EMPLEYMENT ROUNDTABLE:

Engineers are part of a larger system. In this brave new global economy with its disappearing career-long employment, what happens to any one professional depends heavily on the broader nonengineering context— including corporate policies, accounting standards, tax codes, and national policies. If they are to survive, individuals must take an active role in influencing decisions on levels ranging from corporate to national policy. That was the core conclusion of 13 experts at a five-hour roundtable discussion on engineering employment, which IEEE Spectrum convened on Nov. 15, 1995, at the Willard Inter-Continental Hotel in Washington, D.C.

Moreover, globalization is not only pressuring companies to cut labor costs and remain competitive in time and price by going to 24-hour work practices with worldwide teams—it is also pressuring engineers in developed countries to offer ever-better technical and nontechnical competencies (including management, communications, and linguistic skills) if they are to compete with their equally brilliant but lower-cost counterparts in developing countries.

Trudy E. Bell
Senior Editor

Editors should also be prepared to look at interdisciplinary careers or nontraditional work arrangements and, given today's job insecurity, are well-advised to create a financial safety net for themselves.

This report includes discussion of several of the roundtable's major points. Further discussion of other topics can be found on Spectrum's Internet Web site. Note that not all experts discussed all topics. The participants were:

Robert E. Burkart, director of professional development services at the Industrial Research Institute (IRI) in Washington, D.C. The IRI is a nonprofit business league, although all 270 members are profit-seeking corporations. IRI also conducts an annual survey on trends in A&D management.

Robert T. Coulson (M), retired president of the American Arbitration Association, a private dispute resolution agency and author of The Termination Handbook (which describes how workers are being fired and laid off) and Empowered at Forty (which discusses the Age Discrimination Law and the rights of older workers who are being terminated or pushed into early retirement).

Edward J. (Jack) Doyle (M), chairman of the American Association of Engineering Societies (AAES)'s Engineering Workforce Commission. "But the real reason I am here is that Richard Ellis felt there should be a working engine here, so he recruited me."

Richard A. Ellis (M), director of research for the AAES's Engineering Workforce Commission in Washington, D.C. He is also the editor of Engineers, a quarterly published by the commission that deals with engineering careers.

Catherine D. Gaddy, executive director of the Commission on Professionals in Science and Technology (formerly called the Scientific Manpower Commission). The commission, based in Washington, D.C., is the scientists' counterpart to the Engineering Workforce Commission.

Edith Holleman, a consultant on high-performance work systems for the AFL-CIO. A former counsel for the U.S. House of Representatives' Science Committee on workforce issues, she also tracks immigration issues for the AAES, including the admission into the United States of foreign high-tech professionals under the controversial H-1B (specialty occupation) temporary visa.

Laura Mackail, executive director of the National Technical Services Association (NTSA) in Alexandria, Va. NTSA is a nonprofit trade association representing firms that supply a wide range of contract technical staff and support services to public and private sector clients. The NTSA's 211

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Global engineering employment was the topic of a roundtable discussion among thirteen experts who met in Washington, D.C., at the invitation of IEEE Spectrum. Clockwise from the top left: Hollemann, Coulson, Burkart, Napier, Gaddy, Doyle, Mackall, Rosen, Weatherall, Parker, Ellis, Roy, O'Neill, and moderator Bell.

corporate members employ about 280,000 contract personnel, primarily in engineering and information technology.

David Napier, statistical manager at the Aerospace Industries Association (AIA) in Washington, D.C. Annually the AIA conducts an employment survey within the aerospace industry, and one of the data points that emerges is employment levels for scientists and engineers.

Vin O'Neill, senior administrator of professional programs for the IEEE's United States Activities office in Washington, D.C. He is a policy analyst on engineering workforce issues and also interacts with the Federal Government on behalf of the IEEE.

Linda Parker, director of engineering program evaluation at the National Science Foundation's Engineering Directorate in Washington, D.C. She has begun an 18-month project to develop a profile of the engineering workforce by integrating data from many studies.

Howard Rosen, executive director of the Competitiveness Policy Council in Washington, D.C., a Federal advisory council in operation since 1991. The council makes annual reports to the President and Congress on ways to enhance U.S. competitiveness. (The council is not to be confused with the private-sector Council on Competitiveness or the now-defunct Presidential Council on Competitiveness, which was chaired by then-Vice President Dan Quayle.)

Rustum Roy, Evan Pugh Professor of the Solid State at Pennsylvania State University in State College, Pa. He is "both a proposal-writing materials scientist and also a science policy activist."

Robert K. Weatherall, director of the Career Services Office at the Massachusetts Institute of Technology in Cambridge. He is also a member of the AAES's Engineering Workforce Commission, and was previously on a committee of the National Research Council that made recommendations to the National Science Foundation (NSF) on its strategy for counting the nation's science and engineering workforce in the 1990s.

**Downsizing the workforce**

SPECTRUM: In the last few years, the downsizings of high-technology companies around the world have been of unprecedented proportions. In some cases, tens of thousands of people have lost their jobs in one corporate announcement. Companies have shrunk by huge proportions—a third or even a half of their workforce—and the reports are still coming in. What is going on in terms of a larger economic context?

Let's try to keep this discussion as broad as possible, because many countries are facing situations similar to the one here in the United States.

O'NEILL: Technology is clearly making it possible to do more things with fewer people—including fewer engineers—worldwide.

WEATHERALL: On one side of the coin, we have the loss of jobs. But we keep forgetting the other side: increased productivity, which over the last century and a half has greatly increased living standards in the industrialized nations. Greater productivity is achieved by labor-saving devices. But now it's coming at the expense of engineering jobs, and so engineers worry about that.
‘Engineers do not think well about how to protect their own interests in a larger system.’

—RICHARD A. ELLIS
Director of Research, Engineering Workforce Commission

ROSEN: Is that unique to engineers, or is it another expression of what is happening to the rest of the economy? In recent years engineers have begun to be affected by downsizing, but auto and textile workers have been experiencing job losses for the last 20 years. Downsizing in the high-tech industries may be a movement of this general trend up the occupational ladder.

