

What Engineering Shortage?

by Alan S. Brown

Is there a shortage of engineers? It depends on whom you ask.

"You couldn't prove it from my experience alone, but it has been a struggle finding the right engineers," says John Fuhs, vice president of sales and engineering for Swoboda, Inc., of Kentwood, MI.

Swoboda is a stable subsidiary of a German auto parts supplier and pays a premium for engineering talent. The company recruits from excellent schools and surrounding auto suppliers. Yet Fuhs has difficulty finding engineers with hands-on rather than project-management skills. His voice is part of a rising chorus of industrial firms that claim to have difficulties finding engineers with the skills needed.

Paul J. Kostek, who previously managed career activities as vice president of IEEE-USA, the electrical and electronic engineering institute, says there is no shortage. "You saw what happened to the price of gasoline when there was a shortage last summer. If there's a shortage of engineers, why aren't people paying \$200,000 to hire an engineer?"

Kostek seems to have economics on his side. While salaries for engineering graduates have risen in recent years, the median salary for engineers has remained stable. Ask any engineer who has applied for a job—even before this brutal recession—and he or she will tell you that there is plenty of competition. In fact, researchers can point to data showing that the United States graduates many more engineers than it could possibly put to work in the field.

So, do we have too few engineers or too many? Why have technology worker shortages become a hot topic in Congress, blogs, and newspapers? More significantly, is the focus on shortages disguising significant changes in the composition of the engineering work force?

The Gathering Storm

America often worries about technology worker shortages, especially during crises. When the Soviet Union launched *Sputnik* in 1957, the United States responded with a greater investment in science education and an ambitious space program of its own. In the mid-1980s when the Japanese threatened to overwhelm American producers, the National Science Foundation began warning of a shortage of scientists and engineers. Starting in 1997, the information technology (IT) industry claimed that it could not find enough workers to meet demand and successfully lobbied for more temporary H-1B visas for temporary technology workers.

Today, the technology threat comes from China, India, and other emerging nations. While these countries rely on cheap labor, China and India also have large, sophis-

ticated engineering work forces. They may have started by doing low-level computer programming and 3D CAD conversions, but many now do systems integration and engineering design.

Their success has put pressure on the U.S. economy. During the past decade, the nation has offshored an increasing percentage of production, shed 3 million manufacturing jobs, and opened a \$60 billion trade gap in advanced technology products. It is now watching IT and engineering positions move offshore as well.

In 2006, the National Academy of Engineering released the report, *Rising Above the Gathering Storm*, which crystallized national fears. It stated that America's standard of living is based on science and technology innovations and that the nation is in peril of losing its lead in these key areas.

One year later, Lockheed Martin Corporation chairman **Norman R. Augustine**, *New Jersey Delta '57*, who headed the *Rising Above the Gathering Storm* committee, published a second report, *Falling off the Flat Earth*. It marshaled evidence that the United States was failing to produce enough technology workers.

Augustine noted that Asia graduated 636,000 new engineers in 2002, compared with only 122,000 in North America (68,600 in the U.S.). He pointed to an 18 percent decline in U.S. in engineering, math, and physical and geoscience bachelor's degrees during the previous two decades and noted a 40 percent decline in the proportion of students studying these subjects. By 2006, the United States ranked 17th in the percentage of university science and engineering graduates, down from third 30 years before.

Mr. Augustine also voiced concern about the pipeline of future science, technology, engineering, and math (STEM) professionals. He pointed to poor student scores on international science and math tests and noted that many high-school math and science teachers had not majored in their subjects.

The report laid out a series of reforms, including improved STEM education and more incentives for STEM professionals. Congress even passed the \$140 million America Competes Act to implement *Rising Above the Gathering Storm's* suggestions, although it never funded the program.

At a two-year assessment of the report, former NAE president (and MIT president-emeritus) **Dr. Charles M. Vest**, *West Virginia Alpha '63*, warned that the United States could lose its technology leadership in the blink of an eye, "The enemy I fear most is complacency. We are about to be hit by the full force of global competition. We must now establish a sense of urgency, urgency because time has run out," Dr. Vest said.

