WORKING WITH AND MANUFACTURING COMPLEX GEOMETRY AND ORGANIC SHAPES

Learn How Industry Experts Create Complex Geometry and Organic Shapes With Sub-D Modeling

INTRODUCTION

IS IT HARDER TO DESIGN TODAY'S PRODUCTS?

Today, engineers face no end of challenges. Schedules are getting shorter while budgets are drying up. Demand for smart, connected products is driving the addition of software and electronics everywhere. Products must be faster, lighter, and just plain better. Amid all these changes, geometry is getting more complex. Terribly complex.

More and more, engineers are being called on to develop the look and feel of new products. Calls for more ergonomic and aesthetically pleasing products result in more organic shapes. The increased adoption of generative design generates wildly non-prismatic geometry. Reverse engineering three-dimensional scans produces unruly forms.

The price of dealing with more geometric complexity is steep. Remodeling these shapes is a tedious, time-intensive task. It undermines productivity. It steals the opportunity to design. Recreating something that already exists slows down the development process. Any change kicks off the whole cycle again, forcing you into a repetitive, difficult remodeling undertaking.

On top of all that, design intent must be clear so that complex models can be manufactured properly, which requires the right documentation, whether it be with 3D product manufacturing information (PMI), 2D drawings, or both.

The SOLIDWORKS® browser-based design roles, such as 3D Sculptor, 3D Creator, and Manufacturing Definition Creator, can help you overcome these challenges. These solutions run on the **3D**EXPERIENCE® platform, and are fully interoperable with SOLIDWORKS Desktop CAD and other **3D**EXPERIENCE Works roles.

3D Sculptor is a Sub-D modeling solution for creating stylized and organic-shaped models faster and easier. 3D Creator provides 3D parametric design tools for creating concept models. Manufacturing Definition Creator combines model-based definition (MBD) and drawing-based capabilities in one integrated solution that lets designers and engineers easily define 3D models and quickly produce 2D drawings from them in a matter of mouse clicks.

How exactly do 3D Sculptor and 3D Creator address the rising tide of increasingly complex geometry? And how do you ensure designs are manufacture-ready with Manufacturing Definition Creator? Answering these questions is the purpose of this e-book, along with introducing the tools in each of these roles and their respective apps.

The e-book is organized into workflows that engineers face every day. Each workflow details challenges of traditional 3D modeling tools, and the ways that 3D Sculptor and 3D Creator can address these challenges. In addition, it looks at how you can use Manufacturing Definition Creator in the design process to make sure complex geometry can be manufactured correctly. In order to properly manufacture products with complex geometry, you need to define your models properly by creating the correct dimensions, tolerances, and annotations. Once your model is complete, you can add the definition and provide a 3D model or 2D drawing so manufacturers can clearly understand how to manufacture it.