ROY: Job losses are worldwide and across all sectors, and now they are increasingly hitting the high end of the food chain—the science and engineering workforce. But as Nobel Prize–winner Arno Penzias put it in Harmony, his new book about the computer revolution and its effect on employment, this time, folks, it is not the same.

SPECTRUM: To what specifically was he referring? What is different?

ROY: Automation and the computer revolution intersecting with globalization: the outsourcing of software development and the off-shoring of work from developed to developing countries with lower labor costs.

WEATHERALL: Many jobs were lost to labor-saving devices all through the late 19th century and this century. Yet we have found new jobs to take the place of the old ones.

ROY: But this time, with the computer revolution, you are not going to see some other new industry come to use up whomever is put out of a job. There is no other new technology on the horizon that can conceivably absorb those people. So this time, the jobs that are lost are not coming back.

WEATHERALL: Why do you say that? Hand-loom weavers could not predict what was going to come in terms of 19th century technical jobs. We can’t now, either. In fact, enormous numbers of jobs have been created by the existence of computers within user organizations, so much so that these companies come to my office desperately looking for computer talent. That is why I have a reason for optimism.

ELLIS: Well, I am glad to hear some dissenting viewpoints. Such optimism drives engineering employment. But are you basing your optimism on anything more than faith?

ROSEN: History.

WEATHERALL: Until this very second. Why should I doubt that it [job creation by new technology] will stop now?

ROY: But you’re basing that projection on a slope drawn from the past. What new industry do you see on the horizon that can use people who are now out of work? Innovation is no longer a Western monopoly. If you guys are building national policies on the expectations that a new technology will emerge of the size and scope of semiconductors and computers, it ain’t there.

ROSEN: Are you suggesting that we have reached the limit of creativity in our civilization?

ELLIS: I am saying that it is quite possible that ownership of the technologies may not be American.

ROSEN: That is quite different from saying there is no more technology to be invented.

ELLIS: Recently, I talked to the people at the Nanotechnology Center down at Rice University [Houston]. They said that the Europeans are starting to pull away from us, and they suspect the Japanese are also.

ROSEN: So what? It might force us to be more productive. That is the history of the world.

ELLIS: But the fact of the matter is that we are behind.

ROY: If you think that nanotechnology is a sizable business as distinct from a research sales pitch, you guys are nuts—and this is being said by the person who coined the term “nanocomposites” and is deeply into it. There is nothing sizable there, any more than there is in biomimetics. We have been hyping a fantasy that technology will deliver us—the modern version of perpetual motion.

WEATHERALL: Why do you say so quickly that the days of a new idea have ended? No new ideas? That’s most peculiar.

ELLIS: Robert White, who recently retired after serving for many years with distinction as the president of the National Academy of Engineering, has said that we had better face up to the fact that our faith in technological development is just faith, based on an assumption that what we have seen in recent history will continue to happen.

ROSEN: The historical argument is stronger than your assertion that we have met the saturation of technology.

SPECTRUM: Let’s get back to productivity gains from downsizing. A number of books out in the past year, with titles like Creative Distraction, have argued that downsizing forcefully is a good thing. Such authors claim it is necessary for corporations to abolish company loyalty and former corporate cultures to rid themselves of inertia dragging on them from old ideas. They can do this only by a discontinuous shock. In this way they can re-align the company most efficiently.

ELLIS: Abolish company loyalty? How bizarre. That is what happens when you have ideologues run rampant.

BURKART: A July 1993 Harvard Business Review article about engineers’ productivity at Bell Laboratories showed that people in a company keep going to a relatively few star performers. In addition to keeping up with the journals, these star per-

‘In U.S. companies, the profit from productivity gains is being used for investors instead of for growing the business.’

—EDWARD J. (“JACK”) DOYLE
Chair, Engineering Workforce Commission, American Association of Engineering Societies
formers develop extensive information networks of key players both inside and outside the corporation.

More recently, there's a study in the Summer 1995 issue of California Management Review that shows that downsizing disrupts this flow of innovation through the company because it destroys these networks of contacts.

WEATHERALL: If you were the manager of a workforce that had to be cut by 10 percent, whom would you choose to let go first? Not the brightest and most creative people reading all the papers, but the ones who got the lowest evaluation in the last three evaluation periods.

ELLIS: That should be true, but a lot of the downsizings aren't made with that kind of care. Many cuts have simply been made on a geographic basis. The powers-that-be decide that a certain unit has to go, and everyone there is out, whether they were evaluated high or low.

SPECTRUM: Might radical downsizing eventually make it difficult even to discern who is a star performer? The survivors now not only have to do their own work, but also the work of the people who were laid off. Some studies suggest that those people get so overworked that they may not be able to keep up with the field as they did before, unless they do it on their own time—and many are already working 60 hours a week. And during the time an engineer is absorbing information, he is not producing products.

BURIKART: Downsizing may be good, smart business sense. But it comes down to this little productivity formula. The costs keep driving the denominator, and emphasis is placed on increasing the numerator, which is the output of engineers.

WEATHERALL: Regarding that point, there is one historic fact that needs to be remembered. In 1985, Dick's own AAES did a little-reported study called Toward The More Effective Utilization of American Engineers. They found that engineers were grossly underutilized, both in terms of time and intellectual demands, especially in the defense-dominated aerospace industry.

The leading industrial companies in the world—Goodyear, Dupont, Exxon, IBM, General Motors—had no real competition from 1950-ish to 1975-ish. So they were able to employ scores of engineers and leave them partly idle or put them on routine tasks that could have been done by technical support staff. At the time of the study in 1985, few people were thinking about globalization. Now, as these firms have suffered competition, they are figuring out how to better utilize their engineers.

SPECTRUM: A similar thing seems to be happening in Japan, where there are 'window seat employees' who draw their salary for doing almost nothing. Increasingly, though, one reads reports about the disintegration of the custom of lifetime employment. Japanese companies, such as NTT, are finding their workforces are bloated and too expensive.