“There will be winners and losers,” added a blunt Craig Barrett, chair of Intel Corporation and an author of *Rising Above the Gathering Storm*. “If the U.S. is doing anything, we’re looking in the rearview mirror. We’re not looking to the next generation, we’re looking—‘The ’80s and ’90s were great, we’re on top, that’s the way it’s always going to be.’ And folks, that ain’t the case.”

Assessing Data

It sounds ominous. Yet others maintain that there is no real shortage. For example, Augustine pointed to an 18 percent decline in some types of STEM degrees, but seems to have left out others. The number of information technology workers, for example, increased to 3.3 million in 2000, from 646,000 in 1980, according to Bureau of Labor Statistics data tabulated by the Commission on Professionals in Science and Technology (CPST).

The growth of IT catapulted the total number of U.S. STEM workers to 6.9 million in 2000, from 3.5 million in 1980, says CPST. In other words, when IT and biology workers are included, the number of STEM workers doubled over the same period in which Augustine reports an 18 percent decline. Remove social scientists and technicians from the mix, and the 20-year gain was more than 130 percent. This compares with a 30 percent increase in all U.S. workers reporting an occupation during the same 20 years.

Between 1993 and 2002, adds Hal Salzman, a professor of public policy at Rutgers University, U.S. colleges graduated an average of 380,000 STEM bachelor’s, 70,000 master’s, and nearly 20,000 doctoral graduates per year (including IT workers). At that rate, U.S. colleges graduate enough students to replace the entire 6.9-million-person STEM workforce every 15 years (including up to 40 percent of workers in some IT fields who do not hold a STEM degree).

Salzman, who uses a more restrictive STEM definition than CPST, puts the total STEM work force at 4.8 million. That is roughly one-third of the 15.7 million workers who hold at least one science or engineering degree.

His data shows that only about one-third of STEM graduates take jobs in STEM fields. While the data is not precise, it indicates no shortage of engineers.

Nor have companies had trouble filling vacancies, according to research by Vivek Wadhwa, executive-in-residence at Duke University. He surveyed companies about hiring practices. He found that 80 percent of firms filled positions in four months or less. Nearly half the companies reported that more than 60 percent of applicants accepted offers. Four of



five companies said that their acceptance rates had increased or stayed constant. Nearly nine of ten companies either offered no signing bonuses or offered bonuses to less than 20 percent of new hires. These are hardly signs of shortages.

Even at the height of the *dot.com* boom ten years ago, IBM’s acceptance rates were still 55 percent, notes Ronil Hira, an associate professor of public policy at Rochester Institute of Technology. “By 2004 or so, they were back up to 85-88 percent, which is really high. Yet at the same time, IBM’s chairman, Samuel Palmisano, was saying there were engineering shortages,” says Hira.

When it comes to salaries, not too many companies are paying \$200,000 for engineers. CPST found that the average STEM salary (in constant 2005 dollars) rose 7 percent between 1995 and 2005 to \$56,721. Engineers moved up only 3 percent to \$63,526.

CPST data reveal some interesting sector-by-sector variations. Salaries of engineering managers rose 14 percent between 2002 and 2005 alone, to \$92,976. IT professionals’ salaries surged during the *dot.com* boom, then stalled or declined after the bubble burst. Between 1995 and 2005, average salaries for electrical/electronic engineers rose more than 10 percent to \$70,200, and aerospace engineers climbed nearly 9 percent to \$70,824.

How does this compare with other professions? Managers boosted pay 14 percent over the same 10-year period, but averaged only \$51,844. On the other hand, lawyers pay rose 12 percent to \$83,668, and doctors 6 percent to \$80,444.

Moreover, the pipeline remains strong, says Michael Tietlebaum, a program director at the Alfred P. Sloan Foundation, which funds research related to technology and society. “There’s no constraint on the number of kids who come out of the K-12 system who say they want to be scientists or engineers. It has remained remarkably constant, between 30 and 32 percent of entering college freshmen who want to major in science and engineering. If they all did, we’d have way too many graduates. In fact, only half of them complete degrees.”

Leaving the Fold

If the data suggests no real shortage, then why do companies report that they cannot find the STEM workers they need?

