



# Examining the U.S.

*Is the U.S. aerospace industry facing an impending workforce shortfall?*

*The issue has been alluded to and shouted about, often with few hard facts and much emotion. Many fear that the long-range consequences of a workforce shortfall may lead to the U.S. losing its competitive edge in the marketplace and its status as a leader in aerospace endeavors. In addition, as the U.S. is beginning its quest to return to the Moon and travel on through the solar system, the current aerospace workforce is reaching retirement age. The same is true in the defense arena. How do we replenish that?*

*Other questions come to mind:*

- *What are the causes of the problem, e.g., lack of a properly educated pool of candidates from which to draw, citizenship issues [for government and some civil and private concerns],*

*an aging workforce population.*

- *What are some approaches for ameliorating the situation in the long term, including attracting students and young professionals back to aerospace as a career choice?*
- *How do those who design and develop the platforms, and those who bend the metal, see their future?*

*There are also those who believe the problem may be far less serious.*

*On May 12, **Aerospace America** held a roundtable to discuss these and other questions facing the aerospace community. To view the discussion on line, go to <http://www.fednet.net/asx/CPF/aerospace/aa080105.aspx>*

**DONALD W. RICHARDSON** I'd like to begin by having you give a brief descriptor of where you're coming from on the workforce issue as far as your interest or your profession.

**PATRICK MCNALLY** I'm from MSC.Software, and my contention is that we're seeing a change across engineering. This change is forcing us to relook at the way engineering is done. A lot of the tasks that we did in the past are now automated by computer programs, and we're going to continue to see this trend.

In the future, how do we get ready for engineering, where a lot of it can be automated, where we still want to innovate? A great example is the 787—they're saying the first 787 will be built as a functional prototype inside the computer.

So, with all the major projects that are going on, how can we as engineers and as a society take advantage of this trend and retrain our engineers to be ready to use these powerful tools?

**ANNALISA L. WEIGEL** I'm a professor at the Massachusetts Institute of Technology in the Aerospace Engineering Dept., so my interest in the workforce issue is, of course, in terms of educating our future workforce at the secondary-school level.



# aerospace workforce

**THOMAS BUFFENBARGER** As the international president for the International Association of Machinists and Aerospace Workers, I have a deep interest in this conversation as we discuss the terms and the conditions for which we must prepare the future workforce. And then, where we carry on beyond that, assuring that there are going to be good jobs in the U.S. for an experienced, trained aerospace workforce.

**JOHN MALANOWSKI** I'm with Raytheon Company in Waltham, Mass. One of my responsibilities is professional and college staffing at Raytheon, in addition to responsibility for our engineering leadership development program. My interest is, how do I continue to build a pipeline for Raytheon of workers with a potentially dwindling supply of available graduates in the U.S.?

**RICK STEPHENS** I'm the senior vice president for an organization called Internal Services in the Boeing Company. Among my duties is the responsibility for human resources and our community- and education-relations programs. So my interest is making sure we have a workforce ready to be able to meet our needs, and make sure the pipeline is such that we'll have workers who have capabilities, long term, to meet our business needs.

**TOM GANNON** As the director of leadership and technical development for Lockheed Martin Corporation, I work on a lot of workforce planning and staffing issues for the CTO. I'm interested in seeing how we can take this great, well-prepared workforce that we get from our colleges and universities and really maximize their potential, because their potential is virtually limitless.

**MICHAEL T. GIBBONS** I'm from the American Society for Engineering Education, where I am the director for data research. ASEE collects data from almost every engineering school on enrollment and degrees awarded, faculty.

**ROBERT KUNTZ** I'm president of CEF [California Engineering Foundation], which is not limited to California. CEF was actually founded as the result of the

crash of the aerospace and defense industry in the late '60s, at a time when there was a forecast that, unless something drastic was done, the country would see a shortfall in engineers of 270,000.

We hear a lot of discussion about shortages and oversupply or undersupply, H1Bs and L1s [visas and work permits], and offshoring. But the real challenge facing the country is in knowledge management, and that's really a systems engineering challenge.

I'm not on the wavelength of shortage or oversupply. I think that the quicker we can get off the numbers game, the faster we'll look at knowledge management as the greatest asset in the country. Intellectual capital is the greatest asset that the country has.

**RICHARDSON** Knowledge management is an interesting issue. It's one thing to prepare young engineers and stimulate them to get into our profession, keep them in school, keep them in our profession. The other is capturing the knowledge of some of us who are a little older, who have accumulated a lot of knowledge and have left or are leaving the profession but have a lot to offer.

One example is the issue we're facing, not so much from an educational point of view but a case in point—the problem we're going to be having very shortly in the air traffic control world. In about four years, the whole wave of air traffic controllers who were hired during the strike will be forced to retire. We're going to lose all of that, and it takes years of training. It's a different kind of training than the academicians do, but it's the same issue. Knowledge management, capture, and transfer is a problem.

Let's start this with that. Those of you who are dealing with academic institutions, is there a program in your institutions or the ones you deal with concerning knowledge management in any form, as opposed to instilling the knowledge just from an academic point of view?

**MALANOWSKI** I look at the schools that have internships combined with a

degree, with a solid practical internship experience or several internship experiences, as what I would say is probably the closest thing to a knowledge management approach to engineering in academia. We have talked to a number of schools, recruited at several different schools that have combinations of intern programs. We intern people at Raytheon during the summers and send them back to their institutions for graduation in their senior year.

I've not come across anything where there is a knowledge management approach to engineering in academia.

**STEPHENS** I think the knowledge management discussion, particularly with the maturing workforce, is a difficult subject for a number of reasons. One of them, for those of us who came up through the IT [information technology] ranks, is that there's a long-held belief that you could just take all the knowledge, pack it into a repository, and then be able to pull it back out as the new workers come along.

Our experience has been that that is not the case. Knowledge transfer is really a result of experiences, of hands working together. We're seeing new organizations pop up that are beginning to hire recent retirees and make them available to come back as mentors to help the younger workforce in this knowledge transfer; not so much about the particular "what's the problem," but the processes to go solve the problem.

With the availability of online information, it's not about information, it's how do you apply that information without a set of skills. To me, that's the value the mature workforce brings to the table, and that's the challenge we've got to be able to off-work. I think new organizations, like the ones I just described, are a way to help that knowledge transfer.

**KUNTZ** I had the good fortune to walk off the Purdue campus and go to work for a little company called Aerojet. Back then there was the discussion of a shortage of people, but the aerospace industry was very creative. If you were a graduate with a bachelor's degree in anything—not just

## A Roundtable Discussion

engineering but any discipline of engineering, any discipline of science, a history major or English major, whatever—you were hired into the industry because the industry was under cost-plus-fixed-fee contracts. So, it was really overpopulated with all kinds of people.

