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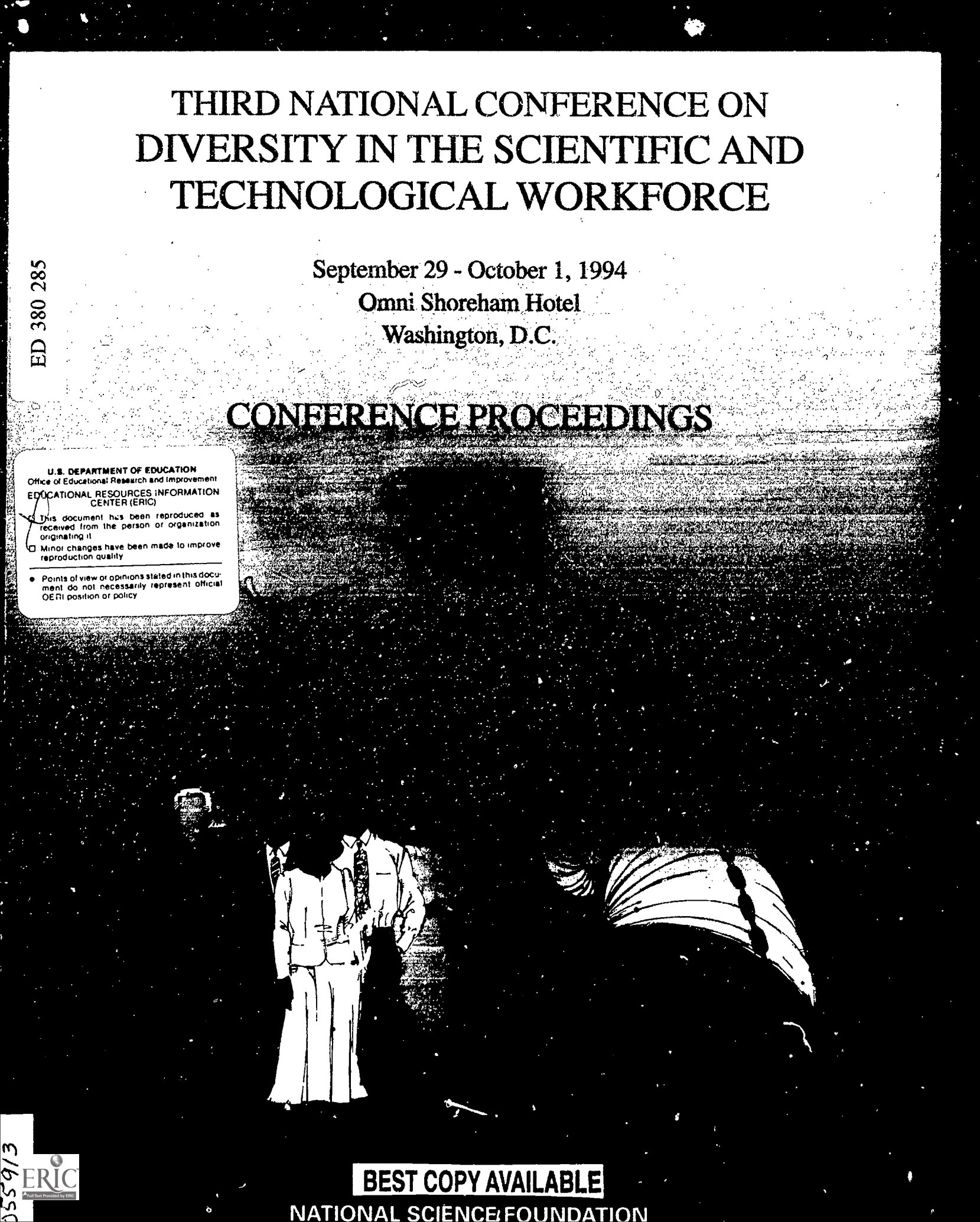
ABSTRACT

The conference served as a platform for presenting and discussing the National Science Foundation (NSF) action plan to increase the participation of minorities in the scientific and technological workforce. A broad group of issues related to conference objectives was discussed in a national videoconference. More than 300 students from elementary to graduate school who participated in NSF-sponsored research activities presented their research in panel and poster sessions (abstracts of all student presentations are available in a separate document). This report includes speeches by national leaders in the field of science and technology education and the award presentations. Included are a transcript of the national videoconference discussion; remarks from the forums and workshops (including the forum on undergraduate education, student forum, and directorate workshops on education activities); and the award-winning research papers in the precollege, undergraduate, and graduate categories. The appendices contain the conference program, a list of conference attendees, and a list of exhibitors. (LZ)

THIRD NATIONAL CONFERENCE ON DIVERSITY IN THE SCIENTIFIC AND TECHNOLOGICAL WORKFORCE

September 29 - October 1, 1994
Omni Shoreham Hotel
Washington, D.C.

CONFERENCE PROCEEDINGS



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THIRD NATIONAL CONFERENCE ON DIVERSITY IN THE SCIENTIFIC AND TECHNOLOGICAL WORKFORCE

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CONFERENCE PROCEEDINGS

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TDD: (703) 306-0090

NSF 94-4
(Replaces NSF 91-10)

EXTRA

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The NSF Times

Laeyo aoiou
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avoi bxyo mnstr laeyo
avoi bxyo mnstr laeyo

Volume XXX | Number 00 | September 21, 1995

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4th ANNUAL NATIONAL CONFERENCE ON DIVERSITY IN THE SCIENTIFIC AND TECHNOLOGICAL WORKFORCE

Washington Hilton
September 21-23, 1995
Washington, D.C.

Featuring . . . . . .

Student Research Presentations

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FIGURE 5
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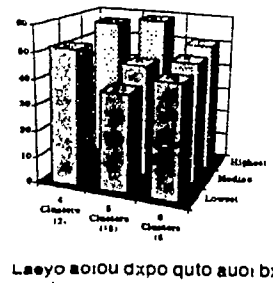

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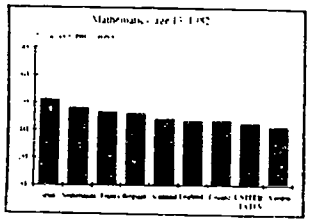

Research Symposia

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Speakers: National S&T Leaders

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Workshops & Forums

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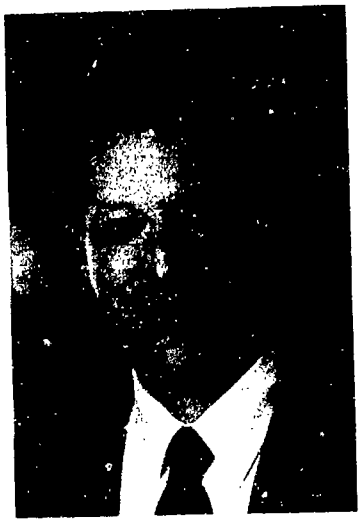


THE VICE PRESIDENT
WASHINGTON

September 30, 1994

Diversity in the Scientific and
Technological Workforce
Third National Conference
Washington, D.C.

Dear Friends:

I am pleased to have this opportunity to send my personal greetings to everyone participating in the Third National Conference for Diversity in the Scientific and Technological Workforce. In particular, I want to commend the National Science Foundation for its leadership in the nation's effort to increase participation in this field.

We rapidly are approaching Workforce 2000, a workforce comprised of the many and diverse groups that make up our society. Traditionally, minority participation in the scientific and technological fields has been dismally low. To increase the participation of minorities, it is important that we address these issues through forums such as the Congressional Roundtable Teleconference that you are conducting today.

Please accept my congratulations and thanks for the efforts all of you are making to increase minority representation in science, mathematics, engineering, and technology education. This Administration shares your vision of true diversity in the scientific and technological workforce.

Sincerely,

Al Gore

AG/wem

TABLE OF CONTENTS

NOTE: All presentations have been edited.

The views expressed by conference participants do not necessarily represent NSF policy.

INTRODUCTION

The National Science Foundation (NSF) Directorate for Education and Human Resources (EHR) sponsored the Third National Conference on Diversity in the Scientific and Technological Workforce from September 29 through October 1, 1994, at the Omni Shoreham Hotel in Washington, D.C. The conference—attended by more than 1,900 persons from the academic, corporate, and government sectors—served as a platform for presenting and discussing the NSF action plan to increase the participation of minorities in the scientific and technological workforce. The action plan was initially formulated at the 1992 diversity conference, and reviewed at the 1993 conference. Presentation of the plan, at this conference, was followed by sessions to gather feedback from participants on implementation strategies. The resulting plan will be published as a separate document after participant comments are incorporated and critiqued by NSF senior policy officials.

A broad group of issues related to conference objectives was discussed in a national videoconference, which expanded the conference audience to include thousands of college students and faculty nationwide. The conference agenda also included a forum on undergraduate education to solicit input regarding the future direction of NSF's efforts in this area.

As in previous conferences, more than 300 students from elementary to graduate school who participated in NSF-sponsored research activities presented their research in panel and poster sessions. (Abstracts of all student presentations are available in a separate document.) For the first time, students in grades 7–9, representing the Summer Science Camps Program of the EHR directorate, presented at the meeting.

The student research competition generated more than 70 outstanding papers, and the winning papers in each category (precollege, undergraduate, and graduate) are presented in these proceedings.

This year there was expanded participation by the NSF research directorates. There were more than 50 research presentations by students sponsored by these directorates. In addition, each directorate presented its education-focused activities in a panel setting.

This report summarizes the conference activities, including speeches by national leaders in the field of science and technology education and the award presentations. The appendices contain the conference program, a list of conference attendees, and a list of exhibitors.

OPENING SESSION

OPENING SESSION

PRESIDER

Luther S. Williams
Assistant Director
Education and Human Resources, National Science Foundation (NSF)

This is the opening session of the Third National Conference on Diversity in the Scientific and Technological Workforce. Dr. Roosevelt Calbert, the division director for Human Resource Development, will bring greetings.

GREETINGS

Roosevelt Calbert
Division Director
Human Resource Development, Education and Human Resources, NSF

Good evening. Welcome to the Third National Conference on Diversity in the Scientific and Technological Workforce. During the next few days, we will celebrate the achievements of the more than 300 students who participate in several focused and nonfocused programs supported by the National Science Foundation (NSF). These students are representative of the nearly 400,000 minority students who participate in NSF programs and who are here in spirit today. What a joy it is to observe these budding scientists and engineers at work. There is a sense of pride, confidence, and energy that permeates the air all around us.

To our project directors: You have done a magnificent job. You have stayed the course. Without your wholehearted support, guidance, and commitment, this event would not be possible. We at NSF thank all of you. To our student participants: You are on center stage. I know you are going to take full advantage of the opportunities at this conference to meet and interact with some of the premiere scientific and engineering talent in this nation. We are proud of you and your persistence toward excellence. To those parents in attendance: Thank you for providing that special love and security that only you can impart to your children. Your caring makes our job in education and research much easier. To Dr. Williams and Congressman Stokes: Thank you for your long-range visions and provision of resources, both human and fiscal, to address the issue of improving education and research across all of this nation.

But in the midst of this celebration, we must also take time for retrospection, because, as you have heard many times before, if we do not learn from the past, we are subject to repeat it. We must never return to the time when we do not make the provision of quality education for all students a priority. This conference confirms our commitment that all students be well served by our educational system, with special emphasis on science, engineering, and mathematics. Again, I thank all of you for your presence at this momentous occasion.

REMARKS

Joyce B. Justice
Assistant Director
Social and Behavioral Sciences and Education, Office of Science and Technology Policy (OSTP)
Executive Office of the President

I am not Congressman Stokes, but I am here to bring you greetings on behalf of the Office of Science and Technology Policy in the White House. It is a great pleasure to be here today. As one of the people who attended the first national conference, it is great to watch something grow and prosper. Science education and the diversity of the scientific and technological workforce are important aspects of what we do and care about in OSTP.

In August, the vice president, on behalf of the president, released our science policy document. In our document, we called for work on a national human resources policy. I am here to pay tribute again

to Dr. Williams and his vision. You have already moved far ahead of where we are. You have given us the blueprint for extending science and mathematics education and science, mathematics, and technological skills to all Americans. This country will not continue to be a leader of the free world unless we find ways to increase the participation of all of us in all that is America.

So welcome. Have a good conference. Learn from each other. Renew old friendships. I am pleased to be here with you.

Luther Williams

Thank you, Joyce. Dr. Justice is fairly new to the White House Office of Science and Technology Policy and obviously has a very important role to play in ensuring that the agenda reflected in this conference stays before the administration.

KEYNOTE ADDRESS

Louis Stokes
Chairman of the Appropriations Subcommittee on the Veterans Administration, Housing and Urban Development, and Independent Agencies (VA-HUD-IA)
United States House of Representatives

Good evening. It is a pleasure and an honor to be here tonight as the keynote speaker for this plenary session of the National Science Foundation's third conference on diversity in the scientific and technological workforce. I want to thank NSF and its director, Dr. Neal Lane, for inviting me to speak before you. I want to also thank Dr. Luther Williams, the assistant director of the Directorate for Education and Human Resources, for his continued leadership in the areas of science, mathematics, engineering, and technology education.

For those who may not be aware, the great strides made by NSF in this area could not have been accomplished without Dr. Williams' commitment to and vision for our Nation's pursuit of excellence in science and technology. This conference—and most notably the students whose work is being recognized during this forum—are a testament to his commitment to this issue.

I am here tonight to speak on an important topic: science and engineering education, especially for minorities. I have also been asked to speak briefly on Congress's views on science and engineering, and the role the VA-HUD-IA Subcommittee has played in these efforts.

As many of you know, as a Member of Congress for 26 years and as chairman of the Appropriations Subcommittee that provides the funding for the National Science Foundation, I am a strong advocate of programs that focus on educating minorities. As only one representative, I cannot present the views of all the Members of Congress; however, as the subcommittee chairman responsible for NSF and an advocate for the minority community, I feel confident in expressing my views on the future of science and engineering education.

It is all too apparent that, in this rapidly changing society in which new technological advances occur at ever-increasing rates, society must be prepared to face the challenges of a technology-driven environment. To this end, Congress has worked for some time—as has NSF—to improve science and science education in America.

To its credit, the administration has also recognized the needs in this area and has recently made efforts to improve our standing in this arena. President Clinton and Vice President Gore have both taken an interest in science, engineering, and technology. I am sure many of you know, or will hear about, the administration's science policy document, "Science in the National Interest," which sets out the goals for science, engineering, and technology in the coming years. This document charges the Nation to raise the scientific and technological literacy of all Americans.

In their opening remarks in this document, the president and vice president describe the importance of science and technology. I would like to quote, just briefly, a few of their remarks: "Technology—the engine of economic growth—creates jobs, builds new industries, and improves our standard of living. Science fuels technology's engine. It is essential to our children's future that we continue to invest in fundamental research. Equally important, science and mathematics education must provide our children with the knowledge and skills they need to prepare for the high-technology jobs of the future, to become leaders in scientific research, and to exercise the responsibilities of citizenship in the 21st century."

I am very encouraged by the administration's leadership with regard to science and education, and its commitment to making an investment in science today for building America tomorrow. I am partic-

ularly pleased that, with respect to our concerns about minorities in science and engineering, the document states as one of its goals the production of the finest scientists and engineers for the 21st century. Referring again to the administration's science policy document, another statement that is equally important is that America's tradition of excellence can only be sustained by engaging the talents of our diverse population. In fact, our Nation's strength was born out of our diversity and diversity continues to be one of our great strengths. Yet, despite America's emphasis on its melting pot, this Nation has not fully utilized or developed the skills of all the people—especially minorities. In most fields of science and engineering, women, minorities, and people with disabilities are underrepresented in proportion to the general population.

As we have seen time and time again, African Americans, Native Americans, and Hispanic Americans continue to be underrepresented and underutilized in a number of areas, but particularly in science and science education. There are numerous studies that document this fact; many of these studies have been directed by some of you present at this conference. Part of the problem, of course, is our educational system. Learning to be a scientist, an engineer, or a mathematician takes many years of training and requires young people to be involved in science education early in the process. The K–12 educational system inadequately prepares or motivates students, particularly minority students, for a career in science and engineering. Twenty-five percent of white, 34 percent of African American, and 37 percent of Hispanic fourth graders receive science instruction no more than once a week.

Further, according to measurements by the National Assessment of Educational Progress and other statistics, science knowledge and skills of African American and Hispanic students lag 18 to 30 percent behind those of white students. In addition, recent reports indicate that the average literacy levels for African Americans and Hispanics ranged from 80 to 90 percent below that of whites for certain language components.

As these statistics indicate, minorities are underrepresented in science, and improved science education is needed for minorities. Without a doubt, it is time to stop talking and take action. It is time to make a change, to improve the science education of all of our children so that we may engage their talents for the future.

Let me take a moment to applaud NSF for taking action to address the problem of educating minorities in science and engineering. NSF has worked to develop a strategy to confront the issue of increasing the number of minorities involved in science and science education. NSF has even gone so far as to publicly state its goals of increasing the number of minority undergraduate science and engineering degree recipients annually from approximately 14,000 to 50,000 by the year 2000 and to increase the number of minorities receiving science, engineering, and mathematics doctorate degrees to 2,000 annually.

NSF has developed several programs targeted at increasing minority participation in the fields of science and technology, including the following:

- Alliances for Minority Participation
- Research Careers for Minority Scholars
- Minority Research Centers of Excellence
- Partnerships for Minority Student Achievement
- Research Improvement in Minority Institutions
- Comprehensive Regional Centers for Minorities

These programs are designed to involve participants actively, from kindergarten through undergraduate school, encouraging them to pursue careers in science.

As the VA-HUD-IA Subcommittee heard from Director Lane when he testified on the fiscal year 1995 budget for NSF, great strides have been made in this area: Dr. Lane stated that genuine progress has been made in boosting the science, engineering, and mathematics enrollment of underrepresented minorities. For example, AMP, started in 1991, has funded 15 AMP consortia thus far, and the aggregate minority science, engineering, and mathematics baccalaureate degrees awarded for the first two AMP programs has increased by 15 percent.

While NSF has worked hard to establish those programs and increase minority participation in science, the VA-HUD-IA Subcommittee has also taken action in this area. This subcommittee has been a strong supporter of science education for many years. Since the mid-1980's, the VA-HUD-IA Subcommittee has not only encouraged NSF to improve science education, but it has provided additional funding to do so. In the past 10 years, the subcommittee has increased the budget requested by the Education and Human Resources Directorate of NSF (which is responsible for science education and

for many of the minority programs) every year. The Education and Human Resources Directorate has gone from a budget of $87 million in fiscal year 1985 to $570 million for fiscal year 1994, a 550 percent increase over a 10-year period. These increased funds have allowed NSF to expand its programs in the educational area and to initiate critical new programs such as AMP. According to NSF statistics, grant awards for minorities in all programs increased from 141 in 1985 to 390 awards in 1994, almost tripling the number of grant awards to minorities.

You may be interested to know that the increased fiscal year 1995 appropriation for NSF was signed by the president just yesterday. For the coming year, the subcommittee was able to provide a total of $3.36 billion for NSF. Included in this total is $606 million for education and human resources, an increase of $36 million over the 1994 level and $20 million more than requested by the administration. This is an increase of more than 6 percent above the current level.

Over the years, the VA-HUD-IA Subcommittee has articulated its support for science, engineering, and technology education in the House reports accompanying our appropriation bills. Once again this year, I made clear my strong support for the NSF programs that are designed to attract and retain more women and minorities in science and engineering. In the House report, I also went further and recommended to NSF that the AMP program be expanded in scope to include a mathematics and science teacher education component under the same terms as those currently serving the AMP students. Through this expansion, the AMP program could address the critical shortage of K–12 mathematics and science teachers of color. I hope that NSF will work to make this recommendation a reality.

I am interested in other issues related to NSF as well. In the past 2 years, I have been instrumental in working with NSF in creating a consortium for studying violence. At the request of the VA-HUD-IA Subcommittee, NSF considered the feasibility of establishing a center for the study of violence and concluded that such a center was both feasible and desirable. For fiscal year 1995, the subcommittee has provided NSF $2 million for initiating a consortium of institutions for the interdisciplinary study of violence. This study should provide valuable insight into the problem of violence which could be utilized in our educational system as well.

NSF has made great strides in improving science and science education in America and should be commended for its instrumental role in this regard. With congressional support, NSF can and has made a difference in seeking new ways to build a sound future for our children through advances in science and technology. In the years to come, I hope that—through the Congress's help and encouragement—NSF will be able to achieve its many goals in increasing participation in the sciences for all generations, and particularly for minorities. Science needs to be diverse. I look forward to working with you in this regard.

Thank you.

SPECIAL PRESENTATION

Presenter: Luther S. Williams, Assistant Director, EHR

Awardee: **Louis Stokes**, Chairman of the Appropriations Subcommittee on the Veterans Administration, Housing and Urban Development, and Independent Agencies (VA-HUD-IA), United States House of Representatives

Mr. Chairman, to do this as it really should be done, regard the words I am about to read to you as coming from the students in the Summer Science Camps, Careers Access, and all the other programs you have talked about, K–12 and undergraduate.

"Presented to the Honorable Louis Stokes, U.S. Congressman, for dedicated, sustained, and outstanding leadership and service developing the nation's diverse talent in science and technology. September 30, 1994."

—Luther S. Williams

NATIONAL VIDEOCONFERENCE

NATIONAL VIDEOCONFERENCE: POLICY ROUNDTABLE

PRESIDER

Roosevelt Calbert
Division Director, Human Resource Development
Directorate for Education and Human Resources (EHR), National Science Foundation (NSF)

MODERATOR

Luther S. Williams
Assistant Director
EHR, NSF

PARTICIPANTS

Peter H. Gerber, Director, Education Programs, MacArthur Foundation
Jaime Oaxaca, National Science Board Member and Vice Chairman, Coronado Communications Corporation
Lynette P. Padmore, Professor of Biology and Project Director, Florida-Georgia Alliance for Minority Participation (AMP)
James L. Powell, National Science Board Member and President and CEO, Los Angeles County Natural History Museum
Diana Garcia Prichard, Research Scientist, Eastman Kodak Company
Terry Cornwell Rumsey, Director, Office of Science Education and Technical Information, Department of Energy

OPENING REMARKS

Roosevelt Calbert

Good afternoon. Welcome to the National Science Foundation's Roundtable Videoconference. This videoconference is one of the major activities of NSF's Third National Conference on Diversity in the Scientific and Technological Workforce.

This national conference has the following objectives:

- To sustain national attention on the issues and concerns that undergird the science, mathematics, engineering, and technology education of minorities who are underrepresented in these fields.
- To highlight the National Science Foundation's accomplishments in broadening the participation of minorities in the science and engineering enterprises through its focused programs for this group.
- To honor leaders in education and research who have made unusual contributions to the academic achievements of minority students in science and engineering.
- To provide a forum for presenting and discussing the revised version of the NSF National Action Plan.
- To provide opportunities for minority students to demonstrate their capabilities in the performance of research.
- To allow broad interactions among the academic, congressional, business, industrial, and professional communities in the education of minorities in science, engineering, and mathematics.

Today, this teleconference will address the last objective. We are pleased to have all of our guests with us today. Dr. Luther S. Williams, Assistant Director for the Directorate for Education and Human Resources at the National Science Foundation, will be our moderator for the teleconference. He will

lead the discussion of several broad issues regarding the enhancement of minority student achievement in science and mathematics, ranging from the federal government's role in assuring scientific literacy for all citizens to the critical need to educate minority students to be productive participants in the workforce of our technological society.

PANEL DISCUSSION

Williams: I would like to start with an exchange on a generic issue. The issue speaks to the frequently expressed call for scientific literacy, which I think has been adopted broadly throughout society as a national goal. The question is not the merit of scientific literacy. It is, rather, the role. I would like you to give your answer to the question, What should be the Federal sector's responsibility for scientific literacy, compared to that of other sectors?

Cornwell Rumsey: First of all, we all recognize that there is a need for appropriate funding, and I am sure persons on the panel will elaborate on that, but beyond appropriate funding, I believe it's necessary for various sectors of the Federal Government to become aware of what other sectors are doing, because an informed constituency would be a supportive constituency. To the extent that our representatives are knowledgeable about what we are doing and are supportive of what we are doing, the public as a whole would be more supportive of our efforts.

Williams: Implicit in your response is the notion that the Federal Government—the various agencies supporting these programs of science literacy—would profit from a communications program in which the Federal Government would state its goals and objectives. That is, the Federal Government should explain the progress it is making toward achieving those goals, as opposed to simply evolving its responsibilities for discrete funding and assuming that a broader community actually understands them or appreciates them.

You also spoke specifically to that constituency. It seems to me that something of the sort that I just described would be required in order to have that kind of communication.

"The problem that we face is not race or people oriented, it is power-transfer oriented. People do not want to give up power. What we must do is develop the talents of the whole American population . . . This leads to people being phased into positions of power. . . ."
JAIME OAXACA
National Science Board

Oaxaca: You know we are going into the 21st century with profound changes in the world, and these changes are going to be largely driven by the one superpower that is left, and that is the United States of America. I think we must all remember that whether we want to accept it or not, any country that has unraveled, did so because it did not meet the three legs of the stool that have made America the premiere country that it is—a strong defense, economic stability, and social progress. Now each one of those legs requires a quality education. It requires the best and the brightest and the vision of these young people who are going to be the leaders of tomorrow.

If we look at Haiti, North Korea, and Bosnia, if we look at any country that has just gone through major turmoil, one or more of those legs collapsed. In each of those countries there was a very small set of "haves" and a very large set of "have nots." That gap is widening.

When Luther and I were on the Task Force for Women, Minorities, and the Handicapped in 1989, the numbers we used were 85 percent of the emerging workforce would be women, minorities, and the physically disabled—I think that number still holds.

The problem that we face is not race or people oriented, it is power-transfer oriented. People do not want to give up power. What we must do is develop the talents of the whole American population in such a way that we become even better than we already are. This leads to people being phased into positions of power, positions of policymaking, positions that are going to be good for our country. We have to attack the whole education problem in parallel across the whole continuum, and we have to do it with programs that go all the way back to prenatal care, because the percentage of kids being born in America to single women is pushing 40 percent. We start at the very beginning with the basic premise that anybody can do it. I am referring to what Jaime Escalante calls "ganas," which is desire.

By the same token, in these days of budget constraints and a changing environment, given the fact that 40 million people today are working out of their home, we must have an initial mindset about computer literacy. We have to jump on the information highway. At the same time, the American public is going to demand accountability, so we must have measures in place along the way so that we can have a midcourse correction. All of these things must be pushed.

Now when we talk about scientific literacy, look at the demands in today's technology. I have a mother-in-law who is 87 years old. She has to take 16 different medicines every week. We had to educate her about the problems if she takes them out of order, if she does not take them at the right time, etc.

So scientific literacy for someone who is elderly is different than scientific literacy for someone who is pregnant or someone who is in the first grade, or someone who is just getting out of high school and is making the decision to go to a community college or a four-year college or to work. If we do not upgrade to that level in parallel with all the other things we're doing, then we have made a terrible mistake.

Williams: On the last point, I would like to use it to direct your attention to another issue. When you were responding, Jaime, I was struck with your general concern about engaging the total society around the broad issue of science literacy. I want to ask your response to that issue if, in fact, you focused it on the agenda of this conference, how to actually change the landscape in terms of participation and diversity, how to change it in a substantial and highly expedited fashion.

For your response, I offer the following: One of the current deficiencies, leaving aside how noteworthy the individual programs are, is that this whole enterprise is not connected with the larger national dynamic. For example, clearly, the country is dealing with health care reform and acknowledging that this is a major step-function, a transition essential for the country into the next century. The country has dealt with fiscal controls, the deficit reduction act (leaving aside how one feels about it), and the crime bill. There is an emergence of reform efforts.

"There is something called education reform that is taking place in the country but it's operating at a different level. . . . It is as if it is a desirable good, not an obligatory good. . . ."
LUTHER WILLIAMS
NSF

But I would submit for your consideration that mathematics, science, and technology education in the specific instance of minorities or even the overall education reform effort is not accorded a comparable position in national dynamics. There is something called education reform that is taking place in the country but it's operating at a different level. It is as if it is a desirable good, not an obligatory good. My inference is that health care reform is obligatory. It has been connected to the very epicenter of national transactions.

Powell: I would like to take off on that, Luther, and in typical Washington fashion, not answer quite the question that you just posed—I have learned that from watching some of the television programs.

I would like to go back to the principle that underlies what you are saying. There are clearly many people in this country who believe that every citizen has a fundamental right to good health care. Probably nobody would deny that in public, but in terms of their actions and their votes, you would have to conclude that people have different feelings about it.

If I go back to why we are at this conference, why you and I are working with NSF and our colleagues are here, I think it goes back to the fact that we believe that every American or every human being has a fundamental right to achieve their human potential. You could argue that is the most fundamental right of all. Therefore, every human being and every youngster has a right to at least have the opportunity to become a scientist or to learn about science.

". . . we believe that every American or every human being has a fundamental right to achieve their human potential. . . . Therefore, every human being and every youngster has a right to . . . the opportunity to become a scientist or to learn about science."
JAMES POWELL
National Science Board

If you turn from the principle of the matter to the practical side of it and you look at a country as large as ours with all sorts of problems and needing to advance in a wide set of areas, it is demonstrable that we need to draw on the talent of all of our citizens. If we only draw on the talent of half of our citizens, we can not thereby support 100 percent of our citizens. So we have to draw, as a practical matter, on the talents of everybody, of all races and both sexes.

I think if you look at our history, at the problems that race has presented for this country since the beginning, if you look at the economic problems of the States and the major cities, I think you would come quickly to the conclusion that education, and specifically science education, is like defense. It is like transportation. It is an issue that cannot be solved and will not be solved on the State level. It has to be solved, if it can be, at the Federal level.

Therefore, I have long believed that there is a very strong, appropriate Federal role in science, engineering, mathematics, and technology. Ten or 12 years ago that was not generally accepted. There was a move to get rid of the Department of Education. There was a move to eliminate funding for science education and NSF. Fortunately, neither of those things happened.

You are taking this a step further, Luther, and asking whether, given all of those things, we need a more targeted effort and a much stronger effort to solve the issues of minority education, and I am inclined to think that we do. I am inclined to think that unless there is a coordinated national, Federal effort— not just at NSF, but at all the agencies—we really will not make satisfactory progress on this goal.

Gerber: Luther, I think we have to be very pragmatic about this. The Federal Government expresses a national interest. The national interest is in having an economy that has more people supporting it than there are people who are depending upon it and not contributing to it. We have a society that would like to have that, but we also have a society where some folks do not like to live next to other people. They do not want to work next to other people. They do not want to have their kids socialize with other kids.

Now in the society we are talking about, everybody is mutually dependent. It is going to take a targeted, strenuous effort on the part of the Federal Government to express a national interest in the collective value that we have for everyone to learn in order to go beyond these individual preferences and social patterns to an educational system connected to an economic system.

Therefore, I think that your idea of a strong communications effort is very appropriate. The problem is that it is going to have to confront people with unsettling ideas and cause them to think about things in their own lives that are not consistent with these thoughts that we are expressing here right now.

Cornwell Rumsey: Yes, absolutely. First of all, I agree with everything that I have heard my colleagues say thus far. Furthermore, if you take a hard look at some of the work that the Federal agencies have done over the last couple of years with respect to supporting science education programs, it has been good, and it should be recognized. However, a lot of those efforts have been fractious. They have been independent. The reality is that there is a sense of urgency now that we have not had before and there is a major need that we must orchestrate and be able to articulate clearly for the American public.

A number of subcommittees are under the guidance of the National Science and Technology Council, one of which is the Committee on Education and Technology. That committee attempts to bring to the table all of the Federal agencies that have a vested interest in ensuring that the pipeline of future scientists and engineers is assured so that our workforce needs are met.

The second need, but equally as important, is to contribute to the larger goal of achieving a scientifically and technically literate workforce.

A number of memoranda of understanding are currently being pursued between the Department of Energy and the Department of Education, between the Department of Energy and the National Science Foundation. We are all in this together, and as my colleague to my right pointed out, it is a problem that is not going to go away. We really do require the best ideas, the best resources in the public sector, in the private sector, and in academia to be able to identify those opportunities for success. We then need a communications strategy that helps people understand how that success translates into making their quality of life better today and in the future.

Williams: Another issue I would suggest is that developments in the last year-and-a-half have served to raise the threshold against all of our efforts and aspirations to move minorities into the scientific and technical arena. They are manifold, but I want to cite three developments and I would like your responses to them, starting with Diana.

One is the advent of the information superhighway, which, as an expression, is rhetoric, but beneath it clearly is a whole set of fundamentally important issues that have to do with learning and productivity; have to do with judicious use of technology in delivering information; and have to do with access—a set of issues, Jaime, that will be much more important in terms of impact than the ability of your mother-in-law to take her medicine appropriately—because the participation level is heightened by technology. The issue of access is one variable, that in the interagency context, has a very important role for a department that rarely does business with us in an interagency context, and that is the Department of Commerce.

Second, in the aggregate, what are we really concerned with in the instance of minorities? What we often refer to as "science education" is what I would term "training." An outlier—and, some might argue, a counterproductive outlier—are the multibillion-dollar expenditures of the Department of Labor.

It seems to me that in terms of its return to society, a Labor Department Job Training Partnership Act program that attempts to take

a 25-year-old person in the City of Chicago and give him short-term training to enter the computer technology sector is an ineffective approach to problem solving; especially if that person brings to that process an absolute paucity of knowledge of mathematics and science. I am talking about an individual who has not benefitted from the K–12 educational process and we're trying to do a repair job at age 25 because the person needs employment. So the second issue I want to raise is the need to conjoin training with education.

The third point is one Peter mentioned, and that is whether the evolving cultural conditions in the country—some of which are promoted by sociobehavioral conditions, that is, are motivated by fiscal stringencies, unemployment, job transformations, etc.—disallow making progress in this arena on equal opportunity considerations alone. In other words, is it good business?

So through three factors I have tried to take what would be an otherwise generic linear problem-solving strategy in which we are really calling for all of the players to come to the table, for which we want to have an effective communications strategy, and I have made it more difficult by saying that there are other major players who are not at the table.

The implications of the advent of the information infrastructure are unknown, but it clearly increases the complexity of this arena. Certainly, in the sociobehavioral domain we need to candidly state to the American people what we are attempting to do. Are we really attempting to provide the opportunity for minorities to join in the scientific and technical enterprise, or are we attempting to redefine quality of citizenship?

Garcia Richard: I would like to comment first on the superhighway. One of the things that I have noticed is the whole generation of people out there who are involved in the information system that now have access to people in the university. For instance, at the Rochester Institute of Technology, there is an Institute for the Deaf. That informational system has opened up a whole new arena to these people. The same could be said about the physically handicapped.

As more and more of the young people get into that informational system, it is very important for all of us to become part of that, and there has got to be some monitoring, because it is surprising what comes through some of those systems.

The other issue I want to comment on is not only communication among agencies, but also their collaboration. If something becomes a national issue, then all the agencies should come together and pool their resources, because there is no question that the fragmented dollar is not going to be as effective as a concerted effort. So I would even go a step further in the communication part of it.

The other part is the training. There are many gaps in people's education as they move along the pipeline that make it harder and harder for them to move farther along. So when they finally come to a job, some people are well trained, others are not. There must be some kind of intervention in these big gaps that we see, like the transition between high school and college and community college, etc.

Job training is a big issue. As we move toward a more technically sophisticated society, there are more people left behind. Being part of the Eastman Kodak Company, where we are "rightsizing" and "downsizing," what I have seen is people who have been there for 10 or 15 years who have lost touch with the technology of today. They are no

longer as productive as somebody who is coming out of school. So we really want the most trained person to come, and science literacy and all the other comments that were made refer to economic development and the urgency of getting to that point of work based on technology.

Oaxaca: I think we face an interesting problem. Historically, "minority" has been associated with an affirmative action check-off box. Consequently, America at large, I am convinced, does not really recognize these programs as an issue of national security. They think it is a "gimme" or throw-away for the downtrodden, which is not the case at all, because whether anybody wants to accept it or not, the demographics are there, and I maintain that 85 percent of the emerging workforce is going to be the so-called minorities, and that is a lot of people.

So you have to change the mindset of Congress, of corporate America, of everybody whom you are dealing with. You are starting to see it in corporate America. You're starting to see it at the conferences, where the recruiters are out there working all of the minorities, because they actually do very well when they make it through the pass.

At the same time, if you look at the policy that was set by the Federal Government in the so-called defense conversion, we have laid off thousands and thousands and thousands of the most talented people in the world, the ones who brought the Soviet Union to its knees, and there has been zero planning about how to utilize that talent. Most of them go out and start their own little businesses, which is fine, and that is what you want, but it is not focused in any way to solve any national problem. It is not focused in any way to set up for the future, to be the mentors and the guiding folk for the young people who are coming along.

The issue of retraining is, in my mind, one of not being effective at all, because you do not see retraining. In today's world of the special interest group, the squeaky wheel gets all of the oil, not just some of it. For example, in Los Angeles, they will lay off a total of 25,000 people at TRW, Hughes, and Northrop and it comes out on page 16 in a little article. You try to lay off 23 people in the City of Los Angeles, and the world comes to an end because they are civil servants who are working for the city and they have a constituency that says the world's going to come to an end. Yet the 25,000 talented people you have laid off are Ph.D.'s and communications scientists.

I have an example in which they called back a TRW employee who has everything but his thesis done for his Ph.D. (in telecommunications and all that transsatellite stuff) to retrain him to be an 18-wheel truck driver, a nine-week course. Why? Because they get a tax incentive at TRW. It is criminal, when these people could be working on all sorts of other stuff. There is no training, there are no programs, there is no tie-in. There is a full-blown disconnect. And until, across the board, people recognize that this is not an affirmative action check-off box, it is an issue of national security.

I think we are now at the point where it is a marketing problem, it is a public relations problem, because all of the infrastructure is in place, but I do not think we can wait for the normal course of events, because America only reacts at a crisis time.

Powell: I would like to take off on your first point, Luther, which has to do with information technology, which I have long been interested in as an amateur, and, as you know, I was a college administrator for many years.

We have been hearing for a long time that the computer is going to revolutionize the way we deliver education and the way people learn, and I still believe that it will. I believe that very firmly. But I would also have to admit that it doesn't seem to have happened yet.

I think before we worry too much about the information highway, we ought to worry about providing access to basic computing equipment to essentially everybody, every student. And if you think about it, I don't believe that we have approached this in a comprehensive way. My understanding is that we are letting 1,000 flowers bloom.

