

ICEO '88 PANEL DISCUSSION  
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**WHERE DO WE GO FROM HERE?**

**Moderators:** R. Barry Johnson, University of Alabama at Huntsville  
Robert E. Fischer, Ernst Leitz Canada Ltd., U.S. Operations

**Panel Members:** Duncan Moore, University of Rochester  
Jim Pearson, United Technologies  
Ken Cupery, Eastman Kodak  
Bob Shannon, University of Arizona

**Robert Fischer** - Barry and I are going to co-moderate and the first question posed to the panel is where do we go from here. Whether this is the first conference of its kind or not we're not entirely sure. There have been other conferences on education in this field in the past but this one certainly was a very successful one. I think everyone will agree to that when we showed up early the other morning and had a pretty good attendance and a lot of interest - that set the tone for the past few days and I heard a lot of favorable discussion. We've talked about curriculum, we've talked about training for the real world, academia-industry interaction, the critical issues facing optics education, so we've covered a lot of ground. It might be a good idea to let each one of our panel members take two or three minutes to give their views and then we will come back and address some of the very specific issues. Duncan, since you made the mistake of sitting on this side, why don't you go first.

**Duncan Moore** - Now what I thought I'd do is refer to my elder colleague at the University of Arizona because he is clearly more experienced than I am.

**Bob Shannon** - The important thing that needs to be developed in the optics field is consistency towards the goals of developing a program. One of the important questions in relation with industry is applied optics, the basic key to what industry desires. If so, there are a lot of important questions that must be addressed. One of these is that in order to graduate with a Ph.D. degree, a student who has experimental as well as theoretical knowledge, it is going to cost somebody between 100 and 200 thousand dollars -- probably more. Lab equipment is expensive. Salaries are expensive. Probably 25 to 50 thousand dollars for each bachelors student. Now these are the realities, and my colleague at the far end, Duncan Moore, brought up these in detail in his paper. They think I'm right with those numbers. Therefore, there is a tremendous investment in these students before they go to industry, so industry may be concerned that when they hire somebody from somewhere they are taking a chance that can be expensive - somebody has already spent an awful lot on their behalf. My feeling on where do we go from here is that we need a good relationship with industry consistently assisting in paying some of the bills and helping us in finding ways to pay some of the bills - little things such as political assistance in telling your state legislator that jobs are important in this area. I think this is already beginning to pay off in several states. That's sort of a beginning toward the partnership. I have some other thoughts but I think it's time to pass it on.

**Ken Cupery** - I think there are two major issues here, and they both stem from the deficiency: what we mean by optics and optical engineering. It sounds like sort of a navel- contemplation issue and I don't mean it to be that way particularly. I've heard comments expressed like the optical industry

should get together and provide funding or do this and do that, and I don't think there's any consensus whatsoever as to what the optical industry is. I'm not sure all of those companies would feel ownership to the problems of optics education in optical engineering, yet they all participate heavily in it. Had I known this was going to be recorded, transcribed and published I would perhaps not use this analogy, but it is kind of like pornography, the supreme court can't decide what it is yet I think everybody who's in the industry has got a working definition of what the subject is. I know who's working in optics, you know who's working in optics. Yet we seem to have trouble defining what the basic commodity is that we're talking about, I think its absolutely essential to do that, particularly when we try to sell optics as an entity and if the optical industry is going to try to define what it is.

**Jim Pearson** - Let me see if I can pick up on that a little bit. There was a proposition that Barry put out regarding some form of certification which was roundly panned by everybody that thought that was a terrible idea, but I think one of the problems we have in communicating to the diverse industrial organizations is what optics is or how they can support it. I don't believe that it's recognized as a profession in the same sense as medicine would be or some of the other longer established engineering professional degrees like electrical engineering or mechanical engineering. We have societies and I think the society such as SPIE or OSA can form the center around which we can bring together the interested parties - the industrial organizations, the academic organizations and bring some focus on the problems in continuing optics education and making optics a more defined and recognized profession. One that legislatures can begin to recognize, one that government is going to begin to pour some resources into from a financial standpoint. Perhaps that is something that SPIE could consider that the governors could take a look at. They might take some guidance from what has been done in the IEEE. A gentleman yesterday commented that they have a council on engineering education and they use that as a way to lobby legislatures. I'm not that familiar with it so I'm not sure to what all uses it is brought but it also might be a conduit through which industrial organizations could bring funds to the problem of optics education that will open up a whole other can of worms of how to redistribute it but I'm thinking out loud here and trying to put forth some ideas about where do we go from here. We've talked a lot about it. If we can't translate some of the ideas and the thoughts and interests here into some real action, we'll be here two years from now saying the same things to each other again, so we need some mechanism, I think, to cause some attention or specific actions to be taken to foster a partnership between industry and academia and bring some better definition to the problem.

