1

"Citizen Engineer" Defined

"The scientist describes what is; the engineer creates what never was."
—*Theodore von Karman*

To put it as simply as possible, Citizen Engineers are the connection point between science and society—between pure knowledge and how it is used. Citizen Engineers are techno-responsible, environmentally responsible, economically responsible, socially responsible participants in the engineering community.

You'll find additional shades of meaning in the term *Citizen Engineer* as you examine its elements separately. What is an engineer? An engineer is a constructive artist. The art of engineering is based on science and mathematics, where the tools and materials are technological. It's a constructive art because engineers build and optimize things. And yes, the intent here is to highlight the concept that engineering is *art*—interpretation, design, creation, invention, and expression—in contrast to the common stereotype that the profession is rigid and formulaic.

Laypeople often confuse engineers with scientists. For example, we're sure you've seen the incredible results from the Mars Rover missions trumpeted as a spectacular achievement of science, and a wonderful way to attract more students to math and science. As engineers, we look at the science components of the mission as interesting—but the engineering, ah, that was monumental! Hey kids, wouldn't you just love to *build* something that crawls around for years digging in the dirt of another planet? How cool is that?

Engineers are idealists, in every sense of the word. While we're focused on finding the simplest, most efficient solutions, we are also utopians. We find ourselves contemplating not only what could be better, but also what could *be*. We're drawn to visionary ideas and idealists. Over the years, engineers have demonstrated incredible courage in pursuing their visions—working for years on concepts that may or may not ever pan out, testing ideas no one else

believes in. We also share the idealism of artists. We see beauty in new ideas, novel approaches, and new ways to tame complexity. We're a stubborn, meticulous, critical bunch, unforgiving of shoddy work and half-baked theories, abhorrent of conventional wisdom, but always eager to learn, to try, to push the limits, and to create something new.

At the same time, engineers are pragmatists. We must deal with the constraints of technological limitations, business requirements, and budget realities. We don't always have the time we'd like to implement our best ideas, or have access to the ideal tools or materials we'd love to use. Sometimes we must content ourselves with the knowledge that the world is better off with a *real* product that delivers 20% more energy efficiency today than with a *theoretical* product that might be 80% more efficient but is unlikely ever to make it to market.

Now consider what it means to be a citizen.

At one level, a citizen is simply a member of a community. But for most people, the term also includes a moral element. As a citizen, one has rights, certainly, but also responsibilities. Citizenship is more than participation in the community; it means working toward the betterment of the community through economic participation and public service to improve the state of all other citizens.

The blending of engineering and citizenship is nothing new. What's new is that engineers are being asked to extend their sphere of responsibility into new areas: the developing world, the environment, the proper use of intellectual property, security and privacy issues; the list goes on. At the same time, society is asking engineers to accept more responsibility for the impacts of the products and services they design. The world is not blaming engineers for climate change, loss of data privacy, and so on, but society is making it overwhelmingly clear that since engineers had a role in creating these challenges, engineers must accept their role in addressing them as well.

We're not saying that engineers should be wracked with guilt if their next product has a nonzero carbon footprint, uses a scarce natural resource, or offers only a modest environmental improvement over a previous design. Engineers must be pragmatists. Your product can never be ideal. Instead, what we are saying is that you need to be aware of the impact your product has—and be creative about minimizing its negative impacts. We're asking you to consider new options and explore new possibilities.

In a sense, "Citizen Engineer" is an ideal. There is no formula or set path for becoming a Citizen Engineer, no specific set of attributes that all Citizen Engineers possess, and no certification process. Attainment of

Citizen Engineer status is deeply personal; only you can define the requirements given your situation, and only you can measure your progress toward the goal.

It's interesting to note that many of the youngest members of the engineering community are helping to drive the new era of socially responsible engineering. Typically, the responsibilities of citizenship are something one grows into as one ages and accumulates wisdom and perspective. What's the explanation? Certainly part of it is that the young have the most to worry about when it comes to the future of our planet. But we believe it's more than that.

We believe the new generation of engineers understands the unprecedented opportunities before them—to create better products and to make a positive, lasting impact on our planet. They can't wait to get started.

Responsibilities of the Citizen Engineer

If you're an engineer you've already enjoyed many rights and privileges. You've received an excellent education. You've put yourself in a good position to effect change and exert your influence on society. And you get paid to innovate and create—who could want more than that?

But with these privileges come responsibilities.

First, the basics: Engineers have an ethical obligation to make decisions that are consistent with the safety, health, and welfare of the public, and to disclose factors that might endanger the public or the environment. Our engineering community has met this obligation exceedingly well over the years. When people cross a bridge or board an airplane or get into an elevator, they're not wondering whether the engineers who built it were socially responsible. Society's trust for engineers is deeply ingrained. And today, society trusts us to get these new things right as well—from the next genetically engineered foods or cancer treatments, to the nanotechnology underlying new ways to create clean water, to the software in your hybrid car that ensures that the brake pedal really does stop the vehicle.

But Citizen Engineers are moving beyond the basics, and are upholding even higher ideals. They are more than problem solvers. They are speaking out on issues within their realm of expertise and engaging in the political process. They're staying abreast of issues that impact their field and are helping to educate others who may be impacted by developments in their field. And they're embracing new forms of responsibility that are becoming increasingly important to our society as a whole.

- **Environmental responsibility:** Citizen Engineers have both the opportunity and the moral obligation to consider the total environmental impact of the products and services they design—over the entire lifecycle, from raw materials through manufacture, assembly, distribution, sales and marketing, use, recycling, and disposal.