If a school right beside Microsoft can scrape up the money (which is a little easier if you are there), it can get thoroughly outfitted with hardware and software and can make tremendous advances, and I am glad that somebody's doing it. But I probably would not have to go very far from here to find classrooms in which it would be surprising to find a computer, and if there were one, it would not be very well used. It would be an Apple II or something back several generations.

"I think a more fundamental revolution is needed, one that sets high standards of learning for all students. That would be a true revolution in this country."
PETER GERBER
McArthur Foundation

In other words, I am saying that I do not see any coordinated massive Federal effort to try to produce this revolution. I think that unless that happens, we are going to miss a great number of opportunities, and I think of it the way I think of the NSF science education programs—the way they were not too many years ago, when we were supporting what you might call pinnacles of excellence, good work here and a good program there. I voted for these; these were fine programs.

Now we are thinking systemic. I believe we ought to think systemically about using information technology to revolutionize the way we teach and students learn. I cannot prove it, but I have a feeling that it could have more of an impact on minority students who generally are more deprived and do not have access to this equipment than it would on majority students.

So I would like to see if there is some way that NSF could take the lead in bringing about this revolution that I see as inevitable, but that is taking longer than I ever imagined that it would.

Gerber: I think a more fundamental revolution is needed, one that sets high standards of learning for all students. That would be a true revolution in this country. And I think following that revolution, we will have equipment, computing power, and other things brought to bear on the education of all kids. Until we have high standards of learning for all kids, we are not going to make the investment because we can slide off of that investment.

Those standards for student learning are going to bear on the standards for teachers. They are going to bear on the standards for the quality of curriculum that's delivered, the timeliness of the materials that are available, the quality of the physical facilities that are available.

An hour ago, the House was supposed to take up the conference report, and I hope that they passed a bill which is intended to elevate the standards through Chapter I of the Elementary and Secondary Education Act. If they did not pass it this year, it will come back again. But I think that is the fundamental revolution.

And the point I would make about that revolution is that the Federal Government has to articulate it, each community in which kids live has to articulate and demand high standards for their kids—not relatively high standards or standards that are compromised by their socioeconomic status or some other factor, but high standards for all kids. This needs to be a cry from the people to the Congress as well as from the government to the people.

Williams: Your reference to standards leads me to another area for your responses. One of the experiences NSF has had in dealing with large urban communities through the Urban Systemic Initiatives Program, has essentially three components.

One: Substantial confusion, vacillation, and I would even say reluctance to make as a uniform condition high standards for the entire enterprise, which is to say for our students.

Two: In many of the transactions in these schools—and I am not implying that the schools in the 25 cities with which NSF is operating are unique, but that is my sample at the moment—there's an incredible infusion of resources in support of what I would call deficit models for education. I am implying, at least from my point of view, that this is undesirable, a deficit as opposed to an achievement model.

Three: I have reached a tentative conclusion that there is a correlation between the amount of resource expenditure and one's ability to institutionalize high standards for our students.

My question to you is, what do you think is required to actually entice these large bureaucracies to make the transition from a deficit to an achievement model? Let me make clear the implications. The achievement model says that a collection of third graders must, in fact, have a series of experiences. In a deficit model, some trivial fraction can escape from it—I am being uncharitable—and move to an achievement model, but for the substantial majority, what they get rewarded for is pedestrian or minimum performance, and if that continues, then you cannot have this high standard of which Peter speaks and you will not have the outcomes that we have all talked about in terms of educational product.

So the question is not trivial: Are there strategies that could be employed by individuals who are outside of that bureaucracy that could aid the system in redirecting those resources?

Let me be very explicit about what I am saying. Maybe everyone else understood this, but what I have discovered in the last year-and-a-half is that in very large urban communities, there is a multibillion-dollar enterprise (when I say "multi," I do not mean tens of billions, I mean hundreds) that is entirely devoted to a deficit model.

Powell: I lived in Philadelphia for several years, a city that is really coming back under an excellent mayor. We also had a wonderful superintendent in Connie Clayton, who has retired. I do not know the new superintendent.

But I think to bring about what you're talking about, it is another kind of revolution along the lines of what Peter was saying, one thing it would require is leadership, and it is not just a cliche. You would have to have leadership from the mayor of Philadelphia, in this case, and I think you would. You would have to have leadership to get a high standards model adopted by the city politicians, by the congressional delegation, by the parent groups. You would have to have a superintendent who really was willing to go out on a limb in favor of it. You would have to generate a wide base of support, led by a few key people. Then you might have a chance.

Padmore: If I may add to that, I think we have to tie high standards to high expectations. In an earlier statement, you mentioned the fact that you can have short-term training, but short-term training should be focused. It is like employing someone for 4 hours of labor. It makes a difference if that individual is thinking, "I am working four hours and I am making $10 an hour"; if he or she thinks, "I am working 4 hours to support my family"; or if he or she thinks, "I am working 4

hours to build a building that will support a structure that will benefit other individuals." You have to tie in high standards with high expectations.

I think to the extent that we do that, our efforts, both in the educational system and outside the educational system, will be more beneficial to society.

Cornwell Rumsey: I think that the language that we use is an important enabler that must be understood. We have talked about communication strategy, we have talked about marketing. One district comes to mind—the unified school system in Oakland, California—that has had significant success with respect to their systemic reform efforts in science and math education.

You talked about deficit versus achievement. Jaime talked about the so-called minority. Language is important. If we are going to advance these notions, making sure that we have all of the partners who have a vested interest in the success, we must come up with a new way of describing this so that people understand.

For instance, I have dropped out of my vocabulary certain words. I don't use the word "minority." We talk in global terms about global competitiveness, the global village. Human resources are global as well. When you take a look at people of color and women, we are not minorities, so I don't use that word. There are messages that get transmitted when you use certain labels, for example, "disadvantaged" or "people at risk."

I am the mother of an 8-year-old son who is at the point in his development where he tries to validate his self-concept and his self-esteem. Can you imagine for a moment being in his shoes, turning on the television, and being confronted with images, both overt and subliminal, that constantly say you are disadvantaged or you are not quite equal?

I think we have to be mindful of that, and I think that we have to find new metaphors and new descriptors to encourage everyone to recognize the value that inclusion brings and the sense of urgency that we have all addressed.

Oaxaca: I have a bit of a disagreement with Peter. I have no problem with high standards. If we look at the military model that was used in Desert Storm and again in Haiti (and there's the classic operable workforce diversity, the only true one probably in the universe), high standards went along with the best equipment and they had no current parallel. We couldn't have one to the exclusion of the other, because the training occurs and it is a closed-loop system that keeps building up, either good or bad. Alternatively, look at the Iraqis with lousy equipment and they went the other way. They had high standards and lousy equipment and they went down the toilet.

I hit the streets in South Central Los Angeles and East Los Angeles. I talk to kids, and then I hang around with the smart set and I talk to those kids, and they know—they are on CompuServe and they are 6 years old. Go to East Los Angeles or South Central Los Angeles and talk about CompuServe or Internet and they give you a blank look. We have to bring in the equipment early, the very best equipment.

We have a mindset, once again, that the groups in those areas merit the used equipment from the smart set because they can use it, as opposed to saying they merit the very best because they need it more.

We also have a group in the science and technology community who don't want any of this to happen, because they are like the American Medical Association. If we only have one brain surgeon, that guy can

really charge for operations. Therefore, they will bring in Soviet scientists at the expense of Americans, and they do it consistently. Yet these people will come into town, get financial aid, and then they will leave town with intellectual property and compete against us—and we give them accolades! It is insane.

We must take care of America first, and then worry about the rest. But there is a mindset that a Viennese accent is worth 50 grand in the marketplace and a ghetto or a barrio accent costs 50 grand. That is dumb. We have to change that mindset, and I submit that the only way we are going to do that is to work hard with the talent that we have, and I think we have enough talent now to put people in positions of policy decisionmaking, and then we need the leader who says, "Here's what's going to happen."

When I was president of one of the divisions of Northrop, they would ask me, "Why did you place so-and-so with that funny last name or that Afro-American there?" That wasn't what they were asking. They were saying, "I don't want him there or want her there." And my answer was very simple. "I'm president."

[Laughter.]

Gerber: Earlier in his remarks, Jaime said that he disagreed with the point that standards needed to precede and pull the investment and the equipment. He sharpened my thinking on this. I do agree with him that we can make a front-end investment. Unfortunately, in education, we have a history of making front-end investments and those front ends have ended up in closets and garages at schools.

What we also need along with the investment and these high standards is a press on the schools to make good use of them, so here are a couple of ideas that I have in that regard.

One would be that the colleges that have significant enrollments of minority students—and still use that term—ought to go back to the elementary schools whence those kids came and take a hard look at the preparation those kids are getting, and exert some pressure on behalf of the kids who are still in 3rd and 4th and 5th grades with regard to what those teachers are doing, the expectations that those teachers have, the satisfaction they have about the progress that those kids are making.

Another suggestion would be that those who advocate and advance civil rights on behalf of folks ought to visit these schools and ought not to be satisfied with the attention given to these kids. You know the old line about comforting the afflicted and afflicting the comfortable—they ought to afflict anybody who is comfortable with the progress that these kids are making in their schools in grades K–12.

I think that the outside organizations based in the community and the colleges that have to do a lot of extra work with these kids both have a stake in a more efficient, effective, and equitable system at the lower grades, and we need that press. Then, when the investment is made, people will make use of it.

Powell: As a former college president, I would agree with you that colleges, faculties, and administrators ought to be concerned about what happens in the grade schools, but they are not and they will not be.

They will not be because they have so many problems and so many demands of their own. There are exceptions, of course, and almost every university now has some sort of a program that reaches out to a grade school or to a high school. I do not want to sound overly cynical.

I just think that they have so many concerns of their own, so many financial problems, they simply will not help us solve the problem of K–12 education fast enough.

I think information technology, the right kind of investment, could do a lot more.

Williams: Your comments about the schools, resources, how to design reform, and the specific instance of minorities stimulate another issue.

There are individuals, albeit I would suspect small in number, who have come to the conclusion that the following obtains. If you consider the problems in the K–12 sector or even pre-K–12 as one dimension, the transition to undergraduate as another (leaving aside whether it is a two-year or four-year college), and then to graduate education, one of the challenges is as follows:

Imagine the whole issue as one very, very complicated problem set, so the issue is problem solving among the professionals who are resident in the K–12 sector and in the college and university sector. This was stimulated by your observation that they will not do it. Even in the industrial sector, we do not have among the constellation of professionals a cadre of individuals who know how to problem solve across multiple domains.

Indeed, Peter, there is a contribution to be made by the collegiate sector working with the high schools, but that is transitory. We do not emphasize as a professional niche individuals who work in the two sectors and who can, in terms of mathematics or science education, blur the distinction between 10th grade and the sophomore year of college.

There are no individuals who problem solve in the instance of youngsters who go into the technological workforce with enormous abilities, work for 10 years, and then the industries change. What kind of retraining should they receive in order to continue to get a return on that investment?

Professionally speaking, it is a highly bifurcated industry; that implies that each of these little sectors is self-contained, and they obviously are not. The suggestion, therefore, is that we really need to grow (for lack of a better expression) a different kind of problem solver and to stop taxing individuals whose expertise really is to be quite good in this little narrow domain, but who are not multifaceted problem solvers.

Long preface to the issue. What is your reaction to it? Do we need such people?

Cornwell Rumsey: I think that your idea is one that holds great merit. When you talk about those professionals who are in the private sector or in the public sector and you look at exchange programs that have worked quite well, the fact of the matter is, we must kick it up a level. We have to think more broadly.

There are skill sets, problem-solving skill sets, that transfer and ought to transfer between the private sector, the public sector, and academia. We talked earlier about learning as a continuum, from prekindergarten all the way through advanced studies.

If that is the case for the students who are traveling through the pipeline, that should be the view of all of us. As we come from our different perspectives, we should take a look at that continuum, and ask a question: How can we contribute, given our certain sets of competencies, to solve the problem? I think you are absolutely right.

Garcia Prichard: I agree with you, Luther. It seems that the educational system has been one-dimensional, or two-dimensional at best, but the world and the economy are changing so they are multidimensional. Not only do you have technological advances, the information age, but you have a change in the people and the demographics in the United States.

So if you take thinkers who are two-dimensional and apply them to systems that are multidimensional, you're not going to get an answer. What you are going to get is what I call a marshmallow effect. You push in here and it pushes out there, so you never really solve the problem until you come in together as a group. The multidimensional and multitask thinker is the one, I think, who is going to solve the problem, because you can no longer take this as a two-dimensional problem.

"It seems that the educational system has been one-dimensional, or two-dimensional at best, but the world and the economy are changing so they are multidimensional. . . . So if you take thinkers who are two-dimensional and apply them to systems that are multidimensional, you're not going to get an answer."
DIANA GARCIA PRICHARD
Eastman Kodak Co.

Williams: That is generally true, and I would argue that it takes on even greater significance in the case of trying to make progress in the programs represented at this conference, because there are, in effect, multiples. There are additional variables that are brought to the process that enhance its complexity.

For several decades, we have been involved in efforts that are reflected in this conference. Some progress has been made. The progress is very unequal, as I implied this morning in my general comments. I think generally one has reason to applaud what has been accomplished from precollege through undergraduate in the case of engineering, but we really do not know what was possible.

Do you understand the point of my comment? Even if we declare it successful, on a relative scale, how does that relate to what could have been achieved? So we need to understand that in terms of production.

Second, the response (at least until recent years) in the case of sciences and mathematics has been somewhat less than exemplary. If in the next few seconds each of you had the opportunity to think about a plan that took (in the classic scholarly context) the best knowledge, practice, and experience that we have today and created an agenda for the next 10 years, what would be the five most important elements of that agenda? And the agenda for the next 10 years is to promote a step-function change from where we are now. I should have said that, in terms of the goal.

What would you do, based on what we know? What is the return for all of the efforts in terms of being able to design the future?

Powell: Just to mention two points that I think we generally agree on, one would be to maintain high standards. The other would be to provide adequate resources, and I would, as you can tell, heavily emphasize the information technology resources.

Padmore: One that I would add would be delivering on our promises. When we recruit undergraduates, we recruit them with the hope that they will graduate in 4 years, maybe 5 years; but we should not recruit them with the expectation that 50 percent of them or 25 percent of them may not make it through the pipeline. It's wrong.

[Applause.]

". . . we should not recruit them (students) with the expectation that 50 percent of them or 25 percent of them may not make it through the pipeline. It's wrong."
LYNETTE PADMORE
Florida A&M University

Williams: So accountability, and for lack of a better term, a contractual understanding with the student.

Padmore: Yes.

Cornwell Rumsey: I think that the strategy has to be well focused and developed with the customer in mind, and I would define mathematics and science at the front end of the spectrum. I think that is essential.

Once we do that, we will be able to, through the process, ask ourselves how we are doing, and if we are not meeting the mark, step back and readjust.

Second, I suggest that the strategy should include the entire family. If you are going to train a child, you must train the entire child, recognizing that a lot of the values and the principles that are instilled are instilled at home. And if you have a situation where you have babies raising babies, then you are missing that very important component.

Gerber: I would say that every family, community, and school ought to have as its goal that all children know themselves as successful learners by the time they are in the second grade. They ought to know that by the joy of learning. They ought to know it by the fact that they learned to read.

Williams: I agree with everything you, Jaime, and Terry have indicated about goals for the near term.

Just to pursue the issue further, are you describing contemporary America? I understand what you are speaking to in terms of goals, but when I say that this enterprise needs a different kind of problem solver, I am speaking in terms of extant realities.

My preferences notwithstanding, the substantial fraction of American students do not come from 1930-model homes. The large percentage of minority youngsters do not even come from 1950-model homes. There is nothing that I am aware of in the near term that suggests that it is going to be substantially revised. Therefore, the student body that presents itself to American schools is exactly what it is. In terms of addressing it, the problem-solving construct has to deal with what is, not the historic glorious past that might have been historic but was not glorious. I am not one of the people who spends a lot of time lamenting what was lost by time. But the point is, that is the reality.

So Jaime, you are right about values, reincarnation of values. You are right about everything you have said. I just want to reiterate: The job is a different one. I can not do my grandparents' lifestyle. This even bears on how you can actually deal with technology—your point, Jim—making the technology generally available to youngsters. But in many cases, it is going to be youngsters without parental supervision. How do you make it work under those conditions—the real conditions, not the ones we would prefer, not the ones we romanticize about?

Powell: I think the catch is to have high standards and increase graduation rates, because most people think that if you raise standards, fewer people meet the standards. Somehow, we have to raise them and make more people meet them, and, of course, that is very easy to say in half a sentence but extremely difficult to bring about. I would like to think that if we brought all the resources that we have to bear on this, it could be done.

We just set policy, Luther. It is up to you to implement it.

[Laughter.]

Williams: I want to raise a few issues about the undergraduate sector. As you know, NSF and other agencies have major programming in that arena. It is an area that obviously we are very concerned with. But there is a view that, as is true with the K–12 sector, it also is antiquated. It could benefit from an overhaul, systemic or otherwise. If, in fact, Lynette, you are going to have the kind of returns you are describing, should we be talking about reform of K–16, as opposed to

K–12, education and having a system work, the entire system work, in the case of minorities?

The issue is that there are pockets of excellence. There are areas where it is working. In the suburbs, it is working. Why does it work in the suburbs and not in the urban schools? Is it high expectations? I expect it might be; not only do we have to bring the technology in, but from what I have seen, we also have to educate the teachers to increase their expectations. You see it when you go to a school board meeting. They bring graph after graph that segments the minority students and they have an "oh, well" mentality that they are performing below standards. There is no accountability for raising their levels, and the number of deficit programs and the dollars that they get perpetuates that low expectation.

I would like to see more of a collaborative effort and a discussion of what we need for college graduates and what we need for the students to be prepared.

Oaxaca: I think with the infrastructure that has now been set up for 4½ years, that we now have to follow the precepts of total quality management: continuous product improvement and elimination of the non-value-added processes. It has to be process driven. The world is not a snapshot. It is always changing. You are going to have to have a dynamic process that you can keep adjusting to the changes that occur, and it is a real-time problem. So you will fall behind in certain areas and you will get ahead in others.

Williams: If I might editorialize, I agree with everything you have said, Jaime, but I would make one additional contrast between suburban and inner-city schools. In the inner-city schools, and especially at the elementary level, basically nothing is expected of the students. There is almost uniformity in terms of performance, resources notwithstanding.

Gerber: Kids are growing up knowing how to program VCR's but not being nurtured in ways that have them feel that they are whole people and that they are people who are connected to the promise of our society.

If we are talking about partnerships, Luther, with Commerce or others, we have to connect these kids to the larger promise of our society, or all of our techniques for teaching them to do things aren't going to mean anything. That is a larger agenda that is in the national interest and calls for real leadership from general government people at the local, the State, and the national level. I think they ought to speak to that and find credible pathways for kids.

The kids have good crap detectors and they know when the speeches do not have any substance behind them, and the "you can be anything you want to be" speech doesn't ring true to a lot of kids in our society. They learn to think critically at least that well, and we have to be accountable for the fact that we are not fulfilling our own promise in that way, as one of my colleagues has said.

Williams: Good. One of the things I am attempting to do as we move through this discussion is to arrive at some end point, so I want to probe another issue that I raised with you. What is the next definitive step? Let me give you an example of what I mean.

It's remarkable but perfectly understandable that after 3 years of national conferences where NSF brings together more than 300 talented young minority students from various sectors who spend several days in Washington exhibiting their accomplishments, that these transactions have been devoid of any serious participation by the media.

The extent to which that is the case, I would argue, represents a major impediment to making progress, even in mathematics and science education, forgetting the challenge that is contained in the larger issue that Peter framed of how to actually produce young people who feel a sense of belonging and a sense of participation, who feel that they can actually grow up and join this adult American society.

Your reaction?

"I would like to see us recognize and celebrate success in mathematics and sciences throughout the learning continuum, on par with how we lift up and celebrate athletics in society."
TERRY CORNWELL RUMSEY
Department of Energy

Cornwell Rumsey: I would like to see us recognize and celebrate success in mathematics and sciences throughout the learning continuum, on par with how we lift up and celebrate athletics in society.

[Applause.]

Williams: Anyone who has in recent times examined the issue—it is not inconsequential that even the U.S. Congress, in spite of its otherwise busy schedule, has given some time to the state of the baseball strike—has to be challenged to move this issue as close as possible to similar placement.

Oaxaca: It is a slow-moving thing. There are a lot of people who, because the United States has always been preeminent in research and development, assume that there is no problem. It doesn't sell newspapers. I think it falls under the category of what our chief scientist at Northrop used to say. He used to ask the question, "Which is worse, ignorance or apathy?" The answer was, "I don't know and I don't care."

That is how the majority of the American public views this, because it is never really surfaced as a drop-dead problem. Unfortunately, the United States only reacts to a crisis that is right at our doorstep, and this is a long-term thing—it takes 28 years to grow a Ph.D. I have a theory that if you can do mathematics and science, you will learn how to read, but not the other way around.

Williams: Or if you can read and you cannot do mathematics and science, it probably doesn't matter that you can read.

Padmore: I think we have to realize that educating a child is the responsibility of all of us. It doesn't end with the parents, and the parents should not assume that their responsibility ends at 8:00 in the morning and then picks up again at 6:00 in the evening. It is a continuous process, and the same thing for teachers and faculty. It has to be a continuous thing.

We have to be sensitive to what is affecting learning. If we have a young man or a young woman who is working 40 hours per week and coming into classrooms and falling asleep, we should be sensitive enough to investigate that process. So it has to be a holistic approach, and unless it is that, we are wasting our time.

Williams: Are there issues that we have already mentioned that you would like to speak to further, or issues we have not raised?

Powell: I would like to make one comment to try to sum up my thoughts. When I come to this conference and when I go back to the great museum where I work, I know at a very deep level that the problem is not with the kids (and by that, I now include all the way up through graduate school). The reason they are not always able to do it is someone else's fault. It is the system. It is us.

So I believe that if enough political will were raised to a high enough level and focused sharply enough, this is a tractable problem. I do not believe that it is impossible, difficult as this is, to bring about what you are talking about. It could be done.

Cornwell Rumsey: If I had to sum up my feelings about where we are now, I would say that the time is right, the conditions are right, and if we can not make real progress now, shame on all of us.

[Applause.]

Oaxaca: I am prepared to go another 40 years.

[Laughter.]

Gerber: I am not sure that the time is completely right. I think that there's very deep-seated racism in America that thwarts individuals and policies and programs. We wouldn't all be as frustrated as we are and we wouldn't be in such recursive cycles of invention if that were not the case.

I think that a lot of kids actually have to save themselves. It may not be their fault, but it falls to them to pull themselves up, unfortunately, and society can join with those kids. I really think that there is not yet a sense of the urgency in the country for raising standards for all kids, for holding the adults who are dealing with these kids accountable for the kids' success. I think that the national leadership doesn't want to make people uncomfortable by making that point, and I think they are going to have to do it.

I think that we are going to have to, as a profession, at least in education in my area, look at ourselves more sharply, and I think that one way that we'll do that is by other folks coming in and looking at us.

The kinds of things that NSF is sponsoring, talking about systemic change, also cause us to reflect on things. So we need to be supportive and we need to be patted on the back for trying, but I think we have to recognize that we are a long, long way from truly helping kids achieve what they need to achieve, which is to be learners.

Jaime was saying that valuing education, valuing ourselves as learners—and the belief that in doing so, one will have an equal shot with everybody else for the rewards that our society strews all around us and puts on the television—is just out of reach of some segments of our society.

Williams: Perhaps at this point we will see if there are questions from the audience.

AUDIENCE COMMENTS

Question: I am a middle school teacher in Baltimore. I would like to know why NSF will fund certain things and then just cut them off after three years or so, especially programs that are helping to fill the gap of what the teachers can not do in the classroom due to the overwhelming number of kids. I have also heard of people not receiving the funding. Why? What does NSF need to do to keep the flag flying?

Williams: Why did NSF make those decisions? Most of them were made before we actually decided to seriously problem solve. That has already been spoken about. We decided to move to systemic approaches if projects are in the same community. For example, if we were funding some highly fragmented, episodic (and in my judgment, trivial, though important to one or two or five teachers) ventures, we ceased to fund them and pulled everything together in one coherent problem-solving domain.

I know that is disconcerting to some individuals, but I try to keep focused on the customer, and the customer is the student. If the students are profiting but the college professor is annoyed because he or she did not get the grant, then that is secondary to the problem solving.

Why three years? The answer is probably the same. We were in the business of making grants, not problem solving. I assure you now we are in the business of problem solving, so that kind of experience should be minimal in the future.

Question: The second part is since you are in the business of making grants, I think it would be fair of your section to have a standard requirement regarding equipment or apparatus or materials that should be in every school for the kids to work with, along with that grant. Thank you.

Williams: And we intend to do that, again, by having the equipment, as you heard here today, be a part of a larger set of issues. The equipment alone is absolutely unimportant. Staff and professional development without the equipment, without high standards, are absolutely unimportant in NSF's view.

In summary, the point is that NSF is making a transition from taking a problem set that has 10 variables and naming each one of the variables a program, operating those in isolation and assuming that we are accomplishing something because we have a large number of grantees. The issue is not the number of grantees. The issue is the number of students who are afforded the opportunity to have challenging and quality-based education.

Question: I am with the California Academic Partnership Program, and, more important, I am a school teacher in science. I am very interested in the issue of technology versus goals and standards, because neither one will work without the other. The reason I have seen so many computers locked up in classrooms is because there has not been the technical support. Have you considered tying to grants that give equipment the requirement for technical support in the classroom?

Williams: Yes. Actually we are considering that in a very active fashion. In fact, we are considering the following. Making provisions for grant support is probably only 50 percent of our task. After we make the grants, do we not have an obligation to provide technical assistance to the individuals we have asked to actually implement the program?

So we are beginning to move into what I call the second phase of our business, and we can not do that in isolation. This is a perfect opportunity to make this a multipartner enterprise because there are local industries, local businesses, private foundations, and a whole host of individuals who could come together and assist us in what I call part two of the process.

Question: First of all, I applaud you on this discussion. I think it has been one of the most useful ones that I have heard in a while.

I think that we would agree it has always taken a community to raise a child, and so my question is whether you think it is reasonable that there should be a children's bill of rights, that a child should have a quiet place to study at night, that they should have access to day care, so that the children can come to school equally prepared or equally able to be prepared.

Oaxaca: I do not think there should be a children's bill of rights. I think the Bill of Rights is there for all Americans. I think that would only create a big police force to make sure it was enforced, which would create another bureaucracy that would then set up foolish rules.

My colleague here said it is a joint problem: It is parents, teachers, government, corporate America, academia. If we as a people fail in accomplishing this, the country goes down the toilet, so we all have a vested interest. We have to get everybody pointed in the right direction, because for a variety of reasons that have been discussed here, it has not happened yet. I think any bureaucratic rules that would set up that sort of thing take away the responsibility from those who should have it to start with—the parents and the schools and that system.

We are going into the 21st century. The politics are right. We seem to be able to reallocate our resources in a better fashion now so we don't have to put as much money into defense, and we can now put money into economic stability and social progress.

Question: I'm wondering why the standards apply to the students, when it was even specifically stated that faculty are too busy to take the responsibility of making sure students get through school.

The reason I ask this is that there are a lot of people taking NSF money to do research, and I am always surprised when I come here how few of those academicians are here participating and taking these sorts of things seriously. What is NSF doing to ensure that those schools are represented here, and that those people (faculty) are doing their job? I think it is a multifaceted problem, and just doing research isn't good enough. I am wondering why those standards are being allowed to propagate.

Williams: Well, part of it is that you are looking at NSF, as Dr. Powell indicated, growing out of a period of imbalance, when the research enterprise was robust and the education enterprise was very modest. That situation has been revised, which we are all pleased with, but there clearly are two strong foci within the agency.

What is needed is a set of activities that would more effectively integrate education and research, and we are beginning to make some progress in that arena. For example, the Faculty Early Career Development Award, which now provides the opportunity (I think for the first time in the history of NSF) for a scientist or an engineer to make an application to NSF requesting a bipolar award. "Here's my discrete research program and here's the educational program, in one transaction." In other words, it is the kind of proposal that should be submitted by members of the professorate, not researchers. So that is a beginning step in the right direction.

Question: While I applaud your ideas and thoughts on this greater issue, there is one thing I have to ask of you. Let me preface by saying that I have friends who have been teaching at various levels of education longer than I have been alive—high school teachers, administrators, etc.—and the one thing I have found out from them is, even at the level of the district school board, the members are really not aware of what is going on in the classroom on a day-to-day basis. While Mr. Clinton can postulate what should happen, once again, there is a disconnect between reality and concept.

I would like to know what NSF or any of the other members here are doing to make sure that the good intentions for which the money is targeted are indeed occurring at that level of education.

Williams: Well, it is being pursued in various modes. At NSF, the strategy we are using, and about which we are most hopeful, is the systemic effort, because that makes every player participate. As Peter

and others have observed, it is impossible for superintendents, or chief State school officers, or the school board, or parents to be other than integral players in the venture, because we—to be blunt—won't do business without them. That is the way to get at that problem. If all the members of the community will not unite in a comprehensive effort to address the needs of the students, then there will be no program. There are other examples in other sectors.

CLOSING COMMENTS

We have to end this panel discussion. I would like to express appreciation to the panelists, many of whom were assembled on short notice. Peter Gerber noted that most members of Congress are committed this afternoon to debating the Elementary and Secondary Education Act, a very important activity, and they would not leave before the vote. This group of talented people was able to come forward and serve, which I think bodes well for the enterprise in terms of the question I raised about whether we actually have the requisite talent. I am more encouraged than I was before you performed.

Thank you very much.

LUNCHEON SESSIONS

LUNCHEON FORUM

PRESIDER

James L. Powell
President and CEO
Los Angeles County Natural History Museum

Good afternoon, everyone. My name is Jim Powell. I am president and director of the Los Angeles County Museum of Natural History and also chair of the Education and Human Resources Committee of the National Science Board. It is my pleasure to join you for this luncheon and to welcome you and to preside over it.

I am very pleased to introduce our speaker, Clifton Poodry, with whom I have really enjoyed chatting as we sat up here together. He grew up on the Tonawanda Seneca Indian Reservation in western New York and then moved a short distance away to SUNY Buffalo to receive his undergraduate and graduate degrees. He then went on to Case Western Reserve in Cleveland to receive his doctorate in biology.

Most of his career since has been spent at the University of California at Santa Cruz, where he moved through the faculty ranks to receive tenure and become professor of biology, chair of his department, dean of natural sciences, and acting associate vice chancellor of the university. Along the way, he also served as a program officer of the National Science Foundation.

The talent spotters here in Washington, D.C., noting this steady rise through academic positions, have recruited him, and he is now serving as director of the Division of Minority Opportunities in Research (MORE), National Institute of General Medical Services at the National Institutes of Health.

Along the way to receiving tenure and becoming a full professor at Santa Cruz, as you would suspect, you have to get research grants, do research, have undergraduate students, send them on to graduate school and out the doctorate door. He has done that. He has received grants from NSF, from the Howard Hughes Medical Institute, the American Cancer Society, and others. He's written many papers and he's served on a number of important scientific and educational panels.

It is my pleasure to ask you to welcome Dr. Clifton Poodry.

KEYNOTE ADDRESS

Clifton A. Poodry
Director
Division of Minority Opportunities in Research (MORE)
National Institute of General Medical Services
National Institutes of Health

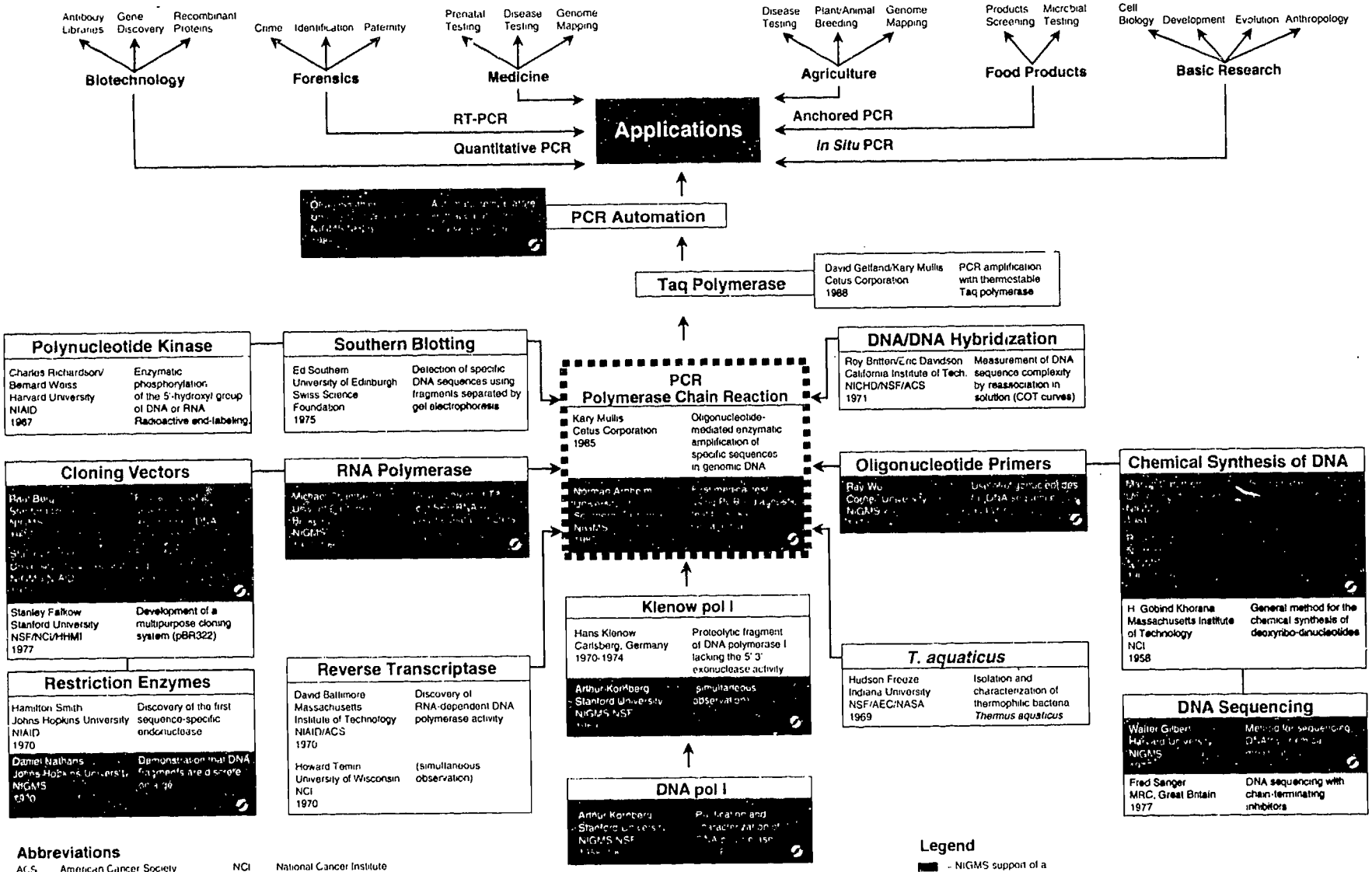
I would like to thank Dr. Williams for the invitation to speak at this luncheon and Dr. Powell for the kind introduction.

First, I want to say that these are exciting times to be a scientist and a teacher. Second, I want to emphasize that minorities not only deserve to be a part of this excitement, but we had better be for our own good! Third, I will share ideas on at least one thing that needs to change in order to get more minorities involved.

As I said, these are exciting times to be a scientist and a teacher. In what seems to have been a blink of an eye, the research in my area, developmental genetics, has moved in great leaps. Topics that were imponderable 20 years ago, unanswerable questions suitable for Ph.D. qualifying exams, are now being approached and solved using new technology. Cloning important genes, sequencing messages and control regions, using the polymerase chain reaction (PCR) to detect and amplify extremely rare sequences were either fantasy or beyond our imagination just 25 years ago. Basic science—curiosity pursued to give us basic understandings of nature—has provided the underpinnings for amazing advancements in applied research. The first figure shows a little history of the studies leading to the development of PCR and some of its applications. As you can see, the applications that we now enjoy from that basic research are important to our well-being in many ways: health, food, economic development, and new basic research. The second figure shows another history lesson in the research that

Basic Research Leading to PCR and its Applications

National Institute of General Medical Sciences



Abbreviations

ACS	American Cancer Society	NCI	National Cancer Institute
AEC	Atomic Energy Commission	NHLBI	National Heart, Lung, and Blood Institute
HHMI	Howard Hughes Medical Institute	NIAID	National Institute of Allergy and Infectious Diseases
MRC	Medical Research Council	NICHD	National Institute of Child Health and Human Development
NASA	National Aeronautics and Space Administration	NIGMS	National Institute of General Medical Sciences
		NSF	National Science Foundation

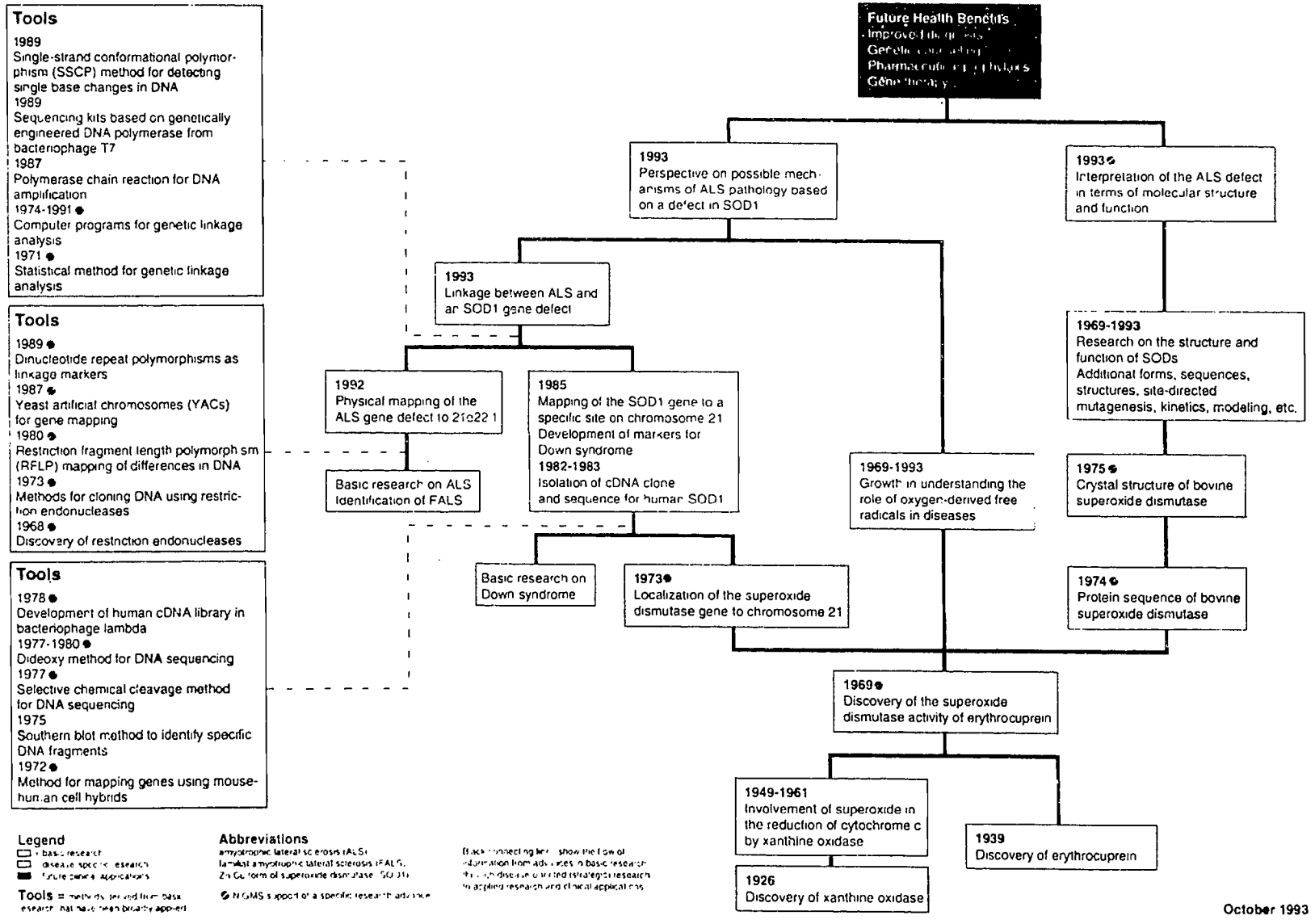
Legend

- NIGMS support of a specific research advance
- [...] = Research not supported by NIGMS

January 1994

Basic Research Contributions to Discovering the Molecular Basis of Lou Gehrig's Disease (ALS)

National Institute of General Medical Sciences



led to discoveries on the basis of Lou Gehrig's disease. As you can see, the products of research in genetics, molecular biology, and chemistry converge to lead to potential clinical applications.