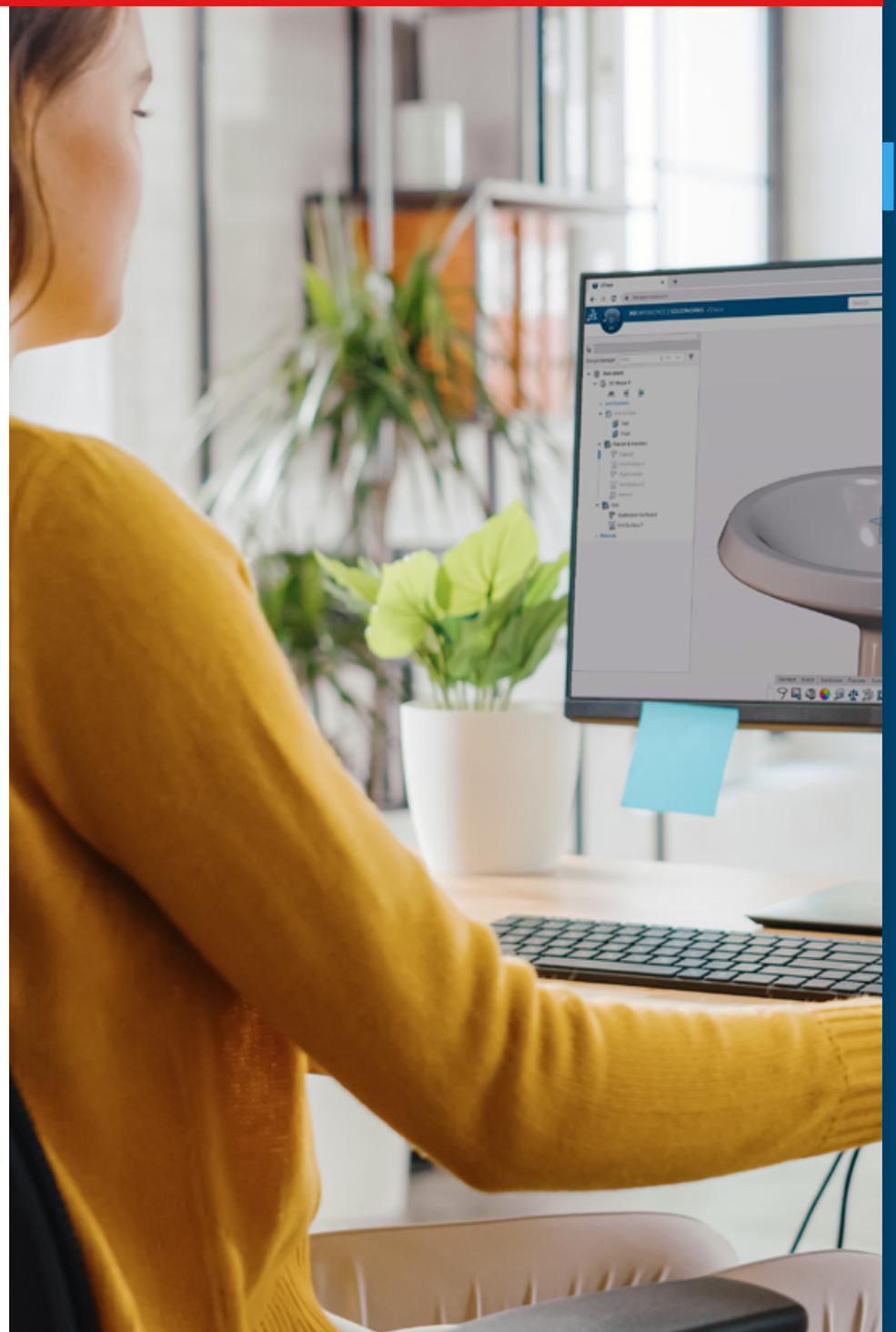
BUILDING CONCEPTS WITH SUB-D MODELING, FAST AND EASY

The demand for complex geometry starts early in the design cycle, right in concept design. The need for organic shapes is diverse. For some, the need to make products aesthetically pleasing or artistic drives these new shapes. For others, ergonomic requirements compel a product's conformance to an intricate shape like a human hand. For yet others, engineering function or physics force a product into unusual forms.

Whether you are an industrial designer, digital sculptor, or mechanical engineer, the goal is the same: Build out and iterate concepts quickly and easily. The workflows for creating concept designs with complex geometry with traditional tools is anything but quick or easy.

One approach is to build up models with curves and surfaces using parametric modeling. This approach is painstakingly slow due to its incremental and progressive nature. All curves must be defined individually before creating a surface, such as a patch or a sweep. Furthermore, the complex interrelationships in these models can be incredibly sensitive. Modify one dimension too much, and you have a cascade of feature failures. This approach is inefficient at best and disruptive at worst.

Another approach is to use a separate aesthetic surfacing application to create complex shapes. The difficulty here lies in cleanly moving the model from one tool to another. Exporting and importing the geometry often results in missing surfaces, misaligned curves, and a host of other problems. Everyone ends up spending an excessive amount of time fixing all of these issues. The challenges, however, don't end there. Concept design



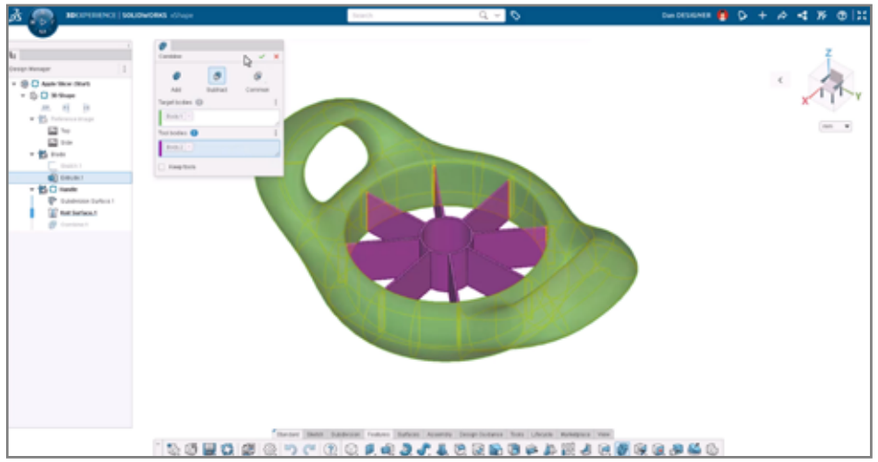
is inherently about change, exploration, and iteration. Modify the model in the aesthetic surfacing application, and the entire process starts again. The design must be exported and imported. The geometry breaks. An inordinate amount of time is spent fixing it—again.

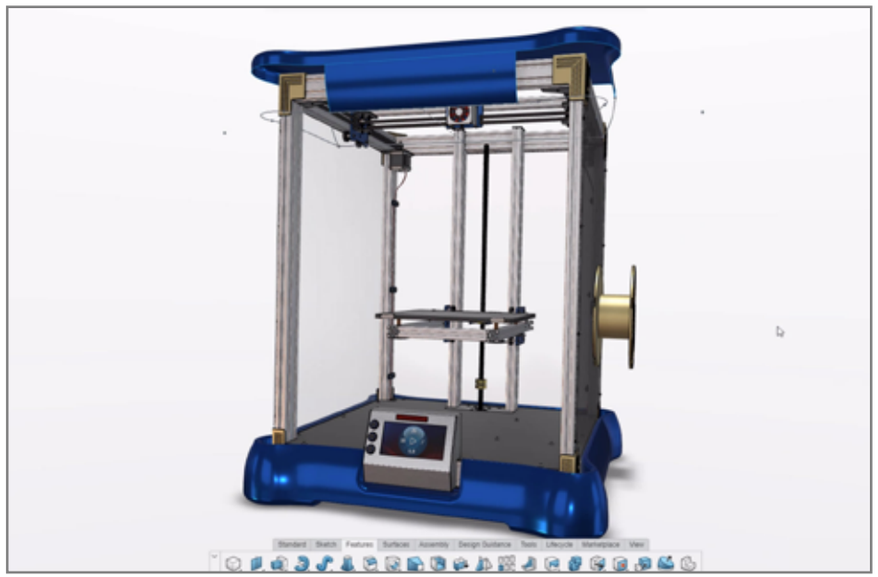
3D Sculptor and 3D Creator address this workflow head on. 3D Sculptor uses a push and pull technique, so you can easily and quickly create a complex shape and access additional Sub-D tools in the xShape app. You start with a digital ball of clay that you can push, pull, and stretch. You can progressively add more handles that allow you to control the geometry with increasing fidelity.