But the first thing that happened was you were given a copy of Robert Goddard's book on propulsion, and nobody understood propulsion. So, from a knowledge management standpoint, you had all of these different disciplines, and put them together and made an action team.

If you go back to that period of time when Sputnik went up, that was a wake-up call. This country was ready to launch a satellite literally for over a year, but Wernher von Braun was prevented from doing so by the CIA. When we

decided that we had to wake up, realized that we had to catch up, 80 days later we put the first satellite in orbit.

The aerospace industry is more than just an industry. It has shown an ability to take totally interdisciplinary people, slam them together, and be able to really have person-to-person knowledge management and learn on the job.

What we're faced with today is that engineering education has changed significantly. About 30 semester hours were chopped out of the undergrad program in engineering. Where did those semester hours come from? They came from the practical application of engineering.

So, if you look at the thing in a much broader perspective, you have to actually look at what's happened over the past 50 years. That seems like a long time, but things happened 50 years ago that we're living with today.

**WEIGEL** I'd like to respond to some of Bob's comments. We have a lot of discussions about what ought to be in the engineering curriculum. You struggle with what you can put into four years and still have the students come out on the other end smiling and happy, and not feeling like they are really burdened by course work.

What you come down to is that engineering should really be a life-long learning process. So we try to set the students up with four years of a foundation, expecting that they will continue to grow and learn and

develop. Part of that is experiential, on the job. Part of it may be further formal education courses; it may be company training. But we want to teach them how to learn and teach themselves, so they will be able to grow and adapt in the industry. And that's somewhat of our approach to knowledge management and helping our students be prepared for what comes.

**RICHARDSON** Pat, you introduced some interesting thoughts when you were talking about the software issues. Could you comment a bit, because that's a little different than some of this practical stuff.

**MCNALLY** That's true when we're talking about knowledge management as well. It's very important to look at a lot of the processes that can be automated, or that can be documented in such a way that young engineers can use those processes and still get to the answer.

What's the ultimate goal? Is it to understand the fundamental underlying mathematical equations so they can drive them themselves? I know we're not doing that as much as we used to.

But the ultimate goal is to be able to create a new project to accomplish some goal. In the aerospace industry, goals are huge. What kind of tools and environment can we put in place so they have the advantages of experience from industry but they also have a creative way to work in an environment and see some things accomplished? That's what I think the computer-based tools can do today.

The other point is that these computer-based tools don't require aerospace engineers completely to run. So, the other question is, what is the role of aerospace engineers in the future? I think they have a unique role for leadership. They understand things like the Moon-Mars initiative from a perspective that a mechanical or a computer engineer does not.

How can we get the aerospace engineers to develop these leadership qualities and take advantage of the tools that are there, the other engineering and technical disciplines that they might have, to work together, in the same way we were talking about earlier that we did to face the Sputnik challenge?

**WEIGEL** Our students today very much



# Examining the U.S. aerospace workforce

expect that there are software tools in place. They grew up playing video games; they grew up using computers.

I teach a senior course in spacecraft design, and the students are frustrated that they have to build and construct their own models in MatLab or Excel or whatever tool they're using. They think, surely out in industry there are lots of tools, and they really want to start using those in a classroom.

So, there's certainly the demand from students, expectations that they're there, and perhaps a reluctance to dig down into the math and into the deep programming that they used to be taught.

**MCNALLY** An important point is that they need to understand the engineering principles. I know there's a lot of concern that you give them a tool and they'll use it the wrong way. There is a need for understanding the underlying engineering principles.

But I do think the tools are maturing to a point where they can have a very effective impact on the design process. And we're seeing it in other industries as well—automobiles that are designed in 12 months now using computer-based tools; and the Boeing 787 I mentioned earlier. Tremendous use of these tools, not just for CAD, but also to look at how the whole plane will come together and how it will fly.

Can we take that trend and leverage that into the next level, which is the Moon-Mars initiative?

**RICHARDSON** Tom, how about some comments from your constituency?

**BUFFENBARGER** Well, I found the remarks earlier to be very interesting, but focused on the front side of the processes in this entire industry and the engineering process, which we understand is absolutely critical.

My perspective comes from my duties to represent those who actually make something physical out of the ideas and the engineering and the concepts developed from the disciplines of academia.

We're very concerned today, as we emerge into a new century and we look at this great industry inside the U.S., the last great export-producing industry of the U.S. We see the numbers of those

who know how to take metal, mold it, form it, shape it, plastics, all the exotic materials we're fortunate enough to get to use and work with—we're seeing that erode. We're seeing the workforce decline in numbers as it is outsourced and offshored. And the problem we struggle with is, as we see engineers develop new ideas, those new ideas finally come to fruition someplace else.

My perspective is one of deep concern that we're not part of the equation anymore. Where are we going to be with this great industry the U.S. certainly fostered to a great extent from its creation?

And the people who want to work in this industry, who find it exciting, who like the challenge of being a part of something new or something bigger or faster, or a leap for the benefit of everyone, without the assurance that there's going to be a job there after they receive their training—and we struggle to provide them with the training they're going to need—that there's going to be something there for them after we reach that threshold.

**RICHARDSON** Tom, one of your responsibilities is career development, which involves a lot of things we've just been talking about. Do you have some perceptions on that?

**GANNON** Absolutely. I would say almost no one would go and study engineering as an undergraduate degree without the intent that they will be working in engineering, either as an individual contributor or in management, because it's a very difficult one. And we know that there are—and this is one of our issues—far easier degrees.

So, they come to us certainly with an intent to join a larger enterprise, one that's critically important to this nation, and to learn and grow and to be all that they can be, as someone used in a different context. It is up to us to ensure that they have a good opportunity to do that.

These issues are very complex. They have to do with the degree to which our federal government is willing to fund research and development, so that those who are interested in R&D have options. They have to do with how efficiently and effectively we do our people manage-

ment, what kind of learning and growth opportunities we give them. Can they come to work each day and be a part of something bigger? That's a challenge we all face.

But one thing about an engineering career and how it's perceived in the popular imagination: No longer is it necessarily thought of as a very secure and lifetime employment kind of career. It does not have a particular focus. There's not one idea of what an engineer does. In fact, it's sometimes a fairly vague concept. So, we're dealing with what the popular culture thinks about engineers as well.