**Duncan Moore** - Where do we go from here? I think one of the main reasons I was an advocate of this meeting was to get educators and industrial people together. I think there is a common misconception among each group as to what our relative role in the Society is. I think that we all really know if we spent some time in thinking about it, but getting us all together to talk about these issues and what is important from each of our standpoints. That is the main function of the meeting.

It was good to have here at the meeting a number of educators from outside the U.S. who commented on what was going on in their country and some of their problems. Particularly I was interested in the writing problem and the communication problem. It's that sort of information transfer that can occur in a professional society when we gather from time to time. I don't think we want to gather every year but doing it once in a while just to review what is really happening in the education process is a very valuable one.

I am very much against a homogeneous model that every optics person should know the same things. I believe the marketplace will sort out a lot of those details. The recruiters will figure out when they want this type of person or that type of person and they will go recruit them. One of the virtues of the American education system versus the Japanese education system is that ours is very

heterogeneous and theirs is very homogeneous. Now the reason that in Japan you can get away with that is that there is a tremendous amount of on-the-job training. The education process doesn't end at all when you go out in the real world and so that is their advantage. We do not have that advantage. We are expected to deliver a product that can do something from day one and that's a bit of extra pressure that is created on the students and created on the faculty.

Another thing that we haven't discussed at all is that all universities, even in optics, can do all areas of research. We have to choose our shots. We choose them based on the fact that we were able to recruit all that we have on staff but for everybody to do all areas in optics, we just can't afford to do it any more. The cost is too high and I don't just mean dollars, I mean manpower, you've got to have critical mass in your faculty in certain areas. We are criticized at Rochester for not covering certain areas of optics. That's the way life is, you just can't do everything and it is a tough decision and you take a lot of heat from your alumni. It's kind of like dropping a traditional area such as football. I can't imagine Arizona dropping a traditional area such as football. But you take a lot of grief from the industrial people if you say no, we're not going to recruit in that area and a classic example at Rochester is thin films which we have as a conscious position, not continued to work in but other places are working on that and that's fine. I think that's the way life has to be. So having a difference of research areas and educational processes I think is the virtue of the American system and we need to play to that.

**Bob Shannon** - One of the issues that came up at the beginning of this meeting was that of identity and the question is what is an optical engineer. Perhaps one of the things that should be addressed is, can we as a society, and a group of professionals attempt to identify what constitutes an optical engineer. We've talked a lot about it but nothing ever happened and one of the major questions is are we trying to be exclusive or inclusive with respect to defining optical engineering. We're trying to be exclusive, it means that we know a field, we know what it needs, we want to develop the programs that will do it but, we're not really interested in being inclusive. That is bringing other fields in to become a part of optical engineering, whatever that may be. I've heard that theme being discussed a couple of times in the last two days -- if we could just accomplish a definition and a decision to which extent we as workers in the field want to be missionaries, that might be a useful result in meetings such as this.

**Robert Fischer** - Thanks a lot. Two things that I think would be nice to come out of this panel discussion are first, when should there be the next meeting if indeed there should. It's always nice to have a consensus on that and I'm not sure we need a reply instantly, but a year is always too soon, maybe two years is good and I just toss it out. The other thing that is always wonderful to come out of these things is action items and I'm beginning to hear a few gel here. We have an Academic Advisory Committee within SPIE which has its meeting in another day or two and I think that would be a wonderful thing if we could come out with 3, 4, or 5 real action items that the committee and the attendees could really tackle. Does any one else have anything really profound to add?

