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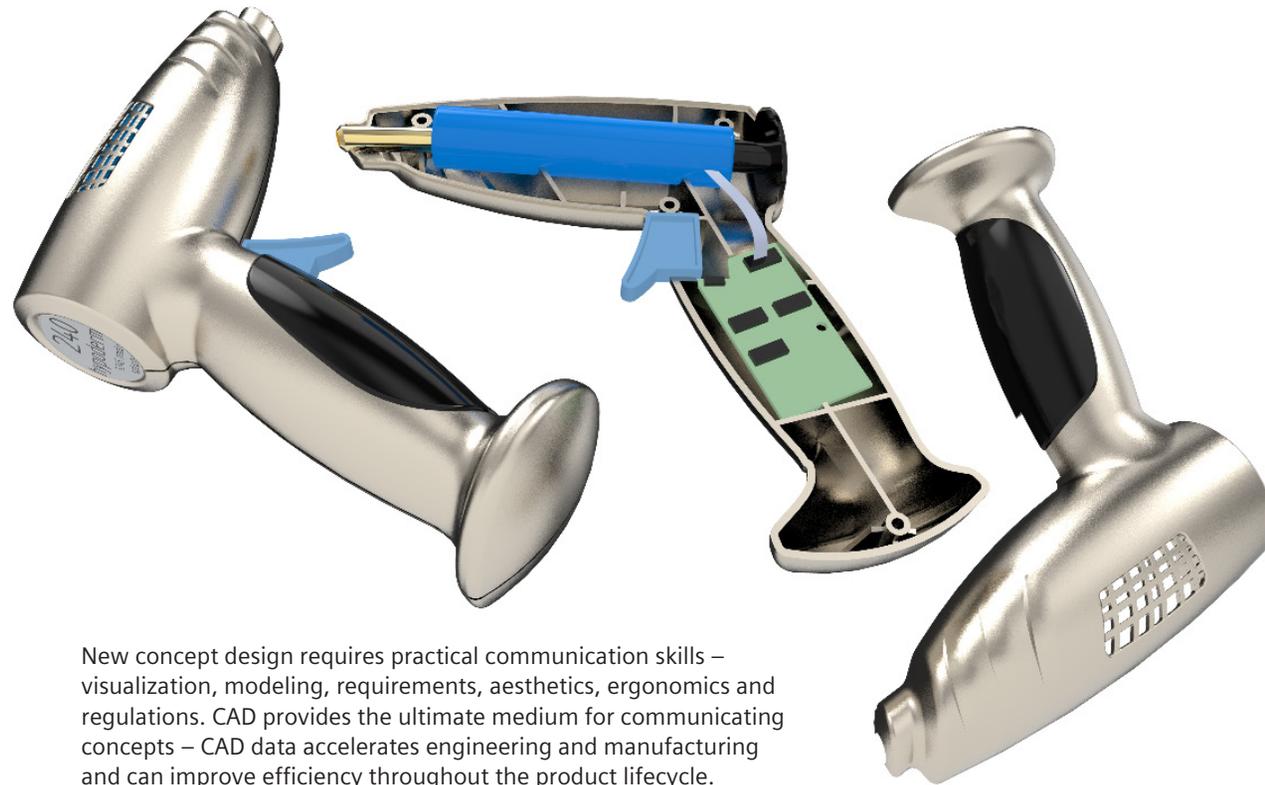
Best practices in complex shape design

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Design happens in the mind

What are the best ways to design complex shapes with computer-aided design (CAD) tools? Best practices can differ across industries and between companies, so it's hard to find consensus on rules and guidelines. Fortunately, some general principles for complex shape design are nearly universal, or apply in many cases. Recommendations of any kind should be taken a grain of context: designing automated machinery is different from designing medical equipment.



New concept design requires practical communication skills – visualization, modeling, requirements, aesthetics, ergonomics and regulations. CAD provides the ultimate medium for communicating concepts – CAD data accelerates engineering and manufacturing and can improve efficiency throughout the product lifecycle. Complex shape design is an essential skill for concept design.