“The simplest distinction we make,” explains Salzman, “is between a shortage in the classical sense and hiring difficulties.” Salzman’s argument is simple: A large pool of highly capable STEM students graduate from college each

year. But many of those students—especially the best of them—are choosing other professions.

In the 1960s, he argues, many of the best students were inspired by the race into space. Today, engineering involves large, production-oriented teams. “We’ve gone from *The Right Stuff* to *Dilbert*, from space-age excitement to cubicle culture,” he says. (The National Academy of Engineering is attempting to re-inject some of that excitement with its ambitious environmental, biomedical, and computational “Grand Challenges.”)

Of course, some students want to see the money. In the 1990s, many top students majored in IT in order to cash in on *dot.com* stock options. When the boom turned bust, IT and computer science enrollments plummeted. Over the past decade, many bright students aimed for Wall Street.

“As a result,” says Salzman, “industry couldn’t hire the people they wanted.” Pre-*dot.com*, the major IT companies would recruit from the top 10 percent of the class. During the *dot.com* boom, those guys went to start-ups, and the majors had to hire from the lower part of the class. During the go-go years on Wall Street, many top engineering graduates went into banking.” There were still plenty of engineers says Salzman, but many chose more lucrative careers.

In addition, experienced engineers often left the field for other professions, says CPST executive director Lisa Frehill. About half the men and women in engineering leave to pursue another career. “The issues are advancement and pay. They are clearly moving into management, which is a fairly common career path,” Frehill says. Given the sharp rise in pay for engineering managers, this is no surprise.

Changing Expectations

Expectations about hiring are also changing. Call it the “Monster effect,” after the Internet job board that hosts millions of résumés. With so many

candidates available from around the world, employers have little incentive to compromise. In fact, they have every reason to keep re-setting the bar higher and higher.

This is sometimes counter-productive. Salzman recalls a company looking for a lower-level Java programmer with 10 years experience. “Java had been out for only 12 years, so anybody who was any good with 10 years experience would be a manager,” he notes. If the company found its ideal candidate, it may have hired a mediocre employee.

Tietlebaum noted a 2005 *Wall Street Journal* article by Sharon Begley, who interviewed engineering recruiters. One, Mike Sylvester of AllTek Staffing and Resource Group, tried to find a mechanical engineer for Wabtec Corporation, which makes train components. He assembled more than 40 résumés and eliminated those without technical degrees or relevant work experience. Wabtec rejected the three résumés he forwarded. Why? Because the engineers had used an earlier version of Pro/Engineer, a 3D CAD application, rather than the newer Wildfire version.

Other headhunters interviewed in the article had similar experiences. Corporations were looking for exact fits. “Increasingly,” says IEEE’s Kostek, “companies want you to start from day one with no learning curve and make an immediate impact. They don’t want to train employees because they’re afraid they’ll leave for another company that offers greater opportunity and more money.”

Hira agrees. “In old days,” he explains, “companies expected engineers to stay around a long time, so they paid for professional development. Now, they want somebody to hit the ground running. They’ve turned engineers from an asset into a variable cost.”

According to Hira, fewer companies reimburse workers for degrees or send them to meetings for informal education. That means engineers must pay for their own training. This has starved some specialties.

Finding the Right Mix

Even if there is no shortage of engineers, Swoboda, Inc., has had a hard time finding the hands-on skills it needs to make its factory hum. The company makes coil windings used in fuel-injector actuators. Its automated plant outside Grand Rapids, MI, is efficient enough to grab business from low-cost Mexican producers, but it takes intense engineering attention to run it optimally, says John Fuhs, vice president of sales and engineering.

Fuhs is happy with his company-trained work force, but he has had trouble finding hands-on engineers who don’t mind working at a desk on the factory floor and implementing, as well as designing, projects.

Swoboda’s plant was designed by German engineers, and Fuhs lavishes praise on student interns from Germany. “They know how to do their own CAD, machine design, and basic tool making. They’ll walk into a tool room and immediately start working. We had four German interns, and they immediately made an impact.”