3D Creator, which provides more traditional parametric modeling tools in its xDesign app, augments this Sub-D modeling approach. As needed, you can add curves and surfaces as features. You can mix and match the Sub-D and parametric tools in xShape and xDesign as much as you need to get the job done. These two apps enable you to create and modify complex geometry fast and easily, and eliminate the non-value-added tasks of the prior approaches.

Beyond the improvements to existing workflows, the flexibility of these tools empowers new activities. Mechanical engineers can explore organic shapes independently. Industrial designers and digital sculptors can experiment with fine-tuned parametric modeling. Each can expand their respective skill sets and make concept design more productive with roles like 3D Sculptor and 3D Creator.

Plus, you can easily switch between the xDesign and xShape apps right from the same model, without having to reopen the model. All that changes is the toolbar. For example, if you are in xDesign and decide you want to quickly make a shape with xShape, you can hit the Switch App icon on the standard toolbar and open the xShape app. You can also simply hit the letter X on your keyboard





to pull up the Switch App menu. The Switch App functionality menus include all the xApps you have access to, so you can easily take advantage of other available tools, such as the xSheetMetal or xMotion Design apps, for instant access to sheet metal and motion analysis capabilities.

THE DESIGN ASSISTANT CAN HELP

The browser-based design roles 3D Sculptor and 3D Creator also feature artificial intelligence (AI) functionality within the Design Assistant. The Design Assistant tools, such as the Selection Helper, use built-in machine learning algorithms that offer design assistance based on your workflows. These AI-powered tools are designed to automate time-consuming and repetitive tasks, such as selecting edges or working with mates, to ultimately help you stay productive and free up time for creativity and the design tasks that need more attention.

The Selection Helper is a great tool for working with complex shapes and geometry. It saves time from having to make manual selections by offering suggestions on what you should select next, based on the work completed so far. It's also a nice companion for picking edges, fillets, or chamfers, as it will identify other edges that are similar or symmetrical, are of a comparable length, or are located nearby, and predicts what other edges you are likely to select. If you add another manual selection, the prediction is refined. If you agree with the prediction, one click gives permission, and the Selection Helper automatically picks all suggested edges. You always have the final say either way.

Say you are working on a motor assembly, and you want to remove some of the sharp edges on a part with a fillet where you'd normally have to make a lot of selections manually. This is where the Selection Helper can come in super handy. Once you make one selection, the Selection Helper will suggest a range of other selections that it can make for you based on the size, shape, and orientation of the geometry. If you make more selections, the prediction becomes more intelligent and more relevant to what you need it to do. And in a much shorter period of time, you'll have all the edges you want with a new fillet on them.

DISCOVER MANUFACTURING DEFINITION CREATOR

Complex geometry usually requires complex manufacturing processes. As a result the 3D geometry is vital to ensure on time, quality parts. To optimize the engineering-to-manufacturing process, many organizations are adopting model-based definition (MBD) practices to utilize model geometry and reduce the effort of creating fully detailed drawings. MBD is an approach that leverages 3D models as the primary medium for conveying product information. It involves embedding the manufacturing and inspection information directly within the 3D model, reducing the definition complexity, and eliminating the need for separate 2D drawings.

By combining MBD with 3D models, organizations can achieve a seamless transition from engineering to manufacturing. MBD allows for the transfer of geometric dimensioning and tolerancing (GD&T) information directly onto the 3D model, ensuring accuracy and consistency throughout the process. This integration reduces interpretation errors, eliminates redundancy, and facilitates downstream automation processes, such as computer-aided manufacturing (CAM) system integration.

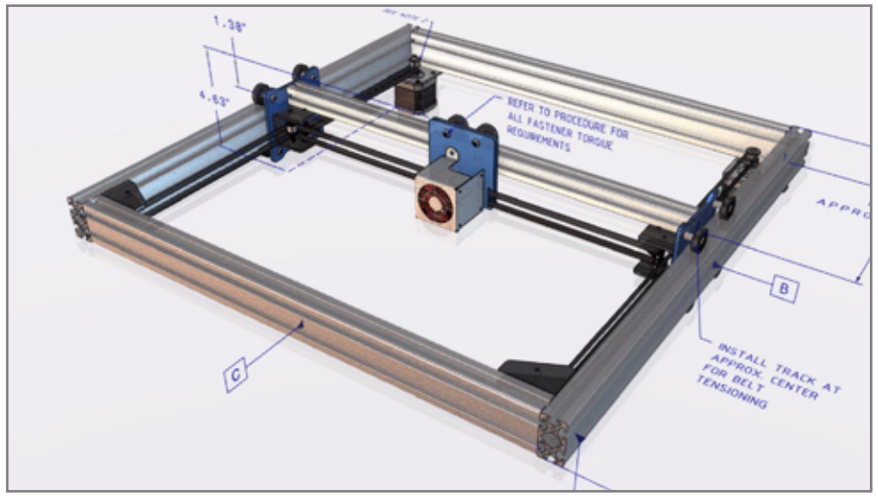
Furthermore, the adoption of MBD practices enables enhanced collaboration and cross-functional communication. Designers, engineers, and manufacturing teams can access the 3D model and associated information, facilitating better understanding and alignment between departments. After all, viewing and interpreting things in 3D is more intuitive; it's human nature to interpret objects in three dimensions as opposed to two. This collaborative environment fosters innovation, reduces lead times, and enhances overall product quality.