WEATHERALL: Such reports are actually cause for some optimism. I think one could argue that we have been seeing a particular one-time event. In 1985, engineers themselves felt underutilized. Now, with downsizing, they are being overworked. Presently the shift to lean employment will have run its course and we will get used to a new equilibrium.

Globalization, jobs, and income

DOYLE: Companies that are downsizing and getting rid of engineers still need to get the work done. More and more, what they are doing is laying off their engineers and contracting out work.

MACKAIL: Contracting and outsourcing are not new phenomena. The Federal government has been contracting out for services since the beginning of time.

HOLLEMAN: The difference between contracting out now and a decade or two ago is that now companies are contracting out more of what people thought was the basis of a corporation, its core. Now, in fact, it's sort of hard to know what the company's core is.

ELLIS: We see some companies that carry this outsourcing concept to extremes. A company may become little more than the top management, which picks out other participants as needed for each piece of work. This structure is a radical shift from the traditional meaning of a company.

WEATHERALL: There are technical services firms—Andersen Consulting is a good example—that are recruiting more engineers on campus than even the largest manufacturing firms, but I'm not sure this necessarily means there are fewer jobs for engineers. It's just that the jobs are in different sorts of firms.

ROSEN: From the individual's viewpoint, there are enormous differences between traditional employment and contract out. One difference is in terms of who employs you. Another is the effect on job security, on longevity with a company, on the kinds of jobs the employee is doing. As a contractor, the worker may be doing the same work for the same company as he or she worked for as a traditional employee, but that person has a lot more insecurity.

MACKAIL: Perhaps there is an element of concern on the longevity of employment. But this type of phenomenon is equally beneficial in that the individual can decrease downtime due to unemployment, because he or she now has an entity—an engineering contract firm—operating as a labor market intermediary whose sole purpose in life is to employ people.

We have individuals working in our industry who have chosen a career working on a contract-by-contract basis. Of our contract employee universe, 44 percent report that their average downtime between assignments is less than 30 days, and 70 percent report that their average downtime is less than three months.

HOLLEMAN: But for an individual, you are talking about a lot of unemployment.

MACKAIL: Not necessarily. In a traditional work relationship I may be employed and work directly for you, but I am captive. In our industry, individuals can continually float their résumés, and accept and reject contracts on an assignment-by-assignment basis.
ELLIS: This scenario is all very nice for people at the peaks of their careers, but that is not the entry level part or the aging part of the workforce. Moreover, the opportunity to move up in management or other directions outside technical performance does not exist for a contract employee.

COULSON: One thing undercutting engineers' power these days is that engineering is a global activity. There is somebody in Taiwan who can do the same job for much less and the employer can transfer the job there.

HOLLEMAN: Not a whole lot different from manufacturing.

ROY: I will give you some numbers. At an unnamed West Coast software house, the minimum salary for a Penn State and MIT type of Ph.D. engineer was $200,000 per year, fully burdened [including non-wage benefits]. In Bangalore it was $3500 for 10 cents on the dollar abroad. That's a threat to the way of life that this country has had for at least the last 50 years.

SPECTRUM: The tensions created by outsourcing and off-shoring are not unique to the United States. Germany is outsourcing to India, Japan did some outsourcing to Korea, and now Korea is outsourcing elsewhere. It almost seems that as soon as a society brings itself up to a high standard of living, and thus a high cost of living, it must then try to reduce labor costs to stay globally competitive.

ROSEN: Even though I'm a labor economist, I have to observe that the issue isn't so much jobs. The issue is income. I feel as though I'm the contrarian here, but maybe these pressures suggest that U.S. engineers are being overpaid.

I am reminded of the steel industry in the 1970s, when workers were making 20 percent more than the manufacturing average. This may have been one reason behind the decimation of the industry.

Maybe the engineering community needs to look at itself and take certain steps now to protect itself in the long run. Otherwise engineers may end up being just like those steel workers.

ROY: U.S. engineers are being overpaid in a globalized economy. There are no ifs, ands, or buts about it.

ELLIS: But engineers in developing countries have an enormous advantage. They are starting at a much lower level.

SPECTRUM: The cost of buying an ordinary, nothing-special tract home in California is several hundred thousand dollars. Even the average house in an Ohio farming community is $50,000. No person making $10,000 or $12,000 in the United States could afford that.

Yet developing nations barely have a power grid, indoor plumbing, or paved roads.

HOLLEMAN: It's a supply-and-demand issue. Globally speaking, there are more engineers available than there are jobs, so wages fall.

SPECTRUM: The salary differential also means that even if the Chinese or Indian engineer is not as productive as a U.S. engineer making $40,000, you could hire two of them and still be ahead of the game.

ELLIS: You can be more ahead than that, because of the 24-hour work practice that suppliers are offering up with development teams spread across different time zones around the world. Some Indian shops will even set up software teams working three shifts on your project for 24 hours a day of effort. The work moves faster. In software development, where there is a race to develop everything that is a major advantage.

What puzzles me is that, despite the trends in downsizing and globalization, the U.S. Bureau of Labor Statistics recently released its data for the third quarter of 1995 on employment of engineers—and it's the highest it has been in history. Coming right out of this recent recession, it's over 2 million people. It has never gone over 2 million people before. Now, what are we to make out of this?

ROSEN: What were their incomes?

DOYLE: Their real income is almost as good as it was 20 years ago. Almost, but not quite. There has been an upward curve in the last couple of years, but they're still behind where they were 20 years ago.

HOLLEMAN: The questions really are these: in a globalized economy, will American young people go into engineering? And why should they if they are just going to be the steel workers of the future?

As a national policy, do we want to give up our technology base to non-U.S. engineers because they work for $10,000 a year? We can't give it up. It's crazy. So how are we going to maintain it?

ROSEN: But wages should somehow be commensurate with the productivity of those workers. If you are suggesting that the productivity of the Chinese engineers is the same as that of a U.S. engineer, yet they are making so much less, then I say that the United States needs to invest more in its people.

It's direct competition. If we invest more in our engineers than the Chinese invest in theirs, then we will develop higher-level products.

