Expert Guide

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DEVELOPING AND MANAGING EMBEDDED SYSTEMS AND PRODUCTS

Methods, Techniques, Tools, Processes, and Teamwork

Kim R. Fowler
Craig L. Silver

Read The Experts To Become An Expert!

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Developing and Managing Embedded Systems and Products

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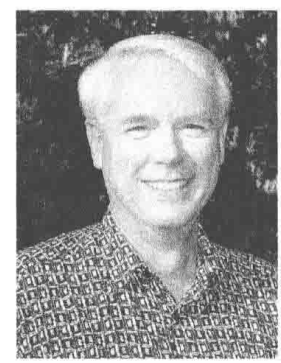

Kim R. Fowler has spent over 30 years in the design, development, and project management of medical, military, and satellite equipment. His interest is the rigorous development of diverse, mission-critical, embedded systems. He co-founded Stimsoft, a medical products company, in 1998 and sold it in 2003. He also has worked for JHU/APL designing embedded systems, for a company now part of Curtiss-Wright Embedded Computing that built digital signal processing boards, and consulted for both commercial companies and government agencies. He is a Fellow of the IEEE and lectures internationally on systems engineering and developing real-time embedded products. He has been president of the IEEE Instrumentation & Measurement society and an adjunct professor for the Johns Hopkins University Engineering Professional Program. He has published widely and has written three textbooks—this book is his fourth. He has 18 patents—granted, pending, or disclosed. He is currently a graduate student in Electrical Engineering at Kansas State University to finally get his PhD.

Co-Author Biography

Craig L. Silver has over 30 years of diverse legal experience for private, commercial, start-ups, and nonprofit entities, serving as litigation counsel for complex commercial disputes, constitutional law claims, aviation torts, and criminal defense. Having served as a general counsel, general manager, and president for defense electronic firms and telecommunications companies, he is experienced with technology companies dealing with software licensing issues, IP protection, and international transactions. He has previously published for the IEEE—"Silver Bullets" and has worn various hats in high technology companies that include business development and technical liaison with field application engineers. He holds a BA degree from the Universityof Maryland and a JD degree from George Mason University Law School. He is a licensed pilot and ham radio operator. He is married and resides in Maryland, USA.

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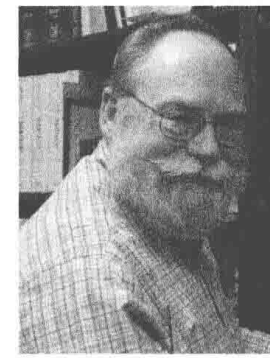
Allison Fritz is an Organization Development and Facilitation professional with over 20 years' experience in a variety of industries. Presently working as a Sr. Organization Development and Training Consultant with the Johns Hopkins Health System, she has also worked within higher education, the petroleum industry, and independent consulting, serving both Fortune 100 and small business, designing and facilitating processes. Allison's expertise is in team development, change management, leader development, strategic visioning, and coaching. With 14 years in management roles, she applies her experience to her work. Allison has a doctoral degree in Organization and Staff Development from the University of Maryland College Park, a Master's degree in Counseling and Student Personnel, and a Bachelor's degree in Communications and Psychology from the University of Delaware; as well as holds several certifications including, *Emotional Intelligence (EQ2.0, 360), Crucial Conversations*, Strong Interest Inventory, and MBTI. Allison focuses her work on encouraging leaders, teams and organizations to realize positive change.

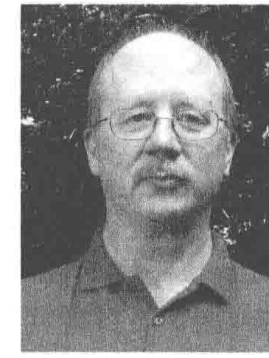


Michael F. (Mike) Gard, received his BSEE from Kansas State University, MSEE (Interdepartmental Program in Biomedical Engineering) from Washington University in St. Louis, and PhDEE (Geophysics minor) from Southern Methodist University. He has over 40 years of industrial experience in aircraft, medical equipment, clinical engineering, petroleum, and construction industries. He is presently Sr. Product Design Engineer at The Charles Machine Works, Perry, OK. An adjunct professor, he occasionally teaches at Oklahoma State University. He is a registered professional engineer, patent agent, inventor (34 US patents), author, member of the IEEE Instrumentation and Measurement Society's Administrative Committee, and editor-in-chief of *IEEE Instrumentation and Measurement Magazine*. His technical interests include real-time data acquisition and precision analog and analog/digital systems for low power and hostile environments.