- **Techno responsibility:** Citizen Engineers use the technological innovations of others responsibly and ethically, building and contributing to the knowledge base in their field. This includes the responsible use of intellectual property, adherence to the terms of licenses, ethical handling of data about others, and honoring the terms and the intent of nondisclosure agreements and other contracts relating to use of ideas.

- **Customer/stakeholder responsibility:** Citizen Engineers are responsible for ensuring the safety, security, and privacy of the people who buy and use the products they design. They must also consider issues such as accessibility; they're responsible for testing, upgrading, and improving their products over time; and they must account for unintended consequences of their products. Citizen Engineers also work closely with customers to ensure that they are partners in minimizing the environmental impact of products and services. After all, customers often control the project requirements, the time frame, and the budget that engineers are working under.

Knowledge Base of the Citizen Engineer

> "It's not what you know, it's who you know."
> —*Old adage*

> "It's not who you know, it's what you know."
> —*Engineering manager*

> "It's not just what or who you know, it's who you are."
> —*Citizen Engineer*

To be successful in the new era of engineering you're going to need to be more than an engineer. That's true whether you're a student, a new hire at a company, an engineering manager, an entrepreneur, or a seasoned engineer with 30 years of experience.

New requirements are encroaching on the traditional tasks of engineering. Most design specs will soon reflect a requirement to minimize environmental impact—do you know what to consider and how to comply? Many new software

projects may consider using open source software—do you fully understand the nuances of the various licenses?

In addition, being a Citizen Engineer means being a leader. And your ability to lead—not to mention your influence and impact as an engineer—will increasingly depend on your ability to communicate, collaborate, and participate across the organization, not just within the engineering department.

As a society, we'll need engineers to take the lead in solving many of the most pressing challenges we face: the environment and climate change, increasing data security and privacy issues, and the ability to sustain quality of life without depleting natural resources. We'll need lawyers, environmental scientists, business experts, and other professionals too, but engineers are critical because only engineers have the expertise and specialized knowledge required to effect these types of changes.

To put it simply, you won't need to "know" more than a traditional engineer; you'll need to "be" more. You'll need to play multiple roles, possess broad knowledge in a variety of disciplines, and know when to seek professional assistance. Here are a few key areas of expertise you'll need as a Citizen Engineer.

Technology

First and foremost, you have to know your stuff. That's getting more and more challenging as fields of technology and engineering become increasingly specialized, but for most engineers it's a labor of love. You keep learning because you're compelled by your own curiosity and interest. If staying in sync with new developments in your field is burdensome, that's telling you something.

Ecology

Within the next few years, virtually every new product or service will include environmental considerations as part of its core design specifications. Whether you see environmentalists as saviors, anti-business tree huggers, or something in between, you will need to be able to respond to the issues, laws, and new requirements for eco-responsible products and services—and be able to take advantage of the opportunities that eco-responsible products represent.

Intellectual Property

Depending on your attitude and experiences, the world of intellectual property (patents, licenses, contracts, etc.) can be a blessing or a curse. But with

engineers collaborating in groups across the Internet, widespread use of open-source software, increases in data collection by products and companies, and more products and services with a large digital component, an understanding of intellectual property (IP) is now central to any engineering project. You need to know how to protect your own ideas through patents, copyrights, trademarks, and so on—and you need to protect the security and privacy of customer data as well.

Business

For more than a few engineers, part of the appeal of engineering is insulation from the harsh realities of the business world. The vision of working in a corporate lab, sealed off from distractions, free at last to pursue visionary ideas unfettered by such inane activities as cost justification or customer meetings, can be a powerful draw to some. Unfortunately, that vision has never matched reality, and engineering increasingly requires more direct involvement with every aspect of business, including finance, sales and marketing, channels, customer support, and competitive analysis. Here's the upside for die-hard techno purists: The more you know about business, the more control you'll have over your ideas and innovations. If you can clearly articulate how your project will solve problems for customers and improve the company's bottom line, you will increase not only the likelihood of funding for your project, but also your influence within the organization.

Public Policy

Whether you're aware of it or not, your products embody your ideals. And as a result, engineers are activists, whether they want to be or not. But engineers are also beginning to realize how important it can be to educate those who make public policy decisions about technology. Nuclear power and genetically engineered foods provide cautionary tales about what can happen when politicians and the public don't understand the realities behind new innovations. Time and again the public has heralded a technological advance as a savior, only to demonize it months later, when in fact both views were way too extreme. Citizen Engineers need to play a more active and assertive role in providing that education. And conversely, Citizen Engineers need to learn more about how public policy actually works, and to be educated and informed about the process itself. It is our duty to make the effort to have the dialog with our communities, not the other way around.

Collaboration

In discussing this book with dozens of engineers, there wasn't much every-one agreed on—but here's one thing: Collaboration skills are becoming every bit as important as technical knowledge for engineers. In short, you have to be a good teammate. Even among NASA astronauts, team skills are now seen as more vital than piloting skills.[1] It's no different in the close quarters of the corporate lab, conference room, or networked workspace. Working together, especially in small, highly communicative teams, is what works.

As you read through the previous sections, a question may have crossed your mind: How am I supposed to do all this? Chances are you're already under intense pressure trying to meet project deadlines, keep pace with new developments in your field, and balance your work and private time.

We're not advocating that you become an expert at everything that touches your work. But you'll need to know the basics about each of the pre-ceding topics, and you need to know when to reach out to other profession-als who can help you with specific issues. That's what this book is all about. We want to help you use your time most efficiently as you come up to speed on new areas of knowledge that will impact your job, your project, and your success as an engineer.