**Jack Gaskill (University of Arizona)** - I am not sure how profound this is, but for twelve years I've been pondering a problem. It has to do with what is optical engineering. In 1976, as I recall, a person at the Air Force Weapons Lab was trying to hire optical engineers and he couldn't hire optical engineers because the civil service commission doesn't have a job classification known as optical engineer. He knew exactly who he wanted to hire but he couldn't hire them. As a result, he developed a tremendously complicated program in which he hired 10 PH.D.'s in Physics and EE. He had 250 applicants - he weeded them out to ten. He hired those people and sent them to school to get a masters in optics and optical sciences or optical engineering and since that time I know I believe when Bob Shannon was the President of the Optical Society a gentleman who works for the government approached Bob and said "hey, can we put together a committee to study

accreditation" and the basic reason for that was he couldn't hire optical engineers. Is there some way we can present to the civil service commission something to create a stir so that the federal government would at least start to recognize the optical engineering discipline. Would that help the rest of the world? I don't know.

**Harry Ingham (Eastman Kodak)** - I would say its not limited only to the government either. I think you'll find that within many corporations there is no title that includes the word optics.

**Robert Fischer** - That's right, I concur with that one.

**John Walkup (Texas Tech)** - I think that when you consider the size of, for example, IEEE which has over 300,000 members. I think one of the really attractive ways of increasing the number of people in optics is to get more EE departments to, in effect, introduce courses. In fact, I think EE departments are under a lot of pressure because we feel that we have to teach students about fibers for example. That we have to bring in some optical information processing and some lasers. Frankly, one of the things that attracted me to EE is that I think EE's define themselves as being able to do all sorts of different, strange and exotic things and have over time picked up a lot of different things. I think I would go along with what Bob said that you want to be as inclusive as possible at this point in trying to stimulate more sources of people. Admittedly all these people won't be able to do all the things that you might like an optical engineer to do, but I don't think that's particularly critical at this point.

Getting back to what Duncan said that Centers will not be able to physically cover all areas particularly in research, it'll be absolutely critical that there be optics going on at all sorts of places.

**Bob Shannon** - Let me comment on some things that were brought up to the Optical Society a number of years ago and I don't even know if they're still working on it but it's an important issue. There is another issue that is important in the optics business, and that is for a student to obtain a real education means hands-on experience in research or laboratories and we have to address again the concept of finite numbers of dollars available, optics is not an unendingly large field and you can't teach it without there being equipment, without there being people and so forth and I think again it gets back to the question of how broad is the field, how thinly should the resources end up being spread in fact.

**Jim Pearson** - I'd like to maybe tie together the problem we see of having finite financial resources back to something you said Duncan and that is let the marketplace sort it all out. I think, in fact, the marketplace will sort out the needs but I think the time-constant there is long and the efficiency is low. We see a rapidly changing technology, shrinking dollar resources, and I'm not sure we can rely solely on the marketplace to do that. That interaction has got to be there but I think we're hearing a need for a definition perhaps of some standards. Maybe the certification the way you discussed it, Barry, there is a germ of an idea in there that ties together what Jack Gaskill said, but I would not rely on the marketplace. I just don't think we can afford it. I don't think the resources are there and I think the competition is getting too strong in the international market for us to do that.

**Barry Johnson** - What I'd like to do now is ask the panel to make a comment on the next question.

There are, as you said, limited resources available as Bob Shannon was pointing out and it's not only in the academic community but it's also in the industrial community. The industrial community and the U.S. Government are primarily on what might be termed a short fuse. It has a short time constant, programs change, needs change radically. The academic community has a much longer time constant probably on the order of one order of magnitude longer and the two

are very difficult to mate. What I'd like to ask the panel is how do you see or what formula or what process might you envision where we in academia can work closer with industry in narrowing that gap or the perceived difficulties of working together and conversely the two panel members from the academic institution, the converse of that. How can you help each other?

**Duncan Moore** - The question of the gap and the time-constants. I think when Jim made some comments this morning it was pretty well placed. That is the federal government is really working on short term projects and you don't have to be a very big businessman to realize that. All of a sudden programs are being turned off in no time. Things are being deferred and there is no long term commitment to science and technology in this country. That has nothing to do with optics. If you're in the DOD contracting business, it may be even worse than it is in some of the other programs but even the National Science Foundation for the academic community is trying to stretch things out because there is an incredible need to make the budget look balanced. So we borrow from next year or we push a program off to next year and then we keep pushing it off year after year and that's a fundamental problem for all of us. I'm not sure how I, as I said this morning, I'm a little worried about how short term our goals should be in the academic world. I think we each have a very important role to study in our Society and we need to recognize the differences in our role. I think one of the reasons we have this meeting is to do that sort of thing. Yes, we do cooperate, we try to get the cash flow generated from all sources possible and we have to interact in that respect but we've got to be real careful about what we do in the long term.