Robert Oshana has 30 years of experience in the software industry, primarily focused on embedded and real-time systems for the defense and semiconductor industries. He has BSEE, MSEE, MSCS, and MBA degrees and is a senior member of IEEE. He is a member of several Advisory Boards including the Embedded Systems group, where he is also an international speaker. He has over 200 presentations and publications in various technology fields and has written several books on Embedded software technology including "Software Engineering for Embedded Systems." He is an adjunct professor at Southern Methodist University where he teaches graduate software engineering courses. He is a distinguished member of Technical Staff and Director of Global Software R&D for Digital Networking at Freescale Semiconductor.

Geoff Patch has over 30 years experience as a software engineer. He has worked for the Australian government, in academia, and for a number of engineering companies. Since 1987, he has specialized in embedded systems, primarily in the areas of radar target tracking, radar signal processing, and command and control systems. He is also keenly interested in software process improvement, technical team leadership, and technical management. He has developed software for numerous commercially successful radar systems ranging from conventional maritime surveillance, through specialized applications such as submarine periscope detection and up to large air defense systems. He is currently the manager of a team of nearly 30 software engineers involved in the development of new radar systems at CEA Technologies in Canberra, Australia.

Eugene Vasserman received his PhD and master's degrees in Computer Science in 2010 and 2008, respectively, from the University of Minnesota. His BS, in Biochemistry and Neuroscience with a Computer Science minor, is also from the University of Minnesota (2003). In 2013, he received the NSF CAREER award for work on secure next generation medical systems.



Tim Wescott has 25 years of real-world experience in embedded systems design, with roles ranging from software designer to circuit designer to systems architect. Tim has worked on small, inexpensive hand-held instruments, on large airborne imaging systems, and on nearly everything in between. He has experience in all phases of system life cycles, ranging from designing new systems from a clean sheet of paper to extending the useful lives of systems that are on the verge of obsolescence. Tim is author of "Applied Control Theory for Embedded Systems", aimed at engineers who slept through control theory class in University, and who now need to design a system that must successfully implement a feedback control loop. Tim is the owner of Wescott Design Services, which provides analysis, design, and troubleshooting of embedded control systems, with a particular emphasis on control of dynamic systems, low-level communications systems, and metrology. Wescott Design Systems has helped customers of all sorts of problems ranging from drives for 1/2-inch diameter brushless motors to implementing communications systems for deep-well drilling platforms.

Steve Zeise is a mechanical engineer and designer with 30 years' experience in all things mechanical. He received a BS in Mechanical Engineering from Rose-Hulman Institute of Technology and immediately went to work for Westinghouse Defense and Electronics Systems Center designing mechanisms, structures, and cooling systems supporting embedded systems in night vision cameras. With positions at Northrop-Grumman and Lockheed Martin, he gained experience in structural analysis and environmental testing. He is currently with FLIR Systems where he helped to setup a small R&D facility in Orlando, FL and for the past 15 years has worked to help FLIR Systems solvė complex vibration problems.