Yes, it is an exciting time to be a scientist and a teacher. Shouldn't minorities be sharing in the excitement? Of course they should. Shouldn't minorities be helping to direct priorities for research, including research to solve problems that disproportionately affect our communities? Of course they should. It goes without saying.

What will it take to get underrepresented minorities less underrepresented in science, math, and engineering? I could cite the depressing statistics of how far we have to go or I could list the programs and the national efforts that are underway to address the problem. I could tell you how programs at NIH are going to address the problem. But I prefer to focus on more personal than programmatic aspects of the issues and share my own ideas on what needs to change at a personal, individual level.

Discovery is fun. It is motivating. Most of you already know that and that is why you are here. From my own experience I also know the importance of internal drive. I was an "underwhelming," "underperforming" student as an undergraduate. My overall average was a C; not a high C, just a C. I was so naive that I thought a C was okay. I had a job interview at the end of my senior year for a position as a technician in a nuclear recycling plant—a veritable Homer Simpson! I didn't get the job.

. . . Homer got it. So what do you do when you don't get the job? I went to graduate school—to get a master's in biology so I could teach high school and, hopefully, coach football.

Events during graduate research changed my direction. I recall my thoughts late one night walking home from the lab where I was working on my project for a master's thesis—on how a newt sheds its skin. It was a cold night in winter in Buffalo, but I was completely oblivious to the weather. I was warm from the glow of discovery. I had just thought of a way to get a series of timed samples after a hormone treatment from the same animal. No one else to my knowledge had ever done it that way. I was darn near giddy. The feelings of euphoria at seeing new things or thinking new thoughts kept me going.

I applied to Ph.D. programs and took the GRE. When I scored in the 98th and 99th percentile I was sure there was a mistake. I went to Case Western Reserve in Cleveland (the home of Congressman Stokes). A couple of years into my Ph.D. research I knew, from my own observations, that the structure of imaginal discs of *Drosophila* was not as it had been recently described in the literature—and that the interpretation made a difference! It was important. How we thought of pattern formation and cellular communication now made more sense. "Wow! This is heady stuff. It might actually get published."

The next several months, as the manuscript went through 10 revisions, were hard work. But let me tell you that the feeling that you get when you put your first manuscript in the mailbox to send it off for publication is incomparable. I had three extra copies in case the manuscript got lost in the mail. For weeks I was beside myself with excitement. I would check the library for the latest journals, worrying, wondering if someone else had made similar observations, wondering whether I'd be scooped before our paper came out. The published paper was 44 pages long with many figures. The process and the reception of the final product reinforced for me the pride in my work and the value of hard work. My paper would stand the test of time.

I learned from my pleasures in research the value of patience, for gratification in research is often delayed. Not every idea pans out. Not every experiment works. But preparation pays. A thorough knowledge of the literature, an experiment or analysis that is just that much more precise than those done previously, the patience and determination, they can pay off with new insights, new observations, or new revelations that no one else has ever had before—and that is a kick in the pants! It is well worth the work involved.

Whether we consider an activity *work* is a state of mind. My friend—scientist, teacher, and textbook author Vernon Avila—told of how as a youngster he had to work on the family farm, often digging and clearing irrigation ditches to keep water flowing to the crops. It was work, hard work. And after work he and his friends would play war. They would build forts and dig trenches. Dig ditches! But this time it was play; not work, just hard play. He realized at an early age that it is not the activity itself but whether or not you are following your own direction that makes something work or play.

Speaking of effort, I want to share with you a story that involves effort and a man's refusal to adopt a victim mentality. Ely S. Parker was an exceptional man from my reservation who, in the middle of the last century, got an education and eventually a law degree. But he was not allowed to take the Bar exam to practice law—because he was not a U.S. citizen. Do you know when American Indians were granted citizenship? It was not until 1924, when my mother was a young girl. What would you do if, after investing all your time and resources in your education, you were not allowed even to take the certification exam? Ely Parker, not knowing that Indians were supposed to be right-brain, nonquanti-

tative thinkers, went back to the drawing board and became an engineer, the first American Indian engineer. Among his many accomplishments, he helped build the Erie Canal and worked for the Army Corps of Engineers. He served with Grant in the Civil War. Ely Parker penned the terms of surrender at Appomattox. I wonder if I would have had his resolve. I wonder what pushed him forward.

Almost as much fun as discovering something yourself is to watch your students have the discovery experience. It is akin to being a proud parent to see your students grow and mature and to share the joy and excitement. Teaching is an endeavor that provides great satisfaction but, as with research, gratification is often delayed. Yet the impact of the phone calls or letters from grateful students, generally a few and sometimes 10 years after the fact, thanking you for something that you do as a normal part of your profession, is tremendous. I know I have been moved by letters from students long forgotten and as a result have redoubled my resolve to be an even better teacher and mentor. It is worth the effort.

Another thing that I have learned along the way is that long lunch speeches are not desirable. Brevity is appreciated. So I want to conclude with two things that I have learned about learning. (When an audience thinks that you are about to conclude they wake up. So I have just told you I am concluding so you'll wake up and pay attention. My mentor used to do this about every 10 minutes in a 1-hour talk. I learned it from him.)

The main reason we are here today is that there are too few minorities in science and engineering. I am particularly concerned about those who are lost from the pipeline, denied the opportunity before they ever had a chance to know whether science, math, or engineering was a possible career choice for them. I attribute this condition, at least in part, to myths. Myths in education about the potential of members of minority groups have certainly been responsible for closing the doors to otherwise capable people. I want to comment on what I believe is one of the most damaging myths. It is damaging because so many people have bought into it—parents, children, teachers, you and I. It is as Pogo said, "We have met the enemy and them is us."

Why is your child getting C's and D's in math? "Johnny just doesn't have an aptitude for math. He's more artistically inclined."

Why are you getting C's in math and science? "I am not good in math. I am not an egghead; I am a people person."

Why are these students not signed up for algebra and a college prep science class? "It is commonly known that minorities are right-brain thinkers. They will be better off taking a course in practical math and vocational training."

What is the myth that I am referring to? It is that natural aptitude, more than effort, is the primary determinant in how well one will do in science or math or in jobs where inquiry and quantitative skills are needed.

Do they still give aptitude tests? I remember that my advisor said that I should be a forest ranger in a fire observation tower. That was because I was very shy and was uncomfortable speaking to people. So I ended up being a professor.

I will not deny that there is a continuum in native abilities. Not everyone has the natural talent to become a professional basketball player, baseball player, or an Olympic medalist. But that pinnacle aside, many people, if not most, have the abilities to enjoy sports, many at a competitive level. One of my proudest accomplishments is having been a third-string football player in college under coach Buddy Ryan. I made it up to second string and even had a partial scholarship by my senior year. Would it be reasonable for everyone not destined to the professional leagues to shun physical activity? Should only potential professional artists learn to play musical instruments or enjoy photography or other art forms? Of course not.

Learning, whether mostly physical or mostly mental, takes time. It takes effort. Depending on the state of mind, that effort may be work or it may be play. The notion that aptitude is more important than effort is not universal, however. When Asian parents were asked similar questions about their children's performance, what do you suppose they said? Their response was that the children hadn't put in enough effort.

I suspect that if we discard the myth of aptitude and instead believe that all children can learn, if we have high expectations, if we provide more opportunities for them to discover, to learn for themselves, to get reinforcement for actual learning and to experience the joy of feeling successful at learning (nothing succeeds like success), they will learn that learning is worth the effort. It will take a broad effort that will necessarily involve parents, community members, teachers, administrators, and scientists. It will be worth our effort.

My Hopi brother and friend Frank Dukepoo encourages students in the Native American Honor Society to strive for a 4.0. In asking youngsters to set real objectives for themselves he relates that people often say, "I would like to get straight A's." Or "Gee, I would like to play the piano like Mary." What they mean is, "I would like to get straight A's without studying" or "I would like to play the piano without having to practice every day." What do you really want to achieve? And what are you going to give up so you have time to do it? Will you put in the effort?

Being a scientist has offered me many challenges as well as many exciting opportunities to be my own boss, to follow my own curiosity, to stretch my imagination, to test my technical skills, and to hold my ideas and interpretations up to any and all for examination. It now offers me, in my position at NIH, an opportunity to put my creativity to work in support of ways to extend those opportunities to groups that have historically been outside of the scientific establishment.

I am hopeful that, with the leadership of the National Science Foundation, systemic educational reform will occur in our communities, that new partnerships will develop to foster the inclusion of minorities in the science and engineering workforce. With your effort, a broader spectrum of Americans will enjoy the fruits of a good education so that a subset, with representation not limited to any particular group, will aspire to the challenges and rewards of being a scientist, perhaps a professor, or maybe even an administrator.

AWARDS LUNCHEON

PRESIDER

Diana Garcia Prichard
Research Scientist
Eastman Kodak Company

I would like to take this time to introduce our speaker. Generally, the speakers that the National Science Foundation presents at the Diversity conference have a curriculum vita much longer than their speeches. Therefore, I'm going to select just a few things to say about our speaker.

She is presently the general superintendent of schools in Chicago. This is the third-largest school system in the country with an enrollment of 411,000 and a staff of more than 45,000. She is also a doctoral candidate in educational administration at Teachers College, Columbia University. She received a master of science degree in science education from Long Island University, Brooklyn, New York, and a master of science degree in supervision and administration from Baruch College, City University of New York. Ms. Johnson has a bachelor of science in biology, with a chemistry minor, from Johnson C. Smith College, Charlotte, North Carolina.

Before coming to Chicago, Ms. Johnson held numerous positions in the New York City school system, serving as a teacher, principal, deputy community superintendent, and deputy chancellor for instruction.

She has been a guest speaker at numerous education association events and a guest lecturer. One of the most interesting aspects of Argie K. Johnson's career is that she was a research biochemist for the Veterans Administration Hospital in Brooklyn, New York, for 6 years.

She has been the recipient of many leadership, educational, and community service awards. I will just mention a few: a citation in the *Congressional Record*; Outstanding Achievement Award from the NAACP; Educator of the Year, Association of Black School Educators of New York; Leadership in Education Award; Super Principal Award. She is affiliated with the National Council of Negro Women, National Alliance of Black School Educators, Phi Delta Kappa Honor Society, and Delta Sigma Theta Sorority.

Argie Johnson has had an illustrative career in education. I would like to welcome her now.

KEYNOTE ADDRESS

Argie K. Johnson
General Superintendent
Chicago Public Schools

Never before in time has there been such a diversity of ethnic, cultural, language, and religious minorities in our Nation's schools. It is estimated that within the next 6 years—by the year 2000—one-third of the Nation's school children will be ethnic minorities. In the city of Chicago, our public schools are currently more than 80 percent minority, with more than 100 non-English languages spoken by our students.

The phenomenon is not unique to Chicago. It is played out in urban areas across the country. In metropolitan areas, the average percentage of students who are African American or Hispanic was 53 percent in 1991, compared to 20 percent outside the central city of metropolitan areas and 26 percent in nonmetropolitan areas.

With the ethnic and racial diversity of our student body growing more evident each year, what are the major issues facing our society and our school systems as we work to educate youth for the 21st century? They are the issues of equity of educational resources regardless of economic class, race and ethnicity, gender, or special needs. Additionally, there is the issue of the process of school reform in the context of national standards that must be raised.

Where then do the poor, ethnic minorities, women, and those who have physical and emotional challenges fit in the school systems of the United States? And what do these students and their families want from our schools?

They want nothing more than what is promised in the State constitutions that outline the processes and procedures for producing a literate citizenry. Today, a literate citizenry must be able to address the issues surrounding science and technology in our society. These families must be encouraged to take their rightful place, to take full advantage of what our schools can offer. The best education for some is the best education for all.

Why science and math? They provide training and ways of thinking and processing information that are the skills necessary to master other academic content material.

Where are we now with respect to the education of the poor, minorities, women, and those with special needs in terms of providing entry into the scientific and technological workplace? How have national standards movements helped this process to move forward? Is school reform making a difference? Are defining national standards and raising requirements for student achievement contrary to reform?

Data from the National Center for Education Statistics have provided a comprehensive analysis of the condition of education and a means to support conclusions about where progress is being made in education as well as where it is not.

We can examine how much progress has been made in the areas we previously discussed:

- How do children from low-income families progress through the educational system in comparison to their high-income counterparts?

— Children from low-income families are less likely to be enrolled in prekindergarten programs than high-income children.
— First graders from low-income families are twice as likely to be age 7 in 1st grade rather than age 6.
— As poor children progress through elementary school, they are more likely to be above the typical age for their grade, increasing from 9 percent in 1st grade to 19 percent in 4th grade to 30 percent in 7th grade.
— Nationally, 11 percent of high school students from low-income families drop out of school compared to 1 percent for high-income families. This statistic does not speak to the enormous dropout rate in urban school districts where the poor are concentrated. There you can find dropout rates from 50 percent to 75 percent. These children are the natural resources of the gang culture.
— Among students who do graduate from high school, only 40 percent from low-income families enroll in college compared to 78 percent from high-income families.

These indicators suggest that children from poor families progress more slowly and not as far through the educational system as those from high-income families.

- Do students who are from low-income families and who leave the education system make a smooth transition to the workforce?

— Among high school graduates who did not enroll in college, those from low-income families were less likely to be employed than those from high-income families (49 percent compared to 73 percent). Dropouts were even less likely to be employed. These young adults are the natural resources of the welfare system.
— Data clearly show that African American high school graduates continue to lag behind whites in terms of employment, but even more tragic is the fact that, on average, white dropouts are more readily employed than African American high school graduates!
— Statistics clearly show that educational attainment has a positive impact on earning power in males, regardless of age, but African Americans continue to trail behind whites in earning power, regardless of educational attainment.
— Data for females is more encouraging, with educated females earning considerably above the average for high school graduates. Keep in mind, though, that the baseline salary is lower for females than it is for males.

- How are racial and ethnic minorities doing as reported in *The Condition of Education 1993*?

— While national trends for the enrollment of 3- to 4-year-olds into prekindergarten programs have increased, the increase was larger for whites than for African Americans and Hispanics.

— The percentage of African American high school graduates going directly to college rose 8 percentage points between 1974 and 1990. During the same period, the enrollment rate for whites rose 14 percentage points.
— In 1990, African Americans and Hispanics were about equally likely to go directly to college, but both were less likely to do so than whites.
— Although overall scores have not changed much over 2 decades, the *National Assessment of Educational Progress* gives evidence that the large gap in achievement between whites and minorities has narrowed substantially. African Americans and Hispanics have improved relative to whites in reading, mathematics, and science, although the improvement among Hispanics was less significant.
— Public schools with *few* disadvantaged youth were *more* likely to have programs for exceptional children, diagnostic services, and extended day program offerings in their schools than public schools with a high level of student poverty.

As the bumblebee wings its way among the flowers on a warm summer day, despite aerodynamic principles proclaiming that it can't be done, so do unrecognized citizens with physical disabilities go about their daily lives achieving what most of us would consider impossible. Despite knowing what can be achieved by people with disabilities, their representation in the scientific and technological workforce is dismally low. Even with Federal legislation such as the 1990 Americans with Disabilities Act, we are painfully slow at giving access, not only to buildings, buses, water fountains, telephones, and washroom facilities, but also to things that really matter—educational programs and job opportunities at the highest levels.

• How are our female students achieving these days?

— An increasing number of girls are reported as having taken high school chemistry and physics classes.
— The average proficiency of females taking high school science increased significantly from 1986 to 1992, whereas achievement of their male counterparts remained fairly constant.
— While males and females have similar proficiency in mathematics in early adolescence, a persistent gap develops in high school. While there is an overall decrease in performance in mathematics between the genders, the performance gap between male and female 17-year-olds appears to narrow only slightly.
— Despite all the efforts of the feminist movement, research into gender equity continues to show females remain underrepresented at the highest levels of management, commerce, science, technology, industry, and higher education. The only area in which women consistently outperform men is in childbearing!

The disparities between males and females, and among racial and ethnic groups, continue as these students pursue advanced scientific and technological education and enter careers.

— Of the 38,814 doctorates earned in the United States in 1992, 37 percent were earned by women.
— Of the 19,043 doctorates earned in the United States in the fields of science and technology, only 24 percent were earned by women.
— Recent statistics show that 83 percent of the doctorates earned by U.S. citizens and those with permanent visas in scientific and technological fields are earned by whites. Asians are far behind with 10 percent. Other minorities trail them.
— Of the 19,000 doctorates earned in 1992 in the fields associated with science and technology, only 201 went to African Americans, 317 were awarded to Hispanics and a mere 47 went to Native Americans.

The challenge to today's schools in particular and to American society in general is to examine ways in which we can parlay this valuable resource of ethnic diversity and talent into fuel for our economic engine so that all citizens can realize the American Dream.

• If education indeed empowers the citizenry, let us take a look at exactly which groups are maximizing educational opportunities in the United States in the areas of science and technology.

— The U.S. Department of Labor, Bureau of Labor Statistics shows a great disparity in the employment of African Americans and Hispanics in various fields of science.

— While women fare much better, many of them are employed in the health care industry in low-paying jobs, such as nurses aides and licensed practical nurses. Few are represented in engineering and precision industries.

• What about the earning power of these graduates?

— In the areas of computer science and engineering, the median salary for college graduates far exceeds that of graduates in other fields. Yet, minorities and women continue to be underrepresented in these high-paying positions.

As school districts grapple with the issue of setting high standards for their students in response to legislation—for example, in *Goals 2000 Educate America*—urban educators are constantly barraged with naysayers who believe that high standards will increase the already alarming dropout rate. Are we raising the bar too high? Research by Angus and Miriel at the University of Michigan and Northern Illinois University, respectively, shows that since *A Nation at Risk*, enrollment rates in both science and mathematics courses have increased. Even more telling is that these increases were in traditional academic courses: biology, chemistry, physics, algebra, geometry, trigonometry, and advanced mathematics. Moreover, enrollment rates in general science courses seem to be on the wane. Changing high school graduation requirements, more rigorous college admission requirements, reform efforts to achieve scientific literacy among the general populace, and efforts to increase the pool of potential scientists and engineers, including minorities and women, have all contributed to this upward trend in numbers and to the kinds of courses students are taking.

This trend was confirmed by the latest *National Assessment of Educational Progress*, which shows that mathematics and science achievement among students aged 9 to 17 generally improved after a period of decline during the previous decade. This comforting statistic has to be tempered with others, which show our children well behind other nations in science and mathematics achievement.

The authors of *Rhetoric and Reality: The American High School Curriculum, 1945–1990* found that African American and Hispanic students who increased their academic course load showed an increase in SAT scores. African Americans taking more rigorous courses also registered a decline in their dropout rate.

Assisted by the National Science Foundation and fueled by the national standards movements of the National Council of Teachers of Mathematics, the American Association for the Advancement of Science, and the National Research Council, the scientific and mathematical needs of all children are being given great attention.

The urban centers of this country are where you find a concentration of the poor, minorities, and the disabled. If any progress in education is to be made with these groups, concentrated, sustained, and systemic reform efforts must be made in order to bring about change. The State and urban systemic initiatives funded by the National Science Foundation will serve as the catalyst for the reform of science, mathematics, and technological education.

How can we attain educational parity with other nations? How can the United States become first in the world in science and mathematics? May I suggest the following:

• Adopting the National Science Foundation Urban Systemic Initiative Goals in all school districts:

— To provide the scientific and mathematical literacy of all students;
— To provide the mathematics and science fundamentals that will permit all students to participate in a technological society; and
— To enable a significantly greater number of students to pursue careers in mathematics, science, engineering, and technology.

• Embarking on a course of systemic change that includes, but is not limited to, the following:

— Building and sustaining a positive climate for change in mathematics, science, and technology education;
— Designing, implementing, and institutionalizing a comprehensive program for improved student instruction, professional development, and community education that ensures high quality mathematics, science, and technology education for all students;
— Advancing policy frameworks that ensure a rich, demanding, and rigorous curriculum of academic subjects;

— Raising expectations and graduation requirements to reflect the skills students will need to be successful in a technological society;
— Improving infrastructures (organizational, physical, and technological);
— Aligning the resources necessary to support high-quality mathematics, science, and technology education for all students;
— Reducing and closing the academic achievement gap between whites and nonwhites and between the urban child and the suburban child with respect to State and national norms in mathematics and science by establishing high standards and attainable benchmarks;
— Changing belief systems with respect to the learning abilities of all children;
— Examining our administrative practices and changing them in accordance with best practices in management.

The technical skills of a nation's workers are a critical component of its economic competitiveness. The youth of today will be tomorrow's workers and will be competing in a global marketplace. They will depend on the mathematics, science, and technology learned in this decade. Their ability to succeed after the turn of the century is largely dependent upon what we do now to prepare them.

Let us make a concerted effort toward celebrating our diversity instead of defining our differences. The whole world marvels at the great American experiment of a heterogeneous society. There is no doubt that, due to our short history, we are making up the rules of American society as we go along. We have made mistakes, to be sure, but there is no mistake that America's diversity is an asset and not a liability, and that her greatness will continue to depend on the contributions made by *all* citizens without regard to gender, race, income level, or ethnicity.

We cannot expect anyone to contribute to society unless he or she is prepared. Schools are the place where this preparation has to take place. If America can dedicate a decade to developing the finest defense systems that money can buy, what precludes it from doing the same with education? What holds America back from investing in the education of its citizens? I suggest to you that an educated citizenry is a very powerful weapon.

My sincere congratulations are extended to those of you who will receive awards today. Your accomplishments are a testament to what can be achieved by those who overcome obstacles, put on blinders to distractions, and participate fully in the American educational process. Your task, however, is not complete. By earning recognition, you also take on the greater burden of serving as mentors to those who will follow you. I urge you to accept the challenge. We who work in schools every day need your help, good will, and splendid example as role models. There are too few of you achieving at this level, so the burden is even greater. I hope that you will accept this challenge in the spirit of this significant lyric:

> The road is long, with many a winding turn;
> Which leads to who knows where, who knows where?
> But I'm strong, strong enough to carry him;
> He ain't heavy—he's my brother.

Thank you for allowing me this opportunity to address you.

AWARD PRESENTATIONS

PRESIDER

Diana Garcia Prichard
Research Scientist
Eastman Kodak Company

An integral part of the National Science Foundation's National Conference on Diversity in the Scientific and Technological Workforce has been the presentation of awards to outstanding students, researchers, and leaders in the field of science, engineering, mathematics, and technology education for minority groups underrepresented in these fields. This third year of the conference we continue this tradition. More than 300 student participants in NSF-sponsored research activities have presented their findings here in panel and poster settings. The disciplines represented include chemistry, physics, engineering, biology, and the social sciences.

Students entered the research competition by submitting a formal research paper based on their conference presentations. Papers were reviewed by NSF research scientists and science educators, and finalists were selected in three categories: precollege, undergraduate, and graduate. The National Science Foundation staff judges attended the presentations of all the finalists, and winners hav been selected.

Before we present the awards, we would like to formally recognize the many NSF scientists, mathematicians, engineers, and science educators who volunteered their time to review the research papers and to judge the presentations. Those of you who are here today, please stand and receive your well-deserved round of applause.

STUDENT RESEARCH AWARDS

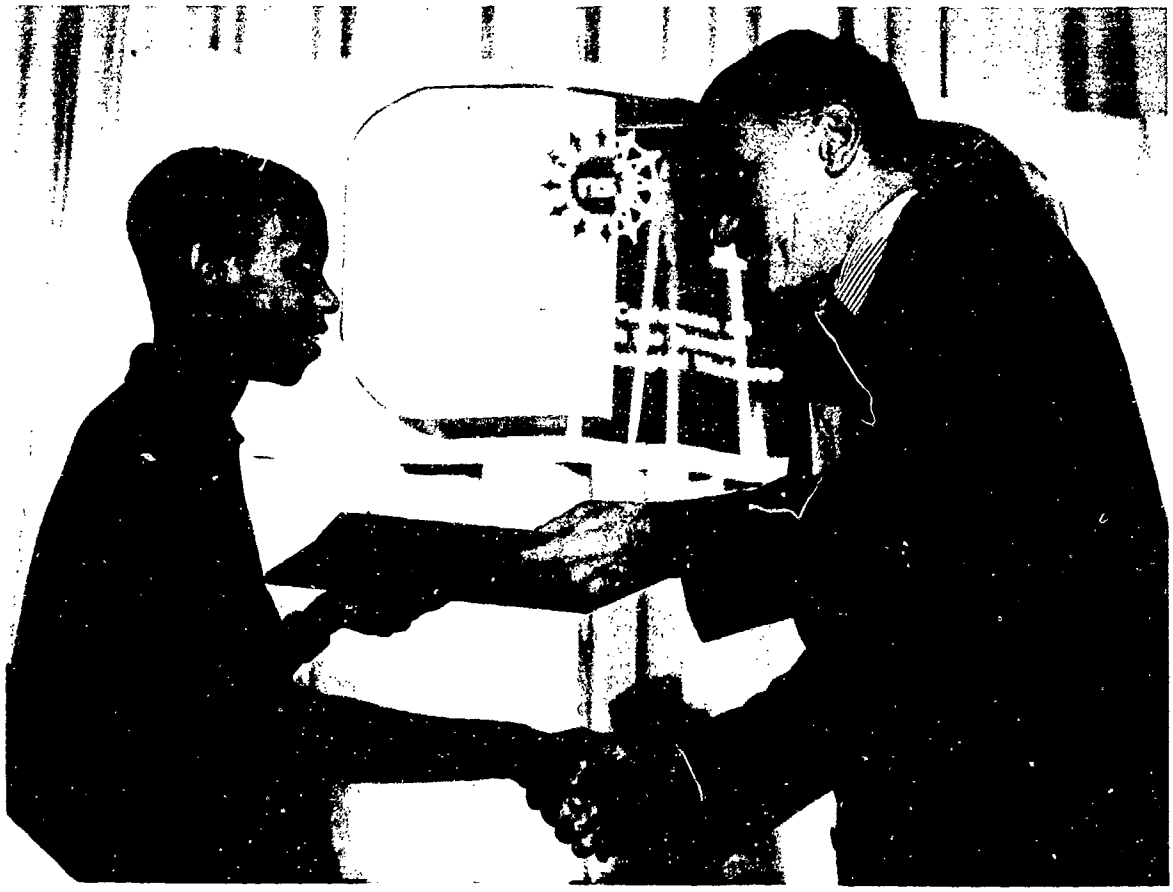
PRECOLLEGE STUDENT RESEARCH AWARDS

Sponsor: National Science Teachers Association (NSTA)

Presenter: Marvin Druger, President, NSTA

Awardee: **Terrence R. Ruffin**, Laney High School, 9th Grade, University of North Carolina Summer Science Camp Program

Title of Paper: "Barrier Island Topography and Vegetation Zones"



PRECOLLEGE STUDENT RESEARCH AWARDS

Sponsor: National Science Teachers Association (NSTA)

Presenter: Marvin Druger, President, NSTA

Awardee: **Felicia Nicole Colon-Barnes**, Holy Name Academy, 9th Grade, Seattle University Summer Science Camp Program

Title of Paper: "Aerodynamics in Action"

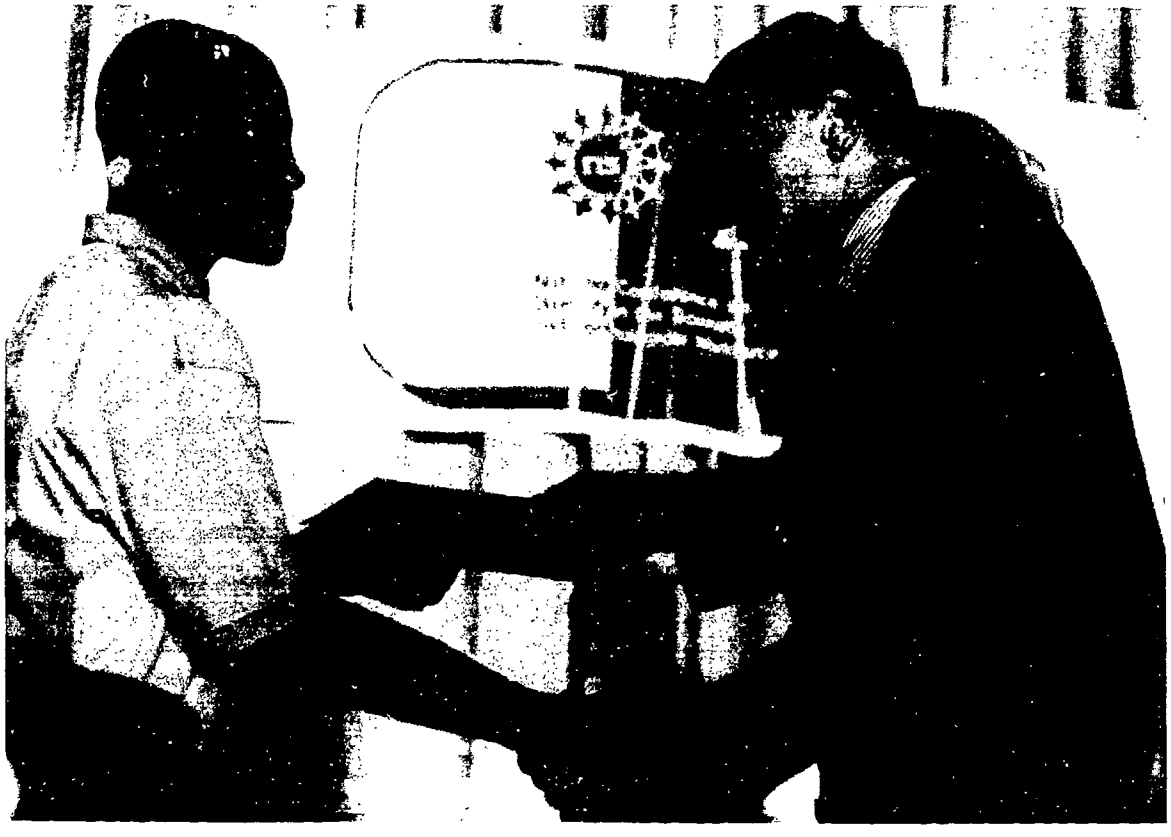
PRECOLLEGE STUDENT RESEARCH AWARDS

Sponsor: National Science Teachers Association (NSTA)

Presenter: Marvin Druger, President, NSTA

Awardee: **Roosevelt R. Love**, Beaumont High School, Senior, St. Louis, Missouri, Comprehensive Regional Centers for Minorities Program

Title of Paper: "Study of the St. Louis Metropolitan Metro-Link Light Rail Station Canopies"



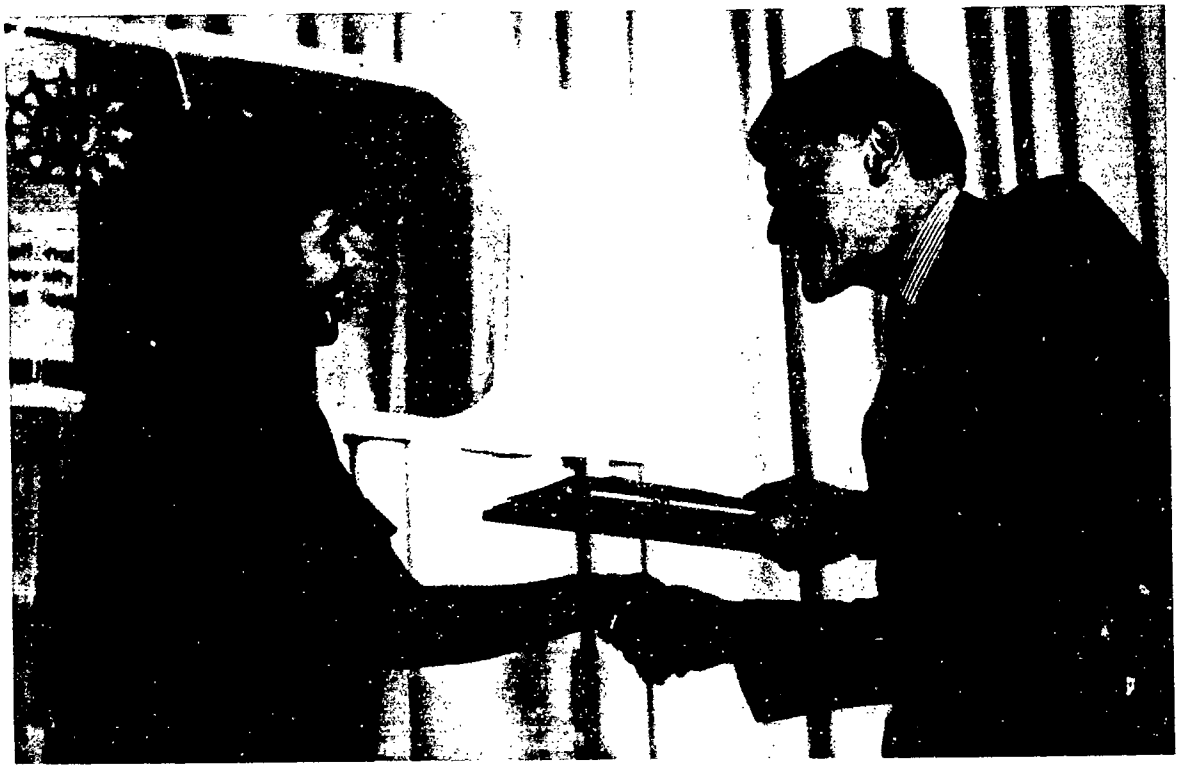
PRECOLLEGE STUDENT RESEARCH AWARDS

Sponsor: National Science Teachers Association (NSTA)

Presenter: Marvin Druger, President, NSTA

Awardee: **Liza Gabriella Ruvalcaba**, Soccorro High School, 10th Grade, El Paso, Texas, Comprehensive Regional Centers for Minorities Program

Title of Paper: "Drainage Time of a Roughly Cylindrical Container as a Function of Hole Diameter and Initial Water Height"



The National Science Teachers Association is the largest organization committed to the improvement of science education in all areas, from preschool to college. Currently, NSTA has about 50,000 members. We provide a variety of journals, conventions, student services, competitions, awards, and many other services.

If anybody would like to join, I just happen to have some cards in my pocket. As president, I'm empowered to give a 10 percent discount, so anybody who'd like to join, please see me.

As president, I also have the privilege and great honor to attend this conference, and notwithstanding the fine presentations of my distinguished colleagues, I was most impressed by the student presentations. More than 40 presentations at this conference were made by middle and high school students who are participants in the Summer Science Camps (SSC) and the Comprehensive Regional Centers for Minorities (CRCM) programs. The NSF, SSC, and CRCM programs served approximately 50,000 precollege students in 1993, and these students are our future scientists, engineers, and mathematicians.

What impressed me most was how bright, creative, poised, and articulate these students are. They're excited about science and they know what they're talking about. Somehow, I can't remember being that smart when I was that young. This is a wonderful opportunity to see what our scientists of the future are like, and they make me feel very optimistic about this future.

Obviously, it was very difficult to select winners. To all the students, I can only say that everybody here is obviously a winner as a result of this experience. To all of the students who are here, you will not forget this. It will become part of what you are; you will remember the friends you met here, and you will remember the excitement of being at a professional scientific meeting.

A famous saying that I just made up: "We learn from everyone whom we meet, and everything that we do becomes part of what we are." So I'm very happy to see that these students have learned something here and will go away with a good feeling about themselves and about their projects.

There are two categories of "winner-winners," which I'll have to call them, since everybody's a winner. One set of winner-winners came from the Summer Science Camp Program, and two winners are from the Comprehensive Regional Centers for Minorities. Each of the four students will receive from the National Science Teachers Association a plaque, a subscription to *Discovery* magazine or *Quantum* magazine, and—because we like to help them go far in life—they also will receive an open airline ticket to anywhere in the United States, roundtrip, of course.