HOLLEMAN: That's the great fantasy—that Americans will always produce so much better than the rest of the world. Do you know how smart these non-U.S. engineers are?

WEATHERALL: The positive side is, we have more engineers employed now than at any previous time. And in the industries where we are ahead, we are very nicely ahead. There is a colossal demand for software people in this country. I really don't think there is any reason for anxiety that some jobs are being transferred to India.

HOLLEMAN: You tell me more engineers are employed than ever before. That would indicate to me that there is a labor shortage or an incipient labor shortage. That means you should have higher salaries. But you don't. That's a new phenomenon. The same is true for software

‘Before the axe falls, you should know enough about your company and industry to see it coming [and] avoid putting your head in the guillotine.’

—ROBERT COULSON
Arbitrator.
programmers. You talk about how recruiters come and can’t find enough talent. Do you see the wages going up? No. The wages actually are going down because of competition overseas.

WEATHERALL: There is a crucial difference between the pedestrian programmer who can redo payroll programs and the exceptionally creative ones who are coming up with the new version of Word. We don’t discuss this enough.

ROY: Let’s examine that. There are a billion Chinese out there plus 800 million Indians. Let’s assume that there’s a bell curve for everybody, and go on to inquire for whom this bell tolls out here at three-sigma. China and India have many more three-sigma folks than the developed countries. And most of them are heading for science and engineering because high-tech is their meal ticket to prosperity. In short, the developed countries are still in a losing race simply because of numbers.

SPECTRUM: Moreover, it sounds as though global competition is creating fiercer competition not only among companies, but also among individual engineers. For the first time, these very smart three-sigma people throughout the world have the same access to phone lines, email, fax machines, a Ph.D. education from MIT or the equivalent—and to job offers—as do engineers in the United States and Europe.

So for the first time, the top 5 percent of engineers in China, India, and elsewhere are directly competing with the top 5 percent in the United States. Since the population of the United States is small, however, compared to the population of China or India, for the first time the competition is not between the top 5 percent and the pedestrian 95 percent in the United States—it is against the top 5 percent here and the top 5 percent from every other country.

HOLLEMAN: No, it is against the top 1 percent. With the populations of those countries, a company no longer has to drop down to 5 percent.

WEATHERALL: Case in point: I was talking to a woman from the human resources department in a large West Coast software company. The company says it now has 1000 vacancies, and it is anxious now about possible government limitations on the hiring of foreign software experts. The reason the company is interested in non-U.S. engineers is that it is in its interest to find the best people it can. As it finds the best world-class people, no matter where they are, it can expand its industry, and thus create jobs here in the United States. If it can’t find the best people, it won’t be successful either here or abroad.

If we want our companies to be globally competitive, the question is: how? If the answer is partly by having software done in India, so be it. It’s hiring Indians to work in the United States, so be it, too. It is better that our high-tech companies should thrive than not thrive.

HOLLEMAN: But I have to throw cold water on that. Several companies have been quoted as having the same missing 1000 people. They are on a campaign right now, and you have just repeated all their propaganda.

WEATHERALL: It’s not propaganda.

HOLLEMAN: Of course it’s propaganda. If they’re all missing 1000 critical technical people, how are these companies successful? How many employees do these places have? Companies needing a thousand key technical people must be just about on the skids. I mean, let’s get real here. What they really want is to have the same job done for cheap.

SPECTRUM: I agree. Companies can’t just imply that as the cost of living here has gone up, the quality of U.S. engineers has fallen.

COULSON: Is it realistic for U.S. engineers to expect any preference? In a global economy, there’s really not much difference between a U.S. and a Japanese company, or whatever. Nationality is becoming less relevant. You’ve got an international global engineering profession that is part of international business. The question is: how are engineers in any given country going to fare?

ROSEN: I am also hearing this fear that we’ve got a technology lock: the technology we have today is all that we’re going to have for the next millennium. If we’re not going to get anything on the growth side, then we will have to get all this squeezing out of what we’ve got now. So that leaves us with a bunch of people clawing at each other.

SPECTRUM: It also sounds almost as if
an engineer in the United States or Europe should be glad to get an engineering job at all and get paid half of what he might have gotten 20 years ago.

**Productivity and investment**

DOYLE: Downsizing, outsourcing, and off-shoring obviously increase productivity. Over the last 20 years productivity in the United States has gone up. But the output of productivity increases—that is, profits—can be used in a variety of ways. One way, and to my mind the best, is to expand the business. That creates more jobs, maybe even for those who have lost jobs because of your increased efficiency.

Another way is to take the money out of productivity and raise the wages of the people who are working. That has not happened in the last 20 years.

The third way is to take the money that comes out of productivity gains and raise your profits to stockholders.

In the last 20 years, both our productivity and our total national income has gone up. But the national income that goes into wages has been flat. And the national income that goes into what they call rentier—that is, investment kind of income—has gone up faster than the total national income.

In other words, the United States is using the profit from productivity merely for the investors. That is one of the major factors keeping engineers and others from earning more money.

ROSEN: The Competitiveness Policy Council has looked at non-defense government spending. The Federal government 30 years ago allocated 25 percent of non-defense spending on research and development, education and training, and public infrastructure. Today that amount is down to 10 percent of non-defense spending. In absolute terms, it is a decline of about $40 billion a year.

Now, these percentages are taken from the federal budget numbers and are really not disputable, unless you may disagree with the definition of education and training. We're just looking at the line items in those categories.

It's ironic that at a time when the United States is facing increasing com-

petition, at a time when we need to stay ahead of the curve, we basically have been disinvesting in our people.

HOLLEMAN: Are you talking about just the Federal budget?

ROSEN: The numbers that I quoted are just Federal spending, but we can talk about private investment as well.

WEATHERALL: IBM has cut its annual R&D budget from $4 billion to $3 billion. The cuts were being done because people at IBM realize that Compaq and Dell and similar firms can compete with them without a huge superstructure of R&D.

In some sense we are discovering that R&D spending over the last 20 or 30 years was not as productive as it was meant to be or as we hoped it to be, and we have to rethink that spending.

