

# Solid Edge Rapid Blue: a new paradigm for complex shape design

**SIEMENS**

## White Paper

Rapid Blue™ software unleashes productivity by overcoming the limitations of existing CAD systems by providing a new level of design control and flexibility for designers, engineers and industrial designers.

## Contents

<b>Executive summary .....</b>	<b>3</b>
Rapid Blue: a new paradigm for complex shape design .....	3
Rapid Blue usability: you're in control .....	3
Rapid Blue: the solution to traditional shape modeling limitations .....	3
<b>Solving the history vs. nonhistory problem .....</b>	<b>4</b>
BlueDots .....	4
<b>Solving the curve creation and associative modifications problem.....</b>	<b>6</b>
Flexible curves .....	6
Shape-preserving curves .....	6
<b>Solving the design iteration problem.....</b>	<b>8</b>
Dynamic edit.....	8
Convert to curve.....	8
BlueSurf .....	8
<b>Putting it all together .....</b>	<b>10</b>
<b>Conclusion.....</b>	<b>11</b>
Appendix A: Solid Edge curve technology .....	12
References.....	13

## Executive summary

### Rapid Blue: a new paradigm for complex shape design

Version 14 of Solid Edge® software extends its broad reach into multiple industries, introducing Rapid Blue – a revolutionary new approach to complex shape modeling that will appeal to customers designing aesthetic shapes prevalent in consumer products and many other industries.

To understand what sets Rapid Blue apart from other shape modeling technologies, it is important to understand the limitations of those technologies. This paper discusses how a careful consideration of the most serious limitations of existing CAD systems led to the development of Rapid Blue.

### Rapid Blue usability: you're in control

It is important to understand the target audience of Rapid Blue, as the “feel” of Rapid Blue has been largely influenced by this consideration. Rather than appealing solely to mechanical designers and engineers, such as those found in machine design industries, Rapid Blue must equally address the needs of the industrial designer. Industrial designers routinely make use of the more fluid mediums of ink, paper, and foam and, as such, are less tolerant of the restrictions which CAD systems often place on their creative design process.

To appeal to the industrial designer, shape design tools must have enormous power and flexibility, while remaining easy to use and sympathetic to the creative process.

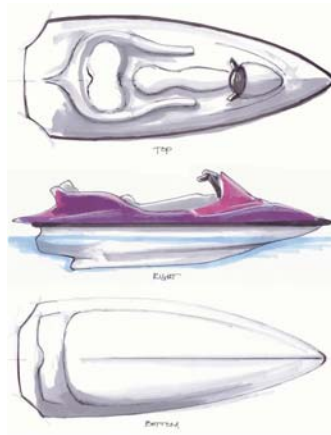
Rapid Blue overcomes the limitations of existing CAD systems and provides a new level of design control and flexibility for designers, engineers and industrial designers.

### Rapid Blue: the solution to traditional shape modeling limitations

This white paper focuses on the three primary limitations that have long plagued the different modeling technologies developed for complex shape modeling:

1. History and nonhistory-based modeling
2. Curve creation and associative modifications
3. Design iteration

Rapid Blue provides an elegant solution to each of these issues, as detailed in the sections that follow.



It is important to remember, however, that it is not any individual feature, but rather the combination of all the features of Rapid Blue technology that unleashes productivity.



## Solving the history vs. nonhistory problem

A history-based modeler is one where geometry depends associatively on the geometry that came before it. In this way, a change to the initial geometry causes a change to geometry that comes later or “downstream” of the original geometry.

Most solid modeling systems are history-based – and with good reason. Solids modeling lends itself extremely well to this paradigm. That is, it makes perfect sense for a cutout to “rely on” the solid that preceded it and to update when that solid updates. We’ll see shortly, however, that this strict order dependence is an unnecessary and very cumbersome complication when it comes to portions of the shape design process.