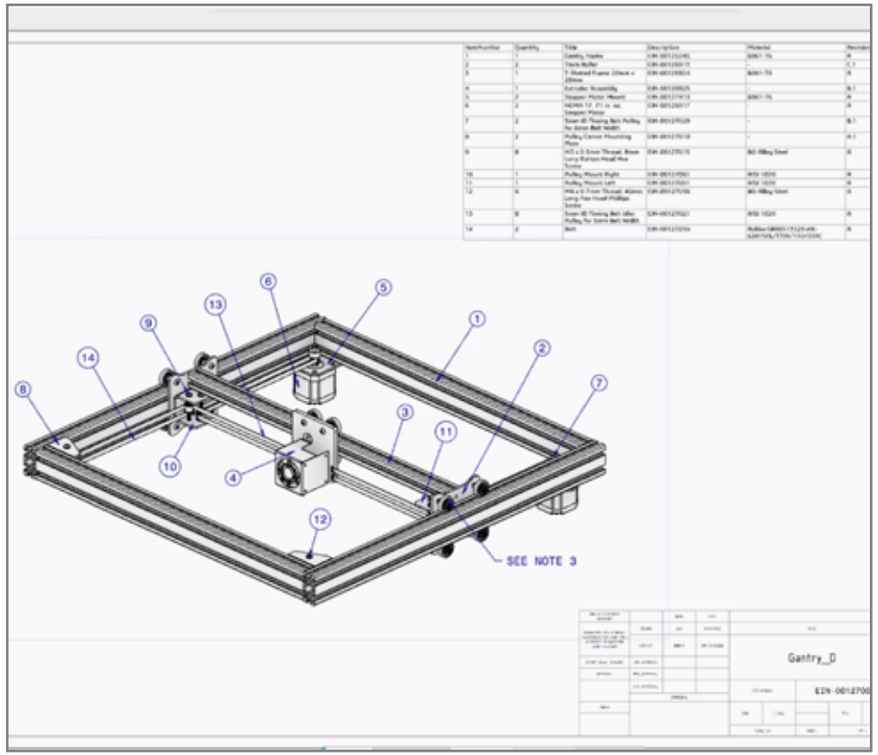
With the advancements of 3D modeling and CAM, the digital representation of a product has become increasingly detailed, intuitive, and packed with more information than a 2D drawing could ever convey. 3D models are always up-to-date, and provide a visual representation that allows engineers and designers to validate the form, fit, and function of a product before it goes into production. They also provide valuable rich information to CAM systems that is embedded in the 3D models to generate toolpaths, simulate machining operations, and drive CNC machines directly, which has revolutionized manufacturing processes. This seamless integration between 3D models and CAM systems has accelerated manufacturing processes, improved accuracy, and reduced lead times.

With Manufacturing Definition Creator, you can define 3D product manufacturing information directly on your models, including dimensions, tolerances, datum symbols, geometric dimensioning and tolerances, balloons, and more. You can easily organize annotations into specific views to communicate and paint a 3D visual story of your requirements with intuitive cross-highlighting to take advantage of the great benefits outlined above.

Yet many manufacturers still require a 2D drawing. Manufacturing Definition Creator allows you to easily create a drawing from your 3D definition and meet the needs of all your suppliers.

With Manufacturing Definition Creator, you don't have to create a 2D drawing from scratch. Your information is utilized across both forms of definition, creating a single source of truth and eliminating any discrepancies. You can create a drawing in a matter of a few mouse clicks. No rework, extra documents, or effort required. Simply place your existing views on a sheet, and you are ready to go. Whether it's 2D or 3D, your views, annotations, dimensions, and tolerances are always up-to-date and synchronized between the model, 3D PMI, and 2D drawing. Why spend a full day's work reworking or recreating a drawing for something you have already defined?





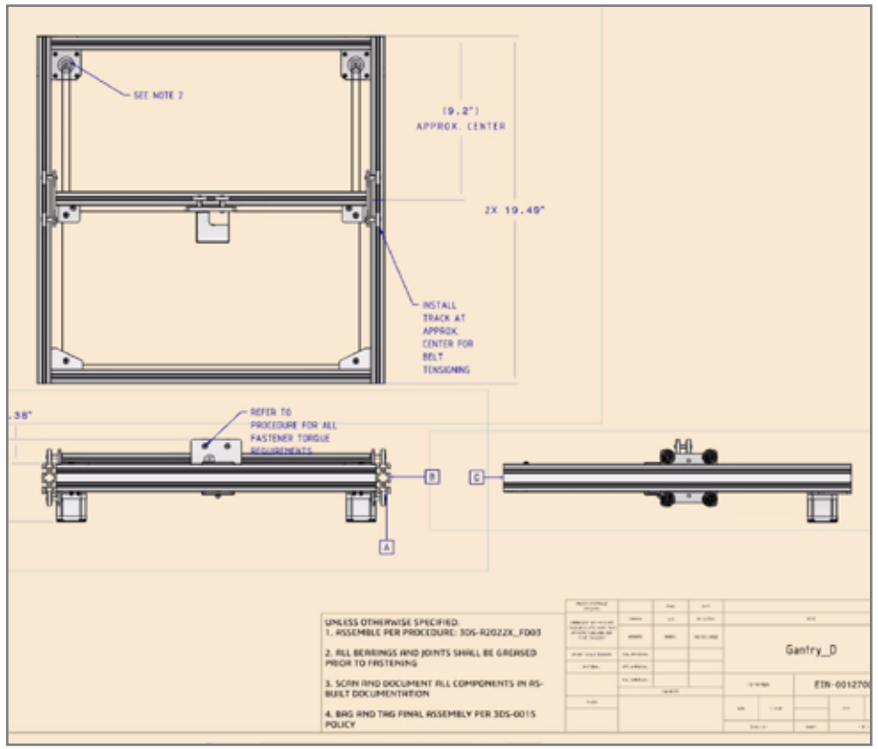
Most importantly, sharing is easy due to the power of the **3D**EXPERIENCE platform. You can easily communicate your manufacturing definition in 2D and 3D, with internal or external stakeholders using standard industry formats like PDF and STEP 242.