Is it perceived as a secure and highly remunerative field? Both yes and no. High entry income from when they're fresh out of college, but many of them have seen their parents or people they know who have been laid off, for no reason other than the government decided to end a particular program.

And certainly that relates to what you were implying—foreign competition.

**RICHARDSON** Well, I'm very concerned about the attrition in our labor force, both in the colleges and in the workforce itself. It's not as exciting as it was when I was younger. I could work on 30 or 40 different airplanes. You can't do that any more. And some of the romance is gone; some of the security is gone.

In my role in AIAA, I talk to a lot of sections, attend the dinners. And unfortunately, most of them are men. But the families are there, and a lot of the women are educators. And it's incredible. I have found that the men and the women together are discouraging their children from entering into our profession, because it's insecure.

There are mergers; jobs are lost; companies fold; contracts are cancelled. And it's shocking to me to see that people who have grown up in our industry are discouraging their children from joining our industry. It's still a revelation to me.

Leaving that for a second, Mike, I'd like to hear something about the numbers you've brought to us, which kind of show from a quantitative point of view in the aerospace education world what you perceive is happening.

# A Roundtable Discussion

**GIBBONS** I agree with Bob. We need to track the numbers—how we're perceiving them and what we're doing with them.

The 1990s were a pretty rough time for engineering as a whole and also for aerospace engineering. In the late 1980s as a whole, engineering peaked, with around 75,000, 77,000 engineering bachelor's degrees. For the 1990s it was pretty flat, in the low 60,000s.

In 1990 there were 3,000 bachelor's degrees in [aerospace] engineering, and that had dropped to roughly around 1,200 for the late 1990s, 2000. That's a pretty significant drop, but that's rebounded over the past few years.

The percentages of women have risen over the past decade, 15 years. And degrees at all levels have rebounded a little bit. Not quite to the levels of the early 1990s, but I think we've seen some growth and some recovery.

From everything we can tell for the near future, we'll continue to see a rebounding of aerospace degrees, at all levels, and I think that's positive. That doesn't mean that we need to rest on that, but continue to cultivate students' interest in aerospace engineering.

That's something that ASEE has been doing with the K-12 initiative, trying to create some imagery for students, both in terms of presenting people who they see as role models and for them to emulate and say, these are interesting people who are going into aerospace and into engineering in general.

Also putting projects in front of them, kind of fingering things that engineers do, aerospace but also all engineers, so students can have something to shoot for and can make the link as to what engineers do.

This has been pretty successful. And I think that the doldrums of the '90s really got a lot of schools to wake up and work through ASEE, but also through the other engineering organizations, to stimulate growth in the pipeline.

**RICHARDSON** I've read a lot in the literature, and I'm very involved in a couple of educational institutions. Let me bring up two different things, and I'd like to get some varied inputs. You talk about perhaps 60,000 or 70,000 engineers in the



educational pipeline. Now, I've heard some numbers from China that mask those numbers, like 300,000 engineering graduates a year in China, 150,000 engineering graduates in India.

We talk about offshore transfer of jobs, but the supply is out there, masking what we do. Do people confirm that number? Is that a problem? Do you foresee that to be a problem, with all that supply out there as opposed to here?

**STEPHENS** I think what we saw 10 years ago that many of us really haven't recognized is there's a tremendous increase in the amount of labor out there, with the fall of the [Berlin] Wall and the opening up of the Asian area. I would contend that we don't have a labor shortage—we have a skill shortage.

And this whole notion about what's out in the workforce, it's a tough challenge, particularly for those of us who are in global markets, who are looking to be competitive in the marketplace and recognize our competitors may operate under different rules. We really are looking for the skills where we can get them, and the best way we can.

There's no question that here in the U.S. we like to use the maximum amount of workforce that we can. It's the balance between capacity and capability, and the economics associated in the global market we compete in.

I don't think the challenges we face in

the aerospace industry are unique. You mentioned the number of people who say, "I'm not going to suggest my kids go participate in aerospace." You would find that same discussion going on in households whose parents are in the medical industry, in the pharmacy industry, almost any technical field, because the competitive environment we face now in the global market is really causing a major shift.

Then the challenge is, with so much transformation going on, how do we really prepare our youngsters to compete in the future marketplace, of which we want many of them in the aerospace industry.

I think that's a very difficult dilemma that we face here in America. And it has to do with images, perspectives. Again, we're not facing a labor shortage; we're facing a skills shortage, if you look at the global market environment, and that's the environment many of us operate in.

**KUNTZ** There's another parameter that has to be taken into consideration. 1967 was when engineering services in this country were maximized in terms of adjustment for cost of living. You have to look at what the value of our market is—and remember that our market in this country is controlled by the investment community, sometimes called the Wall Street paradigm.

When we were asked to take a look at the so-called crisis in the industry, the first thing we did was step back and determine the basis of the crisis. We identified over 30 major challenges facing this country with respect to the aerospace industry. We cooked that down to about seven, and then to three: the Wall Street paradigm, R&D, and intellectual capital. Of that, we identified the highest priority as intellectual capital, and then started looking at what that is.

The aerospace industry is a dichotomy. On one side, it's got to function to satisfy the Wall Street paradigm. On the other side, it's got national and international responsibilities.

Look at the forcing functions for most of the technological development that got started in this country. For example, the first use of the transistor was in the

# Examining the U.S. aerospace workforce

thrust-controlled system of the Titan engine. The aerospace industry at that time, because of superlative support from the federal government, didn't have to justify what was being done or have the investment in R&D pay off this quarter.

In the late '60s, the government determined that you would do R&D because it was specifically oriented toward a weapons system. Since then, there's more and more, "the private sector ought to be investing in R&D." Wall Street doesn't benefit companies for investing in risk aversion or R&D.

As Rick was saying, it's a whole different ballgame. Folks ask, "Why are you bringing H1Bs in this country?" It's for education. A lot of people in India who are doing it now got educated in the U.S. You bring them in on a six-year visa and they're trained by a person who's going to get laid off, because that happens as a result of the Wall Street paradigm.

Our intellectual capital, our greatest asset, is treated as an expendable commodity. This country has not gotten its act together with regard to the reality of what's going on in the world. It's a very difficult, complex problem.

Today, if you don't put problems in 30-second sound bytes, you're nowhere. We in this room are looking at an extremely complex problem, and every factor has to be taken into consideration.

This country is extremely productive, and productive translates into reduction in human resources or man-hours necessary to get the job done. So, what we're faced with is, how we can think smarter, and we go back to education. We've got to produce professionals who can think smarter in the realities of places that are supplying cheaper.

