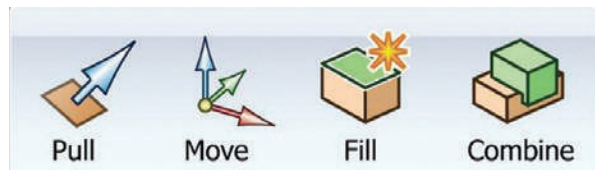
🔺 SpaceClaim's Pull, Move, Fill and Combine tools use feature recognition technology to intelligently present the user with useful modeling options based on the current selection, greatly improving ease-of-use.

ing tool right in front of prospective customers. Designers can use customer geometry as the design specification, regardless of what CAD packages the geometry came from. SpaceClaim also streamlines workflows because it lets users build their confidence in concepts early in the design cycle. Additionally, the software supports other diverse tasks for smaller shops including reverse engineering, machining, and rapid prototyping. ■