CAD details the specific shape and properties of each part and how they go together. The data is used in downstream applications that range from rendering to repair. The one constant is change, yet change is the most difficult thing to plan for. Design intent is the process in CAD that helps with planning for change, and while much has been written about design intent in both history- and non-history based systems, it is still an elusive beast for many users.

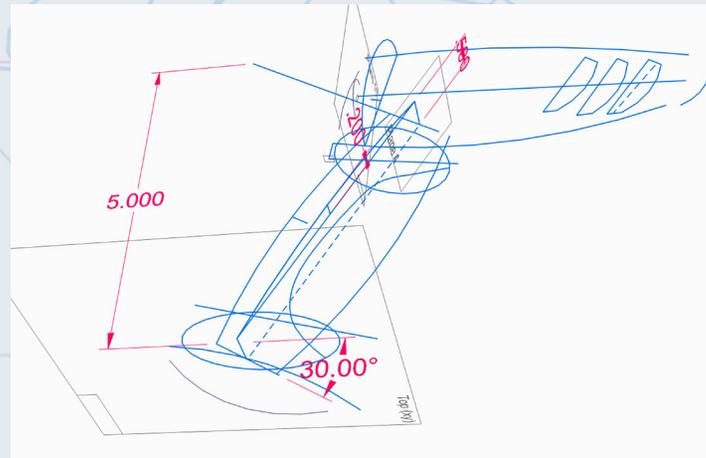
Using layout and master model techniques

One popular method for concept design is to use a layout: a sketch or collection of sketches and planes that help to arrange, locate and relate primary design features.

For the sketch-and-plane layout approach, a hand-held medical device demonstrates the concept. The model is started by sketching 2D profiles and outlines in 3D space, and from there, curves are created to be used for making 3D surfaces. At this point it's not necessary to decide what kind of features to use, as the goal is to sketch a wire-frame for visualization and modeling.

The layout sketches and planes are functional 2D geometry that drives the creation and editing of 3D surfaces and solids. The layout geometry can serve as spatial references or in feature modeling.

The idea is to have items at the top or very near the top of the feature tree that drive the shape of the product. This type of reliability can be tricky to get right in such a way that there is more success than errors when making changes, but that is what design intent is all about.



Complex shape design is an essential skill for concept design.

Solids and surfaces

Solid modeling is more commonly used in design than surface modeling and is the prevailing best practice. With solids, a single feature can create faces on all sides of a model. Surfaces are more typically used to create complex shapes, one face or one side at a time, or in situations where more control is needed over the finished shape than solid features allow for (for example, a propeller blade or wing tip). Surfacing generally takes a lot more time than solid modeling because the designer does manually what the solid modeling functions do automatically.

Surfaces

The non-uniform rational basis spline (NURBS) is the underlying mathematical model for curve and surface design in most CAD programs. Because NURBS describes curves in two directions, surfaces developed from curves work best as four-sided patches. If it's not possible to create a surface that exactly fits the desired location, it is best to overbuild the surface (make the smallest surface that can be cleanly made as a four-sided patch) and then trim it back. It's not always possible to do this, but it is considered the best practice method to get clean models.

Surface-solid workflow

It is considered best practice when designing complex shapes to make a single transition from surfaces to solids. Once you transition to solids, you should continue working in solids from that point on. In the heat of real design work with many changes, this isn't always the way it happens, but switching between solid and surface design techniques in a history-based workflow costs you rebuild time. Most CAD programs allow hybrid design, with solid and surface geometry in the model at the same time.