**MCNALLY** There is this dichotomy, though, that some of the defense companies are faced with. Some things need to be done here. My company can set up a software factory in India. We can hire programmers; we can give them specifications; we can set the requirements. We can utilize that as a resource in order for us to accomplish our business objectives. We have to in order to be competitive.

In a commercial enterprise, the global competition forces your decision-making.

And in the defense infrastructure, other factors come into play. So, how do we change that dynamic, because on the other side, the technology is moving faster than the DOD specifications are.

There's a lot of technology out there in the commercial world, and the commercial world has this business imperative to stay profitable. And it's not just Wall Street; it's the global financial markets now. They're always looking for where to invest; where do I expect the return on investment?

To change it—I don't think we can. It's much bigger than AIAA or the aerospace community. But how do we take advantage of that situation and use it in a way that's smart for aerospace and for the U.S. aerospace leadership? I think that's the challenge.

**RICHARDSON** Well, what I'd like to do right now is turn to Tom. You represent a little different facet of what we've been talking about, but it's where I believe the rubber, or the metal, hits the road, as the case may be. I wondered if you'd kind of share with us your perception of what these other people have been talking about.

**BUFFENBARGER** Well, I was fascinated by

the conversation we were having about the paradigms that Wall Street set into place, that have found their way to govern what happens in this great industry.

We have seen manufacturing in all sectors of the U.S. economy decline rapidly in the last few years. We've shed three million jobs. The U.S. manufacturing workforce is now at its lowest level or capacity in the last 100 years, and it's bleeding terribly.

When things get to be this tough, and workers in this industry are suffering and losing faith that there is much of a future for those who craft the metal, or make the parts go together that take us into the skies, the conversation quickly reverts to some pretty basic things: What is the policy of the U.S.? What kind of value do we put on, not just the engineer, but on the person who makes things in America?

And they see that, if we lose the capacity and do not value those who manufacture our prosperity, we will also lose the ability to manufacture the means of our defense.

So at the end of the day, the conversation I hear from a well-educated workforce is that we're really having difficulty



# A Roundtable Discussion

now understanding—with the flight of jobs to China, the outsourcing to India, to Vietnam, to South America—did the communists really win? Did the Wall Street paradigm, the prayer of capitalism, lose out to a communist plan, a manifesto if you will? We see our competition, their government, their industries, their culture, place great value on the engineering arts and skills. They place value on jobs in those industries. And they have in place a national policy in almost all of these countries that demonstrates their commitment to those jobs.

They devise their national reaction to the changing times in economics to ensure that those in those industries know their government supports them. We don't do that in the U.S. We don't support R&D; we don't support those who try to demonstrate there's a value to these great jobs. And we are disheartening and discouraging hundreds of thousands of workers. I hear it when I travel to Seattle, or to California or to Georgia. The communists won.

That's the message they are talking about among themselves on those floors.

We don't shy away from calling it like it is. We can call it the Asian market, but it's really the value of economic systems. What we're seeing is Wall Street wanting to make a quick return on its investment, at least in the quarterly cycle. China invests in the long term and in their workers. We just don't have the same perception of that happening in the U.S.

The Chinese have a controlled workforce. Wages are low, and capitalist companies flock to China. We make a joke of it. Capitalists love the communists, because the one factor of any manufacturing equation, the cost of labor, is well or at least brutally managed in some of those countries.

We can't compete against that; our government should understand that; our employers should understand that. We should find a way to work together to say, well, we are not going to compete in a race to the bottom. We're going to compete and give value and respect to the jobs that are critically important to the survival of this nation.

I would hope some day the discussions

between industry leaders and the representatives of those who love this industry and work in it can evolve so that we make a united front or a push that demonstrates that our government has a role, and that it should step up to the plate and help us keep this industry in the U.S.

**KUNTZ** The problem is that we got involved in a world economy and a world market where the policy in this country was not toward that.

If you manufacture a product in the U.S., we're in an economic food chain. If you raise the cost \$1.00, by the time it gets to the end of the food chain, it costs \$4.00 in our economy.

Take healthcare, now the responsibility of employers. You add \$1.00 on and that gets increased by \$4.00. So, one of the things that makes it very difficult to compete in the world is there's a different paradigm. All of our sociological stuff in this country, healthcare, environmental, is all an entry-level cost in our food chain.

And it's multiplied to get to the end of the food chain. In a communist country or some place else, we're buying cheap, because there's no workers' compensation, disability insurance, all those other factors that enter the food chain.

What our government needs to do is change the way we handle the costing effect, rediscover vocational education by keeping our technological infrastructure here, and take all of that other stuff that doesn't increase productivity and move it to the exit of the food chain.

Every product that just comes into the U.S., with a \$700-billion trade deficit, doesn't pay a cent into social security, unemployment insurance, or any of our healthcare or environmental stuff.

We've got to revitalize and reindustrialize this country, and change the policies to facilitate that. Then, with all of our productivity and creativity, manage smarter and don't have all these impediments to compete in the world market. But this is complex stuff.

**RICHARDSON** Yes, it's very complex. And we should all be doing what we can to get this message up to Congress.

John, one of your titles is Talent Acquisition. Could you expand on how you're dealing with that? I've never heard a title

like that before, except in Hollywood.

**MALANOWSKI** I was going to say, I'm not the Hollywood talent scout. I'm the Raytheon talent scout! Last year we hired 10,247 people into Raytheon. We have plans to hire about that many people for the next several years.

I want to come back to something we talked about a little while ago. Mike, you know, we suffered a little bit in the '90s. I would argue though that we're seeing the effects of the lack of engineering graduates, not to come back to the topic, but it's a burning issue for us and it's central to talent acquisition.

Look at the 6- to 15-year experienced employees in a lot of our companies. There's a significant shortage of them. So part of my other role is, I run our leadership development programs. We use them as a pipeline tool.

Talent acquisition for us is volumes right now; volumes of people who are technically savvy, understand the value proposition and how to drive business growth through technology innovation.

A lot of what we're talking about here, I wouldn't necessarily characterize it as the communists won as much as technology innovation is going to drive growth—growth in the U.S., growth in the economy, but also growth in our business.

Part of what we're struggling with right now is a workforce a good part of whom will be retirement eligible in the next several years. Look at the decline in the growth in the U.S. labor force. There's actually a shortage in the U.S. of the developmental worker between 35 and 44 years of age. The person we can nurture and grow and help us build a company of the future, there's a shortage in this industry.

So, my talent acquisition hat is a lot broader than that. But we're in the volume hiring business. And it's systems engineers, integration engineers, people who can drive our growth for us. That's the biggest problem we're trying to wrestle with right now at Raytheon.

