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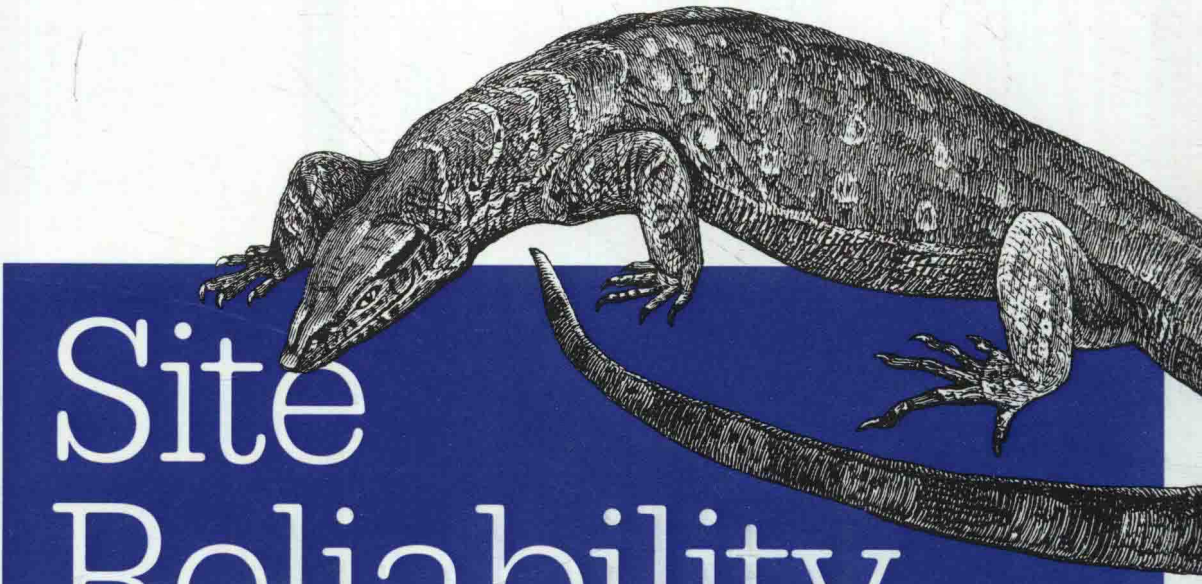

Site Reliability Engineering

网站运维工程（影印版）

Betsy Beyer, Chris Jones,
Jennifer Petoff, Niall Richard Murphy 编

東南大學出版社

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南京 东南大学出版社

图书在版编目(CIP)数据

网站运维工程:英文/(美)贝特西·拜尔(Betsy Beyer)等编. —影印本. —南京:东南大学出版社,2018.1

书名原文:Site Reliability Engineering

ISBN 978-7-5641-7296-1

Ⅰ.①网… Ⅱ.①贝… Ⅲ.①网站建设—英文 ②网站—维护—英文 Ⅳ.①TP393.092.1

中国版本图书馆CIP数据核字(2017)248393号

图字:10-2017-353号

网站运维工程(影印版)

出版发行:东南大学出版社
地　　址:南京四牌楼2号　　邮编:210096
出 版 人:江建中
网　　址:http://www.seupress.com
电子邮件:press@seupress.com
印　　刷:常州市武进第三印刷有限公司
开　　本:787毫米×980毫米　16开本
印　　张:34.5
字　　数:676千字
版　　次:2018年1月第1版
印　　次:2018年1月第1次印刷
书　　号:ISBN 978-7-5641-7296-1
定　　价:118.00元

本社图书若有印装质量问题,请直接与营销部联系。电话(传真):025-83791830

Praise for *Site Reliability Engineering*

Google's SREs have done our industry an enormous service by writing up the principles, practices and patterns—architectural and cultural—that enable their teams to combine continuous delivery with world-class reliability at ludicrous scale. You owe it to yourself and your organization to read this book and try out these ideas for yourself.