Solids

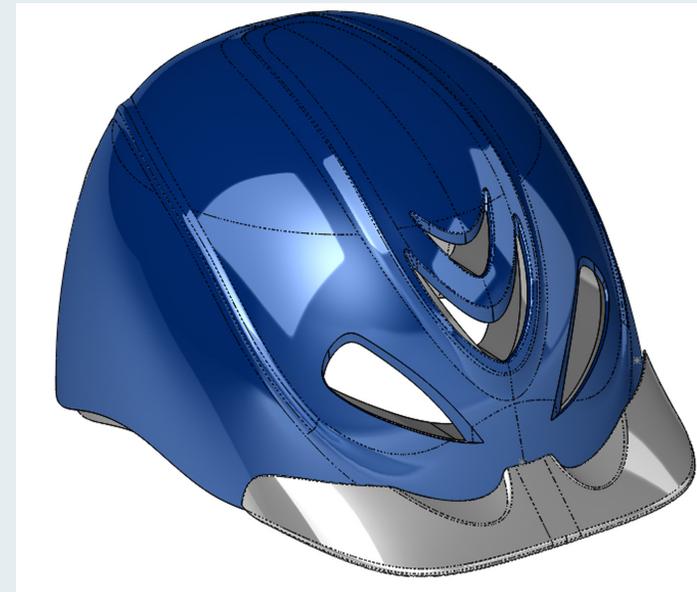
Feature-based solid modeling often helps with specific detail tasks for engineering the fit and interface between parts. These are features like bosses, ribs, reveals, draft and rounds. Before using such features, surface geometry should be solidified and shelled. Hopefully most of the major design changes are done by the time this level of detailed work is underway.

Super features

Many CAD programs have created so-called super features that combine multiple simple geometrical features that are commonly found together into a single feature that makes more complex geometry. These can be huge time savers if the creation of these types of geometry is needed. These features include web network, lip/groove

features, vent mesh, or mounting boss. Typically, a mounting boss would include a cylindrical boss for a screw or a pin connection between parts, and then supporting ribs with fillets and draft and the rotation of the ribs. Advanced users may want to create their own library features, but it is convenient to have something built right into the software on the chance that it perfectly fulfills the design requirements. These tools can be very flexible, and if one takes advantage of super features, it is one way of re-using design information to help save time, keystrokes, and space in the feature list.

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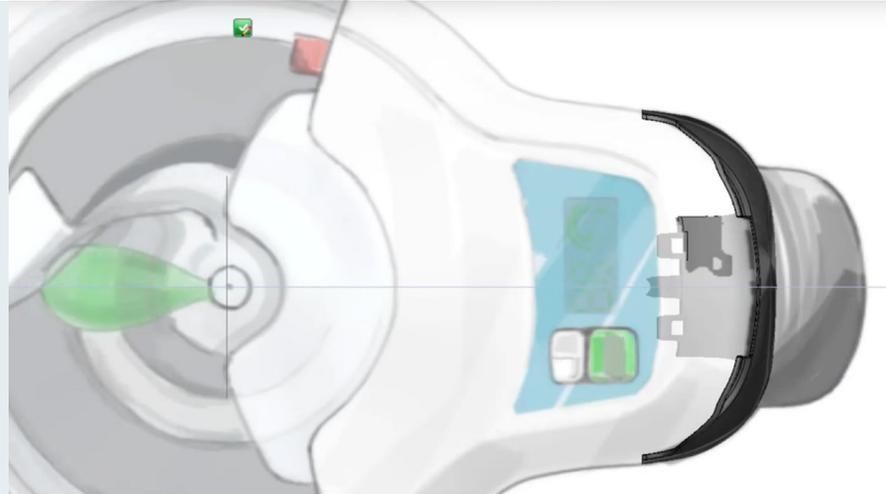