**RICHARDSON** Tom, your title is Leadership and Career Development. I'd like to link the way you approach that to some of the educationalists, the way we're teaching people to be systems engineers ra-

## Examining the U.S. aerospace workforce



ther than technologists. But let me hear from you first as to how you deal with it in your organization.

**GANNON** Well, we—like Raytheon, like Boeing, and like many other companies—are still in the talent acquisition business, and there's nothing more important than what we do. We will succeed or fail on the intellectual capital that we bring in and how we develop and manage them. We get to the specific issue of, is there a shortage of aerospace engineers to be hired? I'd like to talk about that for just a second.

I think there will always be. There will always be a shortage of the best talent, which is what we're all looking for. On the other hand, we're still, each of us, able to hire the numbers of aerospace engineers and systems engineers that we need for our immediate needs. And that has been the case for many, many years. I just want to put that on the table, because it is very germane to the subject.

You mentioned systems engineering. That is a very dynamic subject right now, and there are various schools of thought on that. But we are settling on a particular concept of systems engineering. We are very strong in CMMI. And we've got many programs out there to ensure that systems engineering education and the concept of integrated engineering processes are being spread throughout Lockheed Martin in a way that will help

our program performance in the future.

How do we do that specifically? We have leadership development programs. We have an award-winning training function. And we have a good mix of online and resident-delivered courses in Lockheed Martin.

**GIBBONS** I have a question for John. You know, with the recent economic cycles, more students have been getting advanced degrees. At the doctoral level we haven't seen an increase in degrees, but there are a lot more enrollments. But the master's level has grown a lot within the last couple of years. Does that shorten the timeframe with having this quality of students or employees in that age range that you're talking about? Do you get more advanced-degree students?

**MALANOWSKI** We generally recruit advanced degrees for engineering. It does shorten the timeframe a little bit. But we typically take advanced-degree engineers and put them into one of our leadership development programs, which compresses 10 years of both technical and nontechnical leadership training into a couple of years through a series of rotations. That's part of why or how we're trying to catch up, if you will, and fill some of those holes in our 6- to 15-year experienced employee positions.

The other struggle is, we're seeing different competitors than we've had in the past. There are consulting houses that specialize in systems engineering and systems integration—a different level of competitor than this industry has seen before.

So, the value proposition for a master's degree candidate coming out of MIT or a comparable institution to go to a Ray-

theon or a Boeing or one of the other defense companies versus going to a consulting house sometimes is hard to compete with. That's the other dynamic we're seeing for those students that we haven't encountered in the past.

We think this industry has got the best technology; in fact, I know we do. We must do a better job selling it to folks, and helping them understand the professional opportunity within our companies.

**MCNALLY** That's a good point on the technology, because there are some other hot technologies out there right now that are attracting a lot of the young talent. There's biotechnology. It's growing; it's growing extremely fast. There's a lot of investment there. Electronics; MEMS; nanotechnology, not necessarily for aero-



## A Roundtable Discussion

space applications, but information technology as well. It's a much more competitive market for young engineers and the minds of high school students as well.

If you get to where they want to focus on math and science, now they have a number of other very attractive choices. As an industry, we have to be aware that we're competing not just with the non-math and science or the foreign, but the other industries are really going after some of these young engineers.

And they're exciting topics. I've got a 19-year-old in college right now and he started thinking aerospace and now he's seeing all of these other fields. And he's thinking, maybe I should be in computer science, maybe I should be in biotech. We have to be aware of that as an industry.

**STEPHENS** I think also this thing we call aerospace is not what it used to be 10, 15, 20 years ago. Don, you commented about the number of airplanes that we build. But I would say if you look at the Boeing Company today, while we have a number of aircraft programs, particularly in our commercial side, if you look at the defense side, as an example, Future Combat Systems [FCS], the largest contract that Boeing was ever awarded, has nothing to do about airplanes.

And yet we're taking the technology, the systems engineers and the applications in an area, and applying them directly to be able to solve the challenge for the Army, which is how do they re-architect, how do they retool, how do they prepare to fight the war for the future, but using those same concepts.

We have to recognize that our industry is changing and be able to meet the needs as the world changes. This notion of systems engineering, systems integration, those are the things that allow us to create what the future looks like.

And then the challenge Tom brings up—what are the capabilities that workers need to be able to put those products together—is part of the dynamics that it is not clear that we in the industry have really recognized and wrestled with.

**MCNALLY** FCS is a great example because it is forcing you to have new relationships with new companies you haven't worked with in the past. They bring other tech-

nologies or capabilities to the table.

And as we look at the Moon-Mars Initiative, can we really invent everything all over again, or could we take advantage of capabilities that are out there in the supply chain, companies that build ground vehicles that we may not necessarily have that capability to do. Sure, they're on the Moon or on Mars, but they've got some intelligence there and some capability there we could take advantage of.

So how, again, as an aerospace industry, do we establish the leadership and then bring in some of these other factors to make things happen? I think that's the fundamental challenge looking forward.

**RICHARDSON** Well, here we have all of this discussion and we're beginning to talk about skills that are softer rather than harder. You know, it's not compressible flow and CFD and things like that that we had before. Annalisa, how do you keep the dynamics of the educational process in line with the demands of the industry? I know it's difficult. What are you doing?

**WEIGEL** As I said before, we are constantly reexamining our curriculum and what we put in that. We pay attention a lot more to team skills, to leadership develop-

ment. We now have communications requirements on our students, both written and oral presentations they are to make to get the skills they need to be successful in today's definition of an engineer.

I'd like to return to a point that Pat made about attracting people into this industry. I sit on the supply side of this equation. I work with people who are going to design our systems. Tom's members are people who are going to build those systems. Together, this is a supply.

But if you look at the demand side of that equation, all of the organizations that these people are going to be working in, that's also an opportunity for improvement in terms of attracting the top talent.

I can tell you numerous anecdotes of students who have gone for summer internships in the aerospace industry, terribly excited, and returned terribly frustrated with that experience. A lack of gender diversity, a lack of cultural diversity in the industry; they don't feel supported in those particular cultures.

It's a real problem, because I think we are turning out very talented people, but I'm not sure



# Examining the U.S. aerospace workforce

that we're doing enough in the industry to make it a welcoming place for all those people.

**RICHARDSON** Well that is one of my sore subjects, as I deal with co-op students a lot. The co-op experience can be so valuable. I would rather hire a 3.2 GPA person who has had two co-op experiences than a 4.0 who's never had one, because it's going to cost me so much to teach him what's right and what's wrong.