Even better, you can view, review, and mark up your 3D PMI and drawings directly in 3DPlay, the universal viewer for all data on the **3D**EXPERIENCE platform.

Of course, with Manufacturing Definition Creator, you can define models created in browser-based roles such as 3D Creator and 3D SheetMetal Creator, as well as models imported from outside of the **3D**EXPERIENCE platform.

As cloud solutions and MBD approaches become more mainstream, we understand that choosing a cloud solution or new definition approach may be a big leap for some. However, MBD has captured the hearts of many with its delivery of a single source of truth and streamlined connection between design and manufacturing. It provides an intuitive 3D approach to product definition to communicate design requirements, and reduces 2D drawing discrepancies.

As many know, with MBD it's not only about transforming design and engineering processes. It also requires you to transform the way you think in terms of reducing 2D drawings. 2D drawings have been a staple of engineering processes for hundreds of years and are still used by many. Typically, companies have to choose a path of either model-based or drawing-based practices, with little in between. Not anymore with Manufacturing Definition Creator. It provides a single solution with the benefits of MBD and the traditional look and feel of 2D drawings, eliminating the need to choose from one path or the other, as you can create both forms of documentation simultaneously. You have the freedom to define and communicate it your way in 2D or 3D with no additional effort, allowing you to provide the correct documentation for the job and cater to the specific needs of your suppliers.



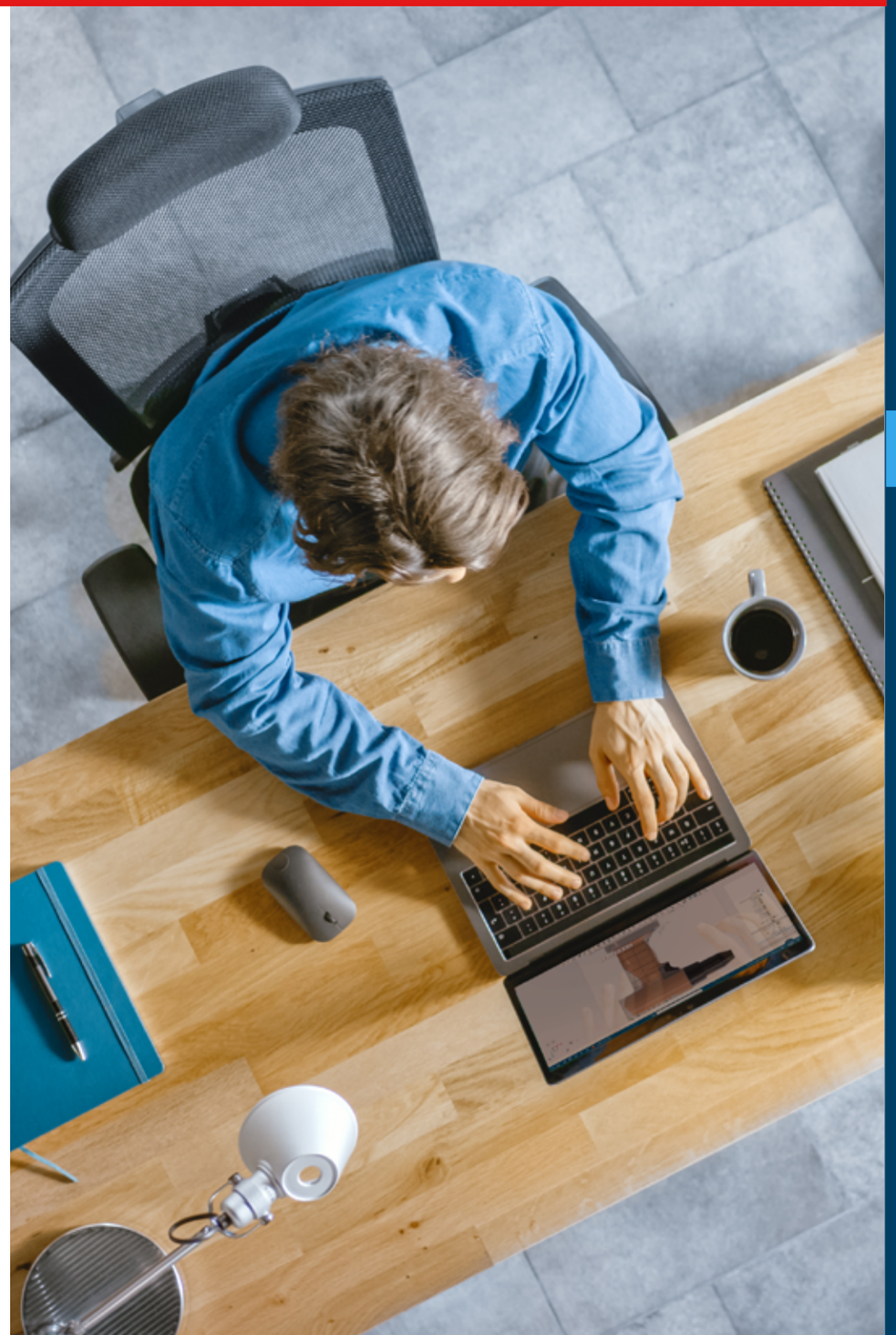
This approach allows for flexibility in the supply chain. Not all suppliers may have the same level of readiness or capability to work solely with 3D models. Some suppliers, particularly smaller ones or those specializing in certain manufacturing processes, may rely on 2D documentation due to their equipment, software, or expertise limitations. By accommodating their preferences and providing the necessary documentation, organizations can maintain a diverse and collaborative supplier network, eliminate additional effort for the engineering team, and avoid potential bottlenecks or restrictions in the manufacturing process.