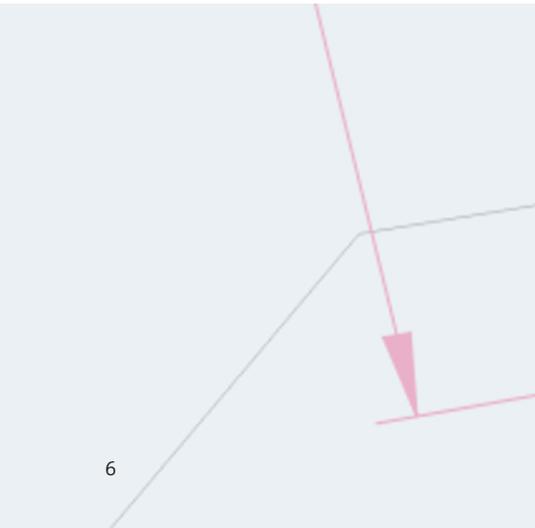
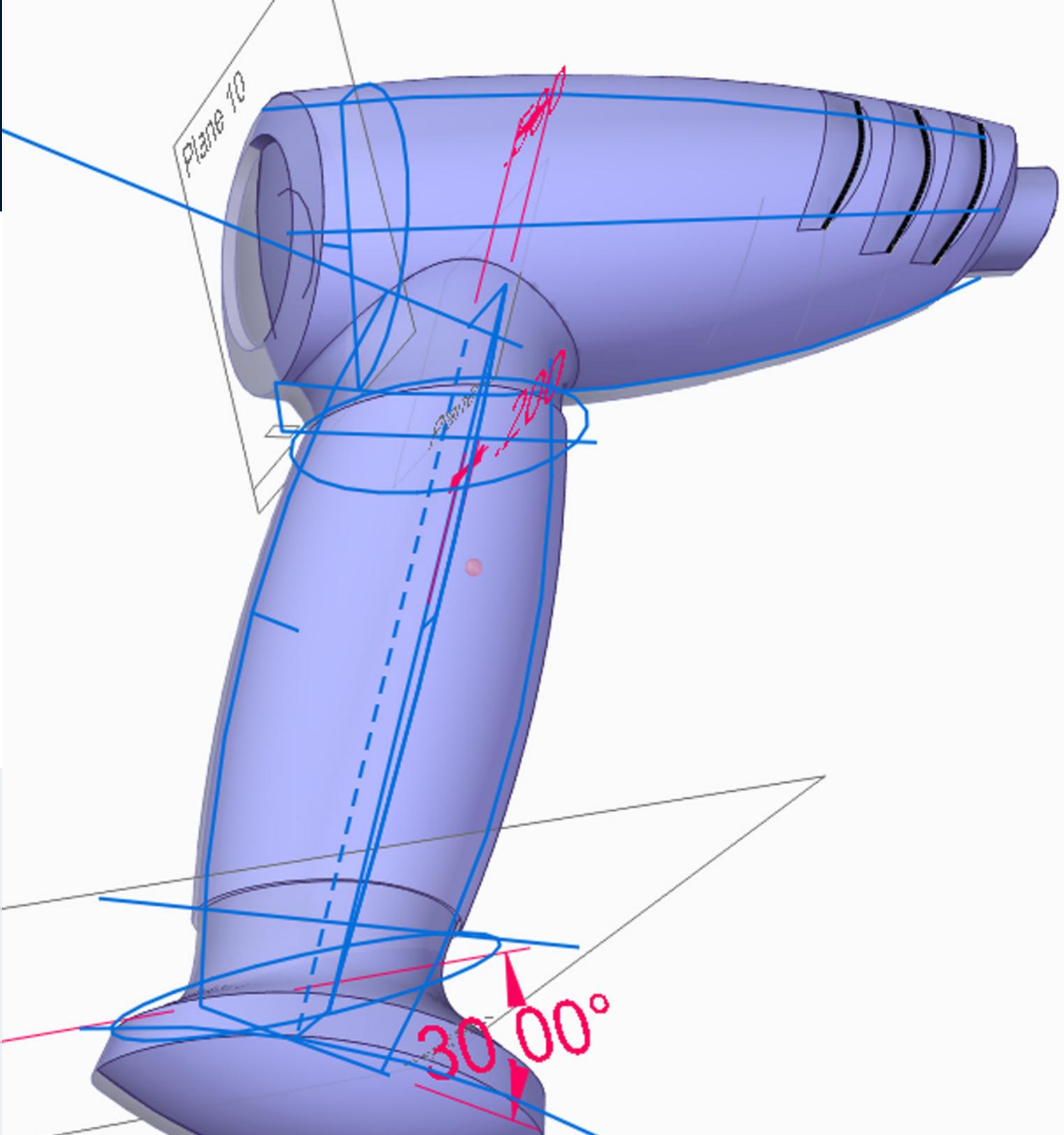
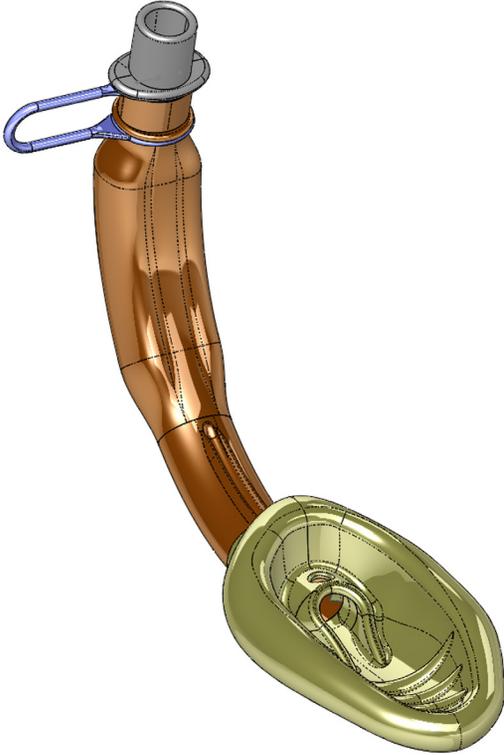
When your concept starts outside of CAD: Reusing industrial design sketches