In contrast, in a nonhistory-based modeler, all the design features are independent. That is, when a change is made to any element, other elements of the model are unaffected. This is the approach that has been used traditionally in some of the more successful surfacing modeling programs (Alias Studio for example). It provides a more flexible modeling method that appeals to the industrial designer, but at the expense of automating the update of related model elements – a key drawback in modeling stylized parts, which often require a significant number of iterations.

The goal of Rapid Blue in this area, then, was to dispense with the negative aspects and heighten the positive aspects of each of these respective modeling technologies. In particular, our goal was to provide a flexible system where the order of the curves in the history tree did not restrict the editing thereof, but yet had all the benefits of properly updating the down-stream geometry as upstream edits were performed. A technology unique to Solid Edge, called BlueDots, provides this “best of both worlds” approach.

### BlueDots

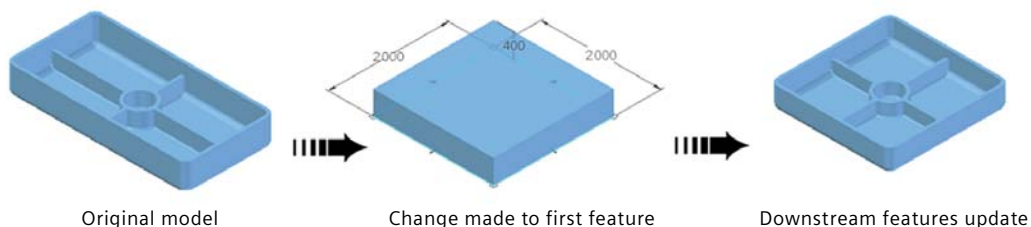
BlueDots connect two independent sketches together and make them peers. This means two things:

1. If they were previously disconnected, they become connected and stay connected as edits are performed. The BlueDot is the glue that binds them.
2. An edit to one will make the appropriate edit to the other(s), regardless of where its peer lies in the history tree – below, or above. BlueDot provides the peer-to-peer connection.

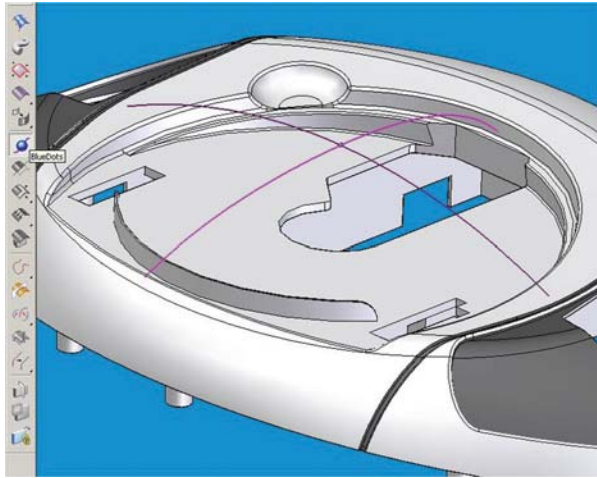
The importance of the peer relationship cannot be overstated. Take the example of a “bound by 4” type surface creation, where four boundaries are used to define the surface shape.

In this example, consider which of the four boundaries should be the first in the tree and which the second and so on. An ordering of these boundaries really makes no sense. Indeed, it is more than just an artificial construct – it is a real productivity inhibitor. In a history-based system, suppose you make curve 2 dependent on curve 1 and curve 3 dependent on curve 2 and curve 4 dependent on curve 3. How is it then that you “close the loop?” – you cannot make curve 1 dependent on curve 4 as curve 1 precedes it in history – a very practical and common problem because of the force-fit between a history tree and shape modeling.

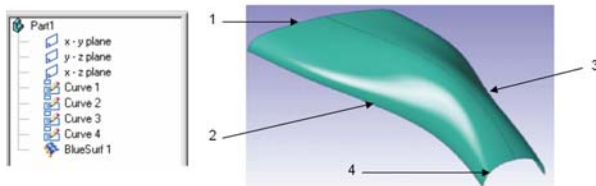
Compared to modern sketching environments, the order-dependence of curves in the 3D environment is quite crude. Users of a modern CAD system would not tolerate the lines within the sketch environment having an order-dependence. It would be unacceptable to have to pay close attention to the order in which the lines are sketched, and be unable to edit



the 4th line and have it change the 1st line. Variational geometry, developed more than 10 years ago, abolished this limitation with in sketches. BlueDots, unique to Solid Edge, now abolishes this same order dependence among sketches.