—Jez Humble, coauthor of Continuous Delivery *and* Lean Enterprise

I remember when Google first started speaking at systems administration conferences. It was like hearing a talk at a reptile show by a Gila monster expert. Sure, it was entertaining to hear about a very different world, but in the end the audience would go back to their geckos.

Now we live in a changed universe where the operational practices of Google are not so removed from those who work on a smaller scale. All of a sudden, the best practices of SRE that have been honed over the years are now of keen interest to the rest of us. For those of us facing challenges around scale, reliability and operations, this book comes none too soon.

—David N. Blank-Edelman, Director, USENIX Board of Directors, and founding co-organizer of SREcon

I have been waiting for this book ever since I left Google's enchanted castle. It is the gospel I am preaching to my peers at work.

—Björn Rabenstein, Team Lead of Production Engineering at SoundCloud, Prometheus developer, and Google SRE until 2013

A thorough discussion of Site Reliability Engineering from the company that invented the concept. Includes not only the technical details but also the thought process, goals, principles, and lessons learned over time. If you want to learn what SRE really means, start here.

—Russ Allbery, SRE and Security Engineer

With this book, Google employees have shared the processes they have taken, including the missteps, that have allowed Google services to expand to both massive scale and great reliability. I highly recommend that anyone who wants to create a set of integrated services that they hope will scale to read this book. The book provides an insider's guide to building maintainable services.

—Rik Farrow, USENIX

Writing large-scale services like Gmail is hard. Running them with high reliability is even harder, especially when you change them every day. This comprehensive "recipe book" shows how Google does it, and you'll find it much cheaper to learn from our mistakes than to make them yourself.

—Urs Hölzle, SVP Technical Infrastructure, Google

Foreword

Google's story is a story of scaling up. It is one of the great success stories of the computing industry, marking a shift towards IT-centric business. Google was one of the first companies to define what business-IT alignment meant in practice, and went on to inform the concept of DevOps for a wider IT community. This book has been written by a broad cross-section of the very people who made that transition a reality.

Google grew at a time when the traditional role of the system administrator was being transformed. It questioned system administration, as if to say: we can't afford to hold tradition as an authority, we have to think anew, and we don't have time to wait for everyone else to catch up. In the introduction to *Principles of Network and System Administration* [Bur99], I claimed that system administration was a form of human-computer engineering. This was strongly rejected by some reviewers, who said "we are not yet at the stage where we can call it engineering." At the time, I felt that the field had become lost, trapped in its own wizard culture, and could not see a way forward. Then, Google drew a line in the silicon, forcing that fate into being. The revised role was called SRE, or Site Reliability Engineer. Some of my friends were among the first of this new generation of engineer; they formalized it using software and automation. Initially, they were fiercely secretive, and what happened inside and outside of Google was very different: Google's experience was unique. Over time, information and methods have flowed in both directions. This book shows a willingness to let SRE thinking come out of the shadows.

Here, we see not only how Google built its legendary infrastructure, but also how it studied, learned, and changed its mind about the tools and the technologies along the way. We, too, can face up to daunting challenges with an open spirit. The tribal nature of IT culture often entrenches practitioners in dogmatic positions that hold the industry back. If Google overcame this inertia, so can we.

This book is a collection of essays by one company, with a single common vision. The fact that the contributions are aligned around a single company's goal is what makes it special. There are common themes, and common characters (software systems)

that reappear in several chapters. We see choices from different perspectives, and know that they correlate to resolve competing interests. The articles are not rigorous, academic pieces; they are personal accounts, written with pride, in a variety of personal styles, and from the perspective of individual skill sets. They are written bravely, and with an intellectual honesty that is refreshing and uncommon in industry literature. Some claim "never do this, always do that," others are more philosophical and tentative, reflecting the variety of personalities within an IT culture, and how that too plays a role in the story. We, in turn, read them with the humility of observers who were not part of the journey, and do not have all the information about the myriad conflicting challenges. Our many questions are the real legacy of the volume: Why didn't they do *X*? What if they'd done *Y*? How will we look back on this in years to come? It is by comparing our own ideas to the reasoning here that we can measure our own thoughts and experiences.