U.S. students seem to have a different orientation. “The last time I tried to recruit someone, I decided I wouldn’t do it. I could see the danger signals. They were describing roles in project management: ‘I’ll write up the work plan, and someone else will do it.’ Maybe that’s okay in a large company, but in our company we need engineers to figure out what needs to be done and execute it themselves,” Fuhs says.

To find the engineers he needs, Fuhs has taken on one intern and is thinking about recruiting from smaller, more hands-on engineering programs, rather than the University of Michigan.

That doesn’t surprise Daryl Weinert, senior director of corporate relations for the school’s highly rated college of engineering. “We get that pressure from industry. They want employees that they can drop in, and they will immediately be productive. The challenge is that we prepare students for so many different industries, we can’t teach the deeper-dive stuff.”

On the other hand, Weinert admits Fuhs has a point about giving students more practical experience. The schools’ new multidisciplinary design program seeks to provide more hands-on opportunities. Michigan is also placing more students in internships so they will have more work experience by the time they graduate.

“Lots of IT workers are self-trained, but are they going to invest in something specialized or in things that have a wider market?”

The same tension between broad skills and specialization can exist in colleges. Swoboda’s Fuhs, for example, has trouble recruiting engineers with a hands-on rather than project-management orientation. (See sidebar.) Yet in an age where business routinely outsources design and manufacturing, other businesses want colleges to emphasize the systems integration and communication skills needed to manage projects effectively.

One World

In addition to salary concerns, promising prospects in other fields, and changing expectations, the internationalization of business and engineering has changed the playing field. The combination of offshoring engineering work to low-wage nations and bringing in as many as 195,000 foreign workers on H-1B visas each year has increased the risk of entering engineering. “You can’t look at engineering salaries without also looking at the risks,” says Hira.

“What’s really happening is that we are part of a global market where there is competition from all over the place,” Kostek notes. “Companies need to get products out the door faster and cheaper, so they are finding the resources to do that. You don’t see people getting 40 percent raises because today the competition for engineering talent is international. Students are not just competing with students from schools in other states, but with students outside the United States.”

The offshoring of engineering jobs began in the 1990s, with IT sending low-level programming and Y2K audits offshore, especially to India. At the same time, industrial companies began hiring Indian firms to convert 2D drawings into 3D CAD files. In China, companies began developing engineering capabilities as well.

Eventually, those offshore engineers worked their way up the value-added ladder. Today, Caterpillar, Daimler, General Electric, General Motors, Honeywell, Siemens, Matsushita Electric, and IBM all have engineering centers offshore. IBM alone increased its Indian technical centers to 73,000 employees in 2007, from 6,000 in 2003. Before the recession, it planned to reach 100,000 workers by 2010, compared with 130,000 employees in the United States.

Of the top 20 U.S. semiconductor companies, 18 have built design centers in India—half since 2004.

There are many reasons to move offshore. Corporations talk about building regional centers of excellence to serve local markets and pursuing the world’s top engineering talent, wherever it may reside. Some even point to shortages in the U.S. But the bottom line, says Duke’s Wadhwa, is cost. A corporation can hire anywhere from two to five workers in developing nations in Asia or Eastern Europe for the cost of a single engineer in the U.S.

“I interviewed companies, and they all told me the quality of American workers is the best and their education is the best. Their understanding of markets is the best. They communicate exceptionally well. They have all the advantages,” says Wadhwa.

“But the engineers in India and China work longer hours, and they’re cheaper. If a new hire costs \$700, you can spend nine months bringing him up to speed. After two or three years, he will be equally productive with American workers and still cost a lot less.”

No one knows how many potential U.S. engineering jobs have moved offshore. Data is hard to come by, says MIT research fellow Timothy Sturgeon. “The U.S. Bureau of Economic Analysis collects data on 16,000 product categories

versus 17 service categories. I can find a synthetic thread twisted left, but all engineering is lumped under *Other Business Services*.”

Emigrants

The well-publicized movement of jobs offshore may raise red flags for students considering careers in engineering. The same is true of the H-1B work force, which brings foreign—frequently low-paid—nationals to the U.S.

The U.S. has always thrived by putting immigrants to work. Even in 1950, 7 percent of STEM workers and 10 percent of all managerial and professional workers were born abroad. By 1990, the percentage of foreign-born workers had dropped to 8 percent in managerial/professional occupations but jumped to nearly 11 percent among STEM workers.