SMOOTHING OUT TOPOLOGY-OPTIMIZED GEOMETRY

In the last few years, the potential to use topology optimization and generative design in development has exploded. This technology can automate the creation of geometry based on structural simulations, removing sections of components that carry little to no load. The remaining material of the component is highly efficient from a functional perspective. Many companies are excited about applying this technology. When they combine it with 3D printing, engineers and analysts can create incredibly innovative and efficient designs. More companies are stepping forward with real-world applications of 3D printing every day.

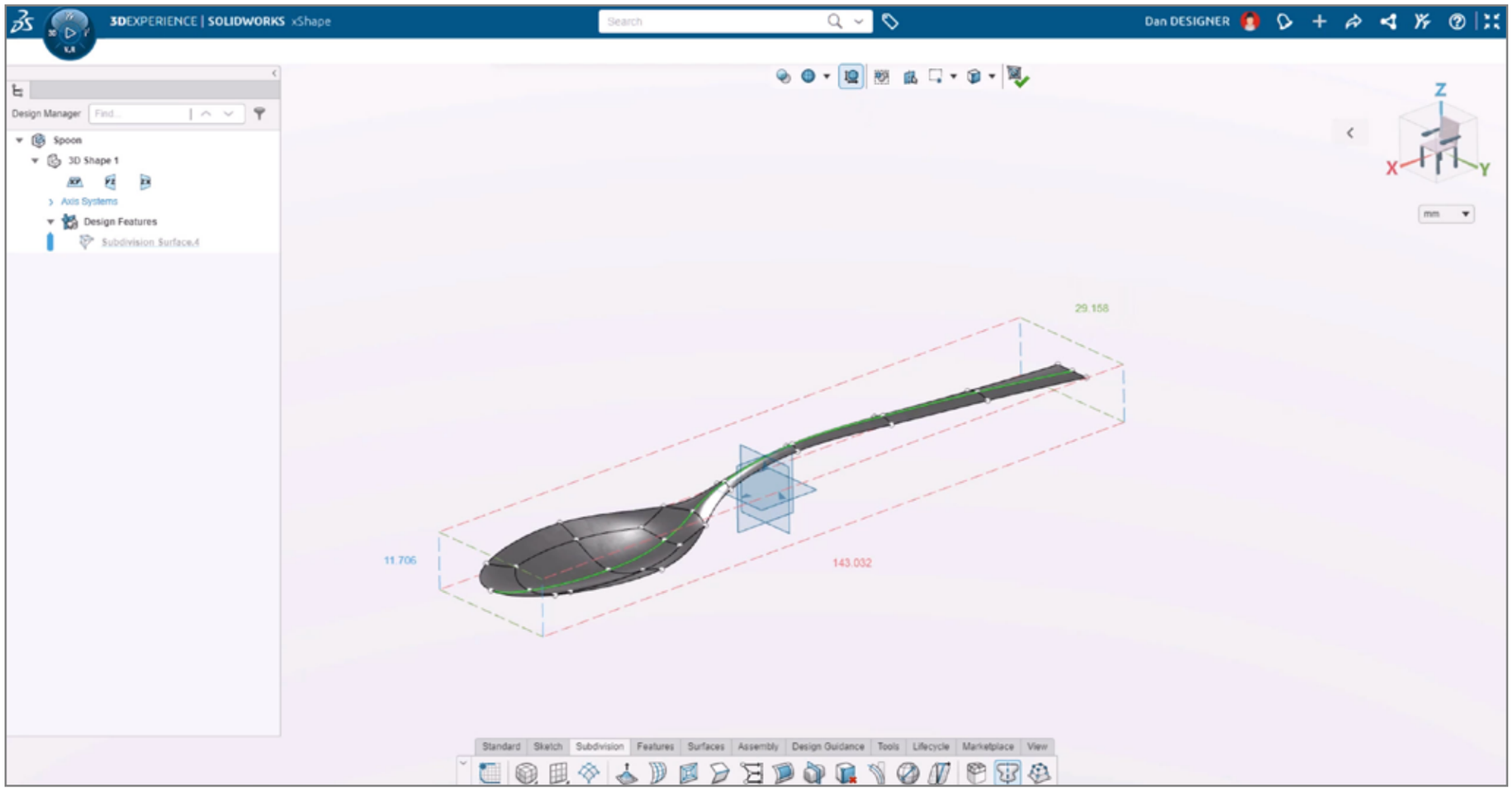
Topology optimization and generative design, however, have some pitfalls. Namely, they produce faceted geometry that resembles a simulation mesh. Extensive modifications are required to prepare such models for manufacturing, like machining or plastic injection molding. Unfortunately, making changes to these models is difficult. There are no features underneath the geometry, so it cannot be changed using parametric modeling. The end geometry is often wildly organic with few, if any, prismatic shapes. As a result, direct modeling cannot be used to make changes either.

Proponents of topology optimization and generative design are in a catch-22. They want to take advantage of the innovative capabilities, yet they have few means to make the models manufacturable. All too often, engineers and analysts are forced to slowly and painstakingly remodel these designs using parametric modeling.



3D Sculptor provides a new streamlined way to get manufacturable models from topology optimization and generative design. 3D Sculptor's Sub-D modeling allows you to create solid geometry over the top of faceted geometry quickly and easily. The critical enabler is the ability to add more controls to the geometry as needed. Anyone can tweak the Sub-D geometry, so it aligns closely with the faceted geometry. This approach is similar to tracing an image with transparent paper.