ELLIUS: Some Federal R&D seems to have been make-work, just sweetheart contracts or boondoggles that provided companies an excuse to bill high-priced time. It wasn't important what engineers did, it was only important that they be there and sign time sheets so the company could send in bills for their salaries. In that 1985 AAES study of the utilization of engineers, defense-intensive sectors like aerospace were especially likely to have R&D people who felt that they weren't being productively used, who were wasting their time.

ROY: Why have the corporate sector leaders taken out the corporate labs? The ROI [return on investment] on basic research not connected to products was zip. And now the public sector is very slowly finding out the same thing and saying, "This has got to stop. We have got to give something tangible back to the public, which pays these bills."

SPECTRUM: Doesn't it strike anyone as a dangerous assertion that the reason that corporate R&D was disbanded was because the return was exactly zip? Aren't you talking about eating the seed corn?

DOYLE: It is important for a company not only to invent things, but also to use them. If you invent it and somebody else develops it and sells it back to you—

SPECTRUM: To be sure, there are a number of cases where U.S. companies—which have excelled in basic research—either have not picked up their own developments or else have rejected them, and then other nations have commercialized them.

The Japanese have not been notable in basic research until recent times, but they have excelled in reading U.S. literature and developing products from U.S. research. Now, however, they are seeing the value of doing their own basic research.

ROSEN: It's no accident that their success also correlates with the fact that Japan is outspending the United States now, too, in R&D research. So if we continue to experience declines in our R&D spending as a percent of the GDP [gross domestic product], there certainly will be no new ideas.

SPECTRUM: And the Japanese have

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**‘Hiring is generally down in the large corporations.
So the hiring will come from the smaller businesses.’**

—DAVID NAPIER

Manager of the Economic Data Service, Aerospace Industries Association

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very strong government cooperation in corporate R&D.

ROY: A few years ago I sat on an advisory committee to a Japanese prime minister and I said: “You guys have got the American basic research disease. You’ve got another 20 years to find out that you’re making exactly the mistakes the Americans made believing that science leads to technology.” There are two commissioners on the committee who say exactly the same thing: “Don’t do it. This basic research you are doing is simply money down a rat hole. Don’t follow the American model.” My best allies are about 100 CEOs of U.S. companies, who have not abandoned R&D but have drastically reduced esoteric research.

I believe that the model of faculty research we created after World War II—that we should have a great time thinking noble thoughts disconnected from the real world—is absolutely wrong. Real U.S. creativity is in research work linked to real problems and in development right at the edges of industry.

PARKER: Both these points—that R&D has not been as productive as it could have been and that U.S. companies have made many brilliant technological innovations that never went anywhere in the United States but certainly did go someplace when picked up legally in other countries—illustrate a flaw in a widespread assumption now current.

In the United States, the assumption is that companies, if left to their own devices, make the best decisions. On the contrary, companies left alone do not necessarily make the best investment, from the standpoint of either personnel, the company, or the country.

ELLIS: That’s a very unfashionable point of view.

[Laughter.]

HOLLEMAN: Maybe we in the United States should just commercialize the Japanese basic research when they do it.

WEATHERALL: There is nothing in this discussion that is pessimistic for engineering. Maybe it’s pessimistic for the basic research labs.

ROY: Absolutely, there is a distinction between so-called basic research and the fundamentals of engineering development.

What are the right choices?

ROSEN: Our most recent report shows that the net stock of U.S. plant and equipment as a percent of GDP has not changed in 10 years.

This is incredible. It has been flat for the last 10 years. That means either we are not investing enough to compensate for depreciation, or we’re just investing in different things. For example, mergers and acquisitions, which are encouraged by our tax code, amount to more than $270 billion in 1995.

DOYLE: Also today the shorter lives of equipment make the amount of fixed equipment out there less than it was last year.

ROSEN: Yet, we’re clearly not investing enough to stay even. That is why our report has the novel conclusion that it’s not just the level but the composition of investment in a country that is important. Now, composition of investment is heresy for economists—I get booed when I say that to my colleagues. But we really do have to start understanding that composition matters, that the investment decisions high-tech companies make are of national concern. Engineers should have some input into these kinds of decisions.

PARKER: One factor here—unfortunately outside the engineers’ purview—is accounting standards. One reason that company profits do not go into salaries, plant and equipment, and training of employment is that those things count as a loss on the books. They can never be converted into a firm’s long-term value. But the senior executives will get rewarded if they turn the company’s profit into dividends and increase the paper value of the company’s stock.

Until the accounting standards are able to reflect accurately the positive results on the firm of tangible investment in salaries, training, R&D, plant, and equipment, this situation will stay the way it is, if not get worse.

ROSEN: These perverse incentives have been in our system for the last 50 years. But now, with the advent of globalization, global competition puts pressure not only against wages, but also against our national policies. We can no longer make investment decisions in isolation.

ROY: Individual savings also drives investment. But with a 3 percent savings rate in the United States competing with Europe at 12 and 15 percent and Japan at 22 percent, we’re in trouble. So I take your point very strongly that it matters where we are putting our investment.

HOLLEMAN: So if we save our money instead of buying all the things that the U.S. economy runs on, what happens to this economy?

ROSEN: Currently Americans are spending 97 percent of their disposable income on consumption. Is all that consumption necessary? We were living very happily at about 85 to 90 percent of our disposable income for the last 50 years.

PARKER: Well, that gets into the broader issue of what our consumer-based society has gotten people to think they must have.

SPECTRUM: This is a hobby horse of mine. I live in a neighborhood of hard-working professionals where people feel they have to have 386 computers for their five-year-olds and a large-screen television with hundreds of videos in an entertainment center—and they go into incredible debt to get those expensive nonessentials. But when you ask these people, “‘How is the health of your 401(k) these days,” they say, “Oh, it’s really hard to save for retirement.”

Regardless of the imprudence or the moral values expressed by such materialism, the fact remains that the United States is a consumer society. And a lot of consumer goods are electronic items and digital toys.