—Marvin Druger

UNDERGRADUATE STUDENT RESEARCH AWARDS

Sponsor:	Phi Beta Kappa
Presenter:	Virginia R. Ferris, Executive Committee, Phi Beta Kappa and Professor of Entomology, Purdue University
Awardee:	**Monica Renee Page**, Tennessee State University, Senior, Research Improvement in Minority Institutions Program
Title of Paper:	"Application of Interval Modeling Techniques to Robust Control of Slewing Beams with Loads"
Awardee:	**Gisela Rodriguez Rosado**, University of Puerto Rico, Senior, Research Careers for Minority Scholars Program
Title of Paper:	"Triisopropylsilanol: A New Phase Transfer Catalyst for Dehydrohalogenation"

From left to right: Gisela Rosado, Monica Page, Virginia Ferris

The Phi Beta Kappa Society is honored to participate in this ceremony and to recognize the achievements of undergraduate students. The purpose of the Phi Beta Kappa Society is to encourage and further education in the liberal arts and sciences. We recognize that the role of science is often undervalued in education and we also recognize the importance for the country of encouraging undergraduates, particularly minority students, in scientific study and research.

Phi Beta Kappa also recognizes the important role that undergraduate student research plays in strengthening interactions between faculty members and students, and how much research encourages students not only to complete their undergraduate work, but also to pursue advanced studies. I speak this from the heart because I am a practicing bench scientist myself and also a teacher.

NSF's leadership role in providing opportunities for minority students to participate in undergraduate research is amply illustrated by the number of undergraduate research presentations in science, engineering, and mathematics at this conference. Of the more than 300 research presentations, approximately 42 percent were from NSF's premiere undergraduate programs, the Alliances for Minority Participation (AMP) Program and the Research Careers for Minority Scholars Program. These programs have an outstanding record of providing the support needed for minority students, enabling them to pursue degrees in science, engineering, and mathematics at the undergraduate level, and together they currently support more than 50,000 of the next generation of minority scientists, engineers, and mathematicians.

Papers were submitted by students representing these two programs and by students sponsored by other directorates at NSF. I should note that because of the large number of high-quality papers submitted to the competition, NSF has joined with Phi Beta Kappa to present two awards today. Both students will receive a check for $500 and a plaque from Phi Beta Kappa honoring their achievements.

—Virginia Ferris

GRADUATE STUDENT RESEARCH AWARDS

Sponsor: Council of Graduate Schools (CGS)

Presenter: Anne S. Pruitt, Dean in Residence, CGS, and member, NSF Committee on Equal Opportunities in Science and Engineering

Awardee: **Thomas Tenorio**, New Mexico State University, Ph.D. student, Research Improvement in Minority Institutions Program

Title of Paper: "Creating an Object-Oriented Test Repository"

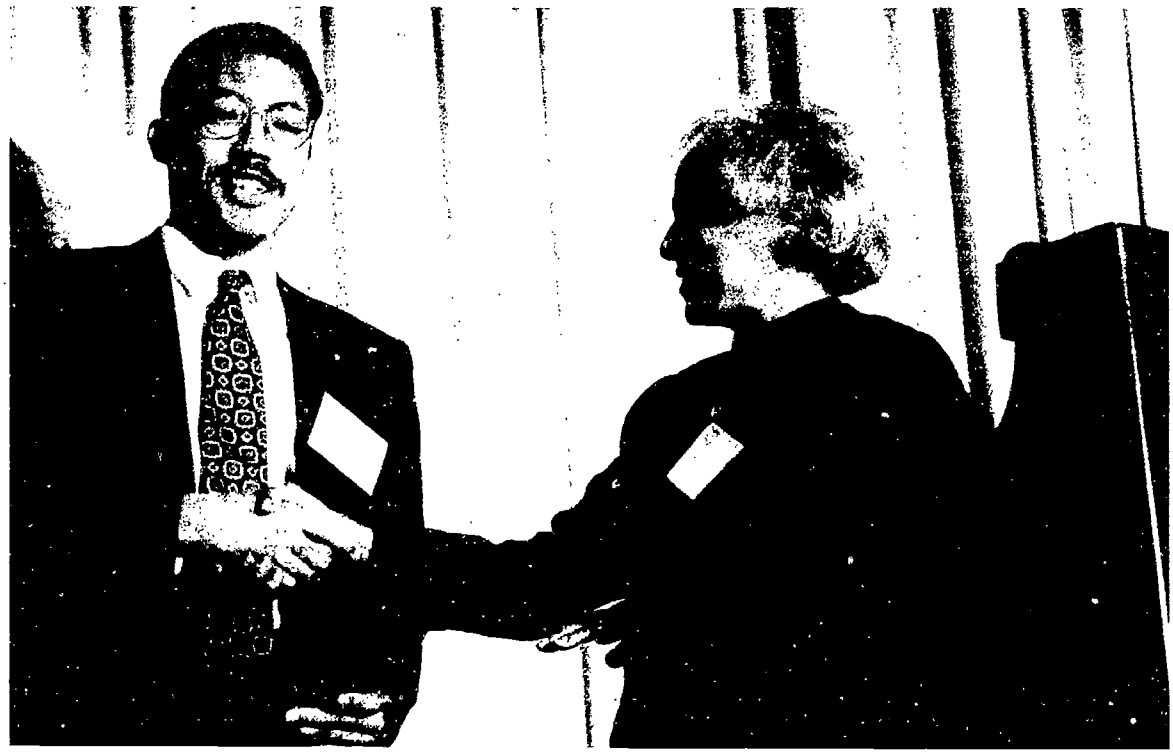
GRADUATE STUDENT RESEARCH AWARDS

Sponsor: Council of Graduate Schools (CGS)

Presenter: Anne S. Pruitt, Dean in Residence, CGS, and member, NSF Committee on Equal Opportunities in Science and Engineering

Awardee: **Nathaniel A. Whitmal, III**, Northwestern University, Ph.D. candidate, Engineering Directorate Program

Title of Paper: "Noise Reduction Methods for Speech Enhancement"



I have two awards to make, but first I want to join the other presenters in saying how impressive this conference has been and that we are, indeed, working with the scientists of the future.

The Council of Graduate Schools is honored to present the awards for the outstanding graduate student research papers and presentations at this conference. We present the award in recognition of NSF's leadership role in providing quality education for minority students who are underrepresented in science, mathematics, and engineering, and as a reflection of our strong support for NSF's efforts.

The graduate students who participated in this competition represent two programs of the Directorate for Education and Human Resources that focus on graduate education for minority students. One program is the Minority Research Centers of Excellence, which seeks to update the capabilities of the most research-productive minority institutions and to provide increased opportunities for minority faculty and students to engage in competitive research.

The second program is Research Improvement in Minority Institutions, which provides grants to strengthen the research capabilities and infrastructures of institutions with substantial minority enrollments that have graduate programs in science or engineering. Together, these programs are responsible for a significant increase in the number of minority doctoral candidates and graduates in the last 3 years.

On behalf of the Council of Graduate Schools, I would like to present each of the winners with a check for $500 and a plaque that reads, "The Graduate Student Achievement Award is presented by the Council of Graduate Schools in recognition of an outstanding research paper presented at the National Science Foundation Conference, Diversity in the Scientific and Technological Workforce, October 1, 1994, Washington, D.C." It is signed by Jules B. LaPidus, President of the Council of Graduate Schools.

—Anne Pruitt

SCIENCE, ENGINEERING, AND MATHEMATICS LEADERSHIP AWARDS

The science, mathematics, engineering, and technology (SMET) education of minority students requires a comprehensive effort involving all segments of the community, including administrators, teachers, parents, and private-sector corporations. Some persons and institutions have a history of involvement in this effort and stand out as leaders in the field of science and education equity; a few persons have devoted their entire professional careers to the effort. NSF has created several awards to recognize and honor these persons and institutions for their creativity, dedication, and long-term efforts to expand educational options for minority students in science and technology. Their efforts have resulted directly in increased participation by minority students in the science and technology enterprise.

The award presentations are summarized below. The awardees each receive a hand-lettered, framed certificate signed by the director, NSF, and the assistant director, Education and Human Resources.

EDUCATOR ACHIEVEMENT AWARD

Sponsor: NSF, Directorate for Education and Human Resources

Presenter: Eugene DeLoatch, Dean, School of Engineering, Morgan State University

Awardee: **Eloy Rodriguez**
James Perkins Professor of Environmental Studies, Cornell University

From left to right, Eloy Rodriguez, Eugene DeLoatch

Dr. Eloy Rodriguez, former professor in the School of Biological Sciences at the University of California at Irvine, is an internationally recognized phytochemist, toxicologist, and dermatoxicologist. He received his B.A. degree in zoology from the University of Texas at Austin and his Ph.D. in photochemistry and plant biology at the same university. During his professional career, he was an Endo-American Fulbright Senior Scholar Lecturer, a visiting professor and research scientist at the University of British Columbia, an invited lecturer of the Chinese Academy of Sciences in the People's Republic of China, and a visiting professor and research scientist at the University of California at San Francisco. Dr. Rodriguez currently holds a chair at Cornell University.

Dr. Rodriguez was raised in Hidalgo County in south Texas, then the poorest per capita region in the United States. Ever conscious of his background, he continues to make special efforts to deliver lectures throughout the southwestern United States, inspiring students to consider careers in science, mathematics, engineering, and technology. He has a special commitment to promote academic excellence among Chicano, Latino, and other minority students in science and engineering.

His efforts have led to the development of several programs: the International Chicano Studies Program, which involves the Chicano community in seminars, special faculty research projects, and the arts; and the Kids Investigating and Discovering Science Program (KIDS), which hosts summer and Saturday science instruction for minority students in kindergarten through 6th grade and their parents. Students in the KIDS Program participate in hands-on data collection and analysis and exchange scientific data with students at schools throughout the Nation and world through the KIDS Network Innovative Telecommunication Program. Dr. Rodriguez also is the former director of the California Alliances for Minority Participation program grant from the National Science Foundation.

Dr. Rodriguez has received the prestigious American Association for Higher Education Hispanic Caucus Award and the first Hispanic Educator Award from the League of Latin American Citizens (LULAC).

—Eugene DeLoatch

EDUCATOR ACHIEVEMENT AWARD

Sponsor: NSF, Directorate for Education and Human Resources

Presenter: Eugene DeLoatch, Dean, School of Engineering, Morgan State University

Awardee: **Mary Hatwood Futrell**
Past President, National Education Association and Director, Institute for Curriculum, Standards, and Technology

Dr. Mary Hatwood Futrell began her formal career in education as a high school teacher in Alexandria, Virginia, in 1963. She received her bachelor's degree in business education from Virginia State College (now University) and her master's and doctorate in education from George Washington University. She moved through the ranks of the National Education Association (NEA) to become the president of this 2.2-million-member organization in 1983.

The development of standards for science and technology education is critical to the national effort to reform science and mathematics education for all children. During Dr. Futrell's 6-year tenure as NEA president, she led the organization's collaborative effort with other national organizations to develop, disseminate, and implement national standards for mathematics and science education. For example, NEA not only endorsed the standards of the National Council of Teachers of Mathematics (NCTM) but also disseminated them to its more than 2 million members through State NEA presidents and national board members and supported implementation efforts. From her position as a board member of the National Board for Professional Teaching Standards (NBPTS), Dr. Futrell facilitated collaboration among NBPTS, NCTM, and NSTA in the development of national teacher certification standards.

Dr. Futrell has been honored by numerous organizations, including the Congressional Black Caucus, the Virginia Women's Hall of Fame, *Ebony* magazine (Outstanding US Black Professional), *Ladies Home Journal* (100 Top Women in America), the NAACP (President's Award), and the National Council on Bilingual Education. She holds honorary doctoral degrees from many universities, including Spelman College, North Carolina Central, Xavier University, the University of Michigan, and George Washington University. She has published in *Phi Delta Kappan*, the *Phi Kappa Phi Journal*, and the *Journal of Negro Education*, among others. She holds office in many national and international organizations,

including the Institute for Educational Leadership, the Carnegie Foundation for the Advancement of Teaching, and the National Commission on Working Women. She is also no stranger to the National Science Foundation, having served on the EHR Directorate Advisory Committee.

Currently an associate professor, Department of Educational Leadership, and director of the Institute for Curriculum Standards and Technology at George Washington University, Dr. Futrell continues her efforts as an advocate for educational reform. As president of Education International, a 20-million-member organization with representatives from 130 countries, she is leading the organization's effort to provide equal access to a quality education for all children. She also serves as project director, Annenberg Mathematics and Science Teacher Leadership Corp Project. In this position, she is responsible for training 100 minority teachers nationwide as leaders in the science, mathematics, and technology education reform movement. Over the last 2 years, these teachers have reached approximately 5,000 of their colleagues.

—Eugene DeLoatch

EDUCATOR ACHIEVEMENT AWARD

Sponsor: NSF, Directorate for Education and Human Resources

Presenter: Eugene DeLoatch, Dean, School of Engineering, Morgan State University

Awardee: **Dr. Freeman A. Hrabowski, III**
President, University of Maryland at Baltimore County

From left to right, Freeman Hrabowski, Eugene DeLoatch.

Dr. Freeman A. Hrabowski, III, is the fifth president of the University of Maryland at Baltimore County. At the age of 42, he is one of the youngest African American presidents of a major American institution of higher education. He is recognized nationally for establishing and managing exemplary education programs, especially for African Americans who will be prominent among the scientists and engineers of the 21st century.

Dr. Hrabowski's hometown is Birmingham, Alabama. He graduated from high school when he was 15 years old, and at the age of 19 he received his undergraduate degree in mathematics with highest honors from Hampton Institute (now Hampton University). He attended the University of Illinois at Urbana-Champaign, where he earned a master of arts in mathematics and a Ph.D. in higher education administration.

Dr. Hrabowski has served in several academic and administrative positions at the University of Illinois, Alabama A&M University, and Coppin State College in Baltimore. He came to the University of Maryland, Baltimore County, in 1987 as vice provost and became executive vice president and vice provost 3 years later. He was inaugurated as president of UMBC on September 24, 1993.

President Hrabowski is perhaps best known for the extraordinary success of the Meyerhoff Scholars Program at UMBC. This program, which began in 1988 with a $522,000 grant from the Robert and Jane Meyerhoff Foundation, is designed to increase student retention and improve the quality of the UMBC student body. This is accomplished through the recruitment of high-ability African American students who are awarded full 4-year scholarships. A great deal of personal guidance is provided to get

them into the best graduate schools. The Meyerhoff Scholarship Program also receives funding from the National Science Foundation, Research Careers for Minority Scholars Program.

One of Dr. Hrabowski's favorite poems is "Hold Fast to Dreams" by Langston Hughes. The poem reads,

> Hold fast to dreams,
> For if dreams die,
> Life is a broken-winged bird that cannot fly.
> Hold fast to dreams,
> For when dreams go,
> Life is a barren field frozen with snow.

Freeman Hrabowski, it is a delightful pleasure for me, as one of your higher education colleagues in the State of Maryland, to award you the NSF Educator Award for 1994. You have truly helped students hold fast to their dreams.

—Eugene DeLoatch

INSTITUTIONAL ACHIEVEMENT AWARD

Sponsor: NSF, Directorate for Education and Human Resources

Presenter: Jaime Oaxaca, National Science Board Member and Vice Chairman, Coronado Communications Corporation

Awardee: **Arizona State University**

Accepting the award, (left), Robert E. Barnhill, Vice President for Research and Strategic Initiatives

Arizona State University is located near the center of metropolitan Phoenix in Maricopa County, where nearly 60 percent of the State's population resides. While the university has been designated as a Carnegie Research I Institution and has an enrollment of approximately 44,000 full-time and part-time students, emphasis is placed on increasing the academic achievement of minorities, who are underrepresented in science and engineering.

Arizona State University prides itself on being one of the leading universities in the Nation in developing programs to address key issues to increase the participation and accomplishments of underrepresented minorities in science, engineering, and mathematics disciplines. These programs include a major role in initiating and implementing a successful AMP program, an undergraduate program supported by NSF to significantly increase the number of minorities who earn baccalaureate degrees in science, engineering, and mathematics disciplines, and the Project to Improve Minority Education (PRIME), a precollege program that introduced systemic curriculum changes with high academic expectations. PRIME has been in continuous operation in Arizona since 1988 and has served more than 50,000 students. The Institute for Strengthening Underrepresented Minority Students in Mathematics and Science (SUMMS) has been successful in increasing the number of minority students who are enrolled as mathematics majors at Arizona State University. Project 1000 is a program that has made an impact on the number of minority students who enter graduate school to study science, engineering, and mathematics.

For its commitment of ensuring that minorities play an expanded and significant role in the university environment as well as in science, engineering, and mathematics, this NSF Institutional Award for 1994 is presented to Arizona State University.

—Jaime Oaxaca

INSTITUTIONAL ACHIEVEMENT AWARD

Sponsor: NSF, Directorate for Education and Human Resources

Presenter: Jaime Oaxaca, National Science Board Member and Vice Chairman, Coronado Communications Corporation

Awardee: **Spelman College**

Accepting the award, (left), Etta Z. Falconer, Calloway Professor of Mathematics and Associate Provost for Science Programs and Policy

Spelman, a private liberal arts college, was founded in 1881 in Atlanta as the first U.S. college primarily for black women. The college's diverse student body is composed of 2,000 women representing 42 states and 20 countries. Spelman's success in producing leaders is quite evident in the sciences. Close to 40 percent of Spelman students major in science, mathematics, or a dual-degree program in engineering, and 30 percent graduate annually in these fields. In 1994, 121 of the 407 graduates earned degrees in science and related fields.

Spelman College is ranked second for the number of African American baccalaureate degrees awarded in mathematics, fifth among all U.S. institutions in the number of African Americans admitted to medical school, and is one of only two historically black institutions ranked by the Carnegie Foundation as Baccalaureate I institutions, based on the competitive admissions process and the number of undergraduate degrees conferred. Last year Spelman established the Center for Scientific Applications of Mathematics to strengthen faculty and student research, contribute to the science and mathematics education of local high school students, expand the body of knowledge on undergraduate education in mathematics, and promote the development of interdisciplinary curricula. With a 45 percent increase in the number of science majors pursuing Ph.D. degrees, Spelman is poised to continue to address the challenge of the participation of African American women in science and technology fields.

—Jaime Oaxaca

INSTITUTIONAL ACHIEVEMENT AWARD

Sponsor: NSF, Directorate for Education and Human Resources

Presenter: Jaime Oaxaca, National Science Board Member and Vice Chairman, Coronado Communications Corporation

Awardee: **Maricopa County Community College District**

Accepting the award, (left), Don Campbell, member, Governing Board, Maricopa County Community College

The Maricopa County Community College District has carved out an important niche in higher education in Arizona and the United States. Ten colleges make up the Nation's second-largest multi-college community college district. This is the State's single largest provider of higher education.

The Maricopa County Community Colleges share a common vision: to strive to exceed the changing expectations of their many communities for effective, student-centered, flexible, and lifelong educational opportunities. Faculty and staff are committed to the principles of diversity. This institution is known for its emphasis on teaching and learning. Nearly 170,000 students attend the colleges each year.

Maricopa serves a large minority population—26.1 percent. More than 11.5 percent of its students are Hispanic, almost 4 percent are African American, 2.6 percent are American Indian and 8% are other minority groups.

Inherent in the district's mission is providing service to minority students who attend the area's elementary and secondary schools. That service and attention include programs such as the NSF-sponsored Comprehensive Regional Centers for Minorities (CRCM), the American Indian Science, Engineering, and Mathematics (AIMES) program, the Urban Systemic Initiative, and additional programs such as Achieving a College Education (ACE), which enables minority students to begin college studies as high school juniors. Another program, Seamless Web, is designed to carry minority students through graduate school.

The Maricopa County Community College District plays a leading role in the Phoenix Think Tank—an umbrella organization dedicated to the success of all students in an education pipeline that extends from kindergarten through high school to the Maricopa County Community Colleges and on to Arizona State University.

The Maricopa County Community College District enjoys a strong relationship with Arizona State University. The two institutions work hand in hand to ensure a solid articulation process, with special emphasis on increasing the achievement of minority students, in science, engineering and mathematics.

For its leadership and dedication to improving the quality of learning in science and mathematics for all students, and for its notable efforts for minorities at the precollege level through the CRCM project, this NSF Institutional Award is presented to the Maricopa County Community College District.

—Jaime Oaxaca

LIFETIME ACHIEVEMENT AWARD

Sponsor: NSF, Directorate for Education and Human Resources

Presenter: Luther S. Williams, Assistant Director, EHR

Awardee: **Warren E. Henry**
Professor Emeritus and Research and Seminar Director, Minority Access to Research Careers, Howard University

This award was initiated at the first Diversity Conference and its purpose is to honor individuals who, over a sustained period, have exemplified the very finest in their individual careers and have had a major mentorship role. The idea is, most assuredly, to honor these individuals for lifetime achievement, but it also develops a pool of senior individuals with respect to stature, not age, who can participate in NSF's programming.

Warren Henry earned a bachelor's degree in mathematics at the Tuskegee Institute (now University); a master's degree in organic chemistry from Atlanta University (now Clark Atlanta); and a Ph.D. in physical chemistry and physics at the University of Chicago. He did postdoctoral work in mathematics at MIT and in physics at the Catholic University of America and the University of Maryland. His academic predoctoral and postdoctoral training included periods of study and research with three Nobel laureates: James Franks, Wolfgang Pauley, and A. H. Compton.

His distinguished academic career has covered more than 50 years, and I'll only highlight a few points here. He has taught at every academic level. He was a high school physics teacher and principal of a small school in Alabama. He served on the faculties of Spelman College, Morehouse College, and Tuskegee University, where he taught physics and chemistry. His research career which has been quite distinguished and of long duration, includes work at the MIT Radiation Laboratory, the University of Chicago Institute for the Study of Metals, the U.S. Naval Research Laboratory, and Lockheed, where he rose to the position of senior staff scientist.

He is involved in several seminal inventions, one of which is the metal dewar used for liquid helium, which makes it possible to study magnetic properties of substances in high magnetic fields at exceedingly low temperatures. Another major discovery involves a fiber optic subsystem, which has made it possible to rescue disabled submarines from deep waters.

An individual of such distinction is listed in all the obvious places, and I'll cite only a few: American Men and Women of Science and Who's Who in America; Fellow of the American Physical Society and

the American Association for the Advancement of Science; member of the Washington and New York Academies of Science; member of Sigma Xi and the American Association of Physics Teachers. Dr. Henry has to his credit more than 100 publications; the majority of these papers were published before the peak of the civil rights era, the significance of which is self-evident.

He has received a host of other awards, including the Alumni Award from Tuskegee, the Outstanding Black Physicist Award, the Living Legacy Award of the National Technical Association, and honorary doctoral degrees from Clark Atlanta and Lehigh University.

In 1969, in the second chapter of his career, he joined the physics department of Howard University and has been involved primarily in graduate education and teaching. It is estimated that half of the approximately 80 African Americans with Ph.D.'s in physics were taught, at least in one course, by Warren Henry. This is an individual unit of distinction, although I'm sure Dr. Henry would agree that the number itself is a national tragedy.

He became a professor emeritus, because universities do that, but he ignored the emeritus status and continued to teach for almost 10 years. He is now involved in leading the Minority Access to Research Careers program that many of you know at Howard University.

Warren, in acknowledgement of your many achievements over a long period of time and your major role in mentoring, NSF is pleased to present to you this Lifetime Achievement Award.

—Luther Williams

Warren Henry

It's a great pleasure to be here, and I just want to say to the young students here—and to the old students, too—that it's worthwhile to pursue your goals and develop your undenied talents. I'm thinking of the poem "Elegy Written in a Country Churchyard" by Sir Thomas Gray. It says,

> Full many a gem of purest ray serene,
> The dark unfathomed caves of ocean bear:
> Full many a flower born to blush unseen,
> and waste its sweetness on the desert air.

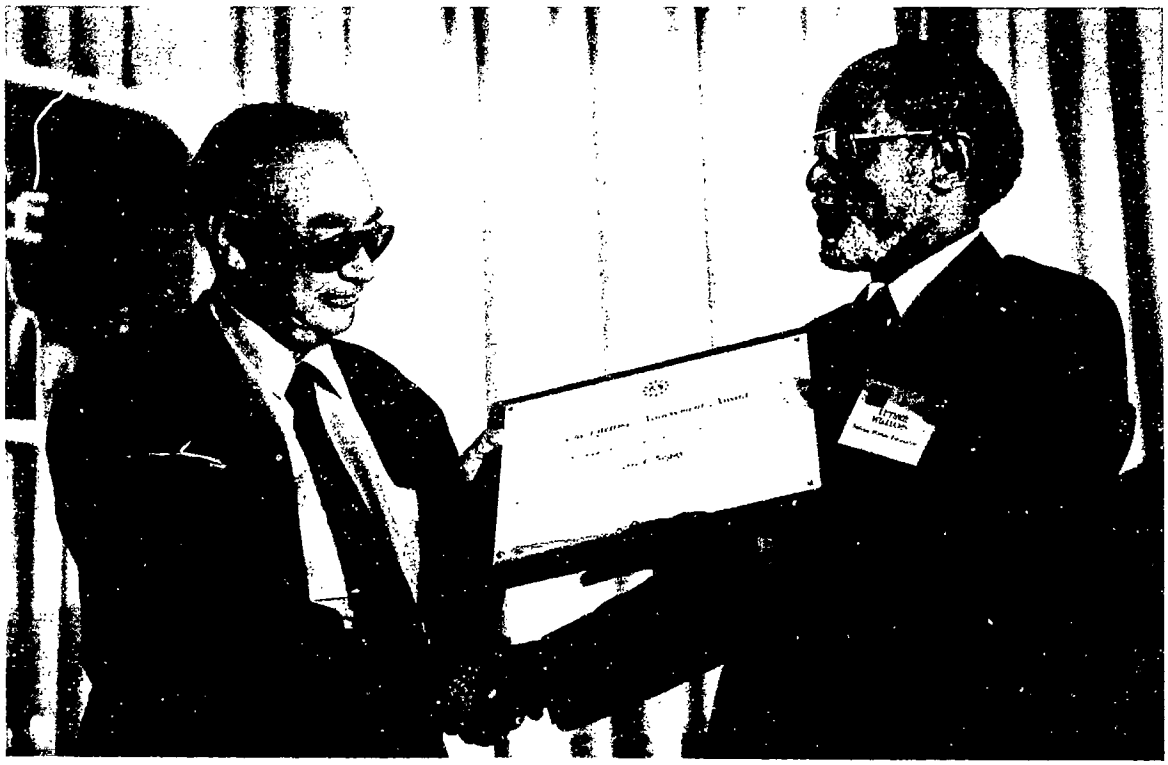
We want to make sure that you develop your talents so that they will not be wasted. Thank you.

LIFETIME ACHIEVEMENT AWARD

Sponsor: NSF, Directorate for Education and Human Resources

Presenter: Luther S. Williams, Assistant Director, EHR

Awardee: **Fred Begay**
Staff Assistant to the Director, Office of Science and Technology, Los Alamos National Laboratory



Dr. Fred Begay, an experimental physicist at the Los Alamos National Laboratory, received a B.S. in physics and mathematics, an M.S. in physics, and a Ph.D. in nuclear physics at the University of New Mexico in Albuquerque. During his illustrious career, he has participated in high-energy gamma ray physics and neutron physics research, as well as solar wind and exploding wire research, and he has investigated fundamental theoretical and experimental plasma physics problems.

Dr. Begay was born on the Ute Mountain Indian Reservation in Towaoc, Colorado. Because the Navajo language is not written, Dr. Begay's name is an Americanized extraction from his native Ute language.

In 1979, Dr. Begay was the subject of a television documentary for NOVA entitled "The Long Walk of Fred Young." In this 1979 production, he explained that "A scientist looks at the world like a child—always wondering what it is made of. What are the pieces?" For more than 25 years, Dr. Begay has devoted his time and energy to understanding fundamental plasma physics problems. His research seeks to demonstrate technically the use of nuclear fusion as a practical, economical alternative source of electrical power with fewer health, environmental, and safety risks.

Beyond his stellar research efforts, he has made substantive contributions to young people interested in science, mathematics, and technology education through his service as president of the Navajo Science and Research Council, a member of the National Research Council, a member of the New Mexico Steering Committee for the White House Conference on Indian Education, and a member of the Committee on Minorities in Physics of the American Physical Society. He currently has dropped any pretense of retirement and is serving as project co-director of the Alliances for Minority Participation Program at Arizona State University.

Dr. Begay, it is a great pleasure for me to present to you the National Science Foundation's 1994 Lifetime Achievement Award. Your dedication to increasing the base of knowledge of physics and your

involvement in increasing the presence of minorities in science and engineering have made a lasting impact on the education and research horizon.

—Luther Williams

Fred Begay

Maybe I should speak in Navajo. It is indeed an honor for me to receive this award this year. I am deeply honored, and on behalf of my wife, Helen (we've been married 40 years and have 7 children and 17 grandchildren)—on behalf of my family, I accept this award.

I, too, am proud to be a member of this meeting, and I, too, want to recognize the youth here. Youth are very important for the future.

I began learning English—formal English—at the age of 23, and I studied physics and mathematics in German, so you see there were many challenges that I had to meet and overcome.

You, also, will have many challenges, and I wish you all the best, for those of you who have this dream of being a scientist. Maybe you can join us at Los Alamos and do experiments!

Thank you very much.

FORUMS & WORKSHOPS

FORUMS & WORKSHOPS-Continued

FORUM ON UNDERGRADUATE EDUCATION: AN OPEN DIALOGUE

PRESIDER

Elmima C. Johnson
Staff Associate
Office of the Assistant Director, EHR, NSF

MODERATOR

Diana S. Natalicio
President
University of Texas at El Paso

RESOURCE PERSONS

Gary D. Keller, Executive Director, Project 1000 of the Hispanic Research Center, Arizona State University
Carolyn Meyers, Associate Dean for Research and Interdisciplinary Programs, College of Engineering, Georgia Institute of Technology
James M. Rosser, President, California State University at Los Angeles
Robert F. Watson, Division Director, Undergraduate Education, EHR

OPENING REMARKS

Elmima Johnson

This is the Forum on Undergraduate Education and it will focus on the major issues surrounding science, mathematics, engineering, and technology education (SMETE) at the baccalaureate level. This forum is part of an ongoing dialogue at NSF and reflects concern nationwide regarding the current status of undergraduate education. It has been more than 10 years since the National Science Board completed its first comprehensive study of undergraduate education, and there is a growing realization today that all citizens need to become literate and competent in science and technology, not just science majors. The focus on undergraduate education is a logical extension of our efforts to reform K-12 SMETE, and includes recognition of changing demographics of those persons attending college.

We have distributed a background paper, a summary of the issues in undergraduate education as identified by the NSF Directorate for Education and Human Resources (EHR). This is not an exhaustive list; it is meant to stimulate and guide the discussion this morning. (See p. 72)

OPENING STATEMENTS

Diana Natalicio

The purpose of this session is to stimulate discussion and to encourage you, the participants in this forum, to share with us and with NSF more broadly your best thinking on directions that NSF can take in addressing the major issues relating to undergraduate education.

We are going to present some introductory remarks and then the program will shift to you. We want this to be an open forum. We want to know what you think about undergraduate education, about the issues that we're facing, and about the ways in which we might best address them.

The focus on undergraduate education is, obviously, no accident. NSF has been looking at precollegiate programs (as was suggested earlier in Dr. Williams' remarks and mentioned by Elmima Johnson), and NSF has also been very active at the graduate level and obviously in research. But what we have discovered within the framework of this educational continuum is that a key element is clearly under-

graduate education: No matter how hard we work to increase the size of the pool within the precollegiate sector, and no matter what we do to enhance research and graduate opportunities, if we don't have undergraduate education well in focus, we are not going to make progress in addressing the critical underrepresentation of minorities in science and engineering. I think all of us are familiar with the kinds of challenges that we face.

The undergraduate experience is critical not only to develop a scientifically literate population and workforce, it is critical not only to produce future generations of scientists and engineers, but it also has the very important function of preparing future teachers. It is this confluence of responsibilities at the undergraduate level that all of us must be concerned about and committed to meeting. It is also very clear, however, that within the framework of higher education, the undergraduate experience has not had the kind of attention, at least during the past several decades, that it has deserved. How do we know that?

We know that not only because of our own involvement in undergraduate education, but also through the rising criticism and commentary coming from the media, elected officials, and from parents who are paying higher and higher levels of tuition and taxes and who wonder why classes are so large, why students are being taught by teaching assistants, and the like. Such questions are raised not only within the higher education community, but by critics on a variety of external fronts, so accountability is a significant issue for us.

I think we are all looking for new directions, ways in which we can improve not only the undergraduate experience in science and engineering, but the general undergraduate experience at our institutions. We thought it would be helpful, as a start, for Dr. Robert Watson, Division Director of Undergraduate Education at NSF, to give us a brief overview of the activities of that division and how it has framed the issue.

Robert Watson

Both the national scene and NSF have changed dramatically over the past several years. Major developments—such as the end of the Cold War, intensified international competitiveness, the restructuring of U.S. industry, the advance of technology, and the increased diversity of American society—have all contributed to a new centrality and importance for undergraduate education in the U.S. educational enterprise. It serves as the wellspring not only for future scientists and engineers, but also for the future technical industrial workforce, leaders, and citizens who need competence in science and technology to function effectively, as well as for future teachers. Indeed, efforts to improve grades K-12 may have limited success without concomitant changes in higher education.

NSF's program for undergraduate education is an agencywide effort, with the Division of Undergraduate Education in EHR serving as the focal point. The overall activity has its origins in the National Science Board study and report, "Undergraduate Science, Engineering, and Mathematics Education," often referred to as the Neal Report.

The current NSF program involves leadership activities and leveraged program support that encompass several principal themes. These include the curriculum (broadly defined), laboratories, faculty development and support, student support, and increasing participation of underrepresented groups, particularly minorities, women, and persons with disabilities.

EHR has mounted two new targeted efforts, the Advanced Technological Education Program (NSF's first focus on the industrial technical workforce) and the NSF Collaboratives for Excellence in Teacher Preparation (aimed at the undergraduate education of future elementary and secondary school teachers).

As a consequence of these changing conditions, trends, and needs, a number of issues confront undergraduate education that are of particular concern and interest to NSF. We ask you to consider the following areas: the preparation and vitality of teachers and professors; science and technology literacy; the preparation of students for careers in both the academic and industrial workforce; and the comprehensive reform of undergraduate education.

Throughout all of these areas and their underlying issues, of highest priority is the goal of achieving equity and diversity in all aspects of SMETE. We welcome your comments and wisdom on these and other issues that you feel are relevant to undergraduate education.

Gary D. Keller

The most popular metaphor for progress in education, beginning in kindergarten and going through graduate school, is the pipeline. The metaphor is a good one because it expresses both the sense of progress and the impediments or obstacles to progress. Those obstacles can well be described as the joints or pressure points in the pipeline.

At the undergraduate level, there are at least three major joints: between high school and the freshman year of college; between community college and the four-year college (or between lower and upper undergraduate status); and at the culmination, between the baccalaureate and graduate program status for those students who are interested in and who would potentially benefit from graduate school.

The Coalition to Increase Minority Degrees (CIMD), which I direct, has paid very close attention to each of these joints in an effort to minimize loss at the pressure points and to maximize the flow or progress of students from one level to the next, more advanced status.

The CIMD has made strong efforts to bind together the 11th and 12th grades with the early college careers of students. We do this by having many of our students take honors or advanced placement courses in the 11th or 12th grades for college credit, once the student has been accepted into college. Not only do the students complete advanced work in high school, but they get a good (and often very successful) taste of working at the college level, and the students earn college credit while still in high school. This fusing together at the joint of high school and college greatly helps our retention of students. Another program that we have used is the summer bridge, which caters to students who have been accepted into college and gives them a strong program of early academic enrichment the summer before the freshman year, emphasizing mathematics, science, and English.

At the joint between community college or underclass-upperclass status the CIMD has established a second summer bridge program, recruiting students into our participating four-year colleges and providing students with additional coursework in mathematics, engineering, science, or English to maximize their potential to graduate from college.

Finally, Project 1000 advises undergraduate students interested in graduate school at the sophomore and junior levels, and helps these students apply to graduate school as seniors. Among the services of Project 1000 are the following: Students can apply to as many as seven graduate programs around the nation on one consolidated application form; application fees are usually waived by the participating graduate schools; students consult with Project 1000 on how to frame their applications and statements of purpose; professors writing letters of recommendation need write only one per student and submit it to Project 1000; and, finally, we work with the participating graduate schools and outside agencies and foundations to help students secure financial aid.

James Rosser

I'd like to begin my remarks in hopes of stimulating some further discussion with some observations. First of all, it seems to me that reform of undergraduate education, especially with an emphasis on SMET, requires that we do something fundamental with regard to what I would call lower division undergraduate education in this country. It seems that at least as far as college students are concerned, that is where the emphasis ought to be placed. Clearly, given a comment that was raised earlier this morning with Dr. Williams, when we talk about lower division undergraduate education, if we're focusing on underrepresented students, such discussions must involve the two-year colleges. So we must be concerned about lower division undergraduate education. That is where, at least at the collegiate level, students either get further turned on to or turned off of (if you will) SMET and SMET-related fields and disciplines. I'm not sure that enough attention is given to that concern.

As we think about reforming undergraduate education with an emphasis on science, mathematics, engineering, and technology, we ought to ask ourselves what all students—irrespective of whether they start at our institution or transfer in and irrespective of what they look like at entry—ought to be able to demonstrate in terms of functional competencies after two years of a collegiate education. Before a student enters the junior level of a collegiate education, shouldn't that student—in terms of oral and written communication skills, math, and science—be able to demonstrate some minimum functional level of competency that enables him or her to choose on a far more appropriate basis where to matriculate for a degree?

Doesn't that help us solve a far more fundamental problem: how teacher education varies across the 50 States? In California, you need a baccalaureate degree and then you enter a credentials program. A great deal of emphasis is placed on what happens at the undergraduate baccalaureate level, but there is no focus, generically speaking, on what a baccalaureate graduate ought to be able to demonstrate functionally.

To the extent we can solve this problem in those first two years, whether it is a two-year or a four-year institution, and to the extent that we can agree that there are some basic minimum functional competencies, we have essentially raised the level of the tide for everybody, thereby creating greater opportunity for everybody.