The most impressive thing of all about this book is its very existence. Today, we hear a brazen culture of "just show me the code." A culture of "ask no questions" has grown up around open source, where community rather than expertise is championed. Google is a company that dared to think about the problems from first principles, and to employ top talent with a high proportion of PhDs. Tools were only components in processes, working alongside chains of software, people, and data. Nothing here tells us how to solve problems universally, but that is the point. Stories like these are far more valuable than the code or designs they resulted in. Implementations are ephemeral, but the documented reasoning is priceless. Rarely do we have access to this kind of insight.

This, then, is the story of how one company did it. The fact that it is many overlapping stories shows us that scaling is far more than just a photographic enlargement of a textbook computer architecture. It is about scaling a business process, rather than just the machinery. This lesson alone is worth its weight in electronic paper.

We do not engage much in self-critical review in the IT world; as such, there is much reinvention and repetition. For many years, there was only the USENIX LISA conference community discussing IT infrastructure, plus a few conferences about operating systems. It is very different today, yet this book still feels like a rare offering: a detailed documentation of Google's step through a watershed epoch. The tale is not for copying—though perhaps for emulating—but it can inspire the next step for all of us. There is a unique intellectual honesty in these pages, expressing both leadership and humility. These are stories of hopes, fears, successes, and failures. I salute the courage of authors and editors in allowing such candor, so that we, who are not party to the hands-on experiences, can also benefit from the lessons learned inside the cocoon.

— Mark Burgess
author of In Search of Certainty
Oslo, March 2016

Preface

Software engineering has this in common with having children: the labor *before* the birth is painful and difficult, but the labor *after* the birth is where you actually spend most of your effort. Yet software engineering as a discipline spends much more time talking about the first period as opposed to the second, despite estimates that 40–90% of the total costs of a system are incurred after birth.[1] The popular industry model that conceives of deployed, operational software as being "stabilized" in production, and therefore needing much less attention from software engineers, is wrong. Through this lens, then, we see that if software engineering tends to focus on designing and building software systems, there must be another discipline that focuses on the *whole* lifecycle of software objects, from inception, through deployment and operation, refinement, and eventual peaceful decommissioning. This discipline uses—and needs to use—a wide range of skills, but has separate concerns from other kinds of engineers. Today, our answer is the discipline Google calls Site Reliability Engineering.

So what exactly is Site Reliability Engineering (SRE)? We admit that it's not a particularly clear name for what we do—pretty much every site reliability engineer at Google gets asked what exactly that is, and what they actually do, on a regular basis.

Unpacking the term a little, first and foremost, SREs are *engineers*. We apply the principles of computer science and engineering to the design and development of computing systems: generally, large distributed ones. Sometimes, our task is writing the software for those systems alongside our product development counterparts; sometimes, our task is building all the additional pieces those systems need, like backups or load balancing, ideally so they can be reused across systems; and sometimes, our task is figuring out how to apply existing solutions to new problems.

1 The very fact that there is such large variance in these estimates tells you something about software engineering as a discipline, but see, e.g., [Gla02] for more details.

Next, we focus on system *reliability*. Ben Treynor Sloss, Google's VP for 24/7 Operations, originator of the term SRE, claims that reliability is the most fundamental feature of any product: a system isn't very useful if nobody can use it! Because reliability[2] is so critical, SREs are focused on finding ways to improve the design and operation of systems to make them more scalable, more reliable, and more efficient. However, we expend effort in this direction only up to a point: when systems are "reliable enough," we instead invest our efforts in adding features or building new products.[3]

Finally, SREs are focused on operating *services* built atop our distributed computing systems, whether those services are planet-scale storage, email for hundreds of millions of users, or where Google began, web search. The "site" in our name originally referred to SRE's role in keeping the *google.com* website running, though we now run many more services, many of which aren't themselves websites—from internal infrastructure such as Bigtable to products for external developers such as the Google Cloud Platform.