**Jim Pearson** - The word I like to use a lot is balance. It builds on what you were saying that in the academic community I don't think you want to shorten that time-constant. I think you want to keep the long term inertia in there that will go through the short term perturbations in government or in industrial "flash in the pan" ideas or needs but we do need to have the meeting ground. It needs to be kind of a smooth transition. There are some things that you need to address in the academic world that perhaps are shorter term and at the same time we in industry need to listen to the wisdom and the pressure to look at the long term. We say that to ourselves a lot and our actions don't often reflect what we talk about with 5 and 10 year strategic plans and the only thing we really worry about is next quarter's profits. But I think through forums such as this or through other meeting grounds, we can begin to understand those needs and get the broad perspective that we have to perform our individual roles. I have found in Florida that working with the high- tech and industry council where we bring together government, industry and the academic people to discuss just this type of issue, the government wants to put the money in this year and see immediate results in new businesses and industries lining up at the door to open plants in the state next year. You have to tell them that it just doesn't happen that fast, hang in there though and work for the longer term and that takes most of the long term or academic voices as well as the voice of industry to make that work. So I'm not sure I specifically addressed the question but those are the thoughts I have relative to it.

**Ken Cupery** - Can we talk about some of the problems concerning the relationships between academic community and industry? We often talk about the fickle nature of the affection industry has for a particular program or the attitude industry sometimes has that universities only approach us when they want money and scholarships and things like that and how come they really don't love us. We're sort of, I think, defining the environment sometimes that we all have to work in. It's the short term versus the long term interests as the different nature of funding the programs that exist, so not things that we necessarily need to change or will change but define the environment within which we have to operate. I think there are some good models out there.

I know my company participates in several consortia co-ops at different universities where there is in fact long term research funded by a number of corporations who have a specific interest in some kind of technology, whether its plastic molding, optical storage or a number of other subject areas.

The key, I think, to establishing those is not to go after them from a corporate grants department from within a corporation, but to go at them from a line of business where there is a real ownership and interest in that technology and there will be a willingness to commit money and interest and personnel to pursuing that relationship.

**Bob Shannon** - I think the thing that needs to be developed is continuing personal contacts between industry and people in a specific academic department. One thing that is frankly increasing which is good, is the number of student fellowships that have been made available. This provides some flexibility in allocating student resources. So a student can find his way through to the end of a program but I think industry also can be more helpful in equipping the student laboratories. It's a positive thing for a lot of companies. Students get access to equipment, maybe they'll buy some later on when they go out in industry and have the big bucks in industry to buy them. But I think more generally companies can help in developing a pool of good quality up-to-date lab equipment.

A couple of comments, the research centers have problems. Duncan referred to some of the difficulties of micro-management but on the other side they do sign up to a several year commitment and do provide some stability to the program and they're positive in that regard. So, in a way I'm in favor of them as long as they don't become a conduit to solve today's problems in industry. One thing that is interesting that maybe we ought to look at as a question of national policy is how things get put back in the pot by the users. Now NSF is supposed to fund research and secondarily education. The users agencies (DOE) should have as part of their mission putting something back into the pot to pay for the education that runs their programs. One interesting little gimmick that just turned up in the defense authorization bill, and I haven't seen how it will be resolved, is that because a particular congressman was displeased about the amount of funds that came back to the community slipped in a goody which said it was no longer legal for academic institutions to negotiate sole source contracts with any DOD agency. Now there's an interesting bomb. You work for years to convince someone that maybe 30 or 40 or 50 thousand dollars might be made available to fund some additional students doing some work in a specific area. Now under this rule if it happens to make its way through all that would have to go to Commerce Business Daily and be competed along with the overshoes and infrared detectors and steel that is being bought. In the academic world, you can't afford the luxury of having a promoter or sales department that goes charging around from agency to agency to find little opportunities and plug the holes. I think that industry can be helpful perhaps in recognizing that we need a 'set-aside' for education similar to the set-asides that go to small business. There are some difficulties with it that I recognize but it is a recognition of keeping the pot boiling and cooking with new students. Finally one of the things that we've all discovered is that the big hope for education in this country's technical education seems to be coming from the states, not the federal government, and then only secondarily from industry. That is great but its got a few years of life until all of a sudden the legislatures discover that we didn't get five thousand new jobs in optics in a given community because we threw a million dollars at education, and that can be a very, very difficult thing. The backlash from it can almost kill programs that have been started. Industry has to be cooperative in helping us with a political sales pitch.