But I speak to a lot of co-op students who say, "I've been offered this opportunity in an organization to co-op and I get so excited and they put me in a library alphabetizing index cards." When I was younger, they put me on the drafting table and I'd erase and make copies.

There's got to be a better way to utilize these bright-eyed young people that we want to keep in our industry rather than offering an exciting opportunity and then dashing their hopes. I think that all of the companies that enter into internship programs have got to have a better feedback mechanism, from both the school and the company, to optimize it so that we keep our people exercised.

Tom, in a lot of our industries, in a lot of our

schools, we have a problem with voluntary attrition, people who said that the course is too hard; I want to switch to a different major. Do you see much voluntary attrition in your workforce because people are getting disenchanted with the stability of it?

**BUFFENBARGER** There's certainly a degree of disenchantment; layoffs. We are still down in numbers, especially since September 11, but it began even before then in employment in the industry.

You know, we have contracts, collective bargaining agreements with 165 companies, mostly of the largest players in the industry in this country. Only two have an apprentice program.

I make it a point to support the two that do very strongly. I visit their sites when they conduct their graduation ceremonies after a very strenuous, very rigid four-year apprenticeship program. The excitement that I see and the deep interest in those mostly young folks, with a few older ones now, is refreshing.

We probably need to go back to where we were 20 years ago, when almost all of these 165 companies had bona-fide apprentice programs, and we attracted

those who truly want to be in this indus-

try, find it exciting, and want to stay with it for their careers.

Where we have them, and we do it in conjunction with many of the universities and colleges throughout this country, we are missing something. Many companies gave up apprenticeships because they said the vocational system will pick up the slack and it won't cost as much to train that worker entering the industry.

The fact is, we have abandoned vocational training for the most part in the U.S., and that's only reinforced why we should never have given up the apprenticeships. It was great for this industry. It was specific for this industry. And some of the greatest talent we represent certainly came through those programs.

I would hope one day we'll make a policy in America to recognize that again, and our country, as well as our companies, will have a policy to go back to that type of a training program.

Many times it introduced people to the desire to further their careers and education, and become engineers and innovators in the industry. I would hope we could do that.

**KUNTZ** If someone would ask me what is the greatest challenge facing the country today in the sci-tech area, I would say unequivocally that it is that when they graduate, 87% of the kids coming out of the K-12 education are sci-tech illiterate.



# A Roundtable Discussion

And we're adding ethanol to gasoline.

It is insane some of the stuff that is going on in this country, because you can get away with a sci-tech illiterate population. Everything that we're talking about here, we're focusing down into what is literally the last 13% of people who would have some attitude or aptitude to go into the sci-tech field, whatever that happens to be.

Look at the talent around this table. I want to see people who are working toward a solution. What we lack in this country is a constituency to carry any of these things forward. We need engineers who know how to communicate better. We need engineers who understand the global economy, who have the know-how to make things, and know how to communicate.

But, if you're going to change undergraduate education—I can just take the experience in California—that is a big task. The budgets for the engineering schools are for full-time-equivalent students. Same as the art school.

The laboratories have to support themselves for maintenance out of the same budget that comes from maintaining the sewers. And where is the political constituency that changes that?

Rhetoric is easy, as we all get together and pontificate on the nature of the problem. But what we lack is an action agenda and a constituency that's going to take that over. Our technical societies aren't doing it and the trade associations aren't doing it. It's always someone else that ought to take it and run with it.

**RICHARDSON** Well, let me ask this of the people around this table. I'm aware of several educational initiatives going through the authorization process on the floor [of Congress] right now in different forms. Some of them are interest-free loans for educational opportunities; some of them are kind of like the ROTC, where they'll pay for your education and you give them back a couple of years or years in a federal agency. Anyone familiar with the status of any of them?

**STEPHENS** Well, I can speak in the state of California, because that's where I've been spending an awful lot of time, even though my office is in Chicago. There are

a number of initiatives.

And I would take issue somewhat, Bob. Nearly everyone I talk to is interested in this discussion of education. If you look at the number of universities, the number of colleges, the number of community colleges, which are so critically important, I've yet to find anyone who is not passionate and motivated about working in that area and supporting the educational initiatives. Helping our youngsters get the education necessary to be successful in society, whether they choose aerospace or not.

One of the challenges that I see—and I go back to Tom's comment—is a lack of an integrated approach on how to press forward. If we look at AIAA or AAEE or AAAS, there are lots of activities going on, but they're not integrated in a way that would bring coherent force to press and go forward.

Frankly, I think that's one of the greatest things we in the aerospace industry can bring to the table. We know how to solve large-scale problems. One of the things we're missing is the opportunity to bring that skill together; to bring the constituencies of the government, of education, of the media (because this is an awful lot about transforming culture), of labor, of the health industry, and all the 501(C)3s together in a way that can really drive and create a fundamental culture change. Because this is not unique to aerospace. This is every industry where technology is running the issues.

Rather than us solving this problem for aerospace, we need to coalesce to look at this from a national basis. Out of that, our system engineering skills allow us to press forward in getting what many would say will fix the educational system, fix the discussion about what are the right motives, the right incentives.

The media, for example. If we look at how aerospace or engineering is portrayed in the media today, while there's anecdotal evidence of some good things going on today—*CSI*, *24* are beginning to get kids excited—by and large, the studies that have been done show engineers portrayed poorly; they're portrayed as inept. And yet our youngsters today have a media diet of six to eight hours per day

[according to a study by Kaiser Permanente last year].

So, if that's how they are seeing us, that's how they're being sold to. They're a \$150-billion-a-year market the industry is selling to. If we're not impacting the culture, we're not impacting the perspectives, the attitudes, therefore the beliefs and the behaviors of the youngsters.

That's a huge challenge we face. That's a little different flavor, but I think there's a lot of work going on from a legislative legal standpoint trying to head in the right direction. It's not integrated.

**RICHARDSON** You raise a point that I was looking for. We've had a lot of diverse discussions and we represent different constituencies. But what I'd like to do is to go around the table and say, there's a whole bunch of facets to this problem. What's your solution? What's your recommended action plan? I mean, as Bob said, a lot of talk, not a lot of action.

What is your perception of what kind of action would be constructive to deal with the many pieces of this problem?

**MCNALLY** One thing we haven't talked about: Let's take it back to a younger age. We've talked about college age, but I think the foundation of where someone's interest is is much sooner—high school, maybe even sooner than that.

