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Matt Lombard

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Bible

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SolidWorks® Surfacing and Complex Shape Modeling Bible

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Matt Lombard

Wiley Publishing, Inc.

SolidWorks® Surfacing and Complex Shape Modeling Bible

Published by
Wiley Publishing, Inc.
10475 Crosspoint Boulevard
Indianapolis, IN 46256
www.wiley.com

Copyright © 2008 by Wiley Publishing, Inc., Indianapolis, Indiana

Published by Wiley Publishing, Inc., Indianapolis, Indiana

Published simultaneously in Canada

ISBN: 978-0-470-25823-1

Manufactured in the United States of America

10 9 8 7 6 5 4 3 2 1

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Library of Congress Control Number: 2008924089

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About the Author

Matt Lombard holds a mechanical engineering degree from Rochester Institute of Technology in Rochester, New York. Matt has worked as a design and manufacturing engineer in the medical and microelectronics industries. Currently, through his company Dezignstuff, he works mainly as a consumer product modeling consultant and technical writer.

Before becoming an engineer, Matt went to music school for two years and performed with the U.S. Navy band for four years. He still plays in local community groups for fun. Having grown up in the Adirondack Mountains of northeastern New York, he now calls the Shenandoah Valley of Virginia home. Contact Matt directly at matt@dezignstuff.com, or visit his blog at www.dezignstuff.com/blog.

This book is dedicated to my parents, Jim and Carol Lombard. Dad is the consummate punster and word play addict, as well as a former math teacher. Mom is a retired music teacher. Between these influences, it isn't any surprise that I have written this book that straddles between the analytical and aesthetic.

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Preface

Welcome to the *SolidWorks Surfacing and Complex Shape Modeling Bible*. I know, that is quite a mouthful for the title of a book. To just call it the "SolidWorks Surfacing Bible" does not do the topic justice because much of the content deals with solids. There was also the temptation to use "Swoopy Shapes" in the title, but editors have little sense of humor when it comes to abusing the English language in that way, so I had to compromise with the phrase "Complex Shape Modeling". The "Bible" part of course comes from the name of the series of books from the publisher, Wiley Publishing, and is not meant to be blasphemous or to put me up on a supernatural pedestal.

This book is intended for intermediate to advanced SolidWorks users. Everyone has a different idea of what those two levels mean, but I'm assuming the reader of this book has a complete understanding of solid functions in SolidWorks, and at least a passing familiarity with surfacing. If you know nothing about surfacing, a surfacing primer is included in the early chapters to help familiarize you with some terminology. Surface modeling requires a completely different way of looking at geometry. Surfacing is essentially building a model one face at a time.

You might look at the *SolidWorks 2007 Bible* as a good pre-requisite for this book. If you understand things at the level of the *SolidWorks 2007 Bible*, you are ready for this book. Assembly topics are used minimally in this book, and there are no sheet metal or weldment topics used here.

The *SolidWorks Surfacing and Complex Shape Modeling Bible* is written from the point of view of an engineer who has to precisely re-create concept shapes provided by artistic professionals in a way conducive to the manufacture of the part. I do not discuss artistic design issues here; I prefer to use the term "modeling" rather than "design". In this case, modeling is the main difficult task, and it is difficult enough without also considering design.

The book is written from the point of view of an engineer primarily because I am an engineer, and it would be difficult for me to write it from another point of view. The information contained in the book is certainly useable by artistic professionals, hobbyists, CNC programmers, drafters, entrepreneurs, students, or others. The goal in most of the examples is to work from some sort of input, which could be point cloud data, digital photos, or scanned hand sketches, and to produce high quality finished geometry.

As in the *SolidWorks 2007 Bible*, the *SolidWorks Surfacing and Complex Shape Modeling Bible* takes the approach that to talk about the capabilities of the software completely, you must also understand its limitations. Discussions of limitations, bugs and work-arounds are not intended to belittle the software or its creators, only to help align your expectations; what should you expect the software to do, and what is beyond the capabilities of the software.

Acknowledgments

The information in this book came from several sources. Most of it came from reverse engineering the software to figure out what certain functions actually did, but there are several individuals whom I must credit for either specific or general information that got me on the right track. Mark Matthews of Essential Design in Boston, MA is an Industrial Design professional who acted as my technical editor for this book. Mark kept me in touch with the ID side of issues, and offered several ideas that I added to the book. Mark Biasotti of SolidWorks certainly deserves much credit as well. He was able to arrange conversations with developers to try to get a better understanding of what was actually going on behind the scenes. Other individuals who contributed ideas or encouragement include Ricky Jordan, John "Muggs" Ferguson, Kim Hardy, Stan Kujawski, and the guys from Spark Engineering. I would be remiss if I didn't also list materials provided to the general SolidWorks user community by people like Mike Wilson, Keith Pedersen, and Ed Eaton; they have made contributions to the SolidWorks surfacing topic long before this book became available.