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Kenneth W. Tobin is the Director of the Electrical and Electronics Systems Research (EESR) Division at the Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee, USA, where he has been working in various R&D and leadership capacities since 1987. The EESR Division is composed of 150 staff who perform R&D in electronics, sensors, communications, and controls for energy efficiency, resiliency, and security. His personal research areas encompass photonics, neutronics, x-ray, SEM, electronic imaging and microscopy coupled with signal processing and machine learning. Science and technology specialty in computational imaging, image metrology, object segmentation, and feature generation from multi-spectral, multi-source imagery for inverse imaging, robust human-level classifiers, image archival and retrieval applications, and image-based informatics. Dr. Tobin was named an ORNL Corporate Research Fellow in 2003 for his contributions to the field of applied computer vision research. He has authored and co-authored over 164 publications and he currently holds fourteen U.S. Patents in areas of computer vision, photonics, radiography, and microscopy. Dr. Tobin is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) and a Fellow of the International Society for Optics and Photonics (SPIE), where he is currently an Associate Editor for the Journal of Electronic Imaging. Dr. Tobin has a Ph.D. in Nuclear Engineering from the University of Virginia, an M.S. in Nuclear Engineering from Virginia Tech, and a B.S. in Physics also from Virginia Tech.

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Lee Barford is master scientist at Keysight Laboratories and professor of Computer Science and Engineering (adjunct) at the University of Nevada, Reno, NV. He leads Keysight's efforts in applying parallel computing to speed electronic measurements. He also leads research to identify and apply emerging technologies in software and applied mathematics to enable new kinds of measurements and increase measurement accuracy and speed. His work has been used to improve R&D productivity and reduce manufacturing cost in the leading companies in the technology and transportation industries, including Apple, Boeing, Cisco, Ford, HP, Microsoft, and NASA. Previously, he managed a number of research projects at Agilent and Hewlett-Packard Laboratories, for example, in visible light and X-ray imaging systems, calibration methods for nonlinear and dynamical disturbances, and fault isolation from automatic test equipment results. He is an author of over 40 peer-reviewed publications and an inventor of approximately 60 patents.

Hong-Liang Xu is a senior research engineer at Keysight Laboratories. He joined Agilent Laboratories in 2007 after earning a master's degree from Beijing University of Posts and Telecommunications. In the field of parallel computing, he focuses on the methods to accelerate DSP and measurement algorithms on common platforms, like multicore CPUs and general-purpose GPUs. His recent work has included a demo of a purely software defined LTE base station with industry partners, including IBM and China Mobile Research Institute, demonstrating the DSP capabilities of multicore CPUs in the handling of wideband wireless communication protocols.

Chun-Hong Zhang is a scientific research staff member at Keysight Laboratories. He focuses on how to efficiently parallelize digital signal processing algorithms on heterogeneous computing platforms and optimize the parallel algorithms based on the advanced parallel computing features provided by different platforms. Previously, he did research projects on high-efficiency, nonreference digital voice and video quality assessment at Agilent Laboratories.

Jake Brodsky has been practicing the art of Control Systems and SCADA Engineering at the Washington Suburban Sanitary Commission for over 28 years. He intends to continue practicing until he gets it right. He is a registered professional engineer of control systems, a ham radio enthusiast, an instrument rated private pilot, a firearms instructor, and an amateur beer brewer—but not all at the same time. He co-founded and moderates the SCADASEC email list, he is co-author and co-editor of the Handbook of Control System/SCADA Security, published by CRC Press, and was recently re-elected Chair of the DNP Users Group.

Daryl Beetner is a professor of Electrical and Computer Engineering at the Missouri University of Science and Technology (formerly called the University of Missouri—Rolla). He received his BS degree in Electrical Engineering from Southern Illinois University at Edwardsville in 1990. He received an MS and DSc degree in Electrical Engineering from Washington University in St. Louis in 1994 and 1997, respectively. He conducts research with the Electromagnetic Compatibility Laboratory at Missouri S&T on a wide variety of topics including EMC of integrated circuits, EMC within embedded systems, and detection and neutralization of explosive devices. He is an associate editor for the IEEE Transactions on Instrumentation and Measurement.

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Developing and Managing Embedded Systems and Products: The Roadmap

Kim R. Fowler

This book is for the entire project team! The book's material contains best practices for developing embedded systems, which includes technical design, teamwork, collaboration, management attitudes, development processes, and legal liabilities. The book addresses these various topics because project development is not just a technical endeavor; it is a human endeavor.

The chapters present in a sequential fashion, but development of an embedded system is anything but sequential. Figure 1, below, is a repeat of Figure 1.2 from Chapter 1 and placed here for your convenience. The figure lists the chapters and when they might be most useful within a project. The multiple paths and connections indicate the parallel and concurrent nature of design and development efforts.