It is important to understand and not be fooled by systems that offer some limited “pockets of order-independence” approach to this problem. For example, some systems provide a “3D sketch” construct where multiple sketches can be forced into a single “bag” where they are solved together. There are several problems with this approach. The first is that these 3D sketches are indeed 3D – that is, they may be nonplanar on creation or may accidentally become nonplanar during editing. The second, and more important, problem is that it requires the user to manually group them in a single location in the feature tree. This is often not possible, and is overly restrictive. With Rapid Blue, the sketches can exist throughout the feature tree as is required by most designs, yet participate in a peer-to-peer solution.



# Solving the curve creation and associative modifications problem

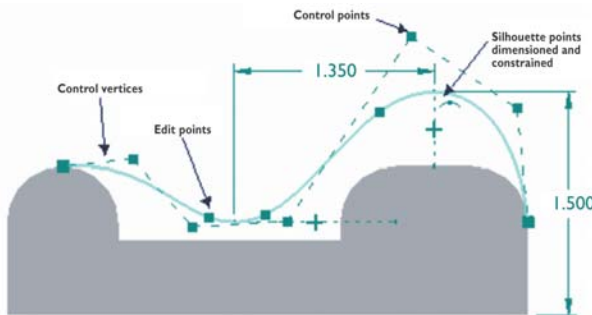
Aesthetic shape design is, by nature, a creative process that requires much editing. And curves<sup>1</sup> are the “hub” of all shape modeling. If the curves have any defects or don’t lend themselves to creating the desired shapes, no amount of good “surfacing” can fix this. It’s critically important, then, for the curves to be able to represent the desired shape and to be flexible in their editing.

## Flexible curves

Most “high end” systems provide access to either the “edit points” (points the curve must pass through) or the “control points” (mathematical points that control the curve shape), which is necessary to achieve the required amount of control. However, this level of control is not common in mainstream systems. In contrast, Rapid Blue provides the most flexible curve control in the industry.

Rapid Blue curves incorporate three different types of points, which may be edited or constrained in any combination:

1. Edit points (called interpolate or fit points in some systems)
2. Control vertices (called control points in some systems)
3. Silhouette points (unique to Solid Edge)



Any of these points, which define the curve, may be used in combination with the existing constraint

commands in Solid Edge. For example, an edit point may be constrained “point on” to an existing edge or the curve may be constrained to attach where another curve “pierces” the sketch plane. Two control vertices can be made to be horizontal or vertical with one another, enforcing tangent takeoff or symmetry. The high and low points of the curve (silhouette points) can be used to attach other key elements which belong at that horizon point. The flexible curves of Rapid Blue mean you are never unable to achieve the shape you want or the associative behavior you desire.

## Shape-preserving curves

In addition to limited curve flexibility, traditional surfacing systems often require excessive “manual intervention” to make broad changes. Changing one part of a curve causes a “waterfall effect”, and many other changes are then necessary to re-achieve the desired shape. High-end systems attempt to work around this problem by providing explicit commands for special curve modifications, such as scaling or moving multiple control points. However, these methods run counter to the goals of an associative system, as they require the user to manually set and execute this method for each curve modification.

In contrast, Rapid Blue provides “shape-preserving curves” which encapsulate in their behavior the ability to preserve their general shape characteristics. The original “design intent” is built into the curve, rather than the designer having to be intimately involved in the manual labor of adjusting each curve when a change is called for.

Consider the simple example of a single surface that has one “spine” (or guide) and five “sections”. Each section needs to stay connected to the guide for a valid surface to be created. Assume that all systems have the ability to make a solid connection between the guide and the sections (which is not actually true) so that any change to the guide will cause the sections to adjust. How exactly should they adjust? This is the question that Rapid Blue set out to answer, and answered very effectively with shape-preserving curves.