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Part I

Laying the Groundwork

IN THIS PART

Chapter 1
Understanding Basic Concepts

Chapter 2
Surfacing Primer

Chapter 1

Understanding Basic Concepts

Everyone has a different idea of what the words "basic" and "advanced" mean. In general terms, some users might consider everything in this book advanced, and others might consider it basic. Still, in order to progress, the concepts have to start from somewhere, and so the initial concepts will form the basis for the more advanced material to come later.

SolidWorks probably has more surface and complex shape functionality than you realize, especially if you are coming to this book from a machine design background. Some of the tools are matured, having been available for quite some time, and some are newly added to the software, with some occasional kinks still left to work out.

Regardless of how you have arrived here, surfacing and complex shapes are areas of the SolidWorks software that have been flourishing in recent years, and improve with each new release of the software. Still, it is an area that doesn't get as much traffic as, say, the extrudes, revolves and fillets, and so bugs, or quirky functionality, can still be found from time to time.

Figure 1.1 shows an example of some of the modeling that you will find in the pages of this book. This is a SolidWorks model of the SolidWorks Roadster, a Shelby Cobra kit car built by SolidWorks employees, and displayed at SolidWorks World 2007. This rendering was done by Matt Sass for the PhotoWorks contest on Rob Rodriguez's site, www.robrodriguez.com.

IN THIS CHAPTER

Assumed basic skills

Concepts, tools, techniques, and strategies

Understanding the difference between design and modeling

FIGURE 1.1

Model of the SolidWorks Roadster

Rendering by Matt Sass

Assumed Basic Skills

The *SolidWorks Surfacing and Complex Shape Modeling Bible* is intended for a diverse cross-section of readers. The first type of reader is the SolidWorks user who is otherwise knowledgeable about the software, but wants to learn about surfacing and complex shape-creation techniques. This reader may have come from another type of design, and is more mechanical than artistic in method. The second is the user of another surfacing program who has learned SolidWorks basics and wants to transfer surfacing skills from the other program to SolidWorks. This reader is more likely an industrial designer or otherwise artistically inclined. This book assumes you already have a good grasp on the basics, such as sketching and sketch relations, the basics of parametric relations between features, and commonly used terminology in SolidWorks. The *SolidWorks Bible* can help bring you to this level, and is a great companion to this book for reference on the more basic concepts.

You will find a small amount of overlap between the current edition of the *SolidWorks Bible* and the *SolidWorks Surfacing and Complex Shape Modeling Bible*. The overlapping topics are splines and multi-body modeling. Both of these skills are essential to working with surfaces and complex shapes, which is why you find them again here, although discussed from a slightly different perspective.

This book was written using early versions of SolidWorks 2008, but most of the concepts discussed can be effectively applied to versions earlier and later. I have tried to make minimal references to version-specific aspects of the interface, but have pointed out where necessary the functional differences if any between features in prior versions.

Assemblies are only discussed in this book in a couple of areas, such as master modeling techniques and multi-body techniques. You will find no reference to any of the specialty techniques such as sheet metal or weldments.

Beyond that, a firm grasp of high school geometry concepts and terminology is necessary. Analytical geometry and simple calculus concepts come into play in the form of tangency, rate of change, and derivatives discussions. Because this book is primarily for actual users of the SolidWorks software, and actual users may or may not have an engineering math background, I will not involve any math or equations directly except for c = 1/r (curvature equals the inverse of radius).

You will find plastic-molded part terminology sprinkled throughout this book, with common references to parting lines, draft, and direction of pull. I have assumed that the reader has a passing familiarity with some form of plastic molding process such as thermoforming, injection molding, rotational molding, or blow molding. A background in metal injection molding, casting, or even forging may also be helpful, as many of the same concepts employed by these manufacturing techniques are also applicable to plastics processes.

Although you will not find drawings discussed in this book, basic mechanical drawing skills are required to get the most out of this book. You must understand basic terminology, such as section, projected view, and orthogonal views.

I intend this book to be primarily for the use of professional CAD operators, whether artist or technical, as opposed to casual or hobbyist users. If you are looking to make characters or equipment for games, SolidWorks may not be your best option. One of the polygonal modelers would be a better bet. Any type of casual user will probably find that complex shapes are easier to create in other software because, as CAD software, SolidWorks tends to require more precision than a tool like Maya or modo, or any of the freeware mesh modelers available.

Concepts, Tools, Techniques, and Strategies

The SolidWorks Surfacing and Complex Shape Modeling Bible is organized into four parts that discuss the concepts and tools (two sections are dedicated to the tools), and finally combine techniques and strategies into a series of longer hands-on model walk-throughs. I believe that this approach answers the how and why questions in addition to explaining and demonstrating what individual button clicks do. Tutorials on their own do not explain the decision-making process, but they do demonstrate the workflow. Lectures on their own do not demonstrate the tools in action. Concepts, of course, are useless without application to realistic scenarios.

Demonstrating techniques and strategies gives you, the reader, a head start with visualizing the application of the tools to real-world modeling scenarios. Most of the models used as examples have been adapted from real-world work projects, to keep them as realistic as possible. Techniques in particular will cover topics such as capping rounded ends, making blends at complex intersections, making sharp edges fade into smooth faces, how to use images as reference, how to deal with draft at the edges of complex surfaces, and many other commonly encountered situations.