Of course, with 3D Sculptor's integration with SOLIDWORKS, anyone can use the geometry developed with Sub-D modeling as a SOLIDWORKS part. With this tool, you can realize the full potential of topology optimization and generative design.



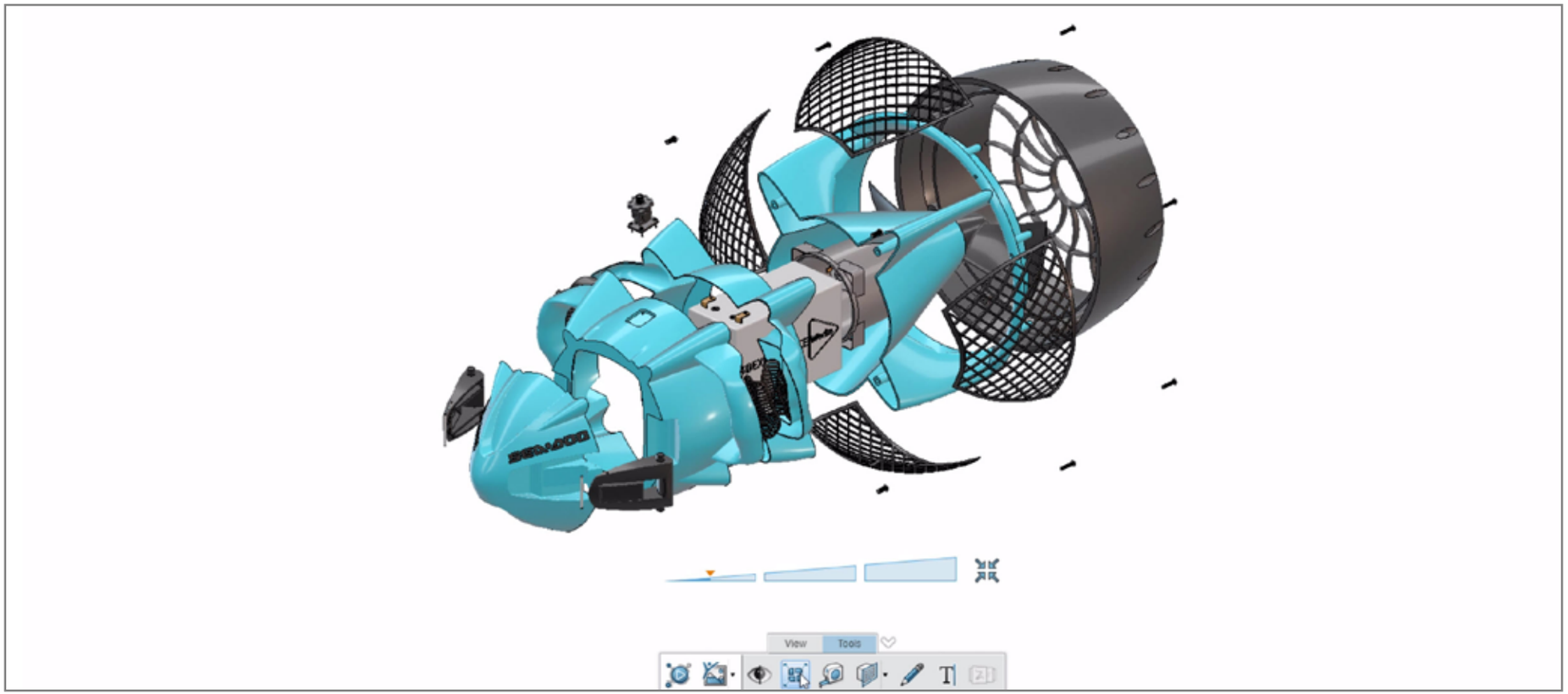
COLLABORATION IN CAD

Developing a concept is one of the first steps in the design cycle. The next one is to collaborate with a range of internal and external stakeholders to assess which design to move forward to detailed development. Subject matter experts provide input on manufacturability, cost, weight, and more. Executives contribute as well, giving their feedback and signing off on one of the concepts. A critical factor in this cooperative step is context. Responses from stakeholders often relate to specific sections of the design. A machinist might point out an underdraft that would result in a high-cost machining operation. A procurement agent suggests that switching to a functional equivalent material would result in a volume discount. An executive might require a change in colors. All of these people need to be able to visualize the design as well as attach comments or markups to specific pieces of its geometry. The objective is to get everyone to participate as quickly and as smoothly as possible. Unfortunately, there are significant barriers to that goal.

The most frequent approach used to enable this workflow today is file attachments and email. The first task is straightforward: Attach a concept model to an email and send it out to all participants. After that, however, the problems kick in. Despite its ubiquity, email for collaboration has inherent shortcomings. Emails can be lost, forgotten, or deleted, adding significant delays in the review process. Email attachments also have flaws: They fall out-of-date if the original model is changed. Likewise, feedback against the original may no longer be relevant. In addition, viewing concept designs requires specialized and unfamiliar 3D visualization tools that must be installed. All of this results in a messy, delayed, confusing workflow that undermines the original objective: Get everyone to participate as quickly and as smoothly as possible.

This workflow is another area in which the **3D**EXPERIENCE platform can solve a variety of problems. Because it is browser-based, sharing is simple. Anyone can provide a simple link to subject matter experts and executives, no matter if they work inside or outside of the company. Everyone can access the same up-to-date model simultaneously. That means providing feedback against the wrong version isn't even possible. Additionally, everyone can add comments and markups attached to specific geometry, removing all confusion about what feedback relates to what part of the design. Based on permissions, everyone can see each other's feedback. Sharing on the platform enables that original objective: Get everyone to participate as quickly and as smoothly as possible.