HOLLEMAN: That’s why we’re the most prosperous market in the world. The whole world is running off our consumerism. But if more savings cuts down on our consumer spending, what is that going to do to this economy?

ROSEN: Come on, we’re talking about raising the savings rate another 1 or 2 percent.

HOLLEMAN: And how much is that? ROSEN: It’s billions. It’s a start.

HOLLEMAN: How many jobs is it?

ROSEN: If that money is invested into college educations, or put into building plant and equipment in this country, it will create jobs.

HOLLEMAN: Do you see any indication that is where it would go? More money available to the government does not
Universities don't respond to the marketplace. Academia has not had its feet held to the fire on this matter.

—RUSTUM ROY
Evan Pugh Professor of the Solid State, Pennsylvania State University

guarantee more education, more jobs, more production, more anything—and corporations make their own decisions about where they are going to produce things. Engineers produce things. If the things are not produced here, you are not going to see the engineering jobs here.

ROSEN: If we're going to stay globally competitive, we have to shift the perverse incentives in the economy. And some of the most powerful perverse incentives are in our current tax code.

ELLIS: Keeping up with the Joneses is not a new phrase. Conspicuous consumption was defined a long time ago—and Thorsten Veblen wasn't talking about the middle class. I am not sure these decisions are being made by ordinary people anyway.

On the contrary, we have a leadership class that has managed to amass a great deal of money and power. Every dime it gets reinforces its ability to get more dimes. Those of us who have paid a little attention to history can see similar eras of acquisitiveness. They have generally tended to end in financial panics or some kind of major economic upset.

We may be in another of those cycles. Whether or not ordinary people—like engineers—get virtuous about how much they save may have little to do with it.

WEATHERALL: It's not just U.S. capitalists reaping the profit from higher productivity and downsizings in the United States. German, Japanese, even now Chinese capital—if not capitalists—are investing in U.S. securities. The capital is as fluid as the jobs.

ROY: Or more so.

COULSON: I don't know that it's very useful to wring our hands over Darwinian international capitalism. But an older U.S. engineer may be concerned about job security and that his job skills are not what they were when he graduated from MIT.

He also should be concerned about the weakening of the labor movement, since many engineers used to be represented by unions and gained job security through them. He is puzzled by some government policies and some academic policies that favor non-U.S. engineers. The fact that there is increasing productivity and good profits isn't going to make such an engineer any less worried about his personal future.

Necessary skills

ELLIS: What does happen to the individual engineer in a globalized economy?

BURKART: Human resources and line management people will be telling engineers, "Look, if you think there is lifelong employment, that went out the window years ago." So you have to take responsibility for your own career. You have to upgrade your own skills, you have to treat yourself as almost an independent consultant.

MACKAIL: Right. Your ability to command a premium rate of pay in this market area is your ability to "value-add" to the company.

Value-add is defined in four key ways. It is your ability to increase quality, decrease costs, decrease cycle times, and increase the productivity of whomever you are helping. If you think of yourselves in terms of an economic unit that can perform to those degrees in any type of income-producing endeavor, you are going to be better off in the long run.

ROY: You didn't put in the environmental issue, but in the industry I work with, "greener" counts, too.

ELLIS: Other obvious things that engineers can do to prepare for global competition include learning foreign languages and emphasizing project management experience, particularly multinational project management experience—anything that gets you into arenas where things are happening.

COULSON: It's a mistake to ignore the political environment in which employment takes place. Explaining how much value you add and how you can help your boss is looking at the political environment as a rational process. But my impression, from a large number of cases involving terminations, is that people have often failed to protect themselves politically within the organization.

Being terminated, whether you are pushed out in retirement or simply fired, is one of the most traumatic experiences that any of us goes through. Before the axe falls, you should know enough about your company and its politics, and about the state of your industry, to see it coming. Then you can avoid putting your head in the guillotine. Perhaps you can save your job or find another job. Being a player in the corporate process, however, is something that doesn't occur to every engineer.

ELLIS: Amen. I think that's one of the most telling pieces of advice I have heard anybody utter here.

BURKART: Unfortunately, the educational system and all the prepping, and maybe even the psychological makeup of the typical scientist and engineer is against that. An engineer is usually an individual contributor, dealing with a technical specialty, and he or she almost shuts the world out. The old attitude was: "Put me in my lab or give me my work-

"Doesn't it strike anyone as a dangerous assertion that corporate R&D was disbanded because the return was exactly zip?"

—TRUDY E. BELL.
(Moderator), Senior Editor, IEEE Spectrum

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bench and give me the problem and I will solve it.”

SPECTRUM: It goes deeper than that. There is a sense that somehow office politics is sullying, and engineers are responding to a higher standard or a higher authority and don’t want to get bogged down.

ELLIS: Trudy, that may be true, but people who are that idealistic may not have a chance to play the game at all. The point needs to be made that the popularity of the “Dilbert” comic strip is no fluke. Here is a major piece of mass communication that has as its basic theme the inherent incompetence of management and the fact that the world is not as rational and straightforward as we would like. Those messages are important.

ROY: I wonder if I could take this one step further. Engineers should also be aware of social politics and national politics. Government policy can make a lot of difference. So I would say there are three levels of awareness: every single engineer better damn well pay attention to his or her own education and preparation, to corporate politics, and also to national politics.

HOLLEMAN: Now this conversation is disturbing me. Engineering is a tough profession. I get the sense from you, though, that engineers are supposed to be these renaissance people. They are at the top of their field, they are specialized, they are generalized. They learn foreign languages, they study music.

Do they have a family? I mean, it is unreal to expect such accomplishment from any human being. It is not only unreal, it is inhumane.

ROSEN: Is it unreal to expect someone who wants to be an engineer in the airline industry to learn something about the future of that industry?

HOLLEMAN: No. But you have laid out agendas where if an engineer never gets any sleep, I am not sure he could be all of these things.