In a traditional system, there is no behavior encapsulation in the curves. They can of course be edited manually using scaling or multiple control point manipulation, but this is a lengthy process – further, since each section is edited in a piecewise manner, there is no guarantee of consistency of results (in fact you will probably have to edit each curve at least twice). But since the curves lack behavior encapsulation there is no alternative for the designer. Allowing the system to keep the curves connected, when associatively triggered by a change, will locally distort the curve, requiring even more manual editing. And most designs have 10's or 100's of surfaces – leading to incessant edits on a grand scale!

Only Rapid Blue shape-preserving curves solve this problem. Although the technical details cannot be disclosed, the behavior is such that it minimizes the edits required in any given situation to maintain a curve's design intent. For example, if a curve is convex along its entire length (as many consumer product designs main faces are) it will remain convex through all but the most extreme edits. Likewise, perturbation to the curvature plot (or comb) of the curve will be minimal. As a result, significant time is saved when creating and editing designs using shape-preserving curves. Additionally, designer fatigue and frustration is significantly reduced, as Solid Edge automates an otherwise highly tedious process.

## Solving the design iteration problem

Engineers and designers all design in an iterative manner, and this is more true in industrial design than anywhere else. Because the style of the part is a key component, many more alternatives need to be explored. Additionally, a subjective element enters the picture. As a result, the industrial designer needs an even tighter feedback loop in the design process, and needs to be able to make changes with continual feedback of the results.

In traditional systems, designers don't have this luxury. Often styling changes must be executed in a vacuum – editing curves without being able to see the effects on the surface they feed or, in the best case, being able to see only a single level update of the surface that is dependant on the curves. In no other system are designers able to see fully shaded feedback of the impact of the changes on all downstream features in real time. Recognizing the importance of highly complete and dynamic feedback, Rapid Blue set out to address this area as well.

### Dynamic edit

With the "dynamic edit" capabilities of Rapid Blue, designers (and others) can make edits anywhere in the feature tree and see the results of those edits live as they draw the cursor on the screen. All design intent and history is preserved, recalculating all (or a portion of) downstream features and updating the graphics display on every mouse move. This unique Solid Edge feature means more iterations can be tried in a shorter time, improving product quality and acceptance. For the first time, designers can now interactively tweak highlight lines and see the effects on all the downstream rounds, fillets and blends.

An additional obstacle designers face is that of designs evolving over time, particularly given input from the various stakeholders as they see the design progress. For example, a designer may sketch a concept using a simple shape (such as an arc) that describes the desired curvature in one direction. After review, it is decided that more flair is needed in the product that can only be achieved with a more flexible curve. With traditional systems, a significant

amount of rework is required, often having to manually repair the history tree if the change is severe. In contrast, Rapid Blue presumes that change is necessary, and that starting simple and adding further control is a valuable workflow. "Convert to curve" and BlueSurf are two key technologies enabling a truly iterative workflow.

### Convert to curve

Convert to curve allows analytic elements, such as lines and arcs, to be converted to NURBS with a single click<sup>2</sup>. With no loss of shape data, the elements become editable curves. Even more importantly, this conversion does not destroy the downstream work that has been completed. Thanks to an extremely robust feature implementation which planned for this eventuality, an arc can be converted to a curve and edited to a more interesting shape and all downstream features will be recomputed properly.

### BlueSurf

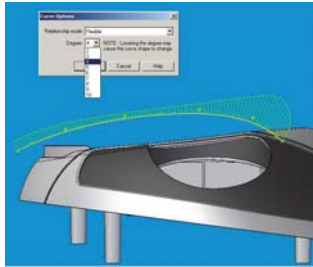
Similar in concept to convert to curve, BlueSurf acknowledges and accommodates the inevitable increase in control required as designs progress. What starts out as a simple  $1 \times 1^3$  sweep in the early stages of design, may well need to be a  $3 \times 5$  loft as the design evolves. BlueSurf is the only technology in the industry to incorporate sweep, loft, and blend into a single simple to use command. So, when the initial simple sweep is no longer appropriate, there is no manual repair of the feature tree required. A single BlueSurf is well suited to the  $1 \times 1$  sweep, all the way up to an  $N \times M$ , with full support for tangency to adjacent surfaces, along both the sections and the guides.