Ten years later, managerial/professional occupations had risen to 11 percent and STEM workers to 17 percent. According to census data, foreign-born workers accounted for 16 percent of U.S. engineers, 11 percent of engineering technicians, and 18 percent of IT/mathematics workers in 2000.



More than 40 percent of U.S. master's degree and roughly 60 percent of doctoral candidates were born in another country. This has proved beneficial for the U.S. economy, says Rand Corporation researcher James Hosek. After graduation, 70 percent of newly minted Ph.D.'s settle in the U.S. for five-to-ten-or-more years and put their knowledge to work for local firms.

They also start businesses. Wadhwa's students called 2,054 engineering and technological companies founded between 1995 and 2005. He found that 52 percent of the firms in Silicon Valley and 25 percent nationwide had an immigrant founder as CEO or CTO. In 2005, those firms rang up \$52 billion in revenue and employed 450,000 people.

This type of immigration bolsters the economy and creates many STEM jobs for American workers. That is not necessarily the case for temporary workers who come to the U.S. on temporary H-1B visas.

The number of H-1B workers who enter the U.S. each year would probably shock most people, says Sloan Foundation's Tietlebaum. Although the program appears to cap the number of H-1B visas at 65,000 per year, another 20,000 graduate students also receive visas. Non-profits, such as universities and hospitals, are not subject to numerical limits. This is in addition to 140,000 legal permanent residents (which includes workers' families), who may opt to become citizens after five years. B. Lindsay Lowell, director of Georgetown University's institute for the study of international migration, estimates the total temporary work force at 704,000, including 500,000 or more H-1B workers.

Of course, not every H-1B visa holder goes into a STEM profession. But many do, and they may distort the market, especially when it comes to salaries. Although the law requires companies to pay the prevailing wage, there are many ways to define what that means. "Employers can always make the case that what they're proposing to pay is prevailing," says Tietlebaum.

H-1B visas also tie workers to employers. "Technically they don't, but in practice they do," says Tietlebaum. "First, the employer has the visa, so if an employee wants to work for another company, that company has to get a visa for him or her. Second, most visa holders are hoping that their employers will apply for a permanent visa. That could take three-to-four-to-five years, and, if they leave their employers, they have to re-set the clock all over again."

As a result, relatively few H-1B workers seek new jobs



with higher pay. Hira, a bitter foe of H-1B visas, recently looked at visa holders' salaries. In 2005, the latest year with demographic data, the average H-1B IT/computer science worker (some with master's degrees) earned \$50,000, slightly less than the \$51,000 median salary paid to college IT graduates with a B.A. In 2007, the U.S. Department of Labor certified at least 5,000 H-1B positions that paid less than \$15 per hour, or \$31,200 per year, which is less than the average starting salary for all college graduates.

Hira notes that U.S. companies can hire H-1B workers even if Americans are available for the job. Many visas go to IT firms that bring H-1B workers to America to coordinate the flow of work back to offshore offices in low-wage nations.

"The guest worker program floods the market and distorts incentives," says Salzman. "When you look at the jobs being sent offshore or supplied with guest workers, it sends a clear message to people going into the field. They have to be concerned about their future job prospects."

Yet, as Tietlebaum noted, the number of students who enter college to take STEM courses has remained remarkably consistent over time. In an age when once fabled *roads to riches*, such as degrees in IT or finance, can turn into slippery slopes to unemployment, engineering still offers students a chance to work with something that is real.

Yes, the field is reeling from salary stasis, changing expectations, offshoring, and a flood of temporary workers. Yet many other occupations have felt the seismic waves of change moving through them as well.

Besides, each generation finds new opportunities. "There are new fields that didn't even exist 10 or 20 years ago, like video gaming and wind and solar energy, that are sexy and cool," Kostek says. The U.S. is likely to invest in green technology and infrastructure improvements. Foreign companies that want a U.S. presence are hiring engineers. Engineers can always create their own companies.

There may not be a classic shortage, but with so many new technologies and new challenges, America still needs its engineers.

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