Even in today's era of high tech tools, many shapes start with pencil on paper. For the people who swear by this method of ideation, it can work seamlessly as the input to a CAD system. An industrial design sketch can be scanned into the software, and then a traced over with a CAD sketch. Some systems even allow a stylus (or digital pencil) to be used, allowing the same feeling as pencil and paper, but digitally capturing the required shape.

Getting the details right

If your design includes surfacing as part of its evolution, it can introduce the opportunity for tiny flaws, which can impact the success of manufacturing and the aesthetic of the final product. The transition between surfaces or faces is subtle, yet critical in complex shape modeling. Some CAD tools allow you to interrogate this with the use of 'Zebra Stripes'; the fluid nature of the stripe helps indicate which type of transition is occurring at that intersection – rough, smooth, or really smooth (more technically known as G0, G1, G2+) – and allows you to adjust to suit your needs.





Best practice for ordered modeling

Ordered or history-based modeling has seen the development of many best practice lists over the past several decades. In fact, these best practice lists tend to highlight some of the major shortcomings of history-based modeling. These shortcomings are part of why synchronous technology was developed. Synchronous eliminates many of these limitations such as the need to regenerate features, the complex and error prone parent/child relationship scenarios, and the abstract association of a feature list with geometry. Most designers have worked with these limitations for decades and simply accept them as a matter of course. Some have even grown to believe that design intent itself is somehow a product of the history-based order of features. Later it will become clear how synchronous technology helps to avoid the limitations of history-based modeling.

Best practice lists for history-based modeling always include suggestions such as adding fillets and draft at the end of the tree; never dimension or make sketch relations to edges that may change or disappear; be careful of accumulating external references between parts and particularly circular references; avoid multi-body parts when a multi-part assembly is more appropriate, and others.

Best practice lists for ordered modeling tend to center on design intent – the practice of modeling to facilitate changes to the model. With ordered modeling, this assumes that you know what kinds of changes are coming, which seldom is the case.