It is my considered opinion that no one should be allowed to teach prekindergarten through the 12th grade who does not meet what I would call minimum functional competencies that someone who graduates from the 12th grade should be able to demonstrate. A kindergarten teacher who can't function at a 12th-grade level probably should not be teaching in a kindergarten. A 1st-grade teacher who can't function at a 12th-grade level shouldn't either, and certainly such a 12th-grade teacher shouldn't be able to continue to teach. It seems to me that this is just a minimum expectation for every teacher: that at some level they can demonstrate that they can function at what we would call a 12th-grade level. Otherwise, how can you explain why there's atrophy across grade levels and why there's an achievement gap that exists among students, even though most students enter the schools with a given level of support?

We have a major responsibility in terms of the workforce that already exists that doesn't meet these competencies, many of whom have not even been discipline-trained in math or science. That doesn't mean putting down people who are currently in the structure. What it means, to my way of thinking, is accepting why they're where they are and the fact that there are things that we can do to mitigate the deficiencies they have.

Faculty who teach, especially basic undergraduate courses, must themselves be competent teachers, not just people with Ph.D. degrees in mathematics or microbiology or physics. A Ph.D. does not guarantee that one is able to teach effectively (especially lower division undergraduate students), since the primary focus of the Ph.D. is generally on research and not necessarily on teaching.

I think we have a major role to play in that context, and that gets us back to the issue of our two-year college colleagues, especially those who teach math, science, and basic competency in communication skills. Clearly, the role of the comprehensive universities and the two-year colleges is important as we go forward.

I would also say that in a lot of our colleges and universities, because of the concern for writing and because of the concern for the ability to use standard written English, we talk about writing across the curriculum. Maybe there ought to be science across the curriculum as well, and maybe we ought to agree among ourselves that, given the nature of knowledge and information these days, the disciplinary boundaries are no longer appropriate and we need to seek more effective ways of communicating information through the curriculum so we are able to retain the interest of students across the curriculum while they're at the institution.

There needs to be, in my view, diversity training in the areas of cultural awareness and cultural sensitivity and across cultural communications for SMET faculty, irrespective of where we might be. That also includes those of us who might feel that because we're of a particular ethnic group we have some particularly inherent knowledge as relates to what that might mean for an African American student. Interestingly enough, the African American students might do better in colleges and universities if they were taught English as a second language as well, in terms of enhancing their capability to communicate in an oral and written context.

There is a need for faculty development and instructional strategy for incorporating technology; additionally, advisement is an extraordinarily critical aspect of this whole notion about retention. There is a need for solid, informed, and consistent advisement, including mentoring.

The last comment I would make is that it seems that there are some programs that NSF has been involved with, that Bob has been involved with over time, that have demonstrated that there are some "best practices" out there. Maybe there needs to be a greater commitment on our part, particularly across those first two years, to ensure that there is some standardization of best practice applications if, in fact, we want to attain the desired outcome for the greatest numbers of students in the near future.

Carolyn Meyers

Engineering, science, and technology have reached a significant milestone in history in that next year marks the 50th anniversary of the document "Science: The Endless Frontier" by Vannevar Bush. On rereading this document, one part strikes me as special and noteworthy: that "It is in keeping with the American tradition, one which made the U.S. great, that new frontiers shall be made accessible for development by all American citizens." Fifty years later, we are certainly still facing endless frontiers in SMETE.

I had the privilege this summer of being a chair for a conference sponsored by the NSF Division of Undergraduate Education. Engineering faculty examined the restructuring of engineering education. With this experience in mind and mindful that I have spent my career in engineering education, I will confine my remarks to engineering education.

Primary and central to the conference was the new vision that my colleagues developed. This vision considers a growing and a national competition, the global environment in which our students will participate, an increasingly diverse population, and, of course, the rapid growth and change in information technology. This new engineering education will welcome and encourage motivated and talented students from all segments of the population. It will also offer flexible curricula that recognize and respond to individual learning styles and diverse career paths. This is a tall order.

In our discussions at the conference we agreed that the responsibility for the quality of engineering education rests on everybody involved in the educational enterprise, as Dr. Rosser just mentioned. Educators at all levels must buy into and embrace this responsibility; my colleagues and I believe that certain levels of science and technological literacy will be necessary for people to be active and contributing participants in society in the 21st century.

This order is getting even taller! Critical to the realization of the vision is the development of faculty, not just at the collegiate level, but at every level in the educational process. It is the faculty who actually comprise the front line in delivering any quality educational system. This faculty is envisioned as diverse, diverse in their cultural and professional experiences. Diverse faculty bring diverse solutions to problems.

Thus, the challenge to the institutions and to each of us in academia is to push for incentives that reward and celebrate diversity, that value the development of this diverse faculty, and that appreciate and recognize diverse solutions and diverse ideas of the faculty.

The Dean of Engineering at Georgia Tech, John White, at our recent retreat, gave us a picture of a global village, which I want to share with you. This is the global village of today:

> If the world were a village of 1,000 people, today there would be 584 Asians, 150 Europeans, 124 Africans, 84 Latin Americans, 52 North Americans, and 6 Australians and New Zealanders.
> Seven out of 10 people would be Africans or Asians.

What many of us do not realize is how diverse our global population really is. And from all demographic indicators, the global village of the 21st century will be even more diverse. From this "village" will come the SMET leaders of tomorrow. It is therefore clear that in order to develop a diverse pool of technically talented, active, and gifted people, the faculty who teach them and who will be involved in the entire educational process must be engaged. These diverse faculty not only offer tangible examples of success for students, but also promote changes in pedagogy and content that all students will need to be productive in the 21st century.

The July 1994 Joint Report of the Engineering Deans Council and the Corporate Roundtable expects that the faculties of the 21st century will reexamine the curricula and the programs, incorporating in their teaching activities an understanding of environmental and societal impacts. Team skills among the students will be built, and collaborative and active learning will be the norms—no more just lecturing, as we heard mentioned this morning. These faculty will respond to different teaching and learning styles of our students. These faculty will promote communication, leadership, and ethics. These faculty will impart to their students a systems perspective to problem solving and design, multidisciplinary approaches, integrated knowledge throughout the curriculum, and an appreciation of diversity.

What they are really doing, what will really happen as a result of these new paradigms is that the message will be sent to the students that the practice of engineering is no longer local or even national: It is a global endeavor. This diverse faculty and student body, as I mentioned, will be celebrated for their differences in leadership and problem solving and perspective, and ultimately will contribute, I firmly believe, to the health of the university and also to the wealth, if you will, of our respective disciplines.

In summary, I am passionate about a lot of things. I am passionate, obviously, about my children and family and traditional things. I am also passionate about my profession and my specialty, which is the mechanical behavior of materials. One of my favorite materials is a quenched and tempered steel. I am happy talking about metals. I love them. It is an old material. It is a workhorse material. This steel is strong, just like the U.S. educational system's track record in educating scientists, engineers, mathematicians, and technicians for the world. Our educational system is good—and is recognized as such. This steel, this quenched and tempered steel, performs its intended function because, in addition to being strong, it is tough and it is ductile.

Now the challenge to us in education is to be tough, to absorb the impact on society of our engineering decisions and designs while still maintaining our strength. We must use our ductility like the steel, our ability to stretch or to bend without breaking. Those of us in education, as well as the systems or units we represent, have a shared responsibility to be strong, tough, and ductile in our actions and reactions. Diversity—in all its many forms—like an alloy addition to metals, can enhance our properties, in this case the pedagogy, content, and overall educational experiences of our students—the leaders of the 21st century.

Thank you.

AUDIENCE COMMENTS

Diana Natalicio

I want to thank all of you who have come to this session. Your presence here suggests that you are concerned about and committed to undergraduate education and we are very grateful for your presence. But your presence is not quite enough. Now we want your input. We'd like you to tell us what you think.

We ask that you be brief, out of respect for all of the people who might want to comment, and we assure you that the remarks that you share with us today will be transmitted through Dr. Robert Watson and through NSF as input into the further development of programs at the undergraduate level.

Audience comments and the responses of resource persons are summarized below.

- We must provide the latest equipment and facilities for high school preparatory science and mathematics cou rses to prevent the need for "catch-up" skill development and content learning freshman year in college.
- At the college level, the information explosion makes it impossible to expose students to all of the knowledge available in a field. Therefore we need to synthesize the growing knowledge base and teach the fundamentals, but in a different context.
- There are attempts to teach (integrate) engineering principles across the curriculum, from freshman through senior year, for example in mathematics, physics, and chemistry classes. The goal is to provide students with perspective and tools.
- A first step in implementing systemic reform is the "fusing" of high school and college. Emphasis should be placed on the senior year of high school and the freshman year of college, because this is the period during which we lose a large percentage of potential scientists. Suggestions included offering courses for college credit beginning in the 11th grade.
- We should deemphasize the current structured timeframe and mode of delivery of information, and focus on accelerating outcomes and learner productivity.
- An interdisciplinary emphasis in undergraduate education serves as the basis of the NSF collaborative program. This program requires collaboration between colleges of science and education and thus serves as a catalyst for the desired interaction.
- Science education reform will not be driven by new technologies, but by the use of the scientific method in instructional delivery. However, many current K-12 teachers were not trained in this methodology, but in a "fact-based" approach. College science faculty will have to assist in retraining these teachers, and their institutions must support them in these efforts. [Dr. Natalicio noted that college faculty play a major role in determining their own reward system: thus, faculty belief in the importance of collaboration with precollege teachers would facilitate obtaining the support of university officials.]

- More college faculty must be convinced that there is a crisis in education and a need for diversity in the workplace.
- Universities are changing the education paradigm from an emphasis on student failure to one on student success (graduation).
- While college-level faculty traditionally have minimum training, if any, in teaching methods, this is a major responsibility for many. The question was raised, Shouldn't teaching faculty be as competent in the art of teaching as they are in their discipline area? It was noted that a few institutions are now evaluating teaching skills of job candidates.
- More support should be given to successful minority science programs. Many are not being institutionalized at their host universities and the need for NSF support for these programs was expressed. An opposing view was that this is an institutional, not an NSF, issue. That is, each institution should be committed to the success of every student that it admits. In addition, individual faculty must become more proactive and vigilant regarding the support of those efforts to assist minority science students.

CLOSING REMARKS

Diana Natalicio

We want input from the community, not only from the higher education community, but also from the broad community that is represented at this conference. We want your help in structuring new ways of thinking about the undergraduate experience. Not in and of itself, but as it relates to all of the other pieces of this complex puzzle that we are attempting to put together. We want to ensure that all young people in our society have a real chance to succeed and to become the scientists and engineers they seek to be.

So we thank you for your input, for your presence here today, and do let us hear from you. We are very interested in your input.

Thank you very much.

Additional comments regarding the status of undergraduate education or suggestions of ways to improve the enterprise should be addressed to

Dr. Robert Watson
Director
Division of Undergraduate Education
Directorate for Education and Human Resources
Room 835
4201 Wilson Boulevard
Arlington, VA 22230

BACKGROUND PAPER

Current Issues in Undergraduate Science, Mathematics, Engineering, and Technology Education

The context for SMETE has changed. NSF recognizes that major developments such as the end of the Cold War, intensified international competitiveness, the advance of technology, and the increased diversity of American society require us to rethink NSF strategy for undergraduate education.

The year 1995 is the fiftieth anniversary of the appearance of Vannevar Bush's seminal report, "Science: The Endless Frontier." This defining document for postwar U.S. science states: "The frontier of science remains. It is in keeping with the American tradition—one which has made the United States great—that new frontiers shall be made accessible for development by all American citizens." Indeed, ensuring that new frontiers of knowledge are created, developed, and accessed by all summarizes much that NSF has done and must continue to do.

NSF views undergraduate education as the linchpin connecting research to teaching, and precollege education to graduate education. That the principal Federal effort in SMETE is in an agency devoted equally to research and education reflects the need to infuse SMETE with knowledge and investigation. Of interest to NSF are 3,000 varied institutions that instruct 13 million American undergraduates. The specific targets of NSF action are all undergraduate students of science, mathematics, engineering, and technology (SMET) and their instructors, with their diverse backgrounds and interests. We invite your thoughts on the reorientation of NSF undergraduate efforts. The following are the areas in which issues pertinent to this consideration arise. Questions might concern what is being done versus what needs to be done, and what should be the scale of activities.

- **The preparation and vitality of teachers and professors**

— Learning how to teach must be balanced by personal knowledge of subjects, the balance depending on level.
— School teachers, especially primary teachers, have unique needs in SMET.
— Teacher preparation is recognized by few SMET faculty; the need to prepare professors to teach is recognized by almost no one.
— The attraction of teachers and professors across race, gender, disability, and ethnicity is uneven.
— The reward systems in schools, colleges, and disciplines may be inadequate to promote excellence.

- **Science literacy**

— SMET should become central in the intellectual heritage and culture transmitted in higher education.
— Institutions must set goals in terms of student learning and competency in SMET.
— We do not know whether quality in the lessons aimed at literacy and those aimed at mastery for majors is the same or different.
— Barriers to SMET literacy owing to ethnicity or gender need attention.

- **Careers**

— Many undergraduates we educate become technicians, yet SMETE has traditionally ignored their needs.
— The attraction of talented young people to careers as scientists, engineers, and technicians across the spectrum of diversity of origins remains vitally important.
— While disciplines remain the homes of quality control of new knowledge and of basic competency, the problems are increasingly interdisciplinary.
— The right connections, networks, and collaborations are needed to facilitate student careers.

- **Comprehensive reform of undergraduate education**

— The exponential growth of our subjects is matched by the growth of capabilities of instructional technology, but development and application of the latter lags the former.
— Our teachers and professors are inadequately informed about advances in pedagogy, content, technology, information resources, connections to societal needs, etc.
— The institutional problems of initiating and sustaining curricular change are intense.
— Change needs to transcend traditional categories, disciplines, and structures.

STUDENT FORUM: "ASK NSF"

The forum sessions provided student participants with an opportunity to interact directly with NSF/EHR officials and grantees who served as a panel of resource persons. These were informal sessions with no set agendas, and students were encouraged to comment on a variety of issues related to their educational experiences and career options. Below are edited and summarized excerpts from those sessions. We thank the students for their participation and candor and invite their continued feedback at the following address:

Directorate for Education and Human Resources
National Science Foundation, Room 805
4201 Wilson Boulevard
Arlington, VA 22230
Attention: Dr. Elmima C. Johnson

SESSION A: PRECOLLEGE STUDENTS

MODERATOR

Joseph G. Danek, Director, Office of Systemic Reform, EHR

RESOURCE PERSONS

Wanda E. Ward, Special Assistant, Office of the Assistant Director, EHR
Costello L. Brown, Program Director, Career Access, Division of Human Resource Development, EHR

Panel member: Why don't you tell me what your project is about?

Student: My project was finding out how harvest ants locate their nest. From that we conducted different experiments to find out if they follow each other, follow chemical substances, follow the sun, radiation waves, and several different things. I also researched experiments that were conducted by major scientists and other people who know more about it than I do. I gathered their information and compared it with mine, and it was very similar information.

Panel member: Do you feel you have a better understanding or even preparation for your regular math and science courses when you go back to school? You just completed this project in the summer, right? Now you're involved in your regular math in school. What's the relationship between your research and your readiness to study when you go back to the regular classroom? When you combine the two, does it make you a better student?

Student: Well, yes, because when I first went to summer science camp, I liked math better than I liked science. We did more science than math. Now I'm more motivated to do things in science class, to talk a little bit more, because I know a little bit more than I did last year.

Panel member: I have a question to ask all of you. Dr. Williams is here and we give out grants. Suppose I give you a million dollars. What two or three things would get more of your classmates interested and excited about science?

Student: I suggest that you put in more programs for the precollege students. Because the point is to get more kids into college and get more programs in the inner-city area where they are needed most. Like Philadelphia. I go to a magnet school and that's probably one of the reasons I'm in this program. Because if I wasn't in the magnet school, I definitely wouldn't have done a science project. It was my teachers who suggested that I do one. So if you've got more programs like that, you'd get more kids interested in science and mathematics.

Panel member: Who else wants a million dollars?

Student: Well, I live in a rural area, and in my school I don't think it's all about money. I think that if people visit our school and get our school to have science fairs—because we have never had a science

fair in our school—and have more activities pertaining to science and more programs like you said—I think students will become more interested. They have to make it fun and not just have lectures all the time. I think that will motivate students.

Panel member: How many of you have never had a science fair in your school? [Hands go up.] Most of you haven't.

Student: I would make school more fun, like looking at the students' interests instead of just doing what you think they're going to do. You look at their interests and do more experiments. Because a lot of kids don't like looking at textbooks. They like doing experiments, so I would bring more experiments into the classroom.

Student: I would just like to say I started a program in which minorities on the college level come to the precollege level as role models or mentors and show them (the kids) that it's cool to be in science. You know, you don't have to be a nerd to do science. And I think students would have more fun in a lab, because you have an older person to look up to, and you have the lab.

Student: Well, first of all, you need to educate people that have the programs. A couple of my cousins go to majority white schools and when they send out the program information, they hand it to the white kids instead of the Hispanics, the blacks, the Asians—minority groups. So people don't know about the programs and they don't get the opportunity to participate.

Student: Part of the reason I'm here at the diversity conference is because of my high school's link with Morgan University. I think that if more high schools had a connection with local colleges, if young high school students were able to walk on the college campuses, be a part of the college atmosphere, and work with science professors, I think more students would have some type of relationship with science in the future.

Panel member: Just to comment on this, we have created what we're calling the Urban Systemic Initiative. We have large projects in a number of cities in which you reside, one in Baltimore, in which we are doing exactly that.

What we're trying to do is link the universities with the school districts, beginning to form a team that can help change the school districts by putting in place quality science programs for all children in the city of Baltimore. So that's an excellent suggestion, and in fact there is an activity at NSF that's beginning to do that.

Panel member: Other comments on the question about what you would do with a million dollars? There's got to be more thinking about it.

Student: I think we should have a camp that's run by students, maybe seniors in high school or something like that. I think we relate better to seniors in high school than to adults. So I would start a camp that had the seniors in high school in charge, and then a couple of adults who would just stand by. We would get the high school students to teach. I think this would be more fun for the high school students and also more fun for us.

Panel member: With nobody over 20 allowed.

Student: Well, I'm not saying that. I'm just saying that the teachers and the people who helped us with our labs and stuff would be the high school seniors, which would be fine.

Panel member: In fact, some of the projects have that feature. They still have the instructors—the math and science instructors, some of whom come from colleges and universities; some come from high schools. Some of the projects, I know, have both undergraduate students and upper high school students who serve as instructional aides. So, in fact, it is a very relevant suggestion that you're pointing out and it's happening in some places, but not in all places, as you know.

Student: I think the colleges should give more scholarships. Everyone's saying, "You should be a scientist. You should be in science and go to college." But not everybody has the money to go to college. Many people want to do great things, but you need money to do all that kind of stuff. So I think you need more scholarships and more information about them.

Student: I think that the idea of being in collaboration with the local university is good. And also, a lot of kids look at the financial benefits of doing programs. Like the students who went up and got plaques, those are confidence builders—plaques and getting $500 for doing something well.

I enjoy presenting in front of people and explaining my ideas. Also I play basketball, so I'm used to a crowd showing up.

Panel member: So there are lots of different ways to show off, right, which is good, both mentally and physically, right? Great.

Student: I'm a high school senior and I'm starting a program something like this: I just got a grant from a company called NETSEF and they help people start their own businesses. Basically the program is going to have high school seniors and juniors teaching middle school students. But it's going to be more than just that. It's going to have science fair projects, mentoring, homework, test-taking skills, note-taking skills—all kinds of things. And its going to have a computer workstation and kids from the neighborhood and from all over Philadelphia can use the computers to find out about different colleges, different contests, and other things that are available to them.

They need more programs like this in other places. My mom helped me come up with the idea.

Panel member: That's great. Other comments? Other questions?

Student: I would make the programs more appealing to students. Because I know a lot of people who, when they come into a forum like this, would just sit in the back, because they think it's going to be real boring. Nobody would ask them questions and they'd just sit there, listening to words that they don't understand. To make a project more interesting, you should talk to the people and not at them or over their heads.

SESSION C: UNDERGRADUATE AND GRADUATE STUDENTS

MODERATOR

Daryl E. Chubin, Director, Division of Research, Evaluation and Dissemination, EHR

RESOURCE PERSONS

Thomas W. Cole, Jr., President, Clark Atlanta University
J. Elenora Sabadell, Program Director, Engineering, NSF

[Session in progress. The panel of resource persons gave brief presentations on the minority-focused programs in the Education and Human Resources and Engineering directorates.]

Panel member: I would suggest that the current undergraduates go to the research office or to whatever office you deal with and ask for the Research Experiences for Undergraduates program solicitation.

Panel member: All of these programs are targeted at various points in the pipeline. So that as one moves along the continuum that Daryl has on his slide, and looks at it going all the way through, we will see 5 years from now, 10 years from now, that the numbers will increase. The bottom line for you is that everywhere in your scientific career there is an opportunity with NSF support—at the undergraduate, master's, and doctoral levels.

And it's very important for you to identify those opportunities, because there should never be a question in any of your minds about whether you're going to graduate school and about whether or not somebody's going to pay for that. Perhaps you don't know where all of the resources are, but now you have the names of three people at NSF who can help you sort through the maze of projects and programs that are available for students when they go to graduate school.

Panel member: Let me add just one item to that. In terms of this national action plan that was presented at the conference, there are specific targets in terms of degree production at all levels. The point is for us as an agency to be able to monitor the progress that we are making at those various points. So we should be able to tell you the numbers of students who are being served by each one of these programs at every juncture in the system.

Your local institutions should be able to give you some of those data, because they're supposed to be collecting them as well. And certainly if there is a request for an Minority Research Centers of Excellence (MRCE) project, they have to generate those data on a regular basis. I know that, because we require that they give us the numbers. So we do this collaboratively.

Unless we have a good sense of how well we're doing in drawing and maintaining students in our programs, we have no way of telling whether our programs are making a difference. We have to evaluate all these programs that have been mentioned, some of which support you in one way or the other.

Panel member: Do you recall the comments made about Lifetime Achievement Award winner Warren Henry today? There was another man sitting at the table with him named Lafayette Frederick. He was recognized last year for having accomplished the same thing in biology that Warren Henry accomplished in physics. There is another gentleman at Morehouse College in Atlanta named Henry MacBay who was honored (by others) for the same thing in chemistry.

The point I'm making is that in almost every case where you look at a successful core of scientists, there is a teacher, either in high school or college. And we don't have enough of them. That's one of the reasons why the pipeline is drying up, because we have not given enough attention to quality science and math teaching at the high school and college levels.

And so if you do teach, I applaud and encourage you to continue that and get others to join you. Because that is as important as pushing back the frontiers of research on the other side of the equation. In the past, NSF has given lip service to research and education, but I think now they mean it. Because they're putting resources behind the Education Directorate and giving more meaning to the mission of education as a parallel responsibility to the research mission of the foundation.

Panel member: We always have been interested in education, so much so that every grant that is given has to have graduate students included in the grant. Undergraduates were added around 10 years ago.

Panel member: Let me expand on a point. The Education and Human Resources Directorate now is the second-largest directorate in the National Science Foundation. I would argue in full support of your comment that NSF really didn't get serious about undergraduates until 1988, and it is just now getting serious about community colleges and the contribution that they make in moving students into four-year institutions and into science, particularly science degrees.

Engineering colleges and universities have been quite good, actually, in harvesting students from two-year institutions. The sciences have lagged behind, for a whole range of reasons, some of which have been discussed at this conference.

Now there's no turning back. The challenge to us at NSF is to do a better job of consolida ng researeh and education along that continuum. We can't pursue these as separate enterprises. The expectations are too high and the needs are too great. And so we are in a position of putting our money where our rhetoric has been.

And you, just by your presence here, are one indicator that we're doing something right. You've got to keep the pressure on at your local institution, which also means you've got to start mentoring the people who are coming up behind you, because we all have an obligation here.

Student: First of all, you asked a question about what programs we are funded by. Well, I'm funded by AMP. My question is, in high school there aren't too many minority teachers in math and science. Has anyone looked into supplementing incomes or opportunities for minority math and science teachers at the high school level?

Panel member: Well, you have to make a distinction, I think. The Department of Education budget is about $18 billion a year. The Directorate for Education and Human Resources' budget is no comparison with that. So what NSF can do in this whole pipeline is act more as a catalyst, more as a facilitator, because the resources are really not there to nationally solve this problem. Also you have to take into account that the State and locality have a large responsibility for their school system. We don't have national standards.

Panel member: I would echo that there is a program called the Urban Systemic Initiative (USI), which is designed to create systemic change in the teaching of science and math in public schools. It does not directly affect the area that you suggested—that is, salaries of teachers—but it can influence the environment, the culture of public education, so that more minorities will want to go into teaching without having to deal with the disincentives that public education now provides. So I think that USI, coupled with programs aimed at producing more minority teachers, will begin to address the problem of the rather small number of minority teachers in the public school system.

Student: Are you saying it should start from the bottom up, like local, then regional, then national, rather than national on down?

Panel member: You have to influence your local PTA, council, whatever. You have to make your voice heard. But you have to put in the money to prepare this teacher.

Panel member: Dr. Williams has come in and we should use this opportunity to get him to answer one or two questions. So this is your chance.

Student: This question springboards off another question. There's been an emphasis on urban high schools and programs to develop inner-city youth and young adults. What has NSF done to help the rural communities?

Dr. Williams: We've launched an initiative that is an analog to the USI that's focused entirely on rural communities.

To be precise, using the Department of Labor's definition of rural communities—rural and economically impoverished. It's for the last forgotten American. It will do precisely what the urban initiative is doing. As Dr. Jones has indicated, these grants will be comprehensive. They will have all of the elements. They almost by design are going to be a mix of education per se (to cater to the educational system) and science and technology training.

One of the things we want to do is improve the economic ambience in rural communities. So the idea is to employ our math and science education agenda to provide the opportunity for young adults in the community—many of whom are marginally employed or unemployed—to join the workforce.

So it's a clear reform program that is precisely the analog of the urban one. It addresses substantial pockets of minorities in rural communities.

There is one set of issues that have to do with urban school systems, and an entirely different set of issues that have to do with rural communities, particularly rural communities in the Southeast and Southwest—communities that have made the transition from an agricultural base to a quasi-high-tech base, but do not yet have the requisite education and training. Basically what you have in these very, very large communities in rural Louisiana, some parts of Georgia, and especially in South Carolina are huge pockets of minorities who basically aren't dealt with by anyone.

Long answer, but that's what we're going to do.

NSF DIRECTORATE PRESENTATIONS OF EDUCATION AND HUMAN RESOURCE-FOCUSED ACTIVITIES

Session A: Directorate for Engineering

Research program officers from the Directorate for Engineering (ENG) will discuss the most advanced areas of research currently being supported by the Directorate. Directorate representatives will also present programs sponsored by ENG to support students at the precollege, undergraduate, and graduate levels, and new and experienced faculty.

Contact Person: Daniel Davis, Program Officer, Research Experiences for Undergraduates Program, ENG/EEC, (703) 306-1380.

Session B: Mathematical and Physical Sciences

The Mathematical and Physical Sciences (MPS) Directorate of NSF will host a short workshop and roundtable discussion highlighting education and research opportunities for minority students in various MPS programs. An overview of MPS activities and programs that directly impact science and mathematics education and research for ethnic minority students will be given. This will be followed by a roundtable discussion in which program directors from the mathematics, astronomy, chemistry, physics, and materials research divisions will describe specific activities within their own divisions, and answer questions from conferees.

Contact Person: Richard Hilderbrandt, Program Director, Physical Chemistry Program, Theoretical and Computational, MPS/CHE, (703) 306-1844.

Session C: Computer and Information Science and Engineering

The Institutional Infrastructure for Minority Institutions program consists of projects designed to increase the number of minority computer scientists and engineers. Awards run up to 5 years with budgets between $750,000 and $1,500,000. Some typical projects that will be described include the following:

- Laboratory Enhancement at Historically Black Colleges and Universities (HBCU's)
- Mentoring and Recruiting at Hispanic-Serving Institutions
- Bridging Activities at a Native American College
- A new Ph.D. Program for Puerto Rico

Most of the remaining Computer and Information Science and Engineering (CISE) activities focused upon minority students are in the Special Projects Program. Among these, the Minority Graduate Fellowships, Minority Attitude Study, Strategy Workshops, and Conference Travel projects will be discussed. Information concerning participation in these and future programs in the CISE Directorate will be distributed.

Contact Person: Dr. John Cherniavsky, Head, Office of Cross-Disciplinary Activities, CISE CDA, (703) 306-1980.

Session D: Biological Sciences

The Biological Sciences (BIO) Directorate will hold a workshop to describe BIO program activities to support training and research in biology. Particular attention will be given to those programs providing special opportunities for minority students and faculty at all career levels. Program officers will discuss application procedures for grants such as Research Assistantships for Minority High School Students, Research Experiences for Undergraduates, Graduate Student Dissertation Awards, Postdoctoral Research Fellowships for Underrepresented Ethnic Minorities, Faculty Early Career Development Awards, Research Planning Grants, and Research Support Grants in biology. Printed program description materials will be available, and questions from the audience will be encouraged.

Contact Person: Thomas Quarles, Deputy Division Director, BIO/BIR, (703) 306-1470.

Session E: Directorate for Geosciences

The Directorate for Geosciences (GEO) supports research in the atmospheric, geological, and oceanographic sciences—advancing scientific knowledge of the Earth's environment and the ability to predict natural phenomena of economic interest such as weather, climate, and earthquakes. The geoscience disciplines require a broad base of talent and a variety of facilities and instruments—including multiuser facilities such as research aircraft and vessels, global arrays of seismometers, and supercomputers—to accomplish their research objectives. NSF is the Nation's principal supporter of academic-basic research in geosciences, providing about 70 percent of Federal support for research conducted at U.S. universities.

Minority students have been involved with geosciences programs in different ways, ranging from work with individual scientists in their laboratories or in the field to major coordinated programs involving a number of scientific groups, or as part of the activities of a national center such as the National Center for Atmospheric Research (NCAR). Specific examples of these activities will be given by representatives of the three GEO research divisions, namely Atmospheric (ATM), Earth (EAR), and Ocean Sciences (OCE), as well as by students who have participated in the programs.

Contact Persons: Pam Stephens, ATM, (703) 306-1528; Judy Hannah, EAR, (703) 306-1557; Joan Mitchell, OCE, (703) 306-1580.

Session F: Social, Behavioral, and Economic Sciences

The Directorate for Social, Behavioral and Economic Sciences (SBE) consists of three divisions, each with distinct programs and goals. A speaker from each division will discuss programs, with emphasis on efforts to encourage or understand minority participation in science and engineering.

Division of International Programs (INT): The division sponsors programs designed to strengthen the international experience of students, postdoctorates, and young faculty in all fields of science and engineering supported by NSF. These programs include summer institutes, postdoctoral fellowships, center-to-center programs, and workshops for junior investigators. The speaker will use examples from NSF's Japan program to illustrate the types of opportunities available to young U.S. researchers for work in many areas of the world.

Contact Person: Patricia J. Tsuchitani, INT, (703) 306-1701.

Division of Science Resources Studies (SRS): Selected findings will be presented from the new NSF report, "Women, Minorities, and Persons with Disabilities in Science and Engineering," which examines the participation of underrepresented groups in the ranks of the Nation's technical workforce.

Contact Person: Mary J. Golladay, SRS, (703) 306-1774.

Division of Social, Behavioral, and Economic Research (SBER): There will be a discussion of NSF programs and opportunities for minority students and faculty in the social, behavioral, and economic sciences. The discussion will provide data and statistics on minority participation in SBER programs and will contain an overview of research supported by SBER on minority issues.

Contact Person: Patricia White, SBER, (703) 306-1762.

Session G: Department of Education

The Department of Education (Eisenhower State Program) session will describe the following two projects.

- Minority Mathematics and Science Education Cooperative (MMSEC) is a partnership inservice program—involving 9 universities, 2 community college campuses, and 28 schools—that is distinctive in integrating affective with cognitive strands to improve the performance and classroom achievements of minority children. It involves teachers and principals in a systematic process of recognizing and comprehending the special contexts and customary ways in which children perceive and construct scientific knowledge. These resources are then applied to facilitate and promote the learning of mathematics and science.
- Four Institutionalized Reforms in Science Training (Project FIRST) How do we develop classroom instructional leaders who mirror the changing California school-age population? This project is designed to increase the number of teachers from underrepresented groups who become master teachers of science while also completing the requirements for enhanced degrees in science. It enables teachers who, through a previous Eisenhower-funded project, developed their skills in teaching science to go a step further to establish their leadership roles.

Contact Person: Christine Jackson, Senior Education Program Specialist, (202) 260-2516.

CLOSING SESSION

CLOSING SESSION

PRESIDER

Luther S. Williams
Assistant Director
Education and Human Resources, NSF

OPENING STATEMENT

We are pleased to have Dr. Anne Petersen, deputy director of the National Science Foundation, provide closing comments on the conference from the point of view of the leadership of the Foundation. She is extremely interested in the efforts that have been the subject of our several days of meeting. As she will indicate, Dr. Lane, the director, is unavoidably involved elsewhere in activities that are extremely important to our agenda. Dr. Petersen was kind enough to come to offer closing comments on behalf of NSF, even though she has another commitment that is almost concurrent with this activity. So at the end of her comments, if you have questions, she will take a few, then she has to depart.

KEYNOTE ADDRESS

Anne C. Petersen
Deputy Director
National Science Foundation

Thank you. It is a great honor to join you this afternoon. I want first to express greetings on behalf of NSF Director Neal Lane. I know Neal wanted to be here with you as well, but he has spent most of this week on the road—traveling in Florida and California. (Somebody has to do it.) Today, in fact, he participated in the dedication of the new National High Magnetic Field Laboratory at Florida State University. I mention this only because, in addition to being a preeminent national and international research facility, this new laboratory holds great promise for promoting NSF's goals in education and human resource development. The facility is already developing plans for outreach activities involving the Tallahassee schools.

This is just one example of how virtually every dollar NSF spends and everything we do as an agency is done with an eye toward promoting diversity in the scientific and technological workforce. Both Neal and I strongly support the goals of this conference, and we want all of you to know that the entire Foundation stands behind your efforts.

Education is at the core of NSF's mission, and increasing diversity in science and technology is a central goal of all of the agency's programs. After I was nominated to become NSF's deputy director and began doing my homework about the agency's programs, I was struck by the breadth of programs NSF supports to improve the participation of women and other underrepresented groups in science and engineering.

I get the sense that we start reaching kids before they enter school—through the television shows and various informal science education activities we support. And our involvement continues at all levels of education and even beyond graduate school—through programs like the Minority Postdoctoral Fellowships and Visiting Professorships for Women. The fact that the Foundation has assumed such a valuable leadership role in these areas is one of the main reasons that I am very excited about working here. The Foundation has taken on this role for many reasons. I know that the changing demographics of our Nation make it imperative that we promote increased diversity in science and technology. But as powerful as these arguments are, I think there are even more powerful arguments that have nothing to do with demographics.

All of us know that research in science and engineering is a process that requires imagination, creativity, and a strong sense of commitment. This process draws upon the talents and ideas of the individual researchers, teachers, and students who participate in the research. For this reason, it almost goes without saying that engineering and science in general will benefit from increased diversity. I like

to tell people that the recipe for good research involves lots of mixing—mixing ideas, blending perspectives, and pulling together diverse ideas. The different and diverse backgrounds that each of us brings to our work are essential to this mixing process. At NSF we want to make this a part of everything we do.

My next point is that the themes of this conference are a top priority not just for NSF, but for the administration as well. Vice President Gore made this clear at the release in early August of the administration's major report on science policy, *Science in the National Interest*. He called on the science and engineering community to become actively involved in raising the scientific and technological literacy of all Americans and attracting more women, minorities, and persons with disabilities to careers in scientific and technological fields. The report itself speaks to this very point. It notes that "America derives great strength from its diversity, yet the country has not had a coherent policy for developing all our human resources for science and technology."

The report made two recommendations that will help to shape this "coherent policy." First, the President's National Science and Technology Council has committed itself to developing a policy for sustaining excellence and promoting diversity in the science and technology workforce. This is important because this policy will affect all Federal agencies, not just NSF. In addition, this policy will affect all programs—research as well as education—in keeping with the important role that research experiences play in education and training. Second, the administration has established a new Presidential Awards program to recognize individuals and institutions that have outstanding records in mentoring students from underrepresented groups in science, mathematics, and engineering. I would not be at all surprised if a number of the first recipients of this award are sitting in this room. The first awards are expected to be announced late next year.

I want to make one other point before I close. In virtually all organizations today—universities, businesses, government agencies—more and more people are focusing on the issue of accountability. In addition to serving as NSF's deputy director, I am also the agency's chief operating officer. This position was created as part of the National Performance Review, the effort being led by the Vice President to reinvent government. This means a large part of my job is to see that our programs are held accountable to their goals. For this reason, it gives me great satisfaction to see that the results of our efforts to promote diversity in science and engineering are beginning to take shape. We now sponsor 20 projects under our Alliances for Minority Participation (AMP) Program, and 75,000 students are enrolled in these projects this year. That's up from six projects and about 41,000 students in 1991. In total, NSF's programs for minority students at the undergraduate level are reaching more than 76,000 students today.

These are very impressive numbers by any accounting. But we also know they are not nearly enough, and at NSF we know better than to contemplate resting on our laurels. As you no doubt have been hearing, NSF has set even more ambitious goals to increase minority representation in scientific and technological fields by the year 2000. Are they attainable or just wishful thinking? I believe they are attainable, through conferences such as this and through action plans such as the one you have worked to develop these past 3 days.

To conclude, therefore, I just want to add that the Foundation will not rest until all segments of the population have the same opportunity to learn and the same opportunity to be productive and prepared citizens. Nothing is more important to the future of America's scientific and technological workforce. NSF is committed to serving as a catalytic agent for change in science and engineering. I hope the day comes when our leadership is no longer needed. But until that day arrives, the Foundation will stand firmly behind its commitment to invest in all students—so that everyone in our society can succeed in science and engineering.

CLOSING REMARKS

Luther Williams

First, I would like to mention that I have just been informed that conference attendance at the last count exceeded 1,900. That is remarkable. That is more than 500 more than last year and more than twice the attendance of the first conference.

What I would like to do now is highlight what I think we have achieved at this conference vis-à-vis the objectives. That's exceedingly important, because, as you know, the point of this conference and

the two previous ones is to use them as an integral part of our overall effort to solve problems, not to have conferences for which there are no explicit outcomes and expectations.