Chapter 1: Introduction to Good Development

Chapter 1 describes the book's purpose to identify important issues in developing and managing embedded systems. The material outlines the technical aspects, the teamwork, the effort, and the cost you encounter in developing an embedded system. It reveals how technical issues impact business and schedules, how personal interactions are just as important as technical breakthroughs, and the interplay of various disciplines to realize the final product. Consequently, ***this book is not solely for managers, it is written for every member of the project team.***

Chapter 2: Drivers of Success in Engineering Teams

While technical work and knowledge are at the core of the engineering team, its success can rest equally on how well the team addresses the human aspects of daily activity. Organizational culture, team dynamics, and individual responses play significant roles in the

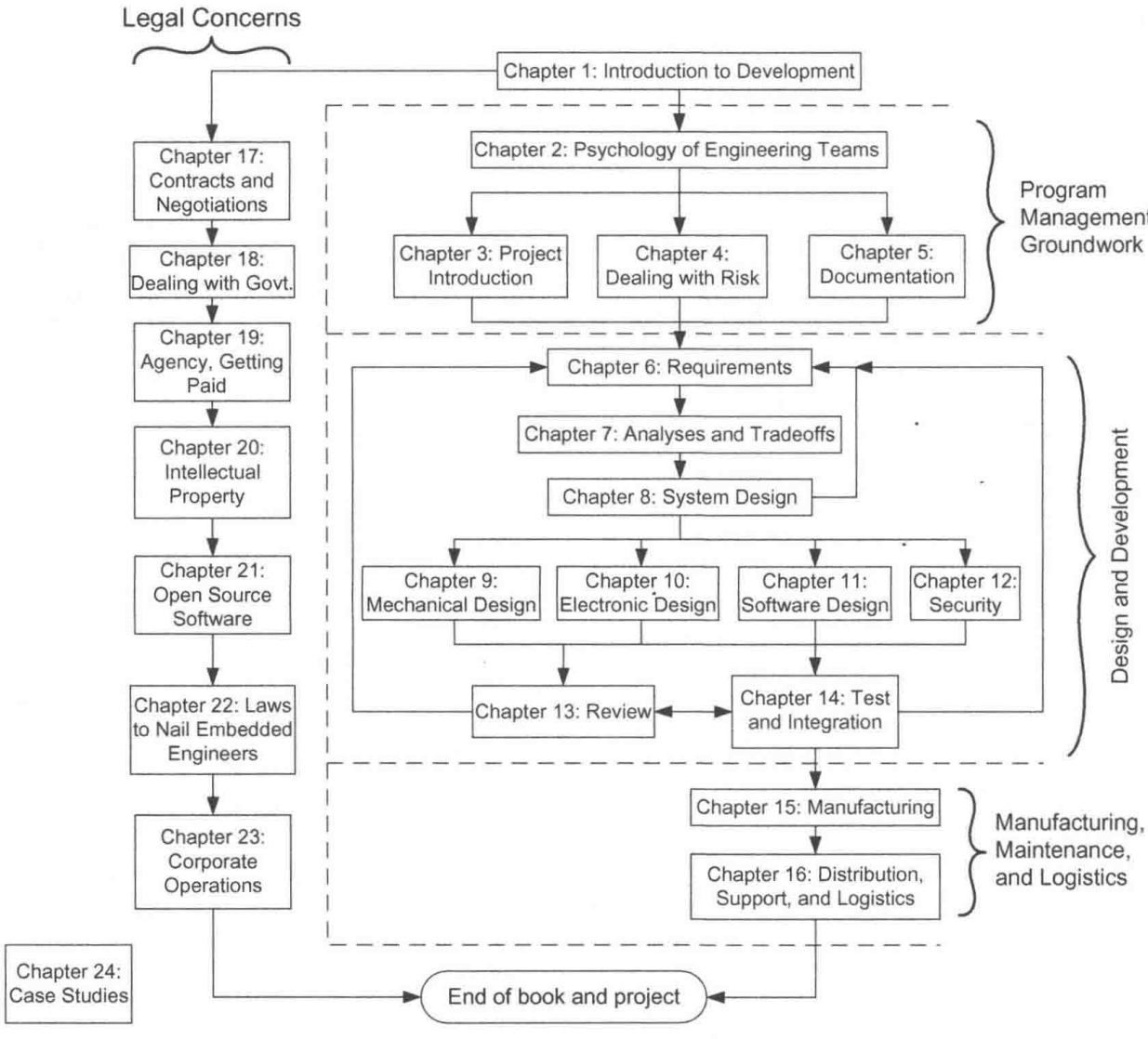

Figure 1:
Book organization and a suggested approach to reading it.

outcomes of the team's efforts. This chapter offers an overview of concepts and theories that relate to the functioning of the engineering team. It addresses the role of the team member, the role of the team leader, engagement, team development, dialogue, emotional awareness, and handling conflict to encourage leaders and members to pursue further study and skills training.

Chapter 3: Project Introduction

What you do in the beginning of a project, sets precedence for the remainder of the project. Start on the right foot.

This chapter focuses on how you begin the long process of designing and building a successful project. It emphasizes the following:

- communicate the vision, mission, goals, and objectives;
- establish the "who, what, when, where, why, and how...";
- define the roles of the team and within the team;
- provide a clear communications plan;
- make the business case; and
- then establish the project plan, the administration, and the resources for the project.

Chapter 4: Dealing with Risk

Risk is the potential to stray outside the defined cost, schedule, performance, or safety constraints. Every project is risky to some degree but risk can be managed. The chapter follows this format:

- first, identify the various risks and analyze them;
- then control risks by reducing, constraining, or transferring them;
- assess the state of the risks by analyzing them again; and
- repeat this cycle throughout the project's development.

Chapter 5: Documentation

Documentation conveys the right information to the right person at the right time. Documentation is corporate communication and memory. Everyone working on a technical project spends 50–80% of their time preparing documentation.