Simultaneous workflows and data management

Design projects are often large enough to have multiple people working on different areas of the design. For example, while one person finishes putting draft and fillets on the model, another can begin to organize the drawings, and someone else may be conducting stress or motion simulations. If the exterior design is finalized, someone else may create marketing images, while yet another designs packaging. If the team is large enough, much of this work can be done concurrently to save time at the end, when the project is always at the highest risk for getting off schedule.

Many organizations attempt to do all of this with a single product assembly model, but it is very risky to have multiple people working with the same live data. A change made to an assembly for a rendering should not affect the assembly that is driving the manufacturing assembly instructions.

Data management must be part of the workflow for all professional design teams. Even if a team is small, data management offers many advantages such as traceability, the ability to retrieve older revisions for repair or testing, large-scale undo of changes, and workflow assignment and tracking. The effort required to use Windows Explorer for file management combined with the high risk of errors makes the use of data management software a best practice.

It will become clear how synchronous technology helps to avoid the limitations of history-based modeling.

Enter Solid Edge

Solid Edge has a complete set of history-based tools on which most of the best-practice techniques have been developed. Solid Edge can drive surface and solid features with sketches, create multiple bodies, split those bodies out to individual parts, and do the detail engineering work to add mounting bosses, ventilation holes, draft, fillets, and bring the finished parts back together in a completed assembly of parts. Solid Edge also offers legendary capability in the areas of sheet metal and 2D drawings.

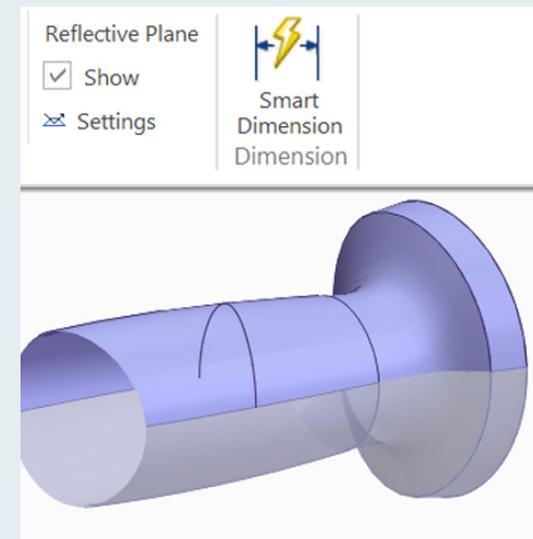
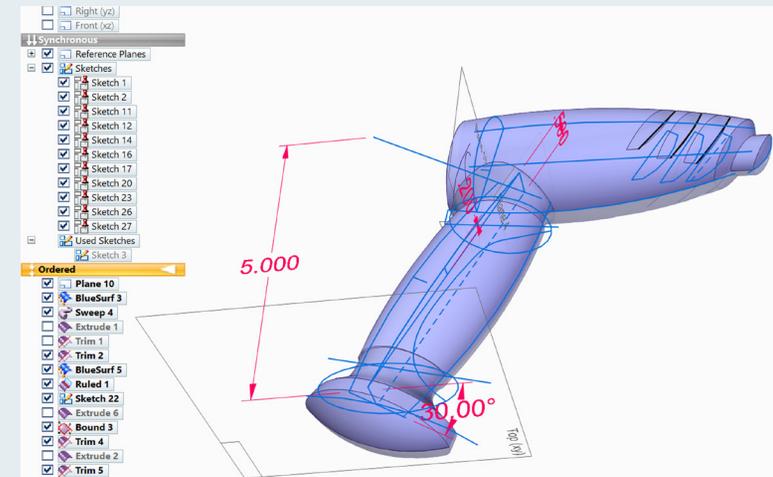
In addition to these traditional history-based tools and techniques, Solid Edge also has built-in synchronous technology, which is a set of order-independent enhancements on top of direct editing. Parts can be entirely or partially built using either synchronous or history-based methods, and these features can be edited in the context of an assembly.