SPECTRUM: I agree. Think about what you folks are saying. To make it in a globalized economy, an engineer must be in the top 1 percent of his field, superproductive in state-of-the-art development, and skilled in overseeing international projects. He has to, without cutting into productivity, keep up with all the technical literature as well as national and international affairs. If he’s not lucky enough to be raised in a bilingual home, then he should acquire a different language. And he needs to network in the halls to stay up with corporate politics—again without reducing productivity.

DOYLE: And if every engineer learned to do that and became the perfect engineer, when that guillotine falls, one of those perfect guys is going to get his head chopped off.

HOLLEMAN: And a lot of perfect people do get their heads chopped off.

DOYLE: With global competition, the individual is not going to be able to make it. In a winner-take-all society such as we have in the United States, the losers get nothing—no matter how intelligent they are or how well they have been trained. If the other guy somehow got the leg up on them, they are out of it and they are poor.

HOLLEMAN: I started in journalism, a very risky career. My professor said to me, “Get yourself a go-to-hell fund.” What is a go-to-hell fund? He said, “When your editor doesn’t print the story that you think ought to be printed, you tell him to go to hell.” It was $1000 at the time. It seemed like a fortune, but it’s a lot more than that now. I think probably what every engineer needs is a go-to-hell fund, a safety net to fall back on.

SPECTRUM: And we’re back to the savings account again.

Education for the big picture

ROY: This whole discussion also points up the fact that engineers don’t work in some kind of isolated vacuum. They have to look at social policies, values, and investment policies all as one system. It is essential that the engineering community enter into the national dialogue about these issues: how do my kids’ values and my neighbors’ values screw up the whole system? You know, Einstein said, “Every leaf that falls disturbs the universe.”

ELLIS: You’re right. Even though engineers tend to assume that their problems are unique to the engineering scene, their problems are part of the much larger system. In fact, right now engineers are cats’ paws to be played with by the bosses because they really don’t pay much attention to the larger picture.

WEATHERALL: I think that we should avoid this notion that somehow engineers are cats’ paws or victims. The managers doing the layoffs are often engineers themselves.

ELLIS: I’m not saying engineers are victims. I’m saying they’re patsies. They do not think very well about how to protect their own interests in a larger system.

In engineering schools, there is enormous pressure to train engineers to be fully competent in their first job. The students give little thought to what happens to them 15 years down the pike. So they are not educated in the classical sense. Many of them have essentially no acquaintance with things like economics or communication or literature or history. And it is exactly those nontechnical subjects that will help them understand what we see going on with economic changes, globalization, and downsizing. So they are poorly equipped to survive in the new world.

BURKART: There’s a more immediate reason for an engineer to be broadly educated and broadly aware: he or she will be more marketable. If you go out to buy a car, you don’t want just an engine and four tires; you also want an air bag, antilock brakes, and certain options.

Similarly, companies that are hiring want more than technical skills in an engineer. They also look for communication skills, management skills, and other competencies to meet their strategic plans in a global society. In a nutshell, they are looking to hire a business person who also happens to be a scientist, an accountant, and an engineer. Consequently, when they go to the campuses, they are looking for a lot more than just the aces in the technical subject matter.

Engineering schools must change

ROY: Academia has not had its feet held to the fire on this matter. Universities don’t respond to the marketplace. Industry says to the university, “Teach engineers to do teamwork, to be interdisciplinary,” and the university’s response is, “Send us a few dollars, we will give you what we want, whether you like it or not.”
and go away.” But the emerging global society isn’t going away. The marketplace is telling us what is real.

Unless we get language in the NSF appropriations bill saying “Thou shalt do this,” changes to engineering curricula won’t happen. Academia has proven that by 50 years of unresponsiveness to society, to the marketplace, and to industry. Engineers are not aware of globalization and they are not politically informed or active—and that is a failure of the entire higher-education system.

WEATHERALL: But if you read the ads in the papers for electrical engineers, the descriptions are extremely specific. There is a paradox in the engineering profession. On the one hand, industry says it wants specialists and all the ads reinforce that. On the other hand, industry managers say they want people to be more versatile, more adaptable, and have a wider understanding. They want both.

ROY: They will take the specialist today because no one is producing the generalist.

WEATHERALL: I am also struck with how during school, engineers are hardly reminded at all that they will be members of a corporation. Someone has power, someone makes decisions—and that someone could include the engineers, if they thought about the issues facing the corporation, not simply the technology they are working on.

ROY: The global engineer has to recognize there’s a society out there, with elections, national policies, environmental regulations. Yet, precious few universities ask, “How can we educate an engineer in 1996 without telling them about society?” At MIT, Penn State, and 50 other universities, we have whole programs now in science, technology, and society. But I bet you less than 1 percent of engineers are even told that these things exist, let alone are required to take such courses.

So it is the educational system’s failure to inform our engineers that if they expect to survive in a competitive world, they had better be involved in all of these types of decisions.

ELLIS: It does make one wonder if people who get their undergraduate engineering degree from a place like Swarthmore—which does offer it—might be better equipped to thrive in a global economy.

ROY: Don’t you mean Princeton?

ELLIS: No, Princeton has a whole engineering school. I mean Swarthmore, which is a true liberal arts college that happens to offer an engineering degree. From what we are saying, the Swarthmore graduates might have an edge in global competition because of their more interdisciplinary educational background.

GADDY: The science community is debating this very same issue. For example, of new physics Ph.D. graduates, unemployment at the time of graduation was up to 14 percent in 1993, it had been only 4 percent 10 years earlier. Unemployment for doctoral physicists six months after obtaining the Ph.D. was 6 percent, compared to 2 percent in 1983. In chemistry, the percentage of Ph.D.s unemployed in the fall after graduation also has climbed to over 15 percent, up from 5 percent in the early 1980s. In other words, the unemployment rate for Ph.D. science graduates is now triple what it was a decade ago.

ROY: Look at all the Ph.D.s who are coming off the line right now. What is their probability of finding a job? Fifteen years ago, every one of my students had 10 offers and flew all over the country for interviews. Today she or he is damned lucky to get one, and most of them are going into the post-doc holding pattern.