Although we have represented SRE as a broad discipline, it is no surprise that it arose in the fast-moving world of web services, and perhaps in origin owes something to the peculiarities of our infrastructure. It is equally no surprise that of all the post-deployment characteristics of software that we could choose to devote special attention to, reliability is the one we regard as primary.[4] The domain of web services, both because the process of improving and changing server-side software is comparatively contained, and because managing change itself is so tightly coupled with failures of all kinds, is a natural platform from which our approach might emerge.

Despite arising at Google, and in the web community more generally, we think that this discipline has lessons applicable to other communities and other organizations. This book is an attempt to explain how we do things: both so that other organizations might make use of what we've learned, and so that we can better define the role and what the term means. To that end, we have organized the book so that general principles and more specific practices are separated where possible, and where it's appropriate to discuss a particular topic with Google-specific information, we trust that the reader will indulge us in this and will not be afraid to draw useful conclusions about their own environment.

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2 For our purposes, reliability is "The probability that [a system] will perform a required function without failure under stated conditions for a stated period of time," following the definition in [Oco12].

3 The software systems we're concerned with are largely websites and similar services; we do not discuss the reliability concerns that face software intended for nuclear power plants, aircraft, medical equipment, or other safety-critical systems. We do, however, compare our approaches with those used in other industries in Chapter 33.

4 In this, we are distinct from the industry term DevOps, because although we definitely regard infrastructure as code, we have *reliability* as our main focus. Additionally, we are strongly oriented toward removing the necessity for operations—see Chapter 7 for more details.

We have also provided some orienting material—a description of Google's production environment and a mapping between some of our internal software and publicly available software—which should help to contextualize what we are saying and make it more directly usable.

Ultimately, of course, more reliability-oriented software and systems engineering is inherently good. However, we acknowledge that smaller organizations may be wondering how they can best use the experience represented here: much like security, the earlier you care about reliability, the better. This implies that even though a small organization has many pressing concerns and the software choices you make may differ from those Google made, it's still worth putting lightweight reliability support in place early on, because it's less costly to expand a structure later on than it is to introduce one that is not present. Part IV contains a number of best practices for training, communication, and meetings that we've found to work well for us, many of which should be immediately usable by your organization.

But for sizes between a startup and a multinational, there probably already is someone in your organization who is doing SRE work, without it necessarily being called that name, or recognized as such. Another way to get started on the path to improving reliability for your organization is to formally recognize that work, or to find these people and foster what they do—reward it. They are people who stand on the cusp between one way of looking at the world and another one: like Newton, who is sometimes called not the world's first physicist, but the world's last alchemist.

And taking the historical view, who, then, looking back, might be the first SRE?

We like to think that Margaret Hamilton, working on the Apollo program on loan from MIT, had all of the significant traits of the first SRE.[5] In her own words, "part of the culture was to learn from everyone and everything, including from that which one would least expect."

A case in point was when her young daughter Lauren came to work with her one day, while some of the team were running mission scenarios on the hybrid simulation computer. As young children do, Lauren went exploring, and she caused a "mission" to crash by selecting the DSKY keys in an unexpected way, alerting the team as to what would happen if the prelaunch program, P01, were inadvertently selected by a real astronaut during a real mission, during real midcourse. (Launching P01 inadvertently on a real mission would be a major problem, because it wipes out navigation data, and the computer was not equipped to pilot the craft with no navigation data.)

5 In addition to this great story, she also has a substantial claim to popularizing the term "software engineering."

With an SRE's instincts, Margaret submitted a program change request to add special error checking code in the onboard flight software in case an astronaut should, by accident, happen to select P01 during flight. But this move was considered unnecessary by the "higher-ups" at NASA: of course, that could never happen! So instead of adding error checking code, Margaret updated the mission specifications documentation to say the equivalent of "Do not select P01 during flight." (Apparently the update was amusing to many on the project, who had been told many times that astronauts would not make any mistakes—after all, they were trained to be perfect.)