The first point in this summary focuses on variables in a larger problem set, that, in my view, we have to effectively address in order to accomplish our goals. Clearly, we need explicit and substantial support from the administration, meaning the President's office. I and others, including Anne Petersen, have referred to the presidential white paper, *Science in the National Interest*. I am unaware of another presidential statement that rendered explicitly a set of activities coupled—I emphasize, coupled—with the epicenter of national transactions having to do with science, technology, and the economy; that elevated individuals underrepresented and underserved by the enterprise to the level that one now finds in *Science in the National Interest*. So we have, in fact, a policy framework, strategic guidance in a context to connect our efforts with the national interest.

Second Point: Obviously another sector or player that is important for the effort is the U.S. Congress. Over the last several years, programs such as AMP have grown from zero to 20 such projects around the country. We also have completed a cycle of Comprehensive Regional Centers for Minorities (CRCM) and employed them to serve as precursors to the Urban Systemic Initiative (USI), which is not designed, per se, to focus on minority students, but will certainly serve them because they are focusing in the 25 cities that have substantial minority populations. The directorate has mounted programs such as the Summer Science Camps and others, and has begun to build a continuum of programs, kindergarten through graduate education, even into postdoctoral education. Paralleling these efforts, to the extent to which resources permitted, there has been a deliberate effort to explain the agenda to selected members of Congress, to try to persuade members of Congress to elevate our agenda vis-à-vis a whole set of competing agendas—welfare, health care, the general state of the economy, jobs, etc.

I think you would agree, based on Congressman Stokes' observations, that we have been able to bring our agenda appropriately to the public policy arena, to the budget and fiscal resource acquisition process, and Congress has supported it. But they also require a high level of accountability. As Mr. Stokes clearly pointed out, they will provide the support, but the expectations with respect to outcomes and achievements are enormous.

Third, we felt when we initiated this effort several years ago that we needed a document, not very different from the President's document, that would speak globally to what the country will attempt to achieve broadly in science and engineering research and education. We needed a document that would explicate what we were attempting to accomplish and would provide a context that would relate our programs to specific goals and objectives. Our objective clearly is not to simply operate a plethora of programs but to achieve a larger goal, for example, ensuring a substantial and appropriate increase in the number of minority professionals who occupy the niche of mathematics and science K–12 instruction. We have gone through several iterations of the plan. We discussed it briefly yesterday. You have had the opportunity to look at the details in more focused sessions this afternoon. While I did not attend those sessions, I am sure NSF staff moderators reiterated that any additional comments should be made in a timely fashion.

We will collect all of the input, write the final version of the plan, publish it, and broadly disseminate it. Most assuredly, we will send it to all of the NSF "performers," principal investigators or project directors, to the administration and the U.S. Congress, but also to the broad community. The idea is to use the plan as a mechanism to explain to all sectors of American society what we are attempting to do.

We are also employing the plan as a device to entice the participation of others. You saw evidence of that yesterday, for example, in the statements by Ms. Cornwell Rumsey from the Department of Energy, which has entered a formal collaboration agreement with NSF. Dr. Poodry did not emphasize this in his comments, but we have a similar agreement with the National Institutes of Health, and with Cliff now in a leadership role, we will do more. We have in place an effort with the Department of Education that focuses on its Goals 2000 program and the congruence between that agenda and ours, and we will pursue others.

The roundtable was initially designed to obtain congressional perspectives on our efforts. Because there is a cadre of very talented people at this conference, we were able to do it without the members of Congress. It was different but important, because what we attempted to do in the context of our programs and the action plan was to identify strategies that would translate our current effort into a national enterprise. That meant that barriers had to be addressed, and the point of the conference was to identify them. They were summarized, and they will be integrated into the action plan. So the roundtable was a very important process, and it certainly is not going to be the last such activity.

We took very few questions from the larger audience during the presentation of the plan; therefore, we are considering a mechanism by which we could repeat this process on a regional basis. I think there are some obvious ways to do it. For example, we could repeat the focused discussion we had here yesterday in areas of the country where we have companies and programs, either cities with AMP projects or the 25 largest USI cities. We could do it in Chicago or in Los Angeles or other places, with the goal of enticing a larger segment of the American public to understand and participate in our agenda.

Another achievement of this conference is the increased attendance from other agencies and from the research directorates at NSF. That is exceedingly important, and it is consistent with Dr. Petersen's observation that under Dr. Lane's leadership there is increased interest in creating synergy between the programs that are supported in research and those supported in education, thereby eliminating the artificial distinction between the two. I should point out to those of you who are from the higher education sector and operate the various programs represented here that such increased integration will have a very profound effect on the kind of proposals that you might submit to NSF in the future.

The awards ceremony is long. Perhaps we can find ways to abbreviate it in duration, but I hope you would agree that we should not abbreviate it in terms of goals and objectives. It is exceedingly important to continue the awards ceremony to acknowledge the historical context for what we are attempting to accomplish, as represented by the Lifetime Achievement Award winners, Jewel Plummer Cobb and Lafayette Frederick last year, Lloyd Cook the first year, and Warren Henry and Fred Begay this year. It is particularly important for the young people who participate in the conference to understand this point. It is also important to continue the other honors, not only because the students deserve them, but because it is important to bring Phi Beta Kappa, the Council of Graduate Schools, and NSTA to our agenda. So we will find ways to do more in less time, consistent with streamlining the government, but not decreasing the activity.

I am extremely pleased that we were able to engage an increased number of participants in the conference through the exhibits, and that activity can only grow. I was there briefly yesterday, and there seemed to be more than 1,000 people, especially young people, who had converted the exhibit hall into an open classroom, and a very exciting and effective educational process was occurring. It even continued through this morning.

We also added participants through the Summer Science Camp (SSC) projects. These were the very young people you encountered who had not participated previously. We did that with some trepidation, because it is somewhat challenging to bring 7th, 8th, and 9th graders to Washington. We had to worry about all kinds of liability. The Foundation's $3-plus billion budget would be almost instantaneously consumed in legal fees if we did not do it well. I have talked with several of these students to get some sense of their security and how they felt about participating. Did they feel awed by the scientists and engineers? The answer to that question was absolutely not.

My sense is that, based on this experience, we should do more in that regard, that is, involve more SSC project students. The memory that I will retain forever of these young people is not just of the projects that they presented, but two additional things: the very healthy sense of self-esteem they have developed and the healthy disposition that says, "I have not allowed anyone to impose restraints on what I can learn." That is absolutely delightful. The challenge is, what can we do to facilitate that learning?

This then summarizes the conference, and I appreciate all of the individuals who have assisted us with the conference. This includes the two members of the National Science Board who are in attendance, Jaime Oaxaca and Jim Powell, who presided and assisted us in presenting awards at the luncheon. I thank Anne Petersen for coming to represent the Director's Office, and I thank members of the Education and Human Resources National Advisory Committee who are here and assisted us—Peter Gerber, Tom Cole, and Diana Natalicio, who is now a nominee to the National Science Board.

I want to express appreciation to the teachers and administrators from the D.C. Public Schools, the Baltimore Public Schools, and all of the public schools whose students came yesterday in very large numbers.

I want to thank Courtesy Associates, the conference contractor who's been with us for 3 years and continues to improve; they are doing a splendid job, also. I appreciate the staff of the hotel; they have been very helpful to us.

There are three people—before I talk about the next steps—whom I would like to acknowledge publicly.

Roosevelt Calbert's division has responsibility for the human resource development programs and I ask you to join me in publicly acknowledging the leadership that he has brought to this process.

When we decided to initiate this conference 3 years ago, I was told that we had a problem. The problem was that we were asking a large number of students to make presentations, and we did not have the staff within the Foundation or a system or process to handle it. Eugene DeLoatch, Dean of the School of Engineering, Morgan State University, agreed to do this, and he has done it splendidly for 3 years. One of the reasons you are able to see the students with their posters and presentations so very well organized is that he is a schoolmaster in the very best sense of the word. Please join me in expressing thanks, much belated and inadequate thanks, to Eugene DeLoatch.

Last, and last for the obvious reason that what I have to say publicly I can say basically in one sentence: There would be no conference this year, nor would there have been one the previous 2 years, without one individual: Elmima Johnson.

We have spent some time debating what we should do in the future. The question for the fourth conference is how to actually build on what has happened in the previous three. That fits my requirement for the dynamics of the fourth conference being more than an extension of the previous ones. We need to do it again because we have, in large measure, changed the stakes. Eugene DeLoatch has to find a way to involve even more students. (I am not sure how, but that is his challenge.) And while the USI has a different mandate, it seems to me after talking to Ms. Johnson, the general superintendent of the Chicago Public Schools, and others, there is an advantage in including elements of that program in this conference. In addition, this is the first time we included the Sumner Science Camp projects and there are, in fact, other programs with precollege students and several reasons they should be a part of this activity. Finally, we need to meet on an annual basis to candidly assess our progress in meeting our goals.

I thank all of you for your participation and want you to know that I value the terrific work that you are doing on these projects in your various institutions and schools. I particularly want to thank the array of people from the NSF Directorate for Education and Human Resources, whom I have not acknowledged by name.

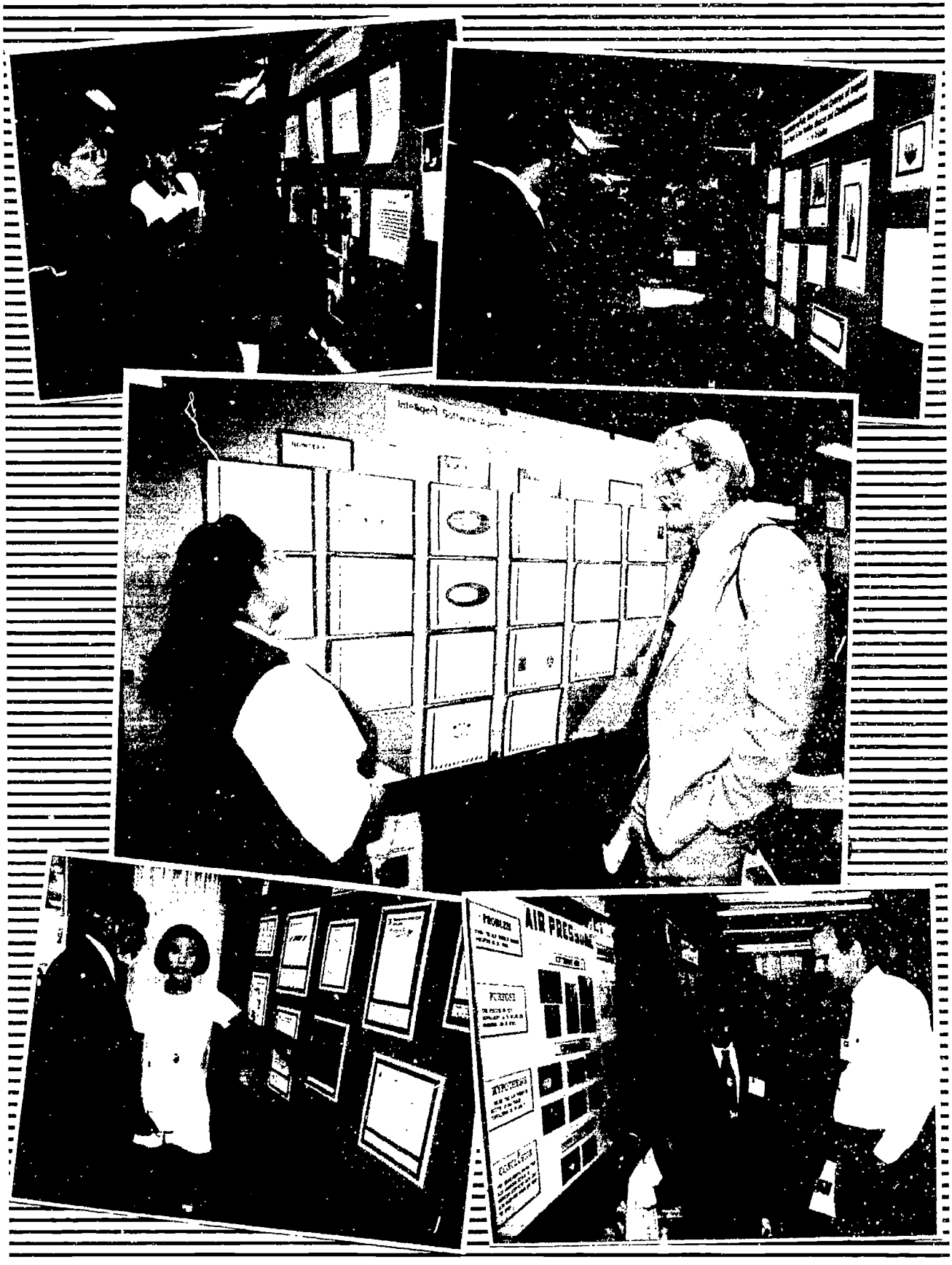
STUDENT RESEARCH PRESENTATIONS

Panel Sessions

STUDENT RESEARCH PRESENTATIONS
Panel Sessions-Continued

STUDENT RESEARCH PRESENTATIONS

Poster Sessions



STUDENT RESEARCH PRESENTATIONS
Poster Sessions-Continued

STUDENT RESEARCH COMPETITION AWARD WINNING PAPERS

PRECOLLEGE AWARD

Terrence R. Ruffin, Freshman
E. A. LANEY HIGH SCHOOL, WILMINGTON, NORTH CAROLINA

Summer Science Camp Project
Principal Investigator, Joseph M. Kishton

BARRIER ISLAND TOPOGRAPHY AND VEGETATION ZONES

Abstract: Data were collected by Summer Science Camp students to demonstrate the relationship among the following: distance inland from the high tide line, changes in elevation, and variation in vegetation along a 100 meter transect at Fort Fisher, North Carolina. Five student teams measured changes in elevation using meter boxes and torpedo levels. The sixth team conducted vegetation counts of one square meter areas at five meter intervals along the transect line. A dune field of primary, secondary, and tertiary dunes was found immediately inland from the high tide line. Vegetation in this zone was primarily sea oats and pennywort, with an occasional American beach grass. *Yucca*, prickly pear, and beach pea were incidental within this zone. A transition zone, dominated by sea ox-eye, preceded the salt marsh, which was dominated by *Spartina*.

INTRODUCTION

The purpose of this study was to determine if vegetation zones on a barrier island were related to elevation and relative position to the high tide line. Oceanfront vegetation is, by necessity, salt tolerant. Exposure to salt spray is related to height and distance from the high tide line. Some salt tolerant plants such as sea oats, are known to thrive in dune fields. They trap windblown sand, burying themselves, further stimulating growth, thereby stabilizing the dune area. Creeping plants may reduce salt exposure by staying low to the ground. Cacti have a waxy cuticle that reduces the dehydrating effect of salt. Salt marsh plants must not only be tolerant of salt, but have to withstand twice daily, the flooding and drying out of the tidal cycle.

QUESTIONS

On a barrier island, is there a measurable relationship with respect to the distance inland from the high tide line, changes in elevation, and types of vegetation?

HYPOTHESIS

Adaptations to salt spray exposure should determine the type and numbers of plants in any particular place on the island. One would expect a dunefield dominated by sea oats to be immediately inland from the high tide line. Further inland from the dunefield, a maritime thicket of yaupon, scrub live oak, and wax myrtle might exist on higher elevations. On the sound side of the island, a salt marsh of *Spartina* should occur.

MATERIALS AND METHODS

Materials for this procedure included five boxes made of meter sticks hinged at the corners, five torpedo levels, 100 meters of stout line (marked at one meter intervals in black, and five meter intervals in red), and five clipboards for recording data. Five groups of four students measured changes in elevation along a 100 meter transect. Each team used the meter stick boxes and torpedo levels to determine changes in elevation at one meter intervals. Total change in elevation was rounded to the nearest twenty-five centimeters for every five meters of distance along the transect. This was done to present the data graphically. A sixth group counted and identified plant species within a one meter square area every fifth meter along the transect.

RESULTS

The accompanying figures depict the relationship among the occurrence of plant species, elevation, and distance from the high tide line, as well as the number of species in each zone along the transect.

Sea oats and pennywort dominated the primary dune area. The large number of pennywort may be deceptive. They are smaller than sea oats. Therefore, larger numbers of individuals may not mean that they are the dominant species of the zones that they inhabit.

FIGURE 1

Barrier island Beach Profile

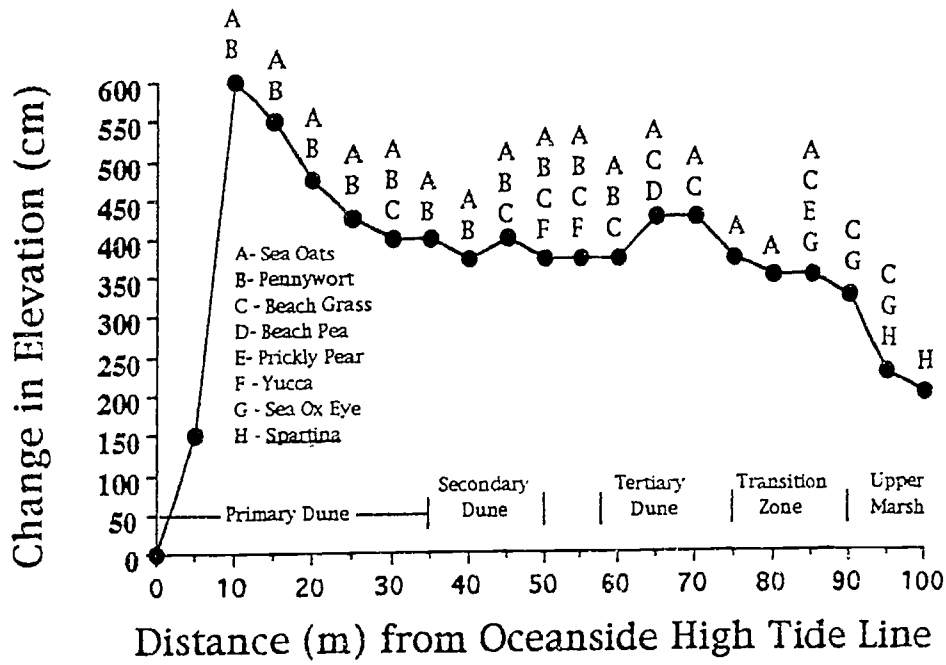
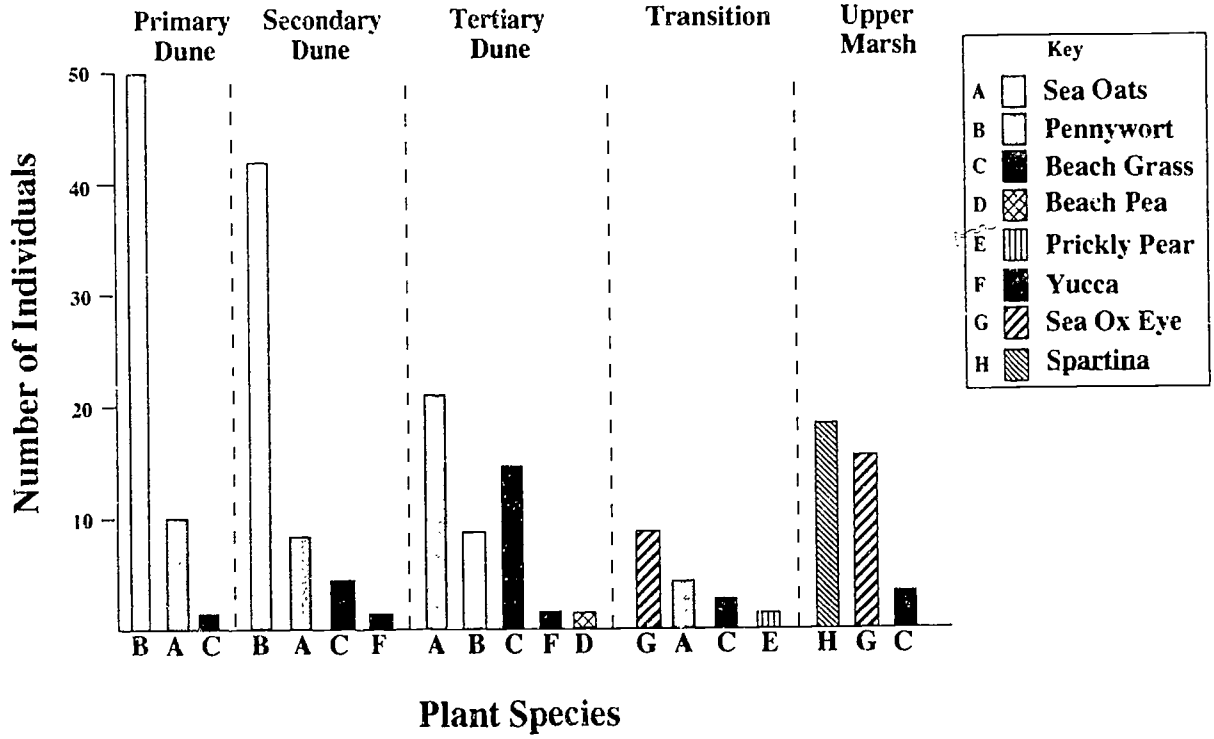


FIGURE 2

Plant Species by Zone



American beach grass was evident on the secondary dune. Sea oats and pennywort were also found here. Beach grass is probably less tolerant of salt spray and first occurs only in the protection of the primary dune.

On the tertiary dune, *Yucca* plants make an appearance, along with beach pea (a creeping vine). That these were not seen earlier along the transect, probably indicates that they also are less salt tolerant than sea oats, pennywort, and even beach grass.

No maritime forest was encountered along our transect. A transition zone, marked by prickly pear and ox-eye daisy immediately preceded the salt marsh characterized by *Spartina alterniflora* (salt meadow cordgrass).

CONCLUSIONS

The primary dunefield contained plants that could tolerate salt spray. The dunes also protected more inland areas from wind and spraying salt. The farther inland one moved along the transect line, the more diverse the species of plants. Within the transition and marsh zones, plants must be able to withstand flooding at high tide. Ox-eye daisy and prickly pear can withstand an occasional floodtide, while *Spartina* must withstand a twice daily flooding by the tidal cycle.

ACKNOWLEDGEMENTS

The author would like to express his heartfelt appreciation to his parents for all their love and support. I would also like to recognize the help and encouragement of Dr. Kishton and Mr. Mayo. I would also like to acknowledge the hard work of all my fellow researchers at the science camp. It was definitely a group project.

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PRECOLLEGE AWARD

***Roosevelt Love*, Senior**
BEAUMONT HIGH SCHOOL, ST. LOUIS, MISSOURI

Comprehensive Regional Centers for Minorities Project
Principal Investigator, Harvest L. Collier

A STUDY OF THE ST. LOUIS METROPOLITAN METRO-LINK LIGHT RAIL STATION CANOPIES

Abstract: Since its introduction in July 1993, the Metro-Link Light Rail Transit System of St. Louis, Missouri has attracted an average of 23,000 riders daily. The success of the system is measured against the projected ridership of 17,000 riders per day. While the overall impact of Metro-Link has been environmentally beneficial, environmental ("green") design was not a requirement of the criteria that the project architects, Kennedy Association, utilized in their original design efforts. The purpose of this project is to redesign the passenger canopies of the Metro-Links outdoor platform stations to include environmental criteria. It is hypothesized that the canopy redesign should differ greatly in form, and in the type of materials used, and it should consider all environmental elements. The canopy design produced by this study was examined against the original design in addition to the objective, and sometimes subjective, criteria of the newly emerging "Green Architecture." The results show the hypothesis to be true. The conclusion is that if mass transit includes environmental criteria in station canopy design energy consumption, pollution, and "unfriendly" materials use will be greatly reduced.

BACKGROUND INFORMATION

The primary purpose of mass transportation is to move people from place to place in a safe, convenient, comfortable and efficient manner. The spin-off benefits include private economic development that produces increased employment and a higher standard of living. Some of the benefits are immediate and measurable, others take time to develop and are not readily recognized. Reduced energy consumption and a reduction of traffic are already being noticed. Improved economics are only in their early stages.

The new Metro-Link system takes advantage of, builds on and repeats some of the region's rich history. In the early part of the nineteenth century, East St. Louis was the western terminus of rail traffic in this area. The Eads Bridge, which is on the National Register of Historic Places, was built to encourage economic growth in St. Louis. Metro-Link utilizes the abandoned rail deck that had gone unused for almost two decades, a rebirth of a structure and purpose that originated 120 years ago. Socially as well as economically, the reuse of the bridge makes East St. Louis less remote and more a part of the metropolitan community, not an isolated satellite lost in the nebula of interstate highway exchanges.

The system extends west beneath downtown in the original limestone and brick arcaded tunnel built at the same time as the Eads Bridge. The tunnel, renovated and illuminated is one of Metro-Link's most extraordinary, and beautiful achievements.

Metro-Link also reintroduces the romance of rail travel to the 100 year old Union Station. Union Station was once the busiest rail yard in the United States and was the crossroads of thousands of military personnel during World War Two. Metro-Link has also contributed to a fifteen percent increase in retail business at Union Station. Metro-Link has had a similar impact on St. Louis Centre, a downtown shopping mall in the heart of the St. Louis business district.

The system runs under the original Wabash Station at Delmar Boulevard and Des Peres Avenue. The beautifully proportioned neoclassical structure is not part of the system, but makes a visible connection to the past. The Wabash Station Building is a perfect location for the type of private development that could take advantage of the 23,000 riders that pass it every day.

Metro-Link passes Washington University and runs through The University of Missouri at St. Louis on its way to the airport, giving thousands of students the opportunity to access higher education at campuses that serve a significant commuter population.

The newest station that opened at Lambert International Airport is the temporary terminus of the system. The station, in only two months of operation is already experiencing a ridership of 2,700 people per day. That traffic, that no longer jams Interstate 70, is made up of business people traveling to and from other cities and conventioneers that are enriching St. Louis' tourism industry.

The quarter cent sales tax that was passed in early August of 1994 will allow designers to extend the system to every point of the compass and allow even more people to take advantage of a system that could be as extensive as Washington DC's in as little as 20 years.

REVIEW OF LITERATURE

Because the Metro-Link light rail system is such a current event, a great deal of information is readily available. The sources of information for this project include written design documentation, oral analysis from the Project Manager for the Architectural design, periodicals from both local and national sources, a video and a design manual.

The initial source of information that was reviewed was the "Design Criteria Manual" that was written in 1986 and was intended to serve as an objective checklist for the designers that began the final design efforts for Metro-Link in 1989. The Design Criteria was essentially design instructions for the engineers and architects that were responsible for the design of electrical, mechanical, plumbing, structural and civil issues in addition to the architectural discipline. The subjects covered by the criteria included pedestrian and vehicular circulation, construction material selection, dimensional requirements, functional requirement, security and lighting standards, landscaping, accessibility for the disabled, and guidelines for addressing historic preservation. The work of the final designers was continually examined against the criteria to assure the design of a safe, durable and cost effective system.

The Construction Documents were the next source of information that was necessary to review the architect's success with the Design Criteria. The Construction Documents, commonly, but erroneously, referred to a blue prints, contain the actual design for the canopy as dictated by the criteria. All of the components of the canopy are represented in these documents that are further described in the procedures.

The Architectural Project Manager, Robert E. St. John of both Kennedy Associates, provided an oral understanding of both the criteria and the drawings. He had originally written the criteria and was responsible for directing his staff's efforts in the design process. Mr. St. John conducted a tour of the alignment and during this tour it was noted that environmental issues were not the primary considerations in the design. As each aspect of the canopy was discussed it became clearer that each component of the canopy might have taken a different form if the environment were a higher priority. Mr. St. John also provided the outline of the design process that was used in the procedures of this report.

The initial discussions of environmental impacts on design led to the discovery of "Green Architecture" as practiced by New York City architects who were responsible for the design of the renovation of the Audobon Building in New York. In the Audobon Building every material, component and assembly was examined for its environmental property and was only utilized if it was compatible with environmental goals. Examples include the use of cotton, not petrochemicals for insulation; cork linoleum, not plastic based flooring, and formaldehyde free processed wood products in lieu of their off-gassing counterparts.

The understanding of the aforementioned sources together with a review of current local news articles in the *St. Louis Post Dispatch* forms the basis of the hypothesis and procedures that are part of this study.

STATEMENT OF THE PROBLEM

The public's perception of the Metro-Link success helped pass a sales tax initiation in August 1994 that funded 100 miles of extension with as many as eight additional stations. Some of the success of the system can be attributed to the cost effectiveness of the design solutions. For example, the right-of-way, or the alignment, was donated by the manicipalitites and railroads. Existing trackwork was recycled for use in the maintenance facility, and bus routes were reconfigured to "feed" the rail system saving thousands of travel miles and wear of the existing buses.

Mass transit has proven itself as a significant past of goals to reduce energy consumption. As overall goal of this redesign project is to recommend that every component and operational feature of a light rail system should be designed to support environmental improvements. Thus, the specific of an improved station canopy should reflect reductions, not only, but in energy consumption, is pollution, and in are of materials detrimental to the environment.

PURPOSE

The purpose of this study is to redesign the canopy of the St. Louis Metro-Link Transit system's out door, open platform stations. The redesign will introduce a new criteria for design that was not required in the original and recently constructed system. The new criteria will be for environmental considerations. The priority for the new environmental criteria will rank near the top together with safety.

HYPOTHESIS

The design of the canopy for the outdoor platform stations of the St. Louis Metro-Link Transit System would differ from the current design if environmental quality is introduced as a significant criteria. It is believed that form, materials and image would all be affected by a change in design approach.

PROCEDURE AND ANALYSIS

Architects are granted licenses by the states to practice their profession when they demonstrate a minimum proficiency in three areas in descending order. The first area includes the ability to follow codes that assure the public of a minimum degree of safety. The second criteria for licensing is the ability to translate the clients goals into usable forms within stated budgetary goals. The third area, which is very subjective, is the ability to provide designs that are aesthetically pleasing. Architectural candidates, through a combination of testing procedures, are tested for their knowledge and ability before they are allowed to practice architecture. For the purpose of this project, environmental concerns will be considered to be the part of an architect's responsibility in the area of public safety. This will rank environmental considerations high in priority in the criteria for design.

Architectural training is a four to six year college course of study. Through the design class, architects are trained to refine a design process that they will ultimately use when they enter the profession. The design process takes an architect through the following steps:

- Analyze the goals, objectives and program of the client,
- Define the client's goal in terms of an architectural solution,
- Analyze the client's goals in terms of public safety,
- Examine the architectural options available that meet safety and the client expectations,
- Examine the component parts of selected options for compatibility with the client's goals,
- Compose the component parts into a cohesive design solution and
- Present the results of the design efforts to the client for approval.

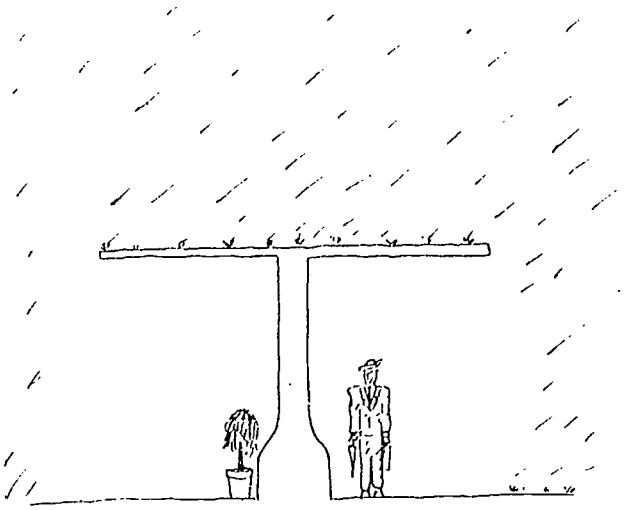
The process that will be used for this study will parallel the basic architectural process.

This report will assume that a canopy is the agreed upon solution for passenger protection at the outdoor platform stations as describe in the criteria. Canopy is the term used to describe a structure that is used to protect waiting transit riders from the elements. In the St. Louis area the structure should protect passengers from the rain and from the sometimes relentless summer sun. The canopy should also enhance a rider's perception of physical safety by being well lit with an open feeling. One of the goal of the canopy was for it to be viewed as an icon for the whole transit system, so it has to have a certain commanding presence. The canopy should be large enough to accommodate 50 people during a driving rain or from low summer sun angles. (see diagram I)

The basic components of the canopy are as follows:

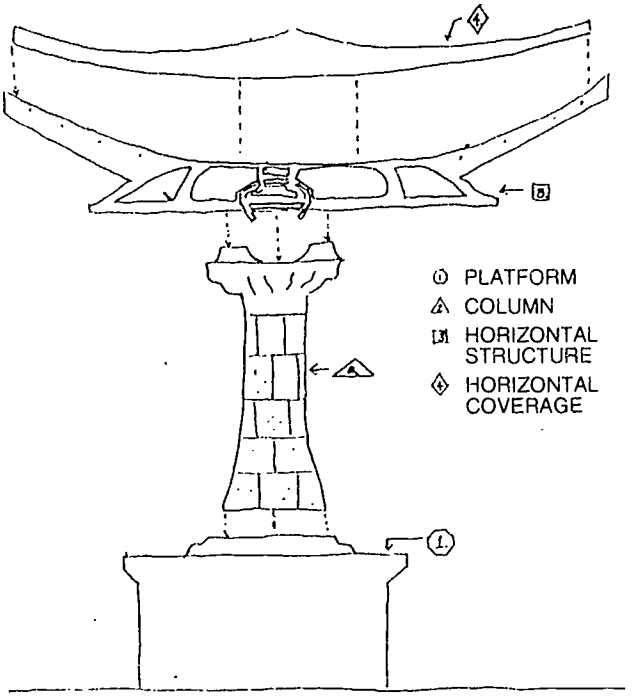
- Vertical structure,
- Horizontal structure and
- horizontal coverage. (see diagram II)

DIAGRAM I



RAIN PROTECTION

DIAGRAM II



The vertical structure is most commonly a set of columns that support the canopy. Bearing walls might be considered as an alternative, but they can obstruct view and reduce a patron's perception of safety.

The horizontal structure is supported by the vertical structure and in turn supports the horizontal coverage. The horizontal structure can take the form of beams, girders and joists or trusswork. The horizontal structure

must be substantial enough to support snow and rain loads, wind loads, and the weight of the materials themselves. An architect will ordinarily design the structure, but a structural engineer will be required to perform the necessary calculations to insure the structure's capacity.

The horizontal coverage extends over, and sometimes under, the horizontal structure to protect an area of the platform form the elements. The coverage may be clear, translucent or opague depending on the criteria for protection. Clear coverage will protect from the rain and will allow for natural illumination for most of the day, buy will not protect from the sun. Translucent canopies have the advantage of the clear alternatives and offer sun protection. Opague canopies will protect from the sun and the rain but may mandate artificial illumination early and late in the day.

An analysis of the component parts is important at this point to begin to understand the impact of choices for form and materials selection. The only decisions that can be intelligently made are those that suggest that columns are made safer than walls, translucent coverage optimizes protection and minimal use of lightning, and that the horizontal structure should allow for the benefits of translucent coverage.

Historically, four basic types of canopy form have been used. They are:

- "V" shaped or butterfly,
- Flat,
- Gabled
- Suspension. (see diagram III)

The butterfly canopy has been used for about a century. This type of structure allows light to penetrate under the canopy and it directs rainwater away from the platform edge and away from the passenger's heads as they board the train. Flat canopies are a very common way to provide protection but do not shed snow well and therefore require relatively more s ructure. Gabled structures have been very successful and represent Metro-Links canopy in the modified barrel vault form. Gabled canopies shed snow well, but right on the passengers and tracks if not properly designed.

Ultimately the selection of a canopy shape should be integrated with the form that the component parts will take and with the desired materials from which to construct it.

The following is an outline of the more generic choices for construction materials that might be considered for the component parts of the canopy: (see diagram IV)

- Vertical Structure
  wood columns
  steel or aluminum pipe or "H" section columns
  masonry or stone bearing walls or columns
  concrete bearing walls or columns
- Horizontal Structure
  wood girders, beams, joists or trusses
  plastic girders, beams, joists or trusses
  steel or aluminum girders, beams, joists or trusses
  concrete cast in place or precast
- Horizontal Coverage
  clear; glass or plastic
  translucent; glass, plastic, fiberglass or fabric
  opaque; conventional standing seam, asphalt or rubber

Materials should be chosen for their functional and environmental properties. Functional characteristics include

DIAGRAM III

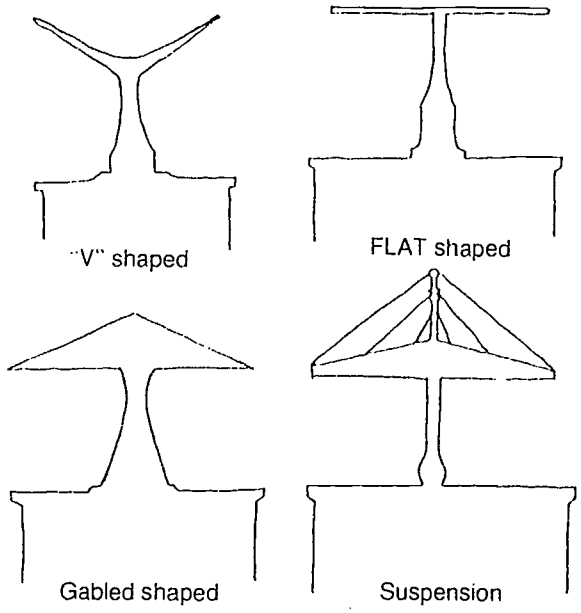
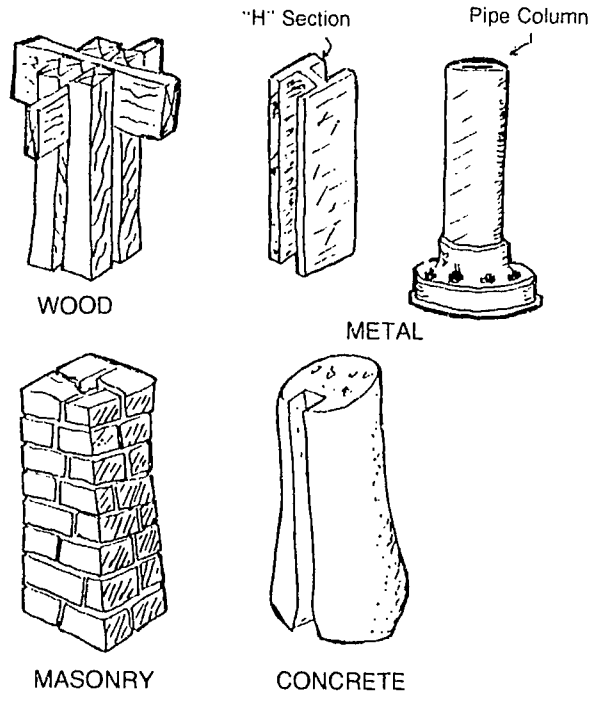


DIAGRAM IV



durability and low maintenance. Environmental characteristics are defined by the answers to the originals of materials, the amount of energy it takes manufacture or fabricate the material and to the long-term impact that the material will have on the environment. The aesthetics of a material should also be considered. Issues of color, reluctance and texture can dramatically affect the appearance of a design. Aesthetic qualities, however, could be a natural results of the properly select environmental and functional material.