Strategies refer to some of the bigger picture questions, like "Where do I start?" On a complex model, it is often difficult to know where to start. Also, if you need to make an assembly where the parts all contain an overall shape, how does modeling of that sort work? The model walk-through chapters in Part 4 answer these questions for you and are meant to spark your imagination to come up with new applications for the tools and techniques, and your own modeling strategies.

SolidWorks corporate documentation explains where to find the tools and generally what they do in the Help documentation. The official SolidWorks training materials offered by resellers are basically instructor-guided tutorials, which are valuable, but they stop short of arming the student with the ability to make modeling decisions based on thorough knowledge of the options. The training materials are also not generally available without paying for the reseller class.

You may also find tutorials on the Web that are either simplistic step-by-step instructions or heady and difficult to comprehend. Again, this book fills the gap between them and tries to do it in a more conversational language that conveys the necessary concepts without talking over your head or down to you.

In the course of talking about concepts, tools, techniques, and strategies, most of the individual topics are covered twice, or even three times from different angles. For example, the Fill surface is a tool that I discuss in Chapter 2 to illustrate the concept of trimmed surfaces, again in detail in Chapter 6, and again in multiple chapters of Part 3 as a practical application in tutorials.

As important as knowing positively what types of features work in which types of situations, it is also important to know the kinds of things that do not work the way you might expect. The purpose of talking about limited functionality is not to be derisive to the software or the parent company, but rather to offer the reader of this book as complete a picture as possible of the capabilities of the software. Often when using software, I have felt that if limitations were spelled out completely in the documentation, I could save a lot of time by avoiding figuring out the limitations for myself. In this book, I have made every attempt to be fair to the software, and if it works, I want to tell the story of how well it works and how to use it to its best advantage. On the other hand, if it doesn't work as you might expect, I feel the obligation to do my readers the service of letting them know where the reliable limits of the software lie.

The point is that whether you use this book as a text to read straight through, or as a reference to look up topics as needed, I hope you find the information well presented and laid out logically. It is not possible to arrange all of the topics in sequential order.

Understanding the Difference Between Design and Modeling

The SolidWorks Surfacing and Complex Shape Modeling Bible, as the name suggests, focuses on modeling parts in SolidWorks with the purpose of manufacturing those parts. This is not a book about design. The act of modeling assumes that the design (or a starting place for the design)

already exists. The design may exist in one of many forms. It could be sketched on paper, scanned into a digital image format, or modeled in clay or foam. It could be taken from a digital camera, the back of an envelope or napkin, or a whiteboard. It could already be drawn or modeled in a different 2D or 3D software, it could exist as a 3D point cloud from a 3D scanner, or it may simply exist only in your head. Wherever the design comes from, it probably exists somewhere else before it shows up in SolidWorks.

Dividing the tasks into design and modeling reflects the way that some companies divide their work force. Industrial designers often create a design in a given media, and modelers build a manufacturing model from the design data. There are some industrial design folks who can do their own manufacturing models, but this usually requires some form of engineering input. The modeler is often an engineer, or from a mechanical discipline in any case.

My background is as a mechanical engineer, and in my work as a consultant/contractor, I have often taken conceptual data from industrial designers and converted it to an engineering or manufacturing model. My point of view throughout this book will be just that: as an engineer re-creating or interpreting design data to prepare it for manufacturing. I avoid using the term design when what I am really talking about is simply modeling. While making the interpretations sometimes necessary in this kind of work, it is always important to remain sensitive to the original intent of the design. Other groups within an organization may also have some input into the design, such as branding established by marketing, stacking features introduced by shipping, material or finish costs driven by accounting, geometrical changes driven by molders, or structural changes made by mechanical engineers. Designs very rarely originate from only a single source. In this book, the design data is treated as if it is complete, and all that is required is the 3D CAD model.

In the course of this book, most of the modeling you will do centers around copying an existing form in one of the media mentioned above into a detailed model in SolidWorks. In some cases the models you finish will be ready for prototyping or manufacturing, and in others you will complete only a sampling of a certain technique.

In many of the tutorials in this book, the designer did not execute the provided design information perfectly. This is often also the case in the real world, where the designer creating two orthogonal views of a shape has drawn views that are incompatible with one another. In many cases, the modeler has to make subjective interpretations. I recommend consulting the original designer in cases when there is some discrepancy, but in situations of this sort encountered in this book, you will apply your own judgment to the model to fill in the gaps.

Summary

SolidWorks software is in many areas surprisingly full of powerful functionality to help you with your surfacing and complex shape modeling. This book will help you understand which functions are available, which to use in certain situations, and which to avoid through describing the underlying concepts at play with surfacing and complex shape modeling, the functions of specific

individual tools and options, how the tools can be strung together into techniques, and how to plan out an overall strategy to accomplish your modeling goal efficiently.

You should also be clear that this is not a book about design in general. I do not cover how design should progress, the sources of design inspiration or design styles, but rather the details of creating 3D models with SolidWorks. The end goal in mind is creating models that are ready for manufacture or prototyping. Sample designs are presented in this book to be used as practice, creating 3D parametric models that update reliably through changes.