Well, Margaret's suggested safeguard was only considered unnecessary until the very next mission, on Apollo 8, just days after the specifications update. During midcourse on the fourth day of flight with the astronauts Jim Lovell, William Anders, and Frank Borman on board, Jim Lovell selected P01 by mistake—as it happens, on Christmas Day—creating much havoc for all involved. This was a critical problem, because in the absence of a workaround, no navigation data meant the astronauts were never coming home. Thankfully, the documentation update had explicitly called this possibility out, and was invaluable in figuring out how to upload usable data and recover the mission, with not much time to spare.

As Margaret says, "a thorough understanding of how to operate the systems was not enough to prevent human errors," and the change request to add error detection and recovery software to the prelaunch program P01 was approved shortly afterwards.

Although the Apollo 8 incident occurred decades ago, there is much in the preceding paragraphs directly relevant to engineers' lives today, and much that will continue to be directly relevant in the future. Accordingly, for the systems you look after, for the groups you work in, or for the organizations you're building, please bear the SRE Way in mind: thoroughness and dedication, belief in the value of preparation and documentation, and an awareness of what could go wrong, coupled with a strong desire to prevent it. Welcome to our emerging profession!

How to Read This Book

This book is a series of essays written by members and alumni of Google's Site Reliability Engineering organization. It's much more like conference proceedings than it is like a standard book by an author or a small number of authors. Each chapter is intended to be read as a part of a coherent whole, but a good deal can be gained by reading on whatever subject particularly interests you. (If there are other articles that support or inform the text, we reference them so you can follow up accordingly.)

You don't need to read in any particular order, though we'd suggest at least starting with Chapters 2 and 3, which describe Google's production environment and outline how SRE approaches risk, respectively. (Risk is, in many ways, the key quality of our profession.) Reading cover-to-cover is, of course, also useful and possible; our chapters are grouped thematically, into Principles (Part II), Practices (Part III), and Management (Part IV). Each has a small introduction that highlights what the individual pieces are about, and references other articles published by Google SREs, covering specific topics in more detail. Additionally, the companion website to this book, *https://g.co/SREBook*, has a number of helpful resources.

We hope this will be at least as useful and interesting to you as putting it together was for us.

— The Editors

Conventions Used in This Book

The following typographical conventions are used in this book:

Italic
: Indicates new terms, URLs, email addresses, filenames, and file extensions.

`Constant width`
: Used for program listings, as well as within paragraphs to refer to program elements such as variable or function names, databases, data types, environment variables, statements, and keywords.

`Constant width bold`
: Shows commands or other text that should be typed literally by the user.

`Constant width italic`
: Shows text that should be replaced with user-supplied values or by values determined by context.

This element signifies a tip or suggestion.

This element signifies a general note.

This element indicates a warning or caution.

Using Code Examples

Supplemental material is available at *https://g.co/SREBook*.

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Acknowledgments

This book would not have been possible without the tireless efforts of our authors and technical writers. We'd also like thank the following internal reviewers for providing especially valuable feedback: Alex Matey, Dermot Duffy, JC van Winkel, John T.

Reese, Michael O'Reilly, Steve Carstensen, and Todd Underwood. Ben Lutch and Ben Treynor Sloss were this book's sponsors within Google; their belief in this project and sharing what we've learned about running large-scale services was essential to making this book happen.

We'd like to send special thanks to Rik Farrow, the editor of *;login:*, for partnering with us on a number of contributions for pre-publication via USENIX.

While the authors are specifically acknowledged in each chapter, we'd like to take time to recognize those that contributed to each chapter by providing thoughtful input, discussion, and review.