Unexpected synchronous advantages

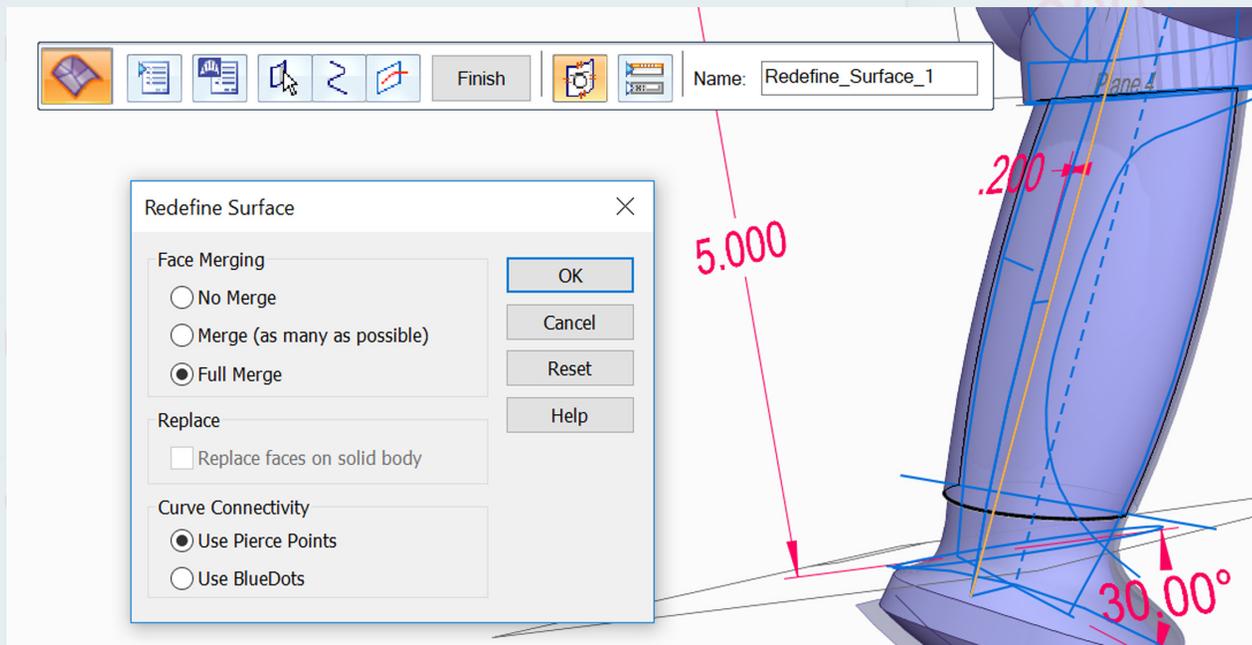
In this sample medical device model, all sketches and planes were made in synchronous mode, while all surface features were made in ordered mode. As a result, when a sketch is manipulated by being dragged, for example, the model updates in real time. This is done without the need to go back in the part history and isolate a sketch to edit it, then rebuild all the sketches and features after it in the hope that all parent/child relationships in the model are still valid. Synchronous can be used independently or in cooperation with ordered modeling. Rather than pick one or the other exclusively, they can be used simultaneously.

Many of the surfaces in this model were created using the staple surfacing feature of Solid Edge, the BlueSurf, but some of the detail surfaces were done with ruled surfaces. Ruled surfaces follow a curve, and in the direction perpendicular to the curve use a straight line. They are great for developing draft, a face normal to another face, an offset or thickness face and other applications. In this model, the thin face around the heel of the handle was created using a ruled surface.

Solid Edge includes a reflective plane display mode where half of the model can be worked on while showing the mirrored half visually only. This is a great assistance to visualization without the added overhead of the additional features and geometry. A simple toggle in the toolbar area turns it on or off.