One of the key ways which control is added to a BlueSurf is by "dropping in" additional sections. The user simply edits the surface and drags planes in either the section or guide direction and drops them, slicing the surface. The resultant slice becomes an editable guide or section, with full dynamic edit

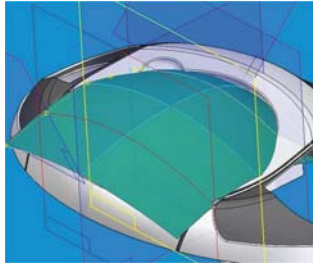
update as discussed previously. Importantly, the resultant surface is  $G^2$  continuous across any sections or guides that have been incorporated into the surface, including any that were added by the “drop section” method. This advanced capability stands in sharp contrast to some other systems where added guides provide only  $G^0$  continuity by default or a very localized  $G^1$  with manual intervention. BlueSurf guarantees a smooth surface fit which fully accounts for all sections and guides as part of the fitting process.

## Putting it all together

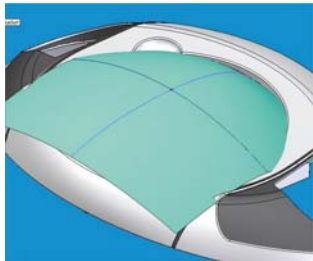
While each of the Rapid Blue technologies described herein is far ahead of the competition, it's the combination of the technologies that puts Rapid Blue light years ahead. A simple workflow illustrates this point.



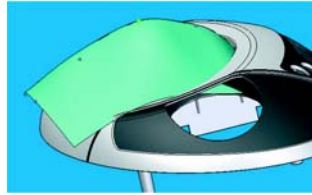
Curves are easily edited and maintain their shape through shape-preserving behavior encapsulation.



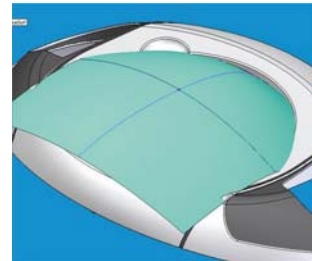
A 1 x 1 network is easily established using BlueDots to connect the curves. Although they lie at different points in the tree, they are peers. Edits to each curve will update its partner.



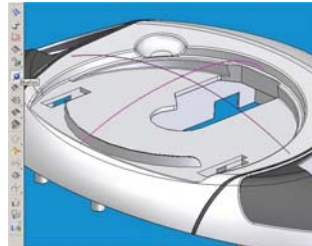
A BlueSurf easily covers the 1 x 1 network.



Edits to either curve recompute the surface "live." Importantly, the partner curve maintains its shape by itself when asked to edit. All design intent, including the rounds are updated using dynamic edit.



More control is needed over the surface shape, so new guides are dropped in place. BlueDots are automatically created, providing the highest editing flexibility.



Editing the new guides updates all partner curves, through a simultaneous solve of the curve network.



Together, the various technologies of Rapid Blue combine to create the single most powerful and easy-to-use stylized shape-modeling capability on the market today.

## Conclusion

Rapid Blue stands alone in the industry as a unique solution to the complex issues involved in stylized shape design. The constraints and limitations of existing systems that stand in the way of the creative process that is critical to styling and industrial design have been eliminated with the introduction of Rapid Blue. Through ground-breaking technologies such as BlueDots, BlueSurf, dynamic edit, and shape-preserving curves, Rapid Blue frees the designer to focus on the design at hand, producing more elegant and effective designs many times more quickly than competing systems.