Some things I really like, and I think I'd like to see how we can capitalize on them. The FIRST Robotics program is an excellent program. To see the kids have the same spirit for a robotics competition that they have for a soccer game or a football game is great, and it really gets teams involved. It's not just the engineers and the programmers; it's also the people who are getting their hands on things, making them work—the future machinists, the future technicians who are really required in the industry.

I'd like to see how we can capitalize and bring together some of these programs, and define them in the context of the major problems we have in aerospace engineering. Take the Moon-Mars Initiative. Why can't we have a competition that's focused on systems-of-systems on a small scale, running around the desert and developing some of these competitive as well as cooperative pro-

# Examining the U.S. aerospace workforce

grams at the high-school level, and developing the skills where they can actually try hands-on?

I talked about computer programming. I think that's great. You can do things with the tools as well to develop these systems, even the systems that are the FIRST Robotics, the Formula SAE, these types of programs.

But we need to get to the point where kids actually see the results of what they do very quickly, then carry that forward into college with projects, combining that with other things at the college level, so they get the feeling that, when they do something, it accomplishes something in fairly short order. They don't start a career at a major aerospace company and wait 10 years to see that payload go into orbit.

So, that's the way I would look at it, trying to build that consensus at the low level, get kids involved with programs like FIRST, and building on that into the college level.

**WEIGEL** I just wanted to echo some of the things that Michael and Rick said. I think we really do need to change the perception of engineers. I see people entering university and they do have a cultural perception about what an engineer is.

Now granted, MIT is a fairly unique place. We have a lot of engineers at MIT and we tend to attract some of the perhaps stereotypical types of people who are engineers. But how much richer could our engineering culture be if we were able to attract people who did not necessarily fit that traditional stereotype? I really think it does have to start

with these cultural changes. They're very challenging to do, but I think they have some of the largest opportunities for payoff.

**BUFFENBARGER** Well, I agree with both Pat and Annalisa. We need to do something on a much larger scale to begin with. Knowing how things get put together and built, we need to come out with the statement that says—and do something about it, which this country has a tough time doing—that in America we have a belief that manufacturing is important.

From that very simple statement, we then cascade what manufacturing is important and how are we going to demonstrate that. And that would be the emphasis and the investment in all of the things, from the research and the development to the educational field, to the support of the arts and disciplines of engineering. To the reach we make to those who want to be not just the astrophysical or the aerospace engineer, but the person who is going to master the mechanics of putting together physical things and making them do something.

And then we get to the point in time where, yes, America does have a manufacturing policy and here's where we put all the pegs in. And at the end of it we come up with that action we talk about, that there is something in America you can study for, you can aspire to, that will be challenging, that will be exciting. And at the end of the day, there will be a reward in many ways for it.

We just have to bring ourselves from the beginning to say, it's important and we have to do it.

I think we can come to terms with it in this room. I do not understand why those who represent us up on that Hill can't make that determination.

**MALANOWSKI** I guess the thing that's burning inside me right now, and we've touched on a lot of things, is that we've got to hook the kids earlier to get them to FIRST Robotics. We've got to channel an interest and start that interest K-6, for example.

Raytheon is involved in FIRST Robotics; we've got a Retiree School Volunteer Association—you name it. A number of us are starting to affect this problem.

What's been missing in some of the discussion I've heard and we've been involved in is, how do we affect the elementary school teachers to help them understand the technical disciplines? What can we invest in the training and education of the people teaching the kids, to start channeling interest into math and science and technical education, because that's what's missing.

It's cultural change. It's a national policy issue. I'd like us to focus on how we help those who are teaching our children.

**RICHARDSON** At the AIAA, one of the major educational thrusts is teachers. We had a group out at Andrews AFB the other day who were so excited. We run teacher workshops every year, and it's one of the most popular programs we have, so I couldn't agree with you more.

**STEPHENS** Some may say that I'm about trying to boil the ocean, but there's a quote that I think is really key. "We're attempting to educate students today who will be



## A Roundtable Discussion

ready to solve future problems that have not yet been identified, using technologies not yet invented, based upon scientific knowledge not yet discovered.” Joe Laskowski said that out at UT of Austin.

At Boeing, I’m responsible for the birth-to-postretirement pipeline. I’ve got all the elements in between, including all the talent, all the training, all the development associated with that, as well as all the application of our Community Educational Relations dollars before that.

My sense is, we’ve lost what goes on from the time a child is born to the time they go all the way through the pipeline. It’s about creating capacity and capability. That capacity and capability is from zero to five, when 90% of the brain is developed.

If we just look at the statistics of what’s going on in this nation, we’ve got a lot of bright youngsters going through college. SAT scores are going up. But today, only 70% of our kids get through high school, and the number is going down.

We have a fundamental cultural thing we need to work, about how do we help parents develop the youngsters. And I would contend, when we start to take a look at that total system, from the time someone is born all the way through the time they’re in the workforce, we will begin to see some of the cultural challenges we need to work, and that will lead us forward.

I think we have the capacity to look at that broad system, pull the constituents in, and help provide some leadership in that area. Programs like FIRST Robotics; Dean Kamen’s program, outstanding in terms of what’s going on with FIRST LEGO League being brought into that.

But look at what’s going on in the broader cultural perspective. Kids don’t build Legos today to build them and tear them down and put them back in. Kids buy Lego kits to build them once and put them on the shelf.

This whole notion about creativity is based upon capacity and capability. We have a lot of data to tell us that, right now, as a nation, at the macro level, we’re missing an awful lot of capacity and capability that we need to go further. We’ve got to jack the bar up a lot

higher in that area.

I spend probably 20 hours a week on this broader subject, outside of my job within Boeing, because it is about getting people in our jobs to look at the broader system.

**GANNON** I think we’re talking about moving the world. Obviously, we have to find some leverage points. And one of the leverage points is education. We know that we have a very, very difficult time getting qualified math and science teachers in K-12 because the compensation is just not sufficient. And many times, unfortunately, our teachers were not the best students themselves. They may be just a little bit ahead of the students.

So, I would say that perhaps one of the leverage points would be some kind of a national initiative to increase the qualifications of our math and science teachers. And certainly K-12, FIRST Robotics, and those things that all of our companies and all of us are involved in are very important.

As they used to say in the GI Joe commercials, “Each action figure sold separately.” Each of us got where we are because at some point in time the critical idea of “yes, I can do that, I can be that, I

can become that, or that is interesting” was planted, either by happenstance or by whatever circumstance, in our minds.

When we’re doing this, we have to recognize that, although we may think our initiative is among the most important, we’re going to be one among very many people trying to do the same thing.