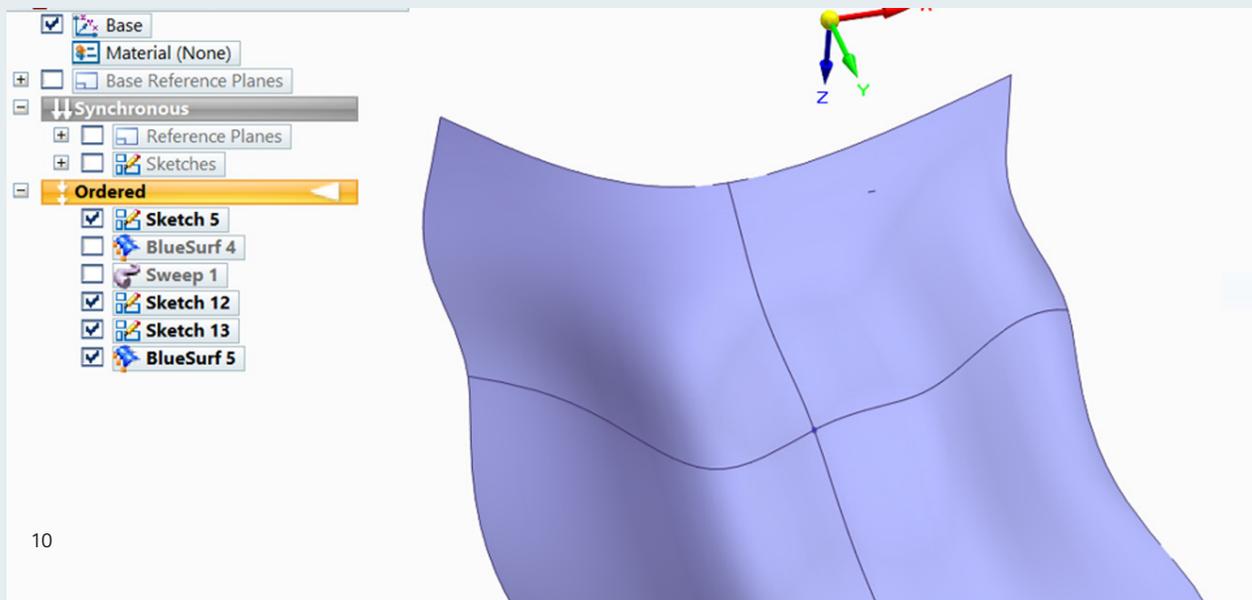


Redefine Surface



The redefine surface capability of Solid Edge was used in the patch shown in the adjacent image. With redefine, the user can replace an existing surface patch with a new patch that has more organic shape controls. It enables designers to employ simpler, more efficient features to create a model and postpone some of the more complex modeling. The surface redefinition capability also helps edit shapes on imported models and can be used to easily make shape changes across multiple faces.

The Blue Dot is a feature that pre-dates synchronous technology, but it was an early attempt at mitigating some of the difficulties of history-based modeling. Take the example of making a BlueSurf, which is essentially a lofted surface, created from a crossing mesh of curves. In a history-based system, even these curves are handled as ordered features. It's necessary to find the points where the curves intersect, while at the same time paying attention to the order in which they were created in such a way that the designer always edits the last one made. Blue Dot enables you to connect crossing curves from sketches in different places in the order and edit them simultaneously, as if they were part of a single history-free mesh. A new world opens up when one realizes the advantages of moving away from history-based limitations in design.





In conclusion

Complex shape design challenges the current capabilities of designers. Best practice for complex design can be used in just about any project, but even best practice concepts are not the same in every type of design work. Best practice is always on the conservative rather than the risky end of the spectrum of design choices, and there are often good reasons to transgress best practice. Don't use best practice as an excuse to hold rigid and unyielding ways of working.

Solid Edge has its own best practice rules that mirror those of general CAD with one exception: Solid Edge combines the power of synchronous technology to help circumvent many of the limitations and shortcomings of history-based tools. With the option to move between synchronous and history, Solid Edge delivers the unique capability to tailor best practices to the specific type of work a company needs done today.



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