As materials are being selected for the component parts of the canopy it is important to consider the source of the material. Does it come from a rain forest? Is it from a recycled source? Does it come form a renewable source? Will obtaining the material be detrimental to it's environment? The hypothetically perfect material would come from either recycle or renewable source. It should come from a place that can be returned to it's natural environmental state. Wood from farmed forests, steel from reclamation, plastics form recycled material and concrete that is comprised from recycled aggregate and reinforcing steel are good examples. It is also important to consider weather or not the materials from a canopy can be reused after it has lived its useful life.

Materials should also be selected that need minimum energy requirements to obtain, refine, fabricate and or manufacture. For example, it takes less energy to fabricate aluminum form recycled cans than it does from the raw bauxite ore. The same is true for glass, steel and plastic objects. Natural stone will require less processing than the manufacturing of brick and block. Stone mining if not properly controlled, however, could lead to the ugly results of strip mining.

The energy requirements of the construction process on the site should be considered as well. Is bolting less energy intensive than welding? Is hand assembly more energy efficient than machine assembly? Is the cost incurred in the additional labor required balanced by the capital cost and energy consumed by power tools? The final design of the canopy should respond to these questions.

The impact of the canopy at eh station on the environment should be minimal. Currently rainwater shed from the canopies enters the existing storm and sanitary sewers. It would be better to direct storm water back to the adjacent land to return to the ground water or to pump it to landscaping that has its own environmental benefits.

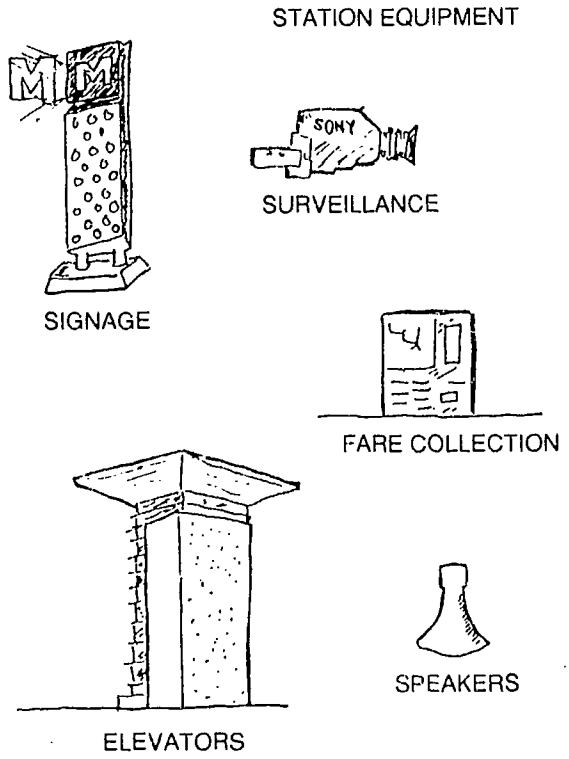
The path the rainwater takes is also important. It should not wash over toxic coatings or materials prior to reentering the ground water.

The resources that are required for the maintenance and operation of the canopy should be reduced. Canopies designed with opague roofs will require artificial illumination in the early mornings and late afternoons, translucent canopies will not. Canopies affixed with solar storage panels could supply the canopies with electricity that could augment requirements for lighting and power necessary for the operation of fare collection machines, security cameras, public address systems and elevators. (see diagram V)

The canopies should be designed for minimum maintenance. The use of water for cleaning the canopy or hosing down the platform should be minimized if not eliminated.

These new environmental issues are, for the purpose of this project, are now considered a part of a revised design criteria. This new criteria is reflect in the revised design of the canopy that follows.

DIAGRAM V



RESULTS

The result of this project is an alternative to the existing canopies. This new design is based on the assumption that environmental considerations are an important part of the Design Criteria.

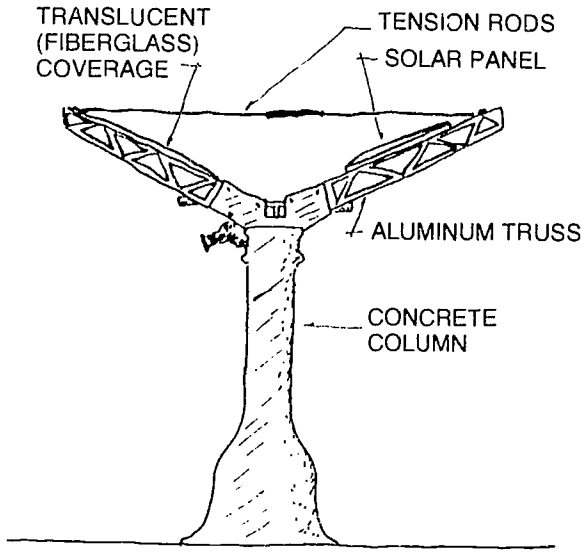
In selecting materials for the vertical structure, concrete had advantages over it's alternatives. Concrete, composed of recycled aggregate and reinforcing steel, requires less energy to produce than new steel. Recycled concrete is preferable to wood that is not necessarily a renewable resource. Concrete also has durability and maintenance advantages over wood or steel.

The horizontal Structure is a combination of aluminum trusses and tension rods. Aluminum is more expensive

than steel and wood, but is probably competitive with cast in place concrete. Because of its weight, aluminum is easier to fabricate and support than concrete. Aluminum is more durable than wood, and requires less maintenance than steel.

The horizontal coverage will consist of a combination of translucent fiberglass panels and solar collection and storage panels. The translucent panels allow light penetration and provide shade. The selection of fiberglass, a recycled resource, is preferable to glass, which can shatter, and plastic, which comes from petrochemicals. The solar collection and storage panels would be installed on the sun facing face of the canopy and would offer supplemental power for station lighting and ancillary systems. (see diagram VI)

DIAGRAM VI



CONCLUSIONS

The originally designed canopy was the result of a collaboration of architects, artists, engineers and contractors. It has been enthusiastically received by the public and praised by the media. It is a testament to the success of the design criteria and to the talents of the designers.

One purpose of this project was to introduce environmental concerns into the design process. The resultant design achieves the stated goals and suggests that future extensions to the alignment should incorporate environmental requirements into a revised Design Criteria. A new Design Criteria could affect the canopies, as demonstrated, as well as the alignment, bridges and other structures. The entire metropolitan area would then benefit from improved transportation and an improved environment.

ACKNOWLEDGEMENTS

This participant would like to acknowledge the following people for their dedication and support in the completion of this project: Dr. Edward Haynie for patiently walking me through the Incubator Scientist Program and for his valuable advice; Mr. Michael Kennedy for allowing me to take advantage of the resources of his architectural firm, for his guidance, and for introducing me to Mr. Robert St. John; Mr. St. John for instructing me on the specifics of the Metro-Link project and procedures of the architectural design process: This was heady and completely foreign to me, and most of all I thank God for giving me the determination to see this project through to the best of my ability. Last, but not least, I thank my parents for their patience, encouragement and support. I still have a long way to go.

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PRECOLLEGE AWARD

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Summer Science Camp Project
Principal Investigator, Kathleen Sullivan

AERODYNAMICS IN ACTION

Abstract: This science project is about building and flying a simplified model of an airplane wing in a wind tunnel to measure the forces associated with flight. Different wing designs were evaluated with the use of computer simulation. The project involved plotting the desired wing shape on paper, and cutting out plywood to match, and then using these wood templates to guide the wire-cutting to create a two-dimensional wing from styrofoam.

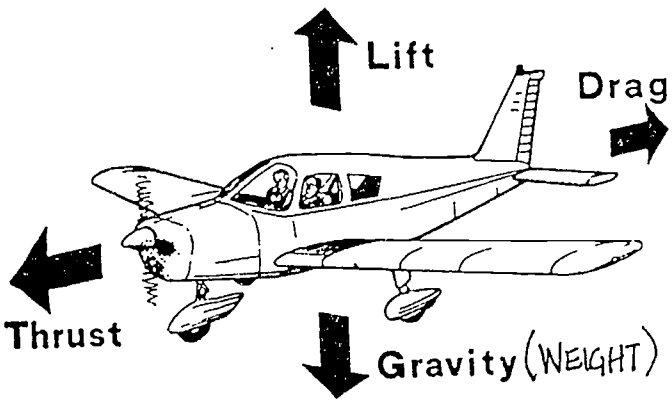
After testing the wing in the wind tunnel, the experimental and theoretical results were compared. In both cases, more curvature in the wing shape produced a higher lifting force. The project followed the same general steps that airplane manufacturers use to test wing designs: computer analysis and design, model fabrication, and wind tunnel testing.

INTRODUCTION

There are four forces acting on an airplane when it is flying. These four forces are: lift, gravity, drag, and thrust, as shown in Figure 1. Lift is the result of lower pressure on the top of the airfoil and higher pressure on the bottom which makes the airplane move upward. The "weight" of each air molecule causes pressure. Gravity is the force that makes the plane move downward because of the weight of the plane. Drag is the force that pushes the airplane in the same direction as the wind. More drag therefore causes more fuel to be used. Thrust is the force caused by the engines of the plane: it makes the airplane move in a forward direction.

FIGURE 1

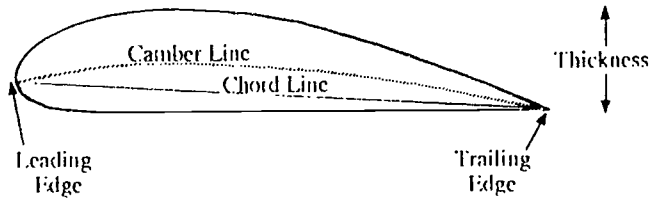
Four Forces Affecting Flight



An important concept in designing aircraft is the shape of the wing, including the camber and angle of attack of the wing cross-section, or airfoil. Camber is how much curve the airfoil has along the middle line as shown in Figure 2. Symmetric airfoils, therefore, have no camber.

FIGURE 2

Camber of an Airfoil



The angle of attack is the difference in where the wind is coming from and the direction that the wing is pointing, as illustrated in Figure 3. The greater the angle of attack, the more lifting force generally results, until the angle is so large that the wing stalls.

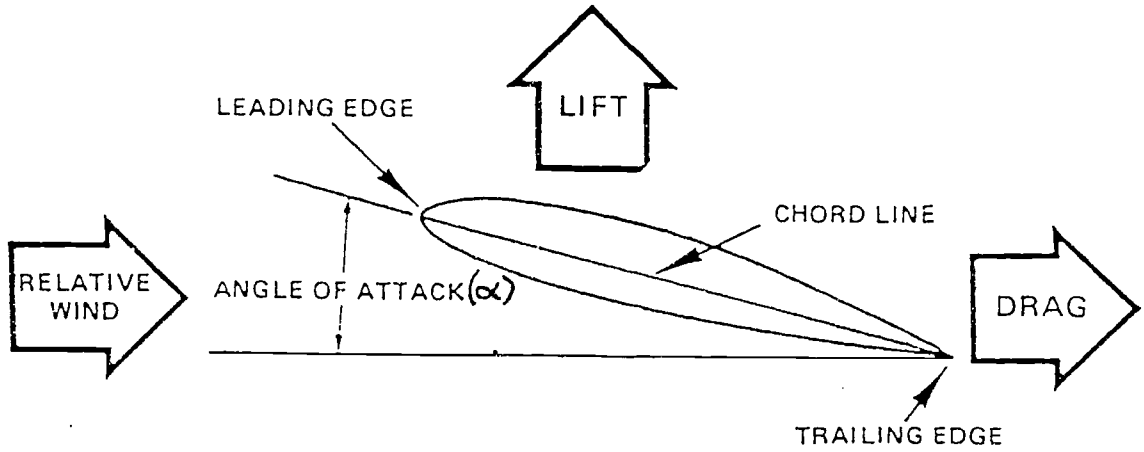
The problem statement is how to design a wing. What is the best shape? Does camber increase lift? Our hypothesis is that camber creates more lift for a given thickness.

PROCEDURE

First, we entered the airfoil shapes into Excel using the profile information in the first reference. There are two airfoils: NACA 4415 and NACA 2415. The first one has more camber than the second one; see Figure 4 for clarification.

FIGURE 3

Angle of Attack Relative to the Wind



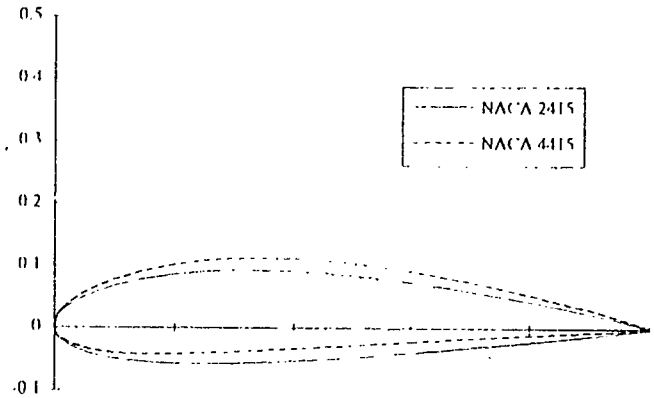
We used the program Panda to simulate flying these different shaped airfoils; within this application, it is possible to set the angle and calculate the lift. Then, we graphed this data in Excel to compare the airfoils' lift theoretically. In order to measure the actual lift the two wings would produce, it was necessary to build them.

The first step was to print the airfoil shapes and using scissors, cut out the figures. We pasted the figures to plywood which was 1/16 inches thick. Then, using a jigsaw, we cut out the wood templates. The edges of the templates needed to be sanded down to the shape of the airfoil to prevent rough edges. Afterwards, we marked and numbered around the edge of the templates. We taped the matching templates to a block of styrofoam after carefully measuring that the distance between the two templates was equally spaced.

Then, we used a hot wire to cut the foam tracing the template's shape. The wire gets hot because there is electricity passing through it. Because of the size of the apparatus, it was necessary to have two people controlling the wire; one's leading, calling out the numbers on the template, and the other is following, making sure they are at the same location. After cutting the airfoil shape, we trimmed the trailing edge from the foam using a razor blade and glued on a trailing edge made from balsa wood, making sure the wood was firmly attached. We affixed a black plastic sheet with adhesive, called monocote, to the wood of the trailing edge. By means of a hair dryer, the adhesive is heat activated and helps smooth the surface of the airfoils. Then, we tested the airfoils in the wind tunnel. We took measurements of lift at angles 0°, 10°, and 20°. Also, we chose to take additional data at 5° and 15° for airfoil 4415. There was a problem with the screw on the balance that interfered with the reading when we were measuring the 20° angle. This difficulty was solved by keeping the door of the wind tunnel slightly open so that the screw would not hit the door when the wind was blowing. Due to the non-precision nature of the equipment, we felt that it did not affect the pressure inside the wind tunnel significantly.

FIGURE 4

Comparison of Airfoil Shapes

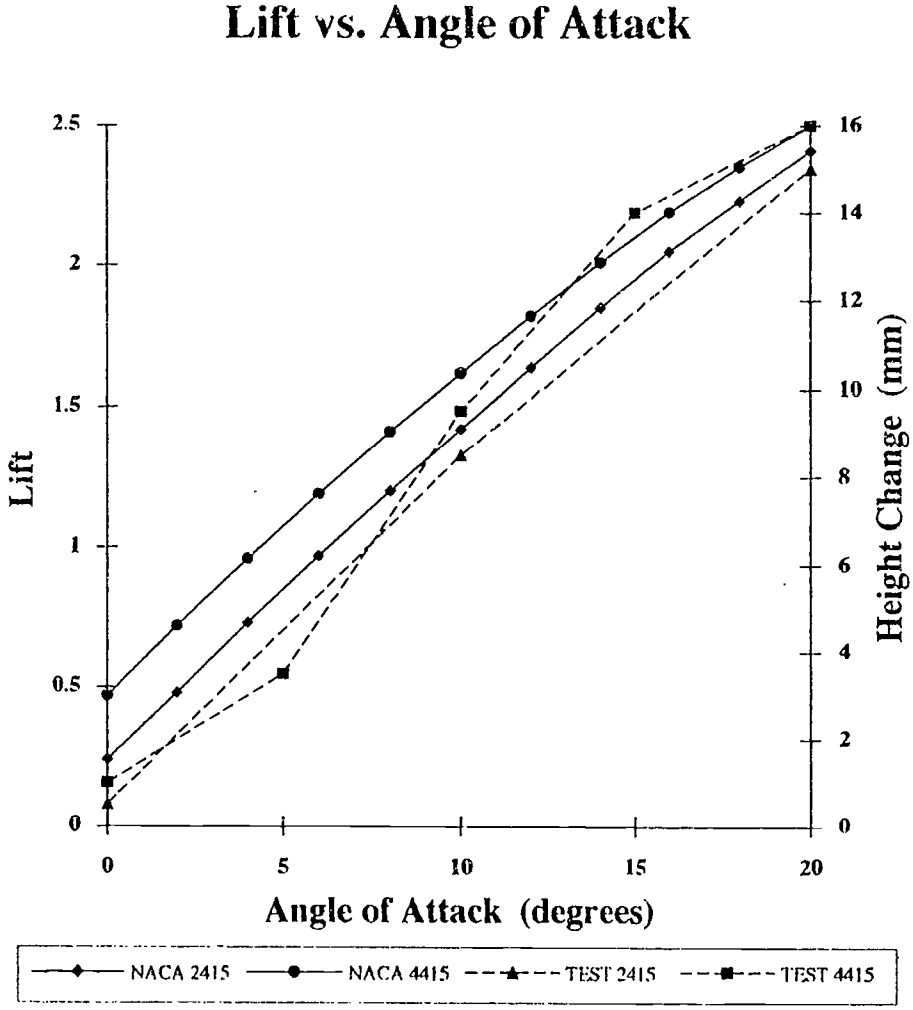


RESULTS

The graph in Figure 5 represents the theoretical and experimental results. The airfoil 4415 did indeed produce more lift at most angles. The solid lines show the results from the computer simulation, and the dashed lines show the data from the actual wind tunnel tests. Even though the test results do not match the theoretical results, they do show the same trend. Some of the inaccuracies in the test may have come from setting the angle of attack on the model, which was done by hand, or the interference of the screw with the tunnel door.

FIGURE 5

Final Tes: Results



CONCLUSIONS

The results showed that more camber for a given thickness creates more lift. Therefore, if we want to design an airplane wing, we should build it with more camber. However, another consideration that has to be taken into account when designing airplanes is that more camber produces more drag force. Drag causes the airplane to burn more fuel which can be costly. Also, sometimes the best design is too complicated to build. Every airplane design is a compromise.

ACKNOWLEDGMENT

I would like to thank Edie Lie of the Boeing Company for helping me with my project, as well as Sister Kathleen Sullivan of Seattle University. I would also like to thank my parents, Estrada Colon and Dean Barnes for their support.

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PRECOLLEGE AWARD

Gabriela Ruvalcaba, 10th Grade
SOCCORRO HIGH SCHOOL, EL PASO, TEXAS

Comprehensive Regional Centers for Minorities Project
Principal Investigator, Stephen Riter

DRAINAGE TIME OF A ROUGHLY CYLINDRICAL CONTAINER AS A FUNCTION OF HOLE DIAMETER AND INITIAL WATER HEIGHT

Abstract: This is a controlled experiment that investigates the time (t)dependence of a draining approximately cylindrical container with respect to initial water height (h) and aperture size (d). The independent variables are controlled, i.e., first the water height is held constant, then the diameter of the hole is held constant. Graphical analysis of linear and log-log plots of the experimental data is utilized to conclude that $t(d,h) = 3.45 \frac{h^{0.75}}{d^2}$.

INTRODUCTION

Drainage time is of interest to engineers who design water tanks and other storage bodies. For my project, I performed a controlled experiment to determine the mathematical relationship between the time t for an approximately cylindrical container to empty and different diameters d of a hole in the bottom and different initial water heights h. For example, one diameter could be 2.0 centimeters (cm), another one could be 5.0 centimeters. From past experience, one knows qualitatively that the container with the larger diameter hole will drain faster than the container with the smaller diameter hole when h is held constant. However, I wished to determine the quantitative relationship. (Note: The initial height of the water was held constant when the diameter was varied, and the diameter was held constant when the initial water height was varied.)

For my project, I used four identical, approximately cylindrical containers (cups), each with a different size hole in the bottom, water, a stopwatch, and a ruler in order to measure the different diameters and different initial water heights. After I had all the materials, I measured and cut the different diameter holes in the bottom of the four containers. Then I poured the same amount of water into each container. Each container was tested for its draining time. The procedure was repeated three more times, varying the initial water height, for a total of 16 time measurements. Results were recorded in Table 1 (see data section), and the data were analyzed using graphical analysis techniques.

RESEARCH

Time

In addition to research on graphical analysis, which I will explain later, I also read about time and how water is held together. Time is one of the deepest mysteries known to man. The ability to measure time makes our way of life possible. One way of thinking about time is to imagine a world without time. Any change that takes place again and again stands out from other changes. The rising and setting of the sun exemplifies this point. The first people to keep time probably counted these natural repeating events and used them to keep track of events that did not repeat. When man began to count repeating events, he began to measure time.

Scientists think of time as a fundamental quantity that can be measured. Other fundamental quantities include length and mass. The noted physicist, Albert Einstein, realized that measurements of these quantities are affected by relative motion, the motion between two objects. Because of his work, time became popularly known as the fourth dimension. Many physicists have considered the possibility that under certain circumstances time might even flow backwards. But experiments have not supported this idea. Some scientists are considering whether time might have more than one dimension.

How Water is Held Together

Water's unusual properties depend on the forces holding it together. These forces are chemical bonds and hydrogen bonds. Chemical bonds are the forces that hold the two hydrogen atoms and the one oxygen atom together in a water molecule. Each hydrogen atom has one electron whirling in orbit around its nucleus. But each of these atoms has room for two electrons. The oxygen atom has six electrons in its outer orbit, but it has room for eight.

Hydrogen bonds are the forces that link water molecules together. Water molecules have a lopsided shape because the two hydrogen atoms bulge from one end of the oxygen atom. The hydrogen end of the water molecule

has a positive electric charge. At the opposite end, the molecule has a negative charge. Water molecules link together because opposite charges attract.

Graphical Analysis

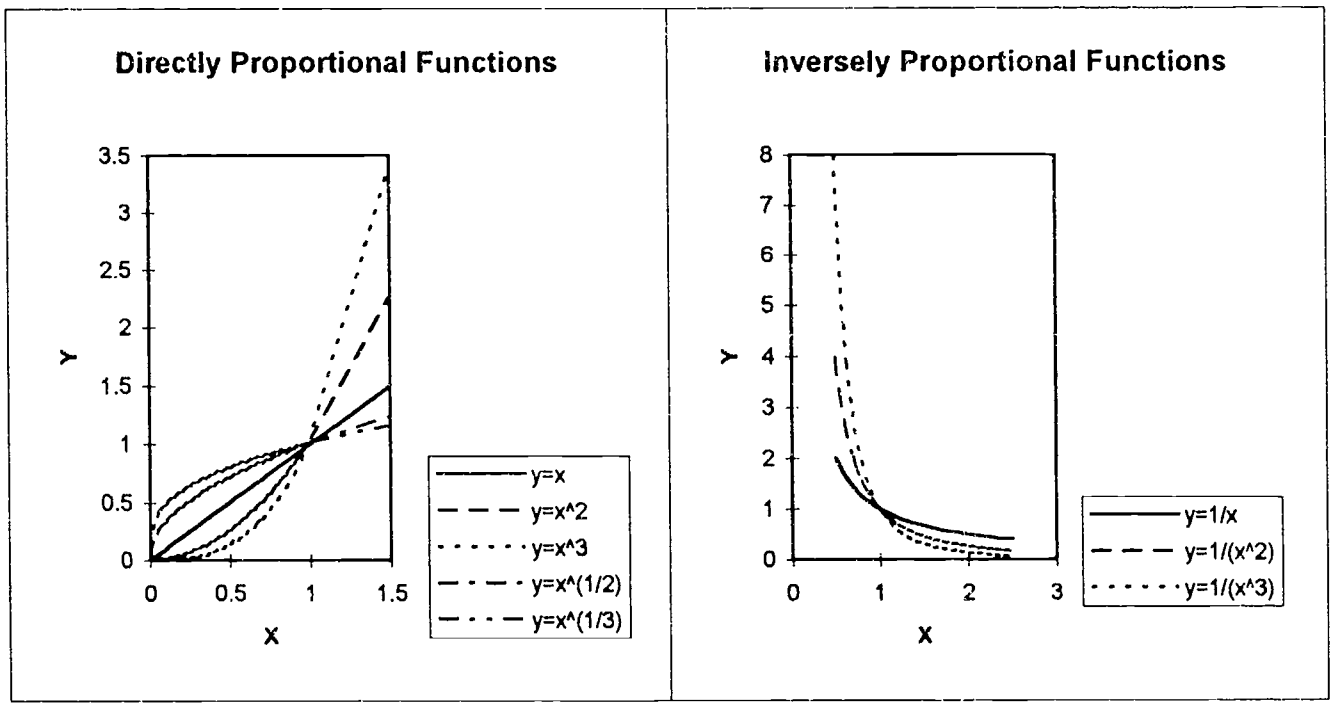
The analysis of data from an experiment is always reduced to finding the relation between just two quantities, so methods used to determine various types of relations will be discussed. If two quantities are related by some regular function, for each value of one quantity, there is a certain value of the other. The outcome is that when a graph is plotted of one quantity against the other, a line is formed. So the first use of a graph is to show if a relation exists, for if it does, the values of one when plotted against the values of the other will appear to fall on a line. In order to define a line, many points are required. The number required depends on the shape of the line; but if its shape is unknown, the larger the number of points, the better. Two points define a line only if it is known that the line is straight; otherwise a larger number of points is required.

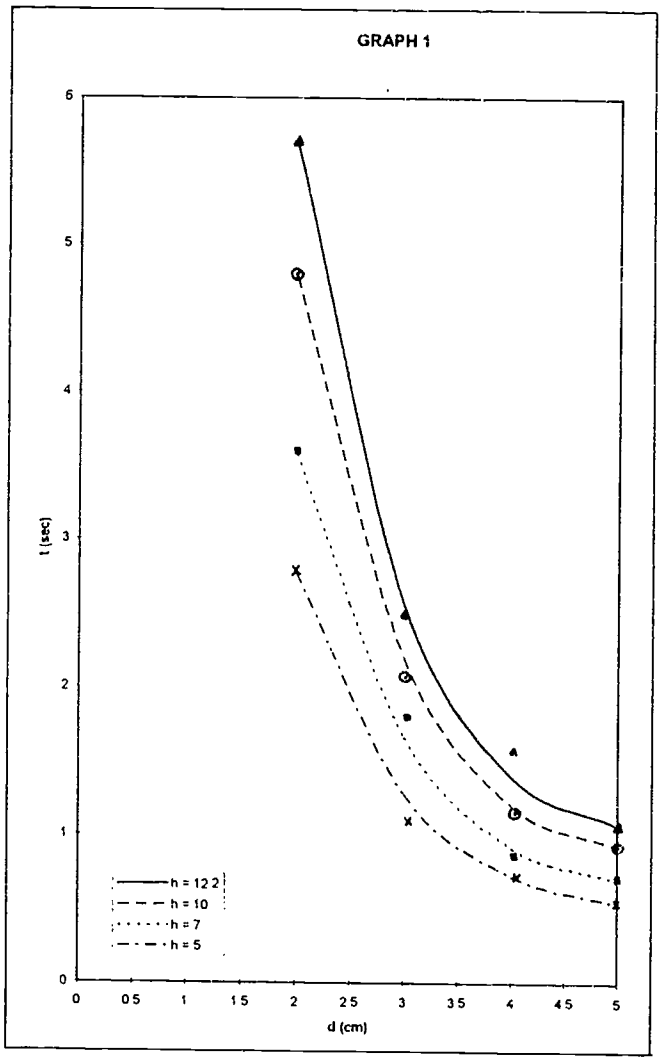
Linear or first power relations

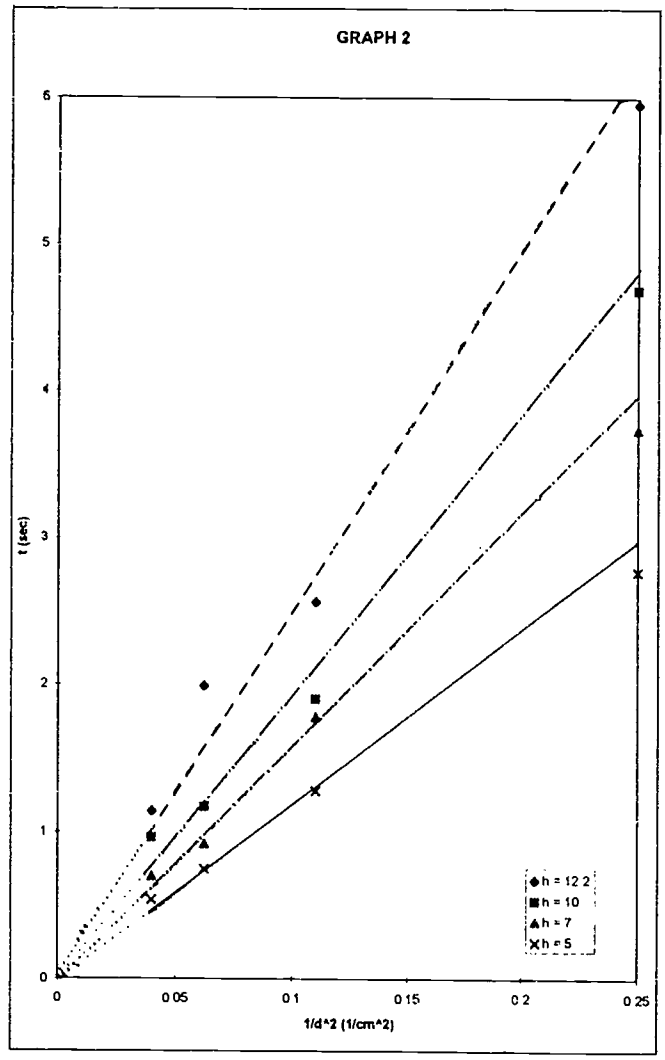
The general equation of a straight line is of the form $y = mx + b$ where b is the value of y when $x = 0$, and is called the y-intercept. If the line goes through the origin, then $b = 0$. The quantity m is called the slope of the line and is commonly expressed as a "rise/run". The rise and run are measured in the units indicated on the y- and x-axis, respectively. With this understanding of slope, the values of y must be plotted in the vertical direction, and those of x must be plotted horizontally. If the slope m is zero, then y does not depend on x. Experimental points may not lie exactly on a straight line; we do not expect them to, because experimental data are never exact. The points may suggest a straight line. If so, a straight line should be drawn among the points. Such a line is called the "best fit" straight line. It will probably go above some points and below others, but it is an honest attempt to show the trend of the data. The data should not suggest that a smooth curve would fit the points better than such a straight line. The fact that the experimental points indicate a straight line show that the trend of the data is linear within the limits of that experimental method. The results of the graph may be compared to the results expected from theoretical analysis. Whether or not your results are sufficiently close to the accepted or to a calculated theoretical value can be determined only if the numerical uncertainty, or error, in the experimental value is calculated.

Power Laws

A very common type of relation is one of the form $u = kv^n$ where u and v are the variables, and the power to which v is raised can be integral, fractional, positive, or negative; k represents a constant. This equation includes all those represented by the curves shown below. Graphs illustrate various mathematical relations. Only the straight line can be identified by inspection.







Taking the log of both sides of the equation, $u = kv^n$ gives $\log u = \log k + n \log v$. Now let $y = \log u$, $x = \log v$, $b = \log k$, and the equation becomes $y = b + nx$, which is the equation of a straight line. The quantity $\log u$ can be plotted in the y direction and $\log v$ in the x direction. A straight line would then result, the slope of the line being the exponent n and the constant k being the antilog of the y-intercept.

EXPERIMENTAL PROCEDURE

The time for a storage tank to drain for example a water tower, is of interest to engineers. This experiment investigates the relationship between time t for the contents of a cup to drain through holes of different diameters when the water level starts at different heights h. The independent variables are height h and diameter d, and the dependent variable is time t. This is a controlled experiment since h was held constant and the diameter d was varied four times. Then the diameter d was held constant and the initial height h of the water level was varied four times, as explained in the introduction. The data are shown in Table 1. The time entries are measured in seconds.

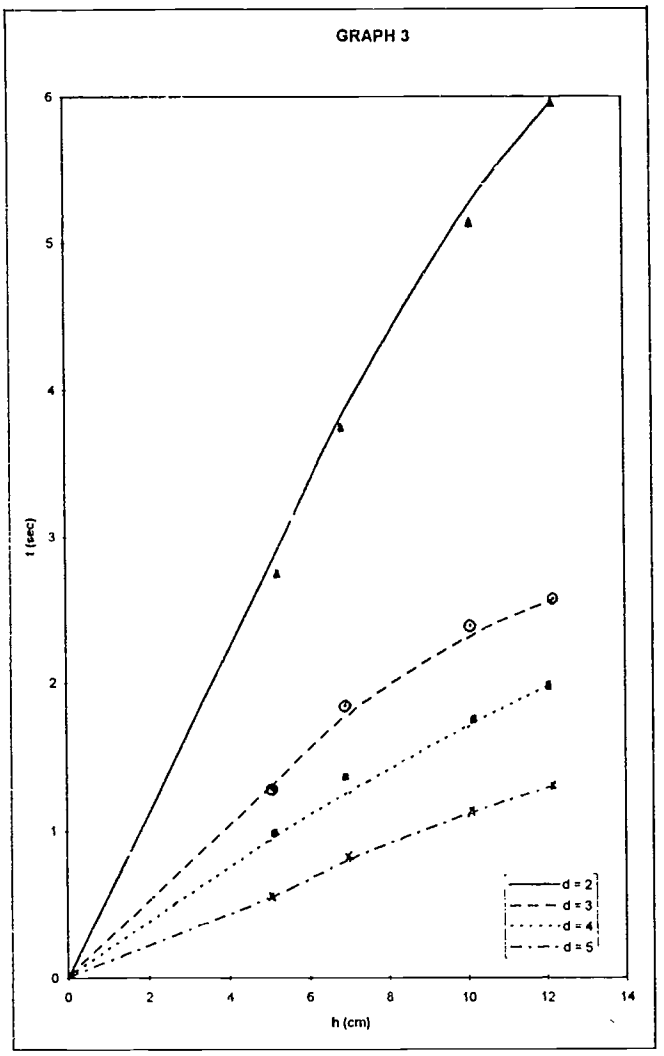
Table 1 Data

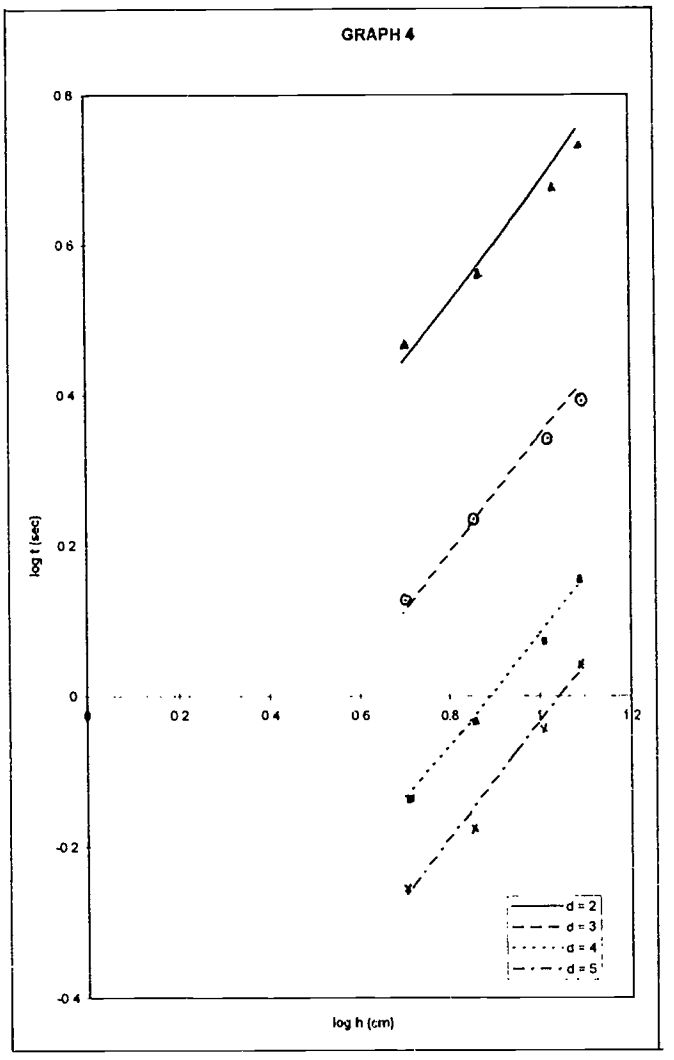
d in cm	h in cm			
	12.2	10.0	7.0	5.0
2.0	5.96	4.69	3.74	2.77
3.0	2.56	1.90	1.78	1.28
4.0	1.99	1.17	0.92	0.75
5.0	1.14	0.96	0.70	0.54

THEORY/ANALYSIS/RESULTS

After recording my data, I graphed time t versus diameter d (see Graph 1). The relationship appears to be a type of inverse relationship $\left(t \propto \frac{1}{d^n}\right)$. Now logic implies that

$$t \propto \frac{1}{Area\ of\ hole} \rightarrow t \propto \frac{1}{\pi r^2} \rightarrow t \propto \frac{1}{\pi(d/2)^2} \rightarrow t \propto \frac{1}{\pi(d^2/4)} \rightarrow t \propto \frac{1}{d^2} \rightarrow t = k\frac{1}{d^2}$$





(where k is a constant of proportionality), so that $n = 2$. This equation is of the form $y = mx + b$, which is a straight line if

$y \rightarrow t$
$m \rightarrow k$
$x \rightarrow 1/d^2$
$b \rightarrow 0$

A graph of t versus $1/d^2$ should be a straight line going through the origin. I did graph t vs. $1/d^2$, holding h constant (Graph 2) and did get straight lines through the origin. Thus, I confirmed that $n = 2$ and $t \propto 1/d^2$ (height controlled). Next, I investigated how the initial water height h affected time t to drain. I plotted t time versus height h, holding d constant (see Graph 3). The shape of Graph 3 suggests that $t \propto h^n$, when $0 < n < 1$ (for $n < 1$ the graph would look parabolic or steeper in shape and $n = 1$ would be a straight line). Now to see if my reasoning is correct, I plotted log$t$ versus log$h$ (see Graph 4), as explained below. Assume that $t \propto h^n \rightarrow t = kh^n$, where k is a constant of proportionality.

$$t = kh^n \rightarrow \log t = \log k + \log h^n \rightarrow \log t$$
$$= \log k + n\log h \rightarrow \log t = n\log h + \log k,$$

which is of the form of a straight line $y = mx + b$, if

$y \rightarrow \log t$
$m \rightarrow n$
$x \rightarrow \log h$
$b \rightarrow \log k$

Thus, if I do get straight lines in Graph 4, I can find the exponent of h since n is just the slope of the line

$$\underbrace{\log t}_{y} = \underbrace{n}_{m}\underbrace{\log h}_{x} + \underbrace{\log k}_{b}$$

When I plotted the t and h data on log-log paper, I did indeed get four straight lines which were parallel to each

other.[1] I found the slope to be approximately 0.75, so $n = 0.75 = 3/4$. Therefore, I found that $t(d,h) \propto \frac{h^{0.75}}{d^2} \rightarrow t(d,h) = k\frac{h^{0.75}}{d^2}$. Now I chose a good point and found the constant k. I plugged $d = 3$ cm and $h = 5$ cm into the above equation and set this equal to my experimental drainage time of 1.28 seconds.

$$t(d,h) = k\frac{h^{0.75}}{d^2}$$

$$1.28 = k\frac{5^{0.75}}{3^2} \Rightarrow k = 1.28\frac{3^2}{5^{0.75}} = 3.45$$

Thus, finally, I found that $t(d,h) = 3.45\frac{h^{0.75}}{d^2}$ for my container.