Not only can you provide feedback on the most up-to-date data, but designers using 3D Creator and 3D Sculptor can stay informed on changes to assemblies with push notifications that will instantly pop up on your screen when another member of your team has made a change. When you are actively working on an assembly, a dialog box will pop up, alerting you that another user has saved changes to a part within your assembly. At that time, you can choose to incorporate the changes or do it later.



TAKING COMPLEX GEOMETRY AND ORGANIC SHAPES TO PRODUCTION

Complex geometry and organic shapes are coming from many sources, including surfacing tools, topology optimization results, and 3D scans. There's no doubt about that. At some point, though, those unusual forms must be turned into parts. Surfaces for a product must be broken up into many individual components. Some may become plastic parts. Others may be sheet metal components. They all must mount to some assembly. They all must conform to packaging. Engineers' objectives are to make this transition happen smoothly, quickly, and efficiently. Furthermore, they must be ready for a change to the original design. Transitioning from complex geometry and organic shapes into production parts is another stage of the design cycle with many deficiencies.

As noted earlier, the outer surface or shape of products is either created in separate tools or developed using curves with parametric modeling. Models built using the former approach must be imported, resulting in time painstakingly spent fixing broken geometry. Models using the latter approach are sensitive to changes, often resulting in cascading feature failures. Changes to the design initiate these processes, repeatedly, wasting time in the design cycle. Additionally, model files are often shared as attachments in emails. This approach introduces more risk of errors, as emails might be lost, deleted, or misplaced, or the file might be out-of-date. These approaches do not support the engineer's objectives to make the transition smooth, quick, and efficient.

In contrast, 3D Sculptor and 3D Creator integrate seamlessly with SOLIDWORKS Desktop CAD and the rest of the **3D**EXPERIENCE Works portfolio of product development solutions. The geometry created in 3D Sculptor using Sub-D modeling is quick and easy to make. Once the surface or shape is broken down into components, SOLIDWORKS

Desktop CAD can be used to develop machining toolpaths and create plastic injection molds, engineering documentation, or any other deliverable needed to take the product to production. Furthermore, changes made in one place show up across all apps. You don't need to recreate models. You don't need to fix broken geometry. These browser-based design roles make sure everything is up-to-date. Overall, these capabilities directly support the engineer's objectives to make the transition smoothly, quickly, and efficiently.

EXPAND YOUR TOOLSET AND ACCELERATE TIME TO MARKET

As your needs grow you can scale up by taking advantage of more **3D**EXPERIENCE Works tools for design, simulation, data management, and manufacturing—purpose-built for the mainstream market to take products from idea to delivery.

Now, connecting your SOLIDWORKS CAD data to the **3D**EXPERIENCE platform is easier than ever with Cloud Services. Cloud Services enables users to connect to the **3D**EXPERIENCE platform, so they can store, access, share, and collaborate on their data conveniently and securely in the cloud, hosted by Dassault Systèmes.

Cloud Services is now available to new purchases of SOLIDWORKS Desktop CAD licenses. Existing SOLIDWORKS Desktop CAD users can easily upgrade to Cloud Services, and take advantage of the new possibilities in the cloud.

Click here to explore Cloud Services benefits and use cases.

SUMMARY AND CONCLUSIONS

To date, incorporating complex geometry and organic shapes has been a painful and challenging ordeal. It has resulted in significant time wasted on recreating models, fixing broken geometry, working against out-of-date files, waiting for delayed feedback, and many other detriments. 3D Sculptor and 3D Creator are aimed directly at improving distinct workflows that eliminate these issues.

In concept designs, industrial designers, digital sculptors, and mechanical engineers can create complex geometry and organic shapes with Sub-D modeling through 3D Sculptor and xShape, and parametric modeling through 3D Creator and xDesign. These tools allow anyone to build out and iterate concepts quickly and easily. When it comes to reviewing and signing off on concepts, being connected to the **3D**EXPERIENCE platform offers serious advantages. It enables internal and external subject matter experts, as well as executives, to provide feedback on the design through a web browser. Everyone can participate quickly and smoothly.

Topology optimization and generative design represent a significant opportunity to increase innovation while creating efficient designs. With 3D Sculptor, anyone can develop smooth geometry over the top of facet geometry, much like tracing. This capability eliminates that painstaking and arduous recreation of geometry.

Engineers must split all of this complex geometry into individual parts for production. Models created in 3D Sculptor and 3D Creator transition smoothly, quickly, and easily into SOLIDWORKS Desktop CAD and any other **3D**EXPERIENCE Works solution. From there, engineers can produce parts for use with machining, tooling design, documentation, and much more.

Dealing with complex geometry and organic shapes in the design cycle can be difficult. However, the 3D Sculptor and 3D Creator roles streamline the process and eliminate non-value-added tasks. Manufacturing Definition Creator completes the process entirely in the cloud so you can ensure your designs are ready for the shop floor. Isn't it time to try it out?

Discover the future of design today. 3D Sculptor, 3D Creator, and Manufacturing Definition Creator are available in the **3D**EXPERIENCE Works portfolio individually or in the SOLIDWORKS Cloud Offer: solidworks.com/cloud.

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Europe/Middle East/Africa
Dassault Systèmes
10, rue Marcel Dassault
CS 40501
78946 Vélizy-Villacoublay Cedex
France

Asia-Pacific
Dassault Systèmes K.K.
ThinkPark Tower
2-1-1 Osaki, Shinagawa-ku,
Tokyo 141-6020
Japan

Americas
Dassault Systèmes
175 Wyman Street
Waltham, Massachusetts
02451-1223
USA