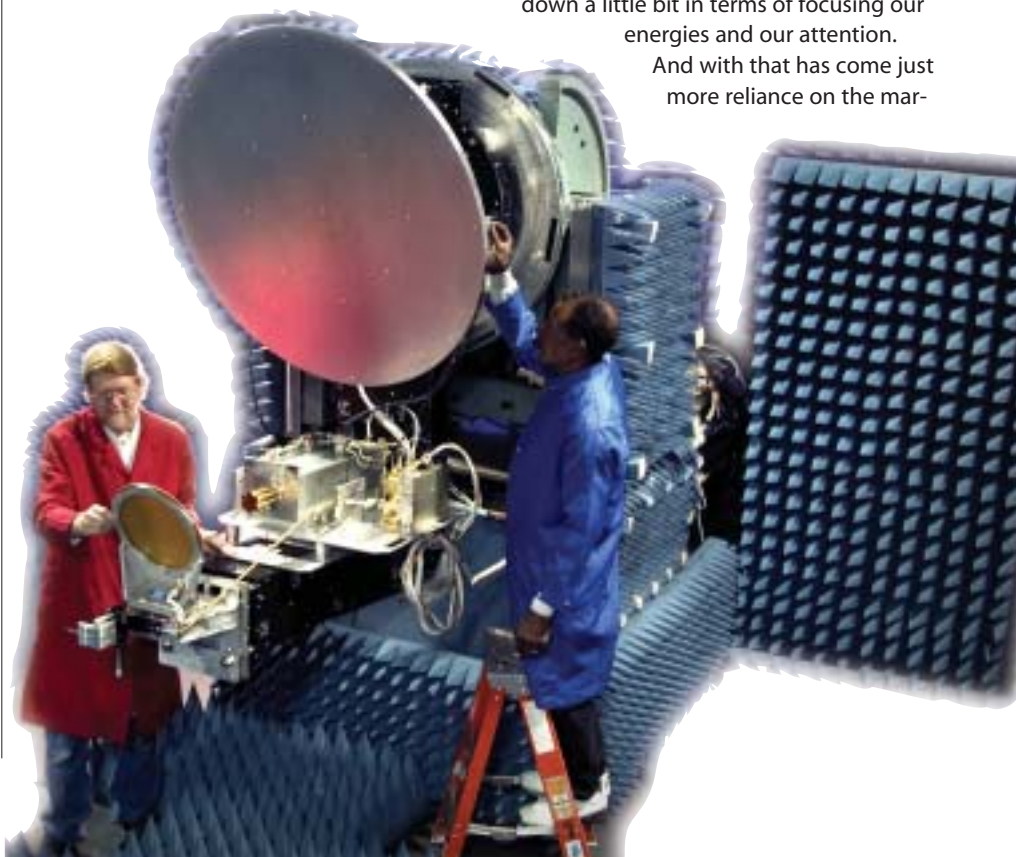
I’ll never forget going, in a different context, to meet with a principal of a school to offer what I could do for him. I thought I was going to be sitting in his office, and actually, I was in an auditorium with about 400 people just like me with a similar agenda, some other kind of idea. It was more art education, more music, more manufacturing.

There are so many of us who want to take our young children and open their brains and put something specific in them of what we have. We’re in competition and we have to recognize that.

**GIBBONS** From our discussion today, something that strikes me, building a little bit on what Tom was saying before, is kind of the effects of the ‘90s and post-Cold War, where the term comes to me, it’s just a void and a mission.

It’s almost like when you were saying the communists won. It’s like we let down a little bit in terms of focusing our energies and our attention.

And with that has come just more reliance on the mar-



ket or Wall Street, which is much more short-sighted in terms of what we need.

On a national level, we need to get the kind of leadership that would focus on a mission that is technologically oriented and focused—those are some of the advantages of a country like China, where they can focus on some of these issues and provide that kind of leadership.

I'm not knocking our leadership, but I'm saying that if we can focus on our needs to advance technologically and bring more students in, that will provide the kind of guidance we need, and all these things will come up from a lower level. There are lots of people who are interested in advancing and coordinating, but I think a bigger picture and a larger mission would help us.

**RICHARDSON** I think I heard that several times today. You get the last word, Bob.

**KUNTZ** From CEF's perspective, intellectual capital is the highest asset this country has. So, the management of that intellectual capital, the knowledge management has got to be number one, because that affects everything else. No matter what you want to do, you've got to have the right people to do it.

Picking up on what Rick was saying, if you're going to do something to increase students' awareness, appreciation, sensitivity in the sci-tech field, you've got to start very young.

When we talk about teacher training, we ought to be teacher training in mathematics or in physics or chemistry like ice cream and cake. The 87% who are sci-tech illiterate, you've got to sell to them like ice cream and cake, not sulfur and molasses. The other 13% are going to get their prerequisites and so on.

In-service training and NSF funds this. We ought to be in-service training the math and science and other types of teachers so that they heighten the students' appreciation, whether they're going to go into that area or not.

We need comprehensive career planning, so that students have the information to make a learned decision in selecting their career, not driving someone because we need more people in an area.

The second thing is that the career tech is at minimum wage. You have guidance

counselors with a student-to-counselor ratio of 700 to 1. And what are they dealing with? Drug intervention; broken families. Do they know anything about career education? The answer is no.

So, as Rick just pointed out, we have no system in place. We need a constituency, because that can be solved. There's no political constituency in this whole area, and what we have to do is develop it.

**RICHARDSON** Well, I asked for a call to action and we certainly got one. There are a

lot of diverse points of view, but it's very interesting that the call to action has kind of compressed a little bit.

There were only a couple of issues that came out of all of your different points of view: education of the teachers; reaching down further; and the political action—we probably are not as aggressive as we should be.

I don't know if we're going to influence the world in any way, but you certainly influenced me. Thank you all.

## PANELISTS



Don Richardson, moderator, is the corporate vice president of SAIC and the immediate past president of AIAA



R. Thomas Buffenbarger is the international president of the International Association of Machinists and Aerospace Workers



Tom Gannon is the director of leadership and career development for the Lockheed Martin Corporation



Michael Gibbons serves as the director of data research for the American Society for Engineering Education



Robert Kuntz is the president of the California Engineering Foundation



John S. Malanowski is the vice president for talent acquisition and corporate human resources for Raytheon Company



Patrick J. McNally serves as the director of industry business development at MSC.Software



Rick Stephens is the senior vice president of internal services for The Boeing Company



Annalisa L. Weigel is an assistant professor of aeronautics and astronautics and of engineering systems at the Massachusetts Institute of Technology