This chapter has a number of suggested outlines and templates of documents. It also has examples of content within important documents.

Chapter 6: System Requirements

This chapter will give readers a number of best practices to improve the quality of the requirements elicitation and development process in their organization. Formulation of high-quality requirements (complete, concise, accurate, modular, prioritized, analyzed, verified, and testable) reduce project risk, improve product quality, and allow for effective control of requirements volatility, which increases the likelihood of a successful project.

Chapter 7: Analyses and Tradeoffs

Analyses and tradeoffs are absolutely necessary to the success of product design and development. Analyses form the feedback between requirements and design. Analyses gauge how well a design meets the requirements. If a design does not match the requirements, then either the design or the requirements need modification.

This chapter provides the motivation for analyses with the business case. It then discusses tradeoffs you might make to produce a design concept. Finally, it discusses a number of different analyses that you might use to refine a design.

Chapter 8: The Discipline of System Design

This chapter shows you how to design the whole system by starting with goals in plain language that a business person might use. Then it proceeds through detailed system design by the team, a process that avoids either redundant effort or missing pieces.

Areas of particular focus in this chapter include:

- how to communicate effectively with nonengineering personnel,
- how to partition a large system into manageable subsystems,
- how to partition system requirements into requirements for individual disciplines, i.e., software, electronics, and mechanical engineering, and
- how to control costs for projects of various sizes and production volumes.

Chapter 9: Mechanical Design

The chapter reviews basics of mechanical design to help nonmechanical staff communicate more effectively with their mechanical engineering colleagues. It addresses the fundamentals of packaging and thermal design so that the project manager may guide product development. The chapter goes on to discuss mechanisms; it focuses on robust design and methods for calculating loads and forces. The chapter looks at analysis and test, discusses how to use Finite Element Analysis effectively, and ends with a simplified approach to solving vibration problems.

Chapter 10: Electronic Design

The chapter considers basics of electronic design allowing project leaders or nonelectrical engineers to communicate effectively with their colleagues in the electrical and electronic arena. Electronic circuit design involves the selection and interconnection of physical devices in a variety of topologies to meet performance specifications, environmental