Chapter 3: Abe Rahey, Ben Treynor Sloss, Brian Stoler, Dave O'Connor, David Besbris, Jill Alvidrez, Mike Curtis, Nancy Chang, Tammy Capistrant, Tom Limoncelli

Chapter 5: Cody Smith, George Sadlier, Laurence Berland, Marc Alvidrez, Patrick Stahlberg, Peter Duff, Pim van Pelt, Ryan Anderson, Sabrina Farmer, Seth Hettich

Chapter 6: Mike Curtis, Jamie Wilkinson, Seth Hettich

Chapter 8: David Schnur, JT Goldstone, Marc Alvidrez, Marcus Lara-Reinhold, Noah Maxwell, Peter Dinges, Sumitran Raghunathan, Yutong Cho

Chapter 9: Ryan Anderson

Chapter 10: Jules Anderson, Max Luebbe, Mikel Mcdaniel, Raul Vera, Seth Hettich

Chapter 11: Andrew Stribblehill, Richard Woodbury

Chapter 12: Charles Stephen Gunn, John Hedditch, Peter Nuttall, Rob Ewaschuk, Sam Greenfield

Chapter 13: Jelena Oertel, Kripa Krishnan, Sergio Salvi, Tim Craig

Chapter 14: Amy Zhou, Carla Geisser, Grainne Sheerin, Hildo Biersma, Jelena Oertel, Perry Lorier, Rune Kristian Viken

Chapter 15: Dan Wu, Heather Sherman, Jared Brick, Mike Louer, Štěpán Davidovič, Tim Craig

Chapter 16: Andrew Stribblehill, Richard Woodbury

Chapter 17: Isaac Clerencia, Marc Alvidrez

Chapter 18: Ulric Longyear

Chapter 19: Debashish Chatterjee, Perry Lorier

Chapters 20 and 21: Adam Fletcher, Christoph Pfisterer, Lukáš Ježek, Manjot Pahwa, Micha Riser, Noah Fiedel, Pavel Herrmann, Paweł Zuzelski, Perry Lorier, Ralf Wildenhues, Tudor-Ioan Salomie, Witold Baryluk

Chapter 22: Mike Curtis, Ryan Anderson

Chapter 23: Ananth Shrinivas, Mike Burrows

Chapter 24: Ben Fried, Derek Jackson, Gabe Krabbe, Laura Nolan, Seth Hettich

Chapter 25: Abdulrahman Salem, Alex Perry, Arnar Mar Hrafnkelsson, Dieter Pearcey, Dylan Curley, Eivind Eklund, Eric Veach, Graham Poulter, Ingvar Mattsson, John Looney, Ken Grant, Michelle Duffy, Mike Hochberg, Will Robinson

Chapter 26: Corey Vickrey, Dan Ardelean, Disney Luangsisongkham, Gordon Prioreschi, Kristina Bennett, Liang Lin, Michael Kelly, Sergey Ivanyuk

Chapter 27: Vivek Rau

Chapter 28: Melissa Binde, Perry Lorier, Preston Yoshioka

Chapter 29: Ben Lutch, Carla Geisser, Dzevad Trumic, John Turek, Matt Brown

Chapter 30: Charles Stephen Gunn, Chris Heiser, Max Luebbe, Sam Greenfield

Chapter 31: Alex Kehlenbeck, Jeromy Carriere, Joel Becker, Sowmya Vijayaraghavan, Trevor Mattson-Hamilton

Chapter 32: Seth Hettich

Chapter 33: Adrian Hilton, Brad Kratochvil, Charles Ballowe, Dan Sheridan, Eddie Kennedy, Erik Gross, Gus Hartmann, Jackson Stone, Jeff Stevenson, John Li, Kevin Greer, Matt Toia, Michael Haynie, Mike Doherty, Peter Dahl, Ron Heiby

We are also grateful to the following contributors, who either provided significant material, did an excellent job of reviewing, agreed to be interviewed, supplied significant expertise or resources, or had some otherwise excellent effect on this work:

Abe Hassan, Adam Rogoyski, Alex Hidalgo, Amaya Booker, Andrew Fikes, Andrew Hurst, Ariel Goh, Ashleigh Rentz, Ayman Hourieh, Barclay Osborn, Ben Appleton, Ben Love, Ben Winslow, Bernhard Beck, Bill Duane, Bill Patry, Blair Zajac, Bob Gruber, Brian Gustafson, Bruce Murphy, Buck Clay, Cedric Cellier, Chiho Saito, Chris Carlon, Christopher Hahn, Chris Kennelly, Chris Taylor, Ciara Kamahele-Sanfratello, Colin Phipps, Colm Buckley, Craig Paterson, Daniel Eisenbud, Daniel V. Klein, Daniel Spoonhower, Dan Watson, Dave Phillips, David Hixson, Dina Betser, Doron Meyer, Dmitry Fedoruk, Eric Grosse, Eric Schrock, Filip Zyzniewski, Francis Tang, Gary Arneson, Georgina Wilcox, Gretta Bartels, Gustavo Franco, Harald Wagener, Healfdene Goguen, Hugo Santos, Hyrum Wright, Ian Gulliver, Jakub Turski, James Chivers, James O'Kane, James Youngman, Jan Monsch, Jason Parker-Burlingham, Jason Petsod, Jeffry McNeil, Jeff Dean, Jeff Peck, Jennifer Mace, Jerry Cen, Jess Frame, John Brady, John Gunderman, John Kochmar, John Tobin, Jordyn Buchanan, Joseph Bironas, Julio Merino, Julius Plenz, Kate Ward, Kathy Polizzi, Katrina Sostek, Kenn Hamm, Kirk Russell, Kripa Krishnan, Larry Greenfield, Lea Oliveira, Luca Cittadini,

Lucas Pereira, Magnus Ringman, Mahesh Palekar, Marco Paganini, Mario Bonilla, Mathew Mills, Mathew Monroe, Matt D. Brown, Matt Proud, Max Saltonstall, Michal Jaszczyk, Mihai Bivol, Misha Brukman, Olivier Oansaldi, Patrick Bernier, Pierre Palatin, Rob Shanley, Robert van Gent, Rory Ward, Rui Zhang-Shen, Salim Virji, Sanjay Ghemawat, Sarah Coty, Sean Dorward, Sean Quinlan, Sean Sechrest, Shari Trumbo-McHenry, Shawn Morrissey, Shun-Tak Leung, Stan Jedrus, Stefano Lattarini, Steven Schirripa, Tanya Reilly, Terry Bolt, Tim Chaplin, Toby Weingartner, Tom Black, Udi Meiri, Victor Terron, Vlad Grama, Wes Hertlein, and Zoltan Egyed.

We very much appreciate the thoughtful and in-depth feedback that we received from external reviewers: Andrew Fong, Björn Rabenstein, Charles Border, David Blank-Edelman, Frossie Economou, James Meickle, Josh Ryder, Mark Burgess, and Russ Allbery.

We would like to extend special thanks to Cian Synnott, original book team member and co-conspirator, who left Google before this project was completed but was deeply influential to it, and Margaret Hamilton, who so graciously allowed us to reference her story in our preface. Additionally, we would like to extend special thanks to Shylaja Nukala, who generously gave of the time of her technical writers and supported their necessary and valued efforts wholeheartedly.

The editors would also like to personally thank the following people:

Betsy Beyer: To Grandmother (my personal hero), for supplying endless amounts of phone pep talks and popcorn, and to Riba, for supplying me with the sweatpants necessary to fuel several late nights. These, of course, in addition to the cast of SRE all-stars who were indeed delightful collaborators.

Chris Jones: To Michelle, for saving me from a life of crime on the high seas and for her uncanny ability to find manzanas in unexpected places, and to those who've taught me about engineering over the years.

Jennifer Petoff: To my husband Scott for being incredibly supportive during the two year process of writing this book and for keeping the editors supplied with plenty of sugar on our "Dessert Island."

Niall Murphy: To Léan, Oisín, and Fiachra, who were considerably more patient than I had any right to expect with a substantially rantier father and husband than usual, for years. To Dermot, for the transfer offer.