**Robert Fischer** - What I'd like to do now is to ask each panelist, what is the most important action item? I've always felt that every meeting I've ever been involved in should end up with a list of action items and I think that it would be good to come up with some real precise actions. Something we can do, and show some benefit over the next 6 months to a year. What's your suggestions for short term action items?

**Ken Cupery** - I don't think we're going to define what optical engineering is but I think we can characterize it. The interesting part of going through the process of trying to pull the survey together and the results is the diversity of the programs that were out there and the way to start to

sort them out and characterize what a degree with a specialization in optics meant in terms of preparation and background at institution A, B, or C. I'm not talking about making value judgments or certifications or accreditations but I think we can do a better job of characterizing what it is we're talking about and perhaps reaching a pragmatic definition of what the subject is.

**Jim Pearson** - I'm not sure what the current charter of the education group within SPIE is, but I would increase its membership a little bit and give it a specific charter that includes the characterization that you were talking about but also promoting the industrial and academic interaction that has been stimulated by this conference whether it is through additional conferences or political action to the state and federal legislatures. All of that could be a role of that committee to develop ways to foster the beneficial things that have come out of the discussion here.

**Duncan Moore** - My action item is not to meet very often. I think one of the great things about this meeting is because it hadn't been held in a long time then we could draw a lot of people here from diverse backgrounds. And I don't want to see us beat ourselves by meeting more often than 2-3 years. I'm not too keen on action items for this one. This is a forum for interaction and talking and mixing socially to find out what each other is about and I don't need a whole series of bullets on this one.

**Bob Shannon** - There are a couple of things. I agree that you don't want to have another meeting just because this one is successful. I think this has been a very interesting forum, I think the guys who came at the end had more trouble finding things to talk about than those who came at the beginning because the issues do repeat themselves. The question is when will there be some new issues. I think a look by the education committee at what constitutes optical engineering, drawing perhaps on the experience of the academics and trying to put a program together and the experience of some of the industrial people in terms of their expectation would be useful. One thing I think should be considered is perhaps a guidebook for prospective students about the pluses and minuses and what they can expect with various kinds of degree programs and various places - it would be worthwhile. While I agree that the marketplace is going to sort out a lot of the programs and it may have already done so; but you know a person who has invested several years of their life in getting a degree only to find out they really made a mistake is not a proper thing for us to let happen. I think a person who goes to some school can expect certain kinds of opportunities. Those who take other programs of limited extent can expect other opportunities. Those two activities, a definition in falling out of it and a statement of expectation, might be useful things the committee could achieve in a year or so.

**Bob Fischer** - Any other action items?

**Gary Wilkerson (Teledyne-Brown)** - In Huntsville, we have a lot of programs called co-op programs in which students study for a quarter then work full time for a company for a quarter. This has three specific advantages. It shows the student what type of company they might like to work for. Also, it teaches them what they're going to do in the workforce and furthermore it can help them in choosing the right branch of their vocation.

**Duncan Moore** - At Rochester we run a masters co-op where a student works for a year. They come in the fall semester but we've found out that going out to work for a year has been a very productive experience for the students and some then come who are full time employees of some company because they can't afford to take off a whole year at a time, but they can take off two semesters at a time. Is that available at Arizona?

**Bob Shannon** - When somebody wants to do it, it's available.

**Duncan Moore** - Well, most of our students go to California. It's not geographically limited. You can find a student to go to California for a one year commitment because its neat but they won't make a commitment to a full time job. They get out there and find out that its a nice place to live, so the retention rate is pretty high. I noticed that, when the students who are gone for a year and come back, they are very directed in the kinds of courses they want to take.