We’re not thinking creatively about what to do with the pool of post-docs that has been generated and paid for by the Feds. Let the Federal government, which is paying that money, provide some kind of boost to small industry. Our tax money has paid $40,000 per year for every Ph.D. physicist who is driving a cab in Chicago. Now that is stupid.

ELLIS: There is also a certain amount of credentials creep. As Ph.D.s become more common, it becomes a marketing advantage to be able to show customers a Ph.D. on your sales staff. Oh, sure, it takes a technically competent person to sell high-tech products to a technical end-user—but it doesn’t necessarily take a Ph.D. That’s what happens when you get a big fat market like this one with more supply than demand.

GADDY: Also, one of the things we’re telling doctorates is to be flexible and to look for emerging opportunities in business and industrial sectors, as well as for non-traditional careers—science journalism, high-school teaching, and other multidisciplinary work.

SPECTRUM: I wonder whether some scientists or engineers who are being advised to be high school teachers—unless they really loved teaching kids—would think that was sort of a comedown.

GADDY: In a shrinking job market for the primary employer of doctorates, academia, and with downsizing in the government and corporations, doctorates need to consider all the options. Besides, careers in pre-college education could in fact have a positive effect of improving our educational system and the pipeline for scientists and engineers.

ELLIS: The reality is that when you get out of engineering school, all you’ve probably got is enough technical pizzazz to get your foot in the door for some kind of initial position. At that point, you’ve got to start learning the management and the communication skills and all the rest. If you get lazy and don’t learn, with all due apologies to the need to be a superman, you are going to be vulnerable.

Concluding advice

SPECTRUM: I feel bombarded. You have all given engineers a lot of food for thought. Before we close the discussion, what one or two important pieces of advice would each of you say is necessary for survival in the globalized employment market?

HOLLEMAN: Almost every developed and developing country—except the United States—sets a policy on the types of industries and jobs it wishes to retain or obtain, and then takes steps to do so.

A few decades ago, the United States decided to give up factory jobs. It was a mistake. Now our trade and competitiveness policies seem to be headed in the direction of giving up engineering jobs as well. If we ignore this, the nation will become a nation of a few Wall Street speculators and a lot of poor people. Engineers need to take their views heard on such crucial national issues.

‘Doctorates need to look for emerging opportunities in business and industrial sectors, as well as in nontraditional careers.’

—CATHERINE D. GADDY
Executive Director, Commission on Professionals in Science and Technology
Coulson: I find it impossible to believe we have reached some kind of plateau of creativity in the engineering field. So, based on that lack of belief, I feel that engineers, particularly middle-passage engineers, should be very alert to opportunities to grow and to make themselves more valuable. They also should be very alert to being a player in the corporate structure if they want to maintain their future job security.

Also, collective action is relevant to some engineers. Through their union, they may get more.

Burkart: It is important for engineers to pay attention to policy issues and act on them by word or by deed—such as voting—to get the message across among their peers and in their community.

Napier: The statistics on employment try to increase their exposure to new industries, decrease their down time if unemployed, and enhance their market value.

Rosen: The key to maintaining a rising living standard is to have economic growth simultaneously with productivity growth. Economic growth creates jobs that absorb back into the economy those people made redundant by improvements in productivity.

The only way to get economic growth is for companies to invest more in their workers, for government to invest more in education, training, and public infrastructure, and for individuals to save more to finance this new investment.

Weatherall: We shouldn’t have in the back of our minds the notion that an engineer takes a job from another engineer. Rather, engineers are just as likely to create jobs for other engineers by making obsolete what was a great idea six—or even three—years ago.

It’s assumed that somehow an engineer in China will take a job from an engineer here. On the contrary, if China didn’t have engineers, we wouldn’t be selling them all kinds of high-tech communications equipment. Uruguay is not famous for its engineering, and consequently it’s not a great market for engineered products. Lawyers create work for lawyers, we know that. Well, engineers also create work for engineers, in their own country and in other countries.

Parkar: It strikes me, as a non-engineer, that engineering is undergoing a variety of simultaneous changes. We are possibly in danger of losing our edge if academia does not become much more focused on the needs of the users of engineering graduates—the supervisors, the companies, the re-engineered Federal laboratories, and increasingly industry-university partnerships.

If our engineering schools do not change their current conception of the field and incorporate appropriate changes into the curriculum, they are not going to prepare new engineers for the new globalized economy.

Ellis: A generation or so ago in the United States, we were raised to think we lived in the most advanced country in the world, that we were way ahead of everybody else, and that things were getting better and better in every possible way. There was a sense that you were kind of one up—you could sort of relax because you had all the advantages.

It’s probably healthy now for people to be stripped of some of these illusions and realize that they are not so privileged and that they live in a competitive world. But it means that a prudent person—whether an engineer looking for a job or a kid deciding whether to pursue the profession—must keep their eyes open.

Roy: Any engineering student today should be looking at preparing herself or himself for employment. Undergrads can take charge of their own lives to get broader and more interdisciplinary—take some courses in business and other areas, because they had better prepare. The university is not officially going to become interdisciplinary very soon, but the system is permissive enough for the individual to do it.

Similarly, as Jack [Doyle] said, engineers had better look at the community, the state, and the Federal structures in which they should participate as citizens. The states are going to get much more powerful, and their laws are going to affect engineers deeply, profoundly, and in large numbers. So really, my advice is for engineers to broaden the base of their interest and education.

Oneill: Clearly the message ought to be that the individual has professional responsibility. The IEEE certainly can help. Maybe the government can, too, although perspectives on the appropriate role of government are changing substantially.

Spectrum: The primary message from all of you seems to be that engineers should stay keenly aware of their context, meaning everything from company politics to international politics. With such awareness, there may be ways they can position themselves for, and thus help decide, where they are going to be put. Definitely engineers should not bury themselves single-mindedly in the lab.

Another major message I hear from you is that engineers cannot afford to be passive. They must sell themselves. They must add nontechnical assets to their repertoire. They can’t assume that just because they are technically brilliant, that they automatically will advance, make more money, and have a future with one company. And they must provide their own safety net.