## Appendix A: Solid Edge curve technology

Solid Edge uses modern NURBS technology as the basis of its curves. NURBS is an acronym for “non-uniform, rational, B-spline,” which is widely regarded as the most flexible mathematical representation for curve elements. This flexibility comes in part from their nonuniform nature and in part from their rational nature. Each of these terms is explained below.

“Nonuniform” refers to how the curve is parametrized from a mathematical point of view. A uniform parameterization only works well if the points to fit are reasonably equally spaced. However, it works poorly in cases where the points have varying distances between them. For this reason Solid Edge always uses a nonuniform parametrization – this ensures a more well-behaved curve when fitting any variety of point data.

The word “rational” is used to describe the fact that a weighting is used to provide more influence for some of the control vertices<sup>7</sup> relative to the others<sup>8</sup>. A weight of 1 provides a neutral weighting at that control vertex. A stronger weight would cause that particular control vertex to more strongly influence the curve (think of it like a stronger magnet, attracting the curve). Using different weightings at the

control vertices can provide further control, but is a fairly abstract concept, so it needs to be used carefully if the system is to remain approachable.

In Solid Edge, when placing and editing a “regular” curve, special weighting is not used. Although the curves are still NURBS, all the weights at the CVs are 1, resulting in equal weighting from all CVs. This provides the most controllable, yet intuitive interface to curves. However, Solid Edge does use weighting in some special cases. Mathematically, it’s not possible to represent an arc, circle, or ellipse without special weights at the CVs (you can get close without them, but never exact). For this reason, when using the “convert to curve” command, a curve with weighted CVs (a rational curve) will result. In this way, an accurate, highly editable representation of the analytic is created. Additionally, imported curves are of course represented as NURBS.

By using the NURBS representation, Solid Edge is capable of representing any type of curve shape imaginable. Highly tuned for the designer, Solid Edge uses a nonuniform parameterization to achieve smooth fits, and uses CV weighting in appropriate circumstances, such as importing geometry and in achieving an exact conversion from analytic geometry.

## References

1. See Appendix A for more information on the technology used for curves.
2. It's important that such a conversion be done using a NURBS representation, as only a rational (the R in NURBS) B-spline can accurately represent an arc or a circle. A nonrational representation is an approximation only.
3. Meaning 1 section and 1 guide
4. G2 is equivalent to "curvature continuous"
5. G0 means edge connected, but "sharp", rather than "tangent"
6. G1 means "tangent" but not "curvature continuous"
7. Control vertices are points that are not on the curve, but instead on a polygon that bounds the curve. The control vertices provide the mathematical definition of the curve.
8. Recall that fractions are called "rational numbers" and hence the use of the term "rational" in this context.

## About Siemens PLM Software

Siemens PLM Software, a business unit of the Siemens Industry Automation Division, is a leading global provider of product lifecycle management (PLM) software and services with 6.7 million licensed seats and more than 69,500 customers worldwide. Headquartered in Plano, Texas, Siemens PLM Software works collaboratively with companies to deliver open solutions that help them turn more ideas into successful products. For more information on Siemens PLM Software products and services, visit [www.siemens.com/plm](http://www.siemens.com/plm).

[www.siemens.com/plm](http://www.siemens.com/plm)

All rights reserved. Siemens and the Siemens logo are registered trademarks of Siemens AG. D-Cubed, Femap, Geolus, GO PLM, I-deas, Insight, JT, NX, Parasolid, Solid Edge, Teamcenter, Tecnomatix and Velocity Series are trademarks or registered trademarks of Siemens Product Lifecycle Management Software Inc. or its subsidiaries in the United States and in other countries. All other logos, trademarks, registered trademarks or service marks used herein are the property of their respective holders.

© 2011 Siemens Product Lifecycle Management Software Inc.

X3 2880 7/11 B

## Siemens Industry Software

### Americas

+1 800 807 2200

Fax +1 314 264 8922

### Europe

+44 (0) 1202 243455

Fax +44 (0) 1202 243465

### Asia-Pacific

+852 2230 3308

Fax +852 2230 3210