**Perry Yaney (University of Dayton)** - I'm a product of the co-op program at University of Cincinnati. I did my co-op at Delco Products and radar work at Wright Field and I did my graduate work in Physics. It points out the fact that what you do in co-op may not lead you where you think it should. I would like to suggest a communication vehicle of some sort. I don't know what it would be, but I am offering that idea to the committee. I know what it means to have such things and I know what it takes to do it. We are together, and when we part we will see each other at meetings but I think it would be nice to have a line of communication such as a periodical newsletter between University and companies and to expand the number of companies, and this could become a very useful mechanism for communication to our students and so on.

**John Walkup** - I'd like to suggest that SPIE consider something akin to OSA's Educators Day, as something to do at the pre-college level. I think that is where the battle is going to be won or lost and if we do nothing the battle is already lost. When you look at Japan and other countries they're turning out significantly more engineers and scientists, and we're hurting badly at the pre-college level. That would be one area and another is summer job programs for those students. This will get them interested in the field.

**Jack Gaskill** - We've been doing some industry bashing, and perhaps we should do some Congress bashing. The authors of the '86 tax reform act need to be bashed a little bit because now that corporations are forced to pay their fair share of the taxes, they don't have the same benefits in educational contribution. Jim, you might want to comment on that.

**Jim Pearson** - With the new tax laws it becomes difficult for companies to have the resources to provide back whether it be in terms of capital equipment grants or fellowships or whatever it might be. I feel that particularly being a defense contractor where the DOD is coming down and saying we're going to allow you to have lower and lower profit margins. We're going to reduce your IR & D budgets, we're going to disallow a lot of the expenses and by the way, we want you to support education by sending money. It's just becoming a smaller and smaller pot. By addressing this through legislative action, we are on a bad roll as far as some of the tax laws and it's going to make it hard to do what we say we're going to do.

**Barry Johnson** - What I'd like to do is recapitulate what we would call action items despite Duncans desire not to have them. One is charges to the Academic Advisory Committee to enlarge its interest areas. I started this support committee last year and continued this year, and that committee has a life at the pleasure of SPIE's President. I expect Bill Wolfe would continue supporting it next year. I think that is what I'm hearing from the panel and the audience unless there is some strong feeling against it. One thing that should come out is a recommendation to Bill Wolfe as next year's President that the Academic Advisory Committee should continue as a support committee of the Society.

The second was to develop a definition of optical engineering. What is an optical engineer? This could be done through survey and with discussions with key people at academic institutions and in industry in particular.

Third, develop ways to foster support of government and industry. That is recommendations to help give guidance to people within the community and ways of doing that.



Fourth, develop a guidebook for students to help them learn about different programs at various institutions.

Fifth, educator's day for pre-college teachers, this should be jointly promoted by SPIE with LEOS and OSA. John, do you concur that it should be jointly done?

**John Walkup** - No, not necessarily. What would make a lot of sense is that we would like to see other Societies pick up and design their own educators days. Since SPIE has meetings all over the country, I think SPIE is a good organization for doing things like this in different regions of the country.

**Barry Johnson** - The final action item is when should the next meeting be. I've heard various feelings that it shouldn't be before 2 or 3 years and I agree with that, but I propose we have another one in about 2 or 3 years and that would be recommended by the Academic Advisory Committee. Let's see a show of hands if you would be in favor of that. Ok, we want to have another meeting in 2 or 3 years as determined by the Academic Advisory Committee. The criteria should be when the Academic Advisory Committee thinks they have something worthwhile and new to say.

**Don O'Shea (Georgia Institute of Technology)** - I think the action items should be carried also to the OSA in that John Walkup is the current chairman of the Education Council which is a statutory committee in which the chairman is an exofficio member of the board of directors of OSA. I will be the chairman for the next 2 years. There will be some continuity, and we will address the problem within the education council of OSA.

**Brij Khorana (Rose-Hulman Institute of Technology)** - I might point out how SPIE is organized. There is a standing committee in SPIE called the Education Committee. It was determined in conjunction with the chairman of the Education Committee that this issue on academics should be discussed separately to address that need because it did need some focused attention. Whether the Academic Advisory Committee will continue or move back in as a subcommittee of the Education Committee is a matter that will be discussed in the future by the Society.

**Barry Johnson** - I'd like to thank the panelists and my very congenial co-moderator and also for the comments from the audience and, at this time, would like to dismiss the panel.

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*Footnote:* This transcript has been painfully and carefully edited by the conference chairmen, and judiciously transcribed by Mark Clark and Erhard Krumpholz.