DISCUSSION OF ERROR

The time entry in Table 1 may be in error by ± 0.1 second since a human hand and eye cannot be trusted to measure less than a tenth of a second. Additional experimental errors (uncertainties) include the errors in measuring diameter d and initial height h. The greatest possible error (g.p.e.) for both d and h can be estimated as half the place holding value of the last significant digit. Since both d and h are measured to the nearest tenth, the g.p.e. can be estimated as ± 0.05cm. Error in cutting perfectly circular holes was also present. The graphing procedures employed in the lab help take all the above errors into account even when the errors in the measured values are propagated by squaring, multiplication, division, etc. The percent relative error can be calculated using the following equation:

$$\textit{percent relative error} = \frac{\textit{measured value} - \textit{calculated value}}{\textit{measured value}} * 100\%$$

For example, for $d = 2.0$cm and $h = 12.2$cm, the measured drainage time is

$$t(d,h) = 3.45\frac{h^{0.75}}{d^2}$$

$$t(2.0,12.2) = 3.45\frac{12.2^{0.75}}{2.0^2} = 5.63$$

Thus, the percent relative error is

$$\textit{percent relative error} = \frac{5.96 - 5.93}{5.96} * 100\% = 5.5\%.$$

The percent relative error for all values of drainage time is summarized in Table 2.

Table 2 Percent Relative Error

d in cm	h in cm			
	12.2	10.0	7.0	5.0
2.0	+ 5.50%	- 3.40%	+ 0.80%	- 3.97%
3.0	+ 2.30%	- 1.37%	+ 7.30%	0.00%
4.0	+ 2.90%	- 3.42%	- 8.70%	+ 3.87%
5.0	+ 2.10%	+ 1.92%	+ 1.51%	+ 14.60%

CONCLUSION

It is possible to find a general mathematical relationship between the time for a cylindrical container to empty and the diameter of a hole in its bottom and the initial height of water within it. Because the "cylindrical" cups were identical, the data from them could be combined to find a general mathematical relationship. For my experiment, as shown above, I found that

$$t(d,h) = 3.45\frac{h^{0.75}}{d^2},$$

which allows us to predict the time t for my cylindrical container to drain given any arbitrary diameter d and initial water height h. So for any h and d, I can find a value of time t without actually measuring it. One of the goals in science is to reduce empirical data to a mathematical equation, as I have done in this experiment. Graphical analysis is seen to be an extremely powerful tool in determining the relationship between experimental variables. Future investigations could include investigating different sized containers, different shaped containers (rectangular, semihemispherical, etc.), or the placement of the hole to see whether the above equation needs to be modified, and if so, to determine the new equation. In addition, other future research could include doing a library search of technical (science and engineering) papers on the topics of drainage time of storage bodies and the theory of water flow through orifices. Reading these papers might provide me with practical applications and new research techniques.

In summary, from doing this project I learned about draining. (It does not matter from where water is draining; it could be from a sink, a bottle, etc.). Also, I learned new concepts and techniques of mathematical and graphical analysis. Finally, I learned more about time and properties of water. All these reasons made this project very worthwhile.

[1] The fact that the log t vs. log h lines are parallel to one another is very important because the goal of this experiment is to find a general mathematical relation that describes all the data. If the lines were not parallel, they would have different slopes, hence different values of n, and no general mathematical relation would exist. Instead, several separate equations would be needed.

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UNDERGRADUATE AWARD

Gisela Rodríguez, Senior
DEPARTMENT OF CHEMISTRY, UNIVERSITY OF PUERTO RICO

Research Careers for Minority Scholars Project
Principal Investigator, Brad Weiner

TRIISOPROPYLSILANOL: A NEW PHASE TRANSFER CATALYST FOR DEHYDROHALOGENATION

Abstract: A new solid-liquid phase transfer catalyst (PTC) has been developed which allows the inexpensive base, potassium hydroxide, to quantitatively convert alkyl halides to alkenes avoiding both ether and alcohol by-products. Triisopropylsilanol (TIPSOH) is effectively deprotonated at the surface of the base forming potassium silanoate (KOTIPS). This highly hindered soluble base effects the deprotonation of alkyl halides regenerating TIPSOH which repeats the cycle. Even primary halides undergo exclusive elimination, an unprecedented result. More acidic in dipolar aprotic solvents than normal alcohols, an efficient proton transfer occurs between the KOH and the silanol providing an entirely new and useful catalytic process. The silanol-silanoate system has also been demonstrated to be an efficient alternative to existing methods in the detoxification of mustard gas analogues and environmental pollutants.

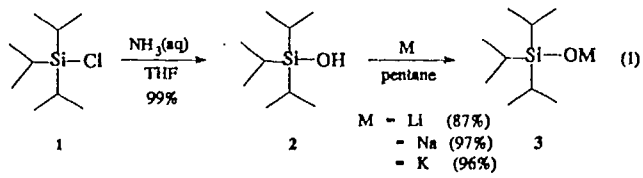
INTRODUCTION

Silanols and their corresponding anions (silanoates) are finding increasing uses in organic synthesis as organic-soluble equivalents of water and hydroxide ions as well as and in organometallic chemistry as stable bulky ligands.[1,2] Silanols are hydrogen-bonding donors and acceptors.[3a-c] Early studies established that silanols are more acidic than the corresponding carbinols,[3a] a feature which we felt could be effectively used to develop an entirely new approach to catalytic dehydrohalogenation, namely through the silanol-silanoate system. Through related studies on the directive properties of the triisopropylsilyl group (TIPS),[4] we had been impressed with the remarkable resistance of this group to undergo substitution at the silicon center, a feature which results in much greater hydrolytic and chemical stability for organosilanes which contain this ligation compared to traditional less bulky derivatives. The fact that the isopropyl groups are smaller than phenyl or cyclohexyl while providing effective steric protection around the silicon was an additional attractive feature of the TIPS group because it renders the silyl derivatives both volatile and easy to analyze spectroscopically compared to these other ligand examples. Moreover, their smaller size was anticipated to increase the water solubility of the silanol compared to larger, more hydrophobic groups. These considerations led us to prepare the new silanol, triisopropylsilanol (TIPSOH, **2**), and investigate its use as a new phase transfer catalyst for dehydrohalogenation reactions.

RESULTS AND DISCUSSION

To initiate this study, we took advantage of the known reluctance of highly hindered silanols to form disiloxanes,[5] developing a simple, efficient procedure for the preparation of TIPSOH (99%) from the ammoniacal hydrolysis of TIPSCl (eq 1). This stable silanol was converted to the corresponding alkali metal silanoates (**3**) directly from the alkali metals.[6] These silanoates proved to be pentane-soluble and very hygroscopic. For analytical purposes, they were silylated with chlorotrimethylsilane (TMSCl) to produce TMSOTIPS cleanly in each case with this ether being isolated in 92% yield from the potassium salt reaction.[7]

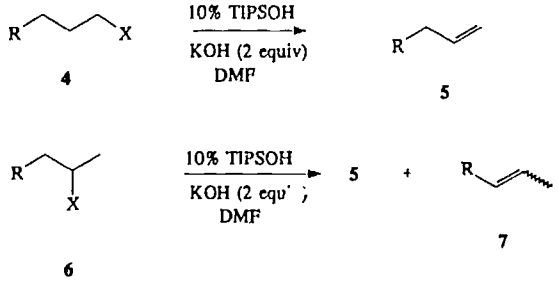
EQUATION 1



The reactions of *primary* and *secondary* alkyl halides with metal alkoxides has been extensively studied.[8] These bases effect the dehydrohalogenation of *secondary* halides through an E2 process giving a mixture of alkene products under stoichiometric conditions. Hindered reagents such as KO(*t*-Bu) in DMSO give the best results,[8a,b] being superior to the less bulky, but less expensive, KOH. However, none of these systems can be used to dehydrohalogenate *primary* alkyl halides without substitution (S_N2)

being a significant competing process. Because we had observed that the bulky TIPS group has the property of impeding reactions at proximate centers,[4] we felt that the substitution process would be disfavored and even avoided using the highly hindered base, KOTIPS, thereby allowing it to function exclusively as a base with even these substrates. While **3** would be expensive for stoichiometric applications, its potential value in this regard could be significantly enhanced if it could be generated efficiently in a catalytic cycle employing the inexpensive base, KOH.

The relative acidity of **2** was compared to *t*-BuOH by the IR method previously developed for related silanols.[5a] Through hydrogen bonding to the base diethyl ether, silanols exhibit IR bands which are shifted nearly twice that of the corresponding carbinols, indicative of their greater acidity. This phenomenon was examined with *t*-BuOH which gave an $\Delta\upsilon = 115\ cm^{-1}$ compared to $\Delta\upsilon = 210\ cm^{-1}$ for **2**, consistent with the greater acidity of the latter. The fact that KOTIPS (**3**), unlike KOH, is highly soluble in non-polar solvents also suggested that if it is efficiently formed from the deprotonation of **2** with solid KOH, that this base could reach the alkyl halide in solvent systems where KOH itself is insoluble. Thus, the TIPSOH-KOTIPS system held promise for providing a method for using the inexpensive base, KOH to generate a highly hindered organic-soluble base which is too hindered to undergo competitive substitution even with *primary* alkyl halides.



Scheme 1

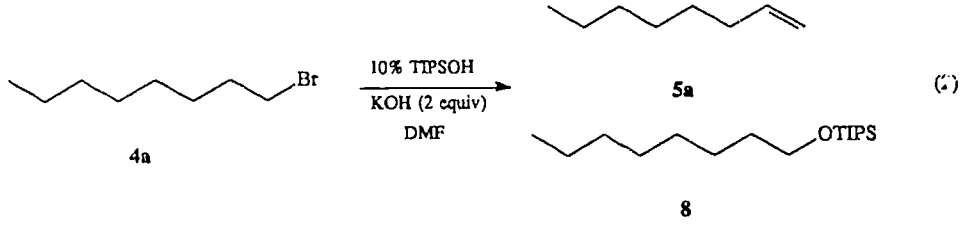
Employing either DMSO or DMF as solvent, we first established that 2-bromooctane (**6a**) underwent no reaction with solid KOH at room temperature in 2 d. The catalytic role played by **2** was clearly demonstrated when, under the same conditions in either solvent, adding 10% TIPSOH to these mixtures results in complete reaction in 5 h producing 1-octene (41%) and 2-octene (51%, *c/t* = 1:6) (Scheme 1, Table 1). However, for 1-bromooctane (**4a**) the choice of the solvent system is critical (eq 2). For example, the dehydrohalogenation of **4a** in DMSO ($\epsilon_{25} = 46.6$)[9] produces only the octyl silyl ether (**8**, 10%) with 90% of **4a** remaining unreacted. However, with **4a** (0.66 M) in DMF ($\epsilon_{25} = 36.7$)[9] a significant improvement in the process was observed, the yield of **5a** being 87% accompanied by 10% of **8**. This suggested that the formation of water ($\epsilon_{25} = 78.3$)[9] from the KOH could play an important role in the outcome of the reaction by raising the dielectric constant of the medium, a change which could favor substitution over elimination. We decided to carry out the reaction with a lower concentration of **4a** (0.3 M), a change which increased the yield of **5a** to 97% (Table 1) and essentially eliminated this deleterious side-reaction. This remarkable result is unprecedented with for **4a** or related derivatives employing any procedure which uses hydroxide or alkoxide bases. Similarly, both 1- and 2-bromoethylbenzene are quantitatively converted to styrene under these conditions (Table 1).

Table 1 The TIPSOH-catalyzed dehydrohalogenation of bromoalkanes in DMF with KOH at 25°C[a]

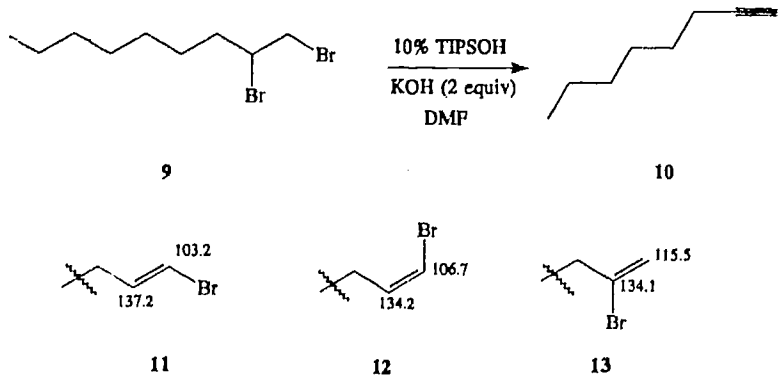
		Yield [%]		
Bromoalkane	R	1-alkene	2-alkene	1-alcohol
4a	*n*-C_6H_{13}	97	0	0
4b	Ph	100	0	0
6a	*n*-C_6H_{13}	41	51[b]	0
6b	Ph	100	0	0

[a]The concentration of the haloalkane was *ca.* 0.3 M. [b]In this case, corroboration of the *cis*:*trans* product ratio of 1:6 was accomplished by the photoisomerization (450 W Hg) of the mixture in C_6D_6 to obtain definitive spectroscopic data for both isomers.

EQUATION 2

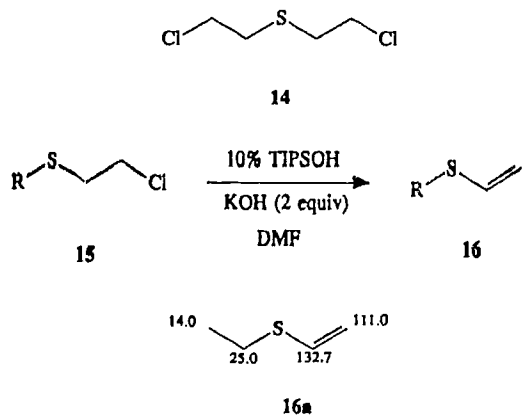


(2)



Scheme 2

This methodology was also applied to the dehydrohalogenation of 1,2-dibromooctane which, while slower, produces 1-octyne (**10**, 94%) efficiently in 12 h at 25°C employing 20% TIPSOH as the catalyst (Scheme 2). The process clearly involves the step-wise elimination and all of the possible isomeric vinyl bromides intermediates (**11-13**) were observed spectroscopically (GCMS, ^{13}C NMR) as the reaction proceeds. Moreover, this methodology was examined as a new alternative for the disposal of mustard gas (**14**) by demonstrating that a related analog undergoes clean elimination to provide ethyl vinyl sulfide (**16**) quantitatively (Scheme 3).[10]



Scheme 3

CONCLUSION

The use of TIPSOH as a phase transfer catalyst in the dehydrohalogenation of haloalkanes circumvents the difficulties previously encountered with alkoxide bases, namely competitive substitution. This is particularly dramatic for 1-haloalkanes which exhibit no substitution, a result not equaled even with highly hindered bases (*e.g.* KO(*t*-Bu) under stoichiometric conditions. This new methodology also avoids the need for excess base (900%) and the large amounts of solvent, and uses the inexpensive base, KOH, to generate the highly hindered KOTIPS from TIPSOH which functions as a new PTC in an effective catalytic cycle.

ACKNOWLEDGEMENTS

This work summarizes the results of ongoing research at the University of Puerto Rico, Rio Piedras Campus to which the author has contributed. The significant experimental contributions of Jaime Vaquer (Ph.D., UPR-RP 1994) and Michael J. Diaz and the research direction of Professor John A. Soderquist (UPR-RP) is gratefully acknowledged. The generous support of this research by the U.S. Department of Energy (DE-FC02-91ER75674) and the NSF-RCMS (HRD-9011964) is also gratefully acknowledged.

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UNDERGRADUATE AWARD

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APPLICATION OF INTERVAL MODELING TECHNIQUES TO ROBUST CONTROL OF A SLEWING BEAM WITH LOADS

Abstract: This project presents an approach for modeling a slewing beam with parametric variations via an interval model of the transfer function. Here the interval model is a model set whose transfer function parameters are bounded. The algorithm attempts to obtain the models of the slewing beam with various loads by using the finite element algorithm which generates a system model based on the stiffness and mass matrices by following the physical laws. Then, the interval modeling techniques are applied to obtain an interval system of the transfer function. In this project, the interval polynomial techniques recently developed in the robust control community are used to analyze the interval model. Both the open-loop and closed-loop systems of the slewing beam with added loads are used to demonstrate and verify the developed modeling technique.

INTRODUCTION

Modeling a dynamic system with parameter changes is an important and challenging problem in the fields of structural dynamics, system identification, and robust control. For the space structure operated in the space environment, there is the possibility of added loads to the structure. To maintain structural control, it is necessary to consider this type of system change.

In this paper, we address the problem of modeling a flexible beam with added loads. Using a set of differential equations to model a system with parameter changes provides the physical representation. Since each differential equation can be expressed as a transfer function, this system can be modeled as a set of transfer functions. The interval model of the transfer function is used to model the flexible beam with various loads. In the last few years, the interval modeling techniques developed in [1,2] have been used to model dynamic systems with parameter changes and dynamic systems with model uncertainty.

The first step of the proposed algorithm is to obtain the models of the slewing beam with various loads by using finite element analysis[3], which generates a system dynamic model based on the stiffness and mass matrices by following physical laws. Then a model reduction technique[4] is applied to obtain a reduced order model with low frequency modes of interest. After we obtain the models for various cases, we apply a singular value decomposition technique[1] to obtain an interval model of the transfer function. Both the open-loop and closed-loop slewing beam systems are used to demonstrate and verify the developed approach. For the closed-loop system, a PD[5] feedback controller is designed to suppress the vibration of the slewing beam.

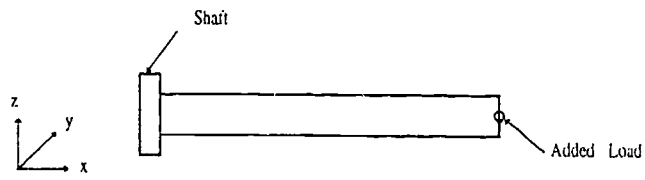
FINITE ELEMENT MODELING

Finite element analysis has been widely applied to generate the model of a dynamic system in the space and automobile industries due to the availability of digital computers to carry out the numerical aspects of structural dynamics problem solving. When modeling a free-pinned Euler beam, which is the beam component of the flexible beam system with various loads as shown in Figure 1, the vibration of the uniform beam is governed by Euler's beam differential equation[6]

$$EI\frac{\partial^4 y}{\partial x^4} + m\frac{\partial^2 y}{\partial t^2} = f \qquad (1)$$

FIGURE 1

Flexible beam system with loads



This is a continuous model based on Newton's law, and it represents an infinite degree of freedom (DOF) system without analytical solution. Using finite element analysis,

we can generate an approximated discrete model with finite N-DOF for the dynamic analysis of this Euler beam. The approximated solution can be expressed as

$$y(x,t) = \sum_{i=1}^{N} \Psi_i(x)u_i(t) \quad (2)$$

where each $\Psi_i(x)$ describes the deflected shape corresponding to the vibration $u_i(t)$. The kinetic energy and potential energy of the beam can be written as[3]

$$T = \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} m_{ij}\dot{u}_i\dot{u}_j \quad (3)$$

$$V = \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} k_{ij}u_iu_j \quad (4)$$

where m_{ij} and k_{ij} are the elements of the stiffness and mass matrices, respectively. For the Euler-Bernoulli beam, the stiffness and mass matrices of the *ith* element are

$$k_i = \frac{EI}{L^3}\begin{bmatrix} 12 & -6L & -12 & -6L \\ -6L & 4L^2 & 6L & 2L^2 \\ -12 & 6L & 12 & 6L \\ -6L & 2L^2 & 6L & 4L^2 \end{bmatrix} \quad (5)$$

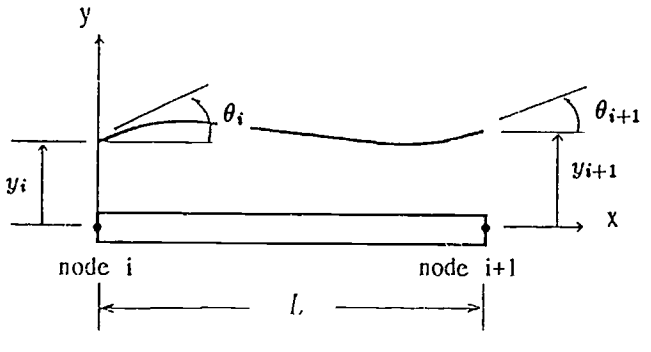
$$m_i = \frac{\rho AL}{420}\begin{bmatrix} 156 & 22L & 54 & -13L \\ 22L & 4L^2 & 13L & -3L^2 \\ 54 & 13L & 156 & -22L \\ -13L & -3L^2 & -22L & 4L^2 \end{bmatrix} \quad (6)$$

where E is Young's modulus, I is the second moment of inertia, L is the length of the *ith* element, ρ is the mass density, and A is the cross-sectional area. These matrices correspond to the coordinate of the *ith* element as shown in Figure 2.

$$q_i = [y_i\ \theta_i\ y_{i+1}\ \theta_{i+1}]' \quad (7)$$

FIGURE 2

Deflection of the ith element



The generalized coordinate vector of the beam with n nodes is

$$q = [y_1\ \theta_1\ y_2\ \theta_2\ \ldots\ y_n\ \theta_n]' \quad (8)$$

The stiffness matrix $\boldsymbol{K}_q$ (mass matrix $\boldsymbol{M}_q$) of the beam is the summation of the stiffness(mass) contributed from each element. After generating the mass matrix of the beam, the moment of inertia of the shaft component, where the beam is clamped, is added to the mass element m_{22}, which corresponds to the angular displacement θ_1 at the first node. Since the beam is clamped at the hub, the first row and column of $\mathbf{M}_q$ and $\mathbf{K}_q$, which correspond to the coordinate y_1, are eliminated to generate the mass matrix $\boldsymbol{M}$ and the stiffness matrix $\boldsymbol{K}$. Using Lagrange's equation[3], we can obtain the dynamic equation

$$M\ddot{q} + Kq = B_q f \quad (9)$$

where B_q is the input matrix. This differential equation can be transferred as a state space model

$$\dot{x} = Ax + Bf \quad (10)$$

$$x = \begin{pmatrix} q \\ \dot{q} \end{pmatrix},\ A = \begin{pmatrix} O_{2n} & \mathbf{I}_{2n} \\ -\mathbf{M}^{-1}\mathbf{K} & O_{2n} \end{pmatrix},\ \mathbf{B} = \begin{pmatrix} O \\ \mathbf{M}^{-1}\mathbf{B}_q \end{pmatrix} \quad (11)$$

where O_{2n} and I_{2n} are $2n \times 2n$ zero and identity matrices. The displacement output measurement can be written as

$$y = Cx \quad (12)$$

The transfer function corresponding to the input-output of this state space model is

$$g(s) = \frac{y(s)}{f(s)} = C(sI - A)^{-1}B \quad (13)$$

After we obtain the state space model of the high order finite element model, a model reduction technique[4] is used to obtain a reduced order model with the modes of interest. In this paper, we consider 21 cases with various added loads, $m_{ti} = (0.01i)W_b$ $(i = 0,1,2, \ldots, 20)$, at the tip of the beam. Here W_b is the weight of the beam. In the finite element modeling, these added loads are added to the mass element corresponding to the coordinate y_n. The results of using finite element analysis to model the flexible beam with various loads will be discussed later.

INTERVAL MODELING TECHNIQUE

The interval modeling algorithms have recently been developed for modeling the model uncertainty and the parameter changes of a dynamic system. the model structure chosen in this paper is a linear interval system of the transfer function.

$$G(s,p) = \{g(s) | g(s) = \frac{n_n(s) + \sum_{i=1}^{n}\alpha_i n_i(s)}{d_n(s) + \sum_{i=1}^{n}\alpha_i d_i(s)},\ \alpha_i \in [\alpha_i^-, \alpha_i^+]\} \quad (14)$$

where $n_n(s)$ and $d_n(s)$ are the numerator and denominator of the nominal model. The bounded variables α_i represent

the parameter uncertainty part in the directions of the polynomials $n_i(s)$ and $d_i(s)$.

The transfer functions of the previous reduced finite element models of the k cases with different loads are expressed as

$$g_i(s) = \frac{n'_m s^m + n'_{m-1} s^{m-1} + \ldots + n'_0}{s^m + d'_{m-1} s^{m-1} + \ldots + d'_0}, \quad i = 1,2,\ldots,k \qquad (15)$$

with the parameter vectors

$$p_i = [n'_0 \ldots n'_{m-1} \; n'_m \; d'_0 \ldots d'_{m-1}]', \quad i = 1,2,\ldots,k \qquad (16)$$

A judicious choice for the nominal model is the average of all the models. The parameter vector corresponding to the nominal model is

$$p_0 = \frac{1}{k}\sum_{i=1}^{k} p_i \qquad (17)$$

The uncertainty part of the interval model is contributed from the difference between the nominal model p_0 and the finite element models p_i. The model difference between p_i and p_0 is

$$\Delta p_i = p_i - p_0 \qquad (18)$$

Then we use the model difference vectors to generate a parameter uncertainty matrix

$$\Delta P = [\Delta p_1 \; \Delta p_2 \ldots \Delta p_k] \qquad (19)$$

The algorithm in Appendix[7] is used to process the matrix ΔP to obtain the polynomials $n_i(s)$, $d_i(s)$ and the parameter bounds α^+, α^-.

NUMERICAL RESULTS

An aluminum slewing beam clamped to a shaft with parameters listed in Table 1 is the test article considered in this project.

Table 1 Parameters of Slewing Beam System

Young's Modulus	E	7×10^{10} N/m^2
Mass Density	ρ	2710 kg/m^3
Length	L_b	0.926m
Width	h_b	0.038 m
Thickness	h_t	0.00159 m
Weight of beam	W_b	0.152 kg
Shaft moment of inertia	I_s	3.53×10^{-6} kgm^2

In the finite element modeling, the node number n is chosen to be 16. The finite element models with 16 nodes has 31 modes. Five of these 31 modes are within the 100 HZ frequency range. Table 2 shows the natural frequencies of these five modes for the beam without added loads.

Table 2 Natural Frequencies of Slewing Beam System

	Mode	Natural Frequency (HZ)
1	Rigid body	0
2	1st Bending	6.684
3	2nd Bending	21.951
4	3rd Bending	46.828
5	4th Bending	82.491

In this project, we consider the model of the first three modes, the rigid body mode and the first two bending modes, with one input and one displacement output both of which are located at the tip of the beam and are in the y direction. The model of the first three modes is obtained by using the model reduction technique in [4]. The transfer function of the single-input, single-output three mode model for the flexible beam system without added loads is

$$\frac{7.216 \times 10^1 s^4 + 9.560 \times 10^5 s^2 + 6.624 \times 10^8}{s^6 + 2.079 \times 10^4 s^4 + 3.355 \times 10^7 s^2} \qquad (20)$$

The nominal model, which is the average of the models of the 21 cases, of the interval model is

$$\frac{3.949 \times 10^1 s^4 + 5.102 \times 10^5 s^2 + 3.510 \times 10^8}{s^6 + 1.710 \times 10^4 s^4 + 2.196 \times 10^7 s^2} \qquad (21)$$

In Table 3, which shows the results of the uncertainty part of the interval model, the interval length, $\alpha^+ - \alpha^-$, indicates the parameter uncertainty distributed in the directions of n_i and d_i. The parameter change is dominated in the direction of the first singular vector. The parameter uncertainty distributed in the direction of the first singular vector is about 10^7 times larger than that of the fifth singular vector.

Table 3 Results of Interval Model

	n_1	n_2	n_3	n_4	n_5
s^4	6.465e00	1.069e01	-6.657e00	-2.931e00	-5.766e-2
s^2	8.648e04	-4.357e04	-5.551e04	1.578r05	6.065e03
s^0	6.007e07	-6.727e07	-2.287e07	-6.224e07	7.412e07
	d_1	d_2	d_3	d_4	d_5
s^4	7.222e02	4.336e02	1.318e03	1.738e02	3.612e02
s^2	2.245e06	-1.415e06	5.092e05	-1.287e06	-4.030e06
α^+	5.133e00	2.043e-2	1.822e-3	1.634e-5	8.754e-7
α^-	-2.502e00	-4.658e-2	-1.556e-3	-1.100e-5	-1.945e-7

To verify the identified interval model by using the closed-loop system, we first design an optimal PD feedback controller to suppress the vibrations of the first three modes. Figure 3 shows the block diagram of this feedback system. The control design is based on the flexible beam without added loads. This design is basically to increase

the damping of each mode to satisfy the performance of vibration suppression and to maintain the control force as small as possible. The transfer function of this designed PD controller is

$$K(s) = 0.1910s + 0.1402 \qquad (22)$$

FIGURE 3

Block diagram of the feedback control loop

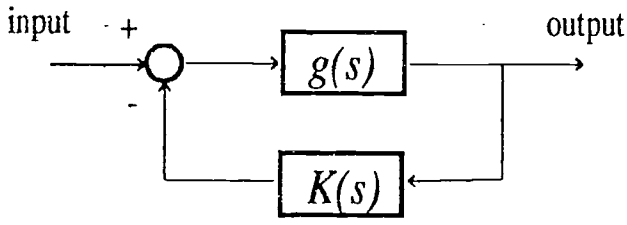


Figure 4 shows the transfer function magnitude plots of the open-loop(solid line) and closed-loop(dashed line) systems for the beam without added loads. The vibration of each mode is significantly suppressed. From the open-loop interval model, we can generate the closed-loop interval system as

$$T(s) = \frac{G(s,p)}{1+G(s,p)K(s)} = \frac{n_0(s)+\sum_{i=1}^{\ell}\alpha_i n_i(s)}{d_0(s)+K(s)n_0(s)+\sum_{i=1}^{\ell}\alpha_i[K(s)n_i(s)+d_i(s)]} \qquad (23)$$

Then we apply the edge theorem[8], which is developed to compute the boundaries of the roots of the linear interval polynomials, to obtain the boundaries of the poles of this closed-loop interval system. The transfer function of the closed-loop systems of the previous 21 cases with various loads are

$$t_i(s) = \frac{g_i(s)}{1+g_i(s)K(s)}, \quad i = 1,2,\ldots,21. \qquad (24)$$

In Figure 5, '.' represents the boundaries of the poles of the closed-loop interval system and '*' represents the poles of the 21 closed-loop cases. The root clusters precisely represent and cover the poles of the closed-loop systems with various loads. This verifies that the identified interval model precisely represents the cases with various loads. Also the performance of vibration suppression for the cases with various loads can be predicted by using the root clusters of the closed-loop interval system.

CONCLUDING REMARKS

This paper presents an algorithm to model the flexible beam system with various loads. The finite element analysis is used to generate the models for the system with various loads. The model reduction technique is applied to obtain the reduced order model with the modes of interest. Then the interval modeling technique is used to generate an interval model. The numerical results of the interval model show that the range of the uncertainty parameter of the interval model indicates the uncertainty distributed in the direction of the corresponding polynomials. Also the results of the closed-loop system verify that the identified interval model precisely represents and covers the original cases with various loads. In the future, we will implement experiments and compare the experimental results with the results in this paper.

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FIGURE 4

Transfer functions of open-loop and closed-loop systems without added loads

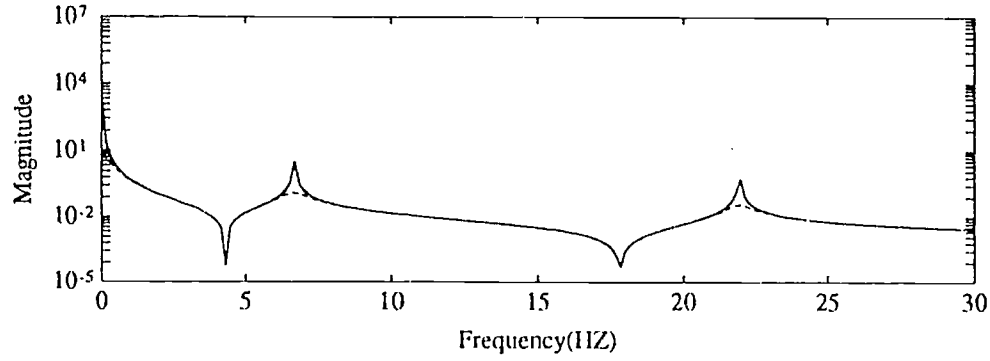
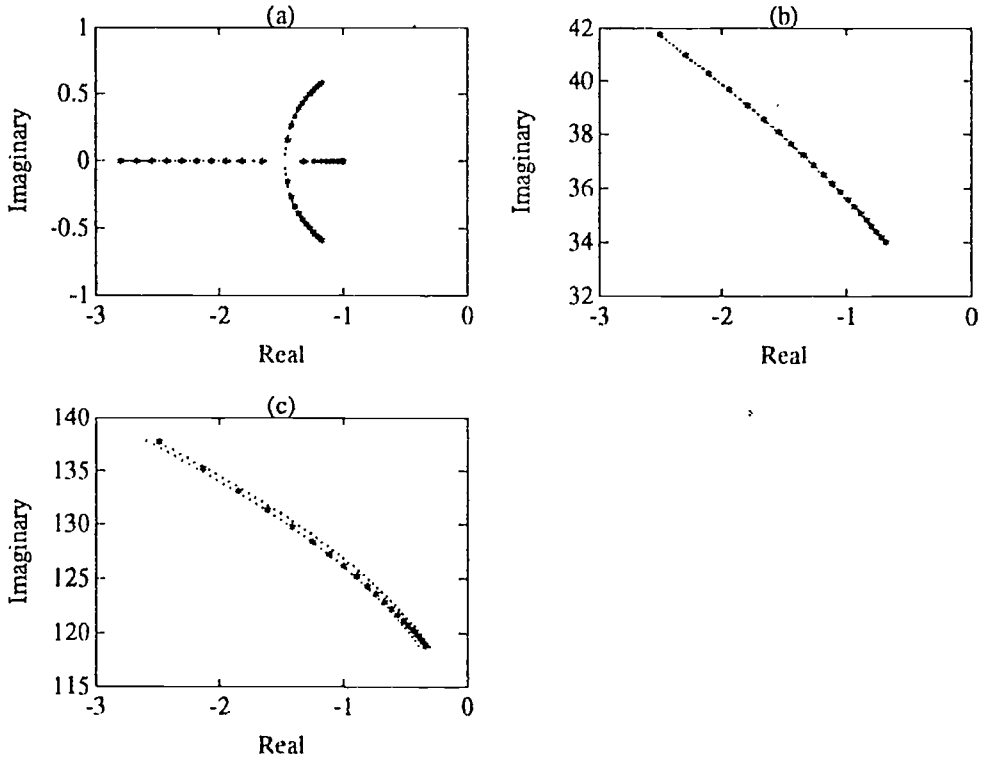


FIGURE 5

Root clusters of closed-loop interval system (a) Rigid body mode (b) 1st bending mode (c) 2nd bending mode



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APPENDIX

1. Compute the weighted uncertainty matrix ΔP^W

$$\Delta P^W = W^{-1}\Delta P$$

where $W = diag[w_1\ w_2\ \ldots\ w_{2m+1}]$ and w_i is the standard deviation of the *jth* element of p_i.

2. Use SVD to factorize ΔP^W

$$\Delta P^W = USV^t$$

where U is the basis matrix of ΔP^W.

3. Compute the basis matrix for ΔP

$$U_p = WU,\ U_p = [U_1\ U_2 \ldots U_{2m+1}]$$

4. Compute the coordinate veetor of Δp_i corresponding to the basis matrix U_p

$$\Delta\alpha_i = U_p^{-1}\Delta p_i$$

5. Compute the polynomials $n_i(s)$ and $d_i(s)$

$$n_i(s) = \sum_{j=1}^{m+1} U_i(j)s^{m+1-j},\quad d_i(s) = \sum_{j=m+2}^{2m+1} U_i(j)s^{2m+1-j}$$

6. Compute the parameter bounds

$$\alpha_i^+ = \max\{\Delta\alpha_1(i)\ \Delta\alpha_2(i) \ldots \Delta\alpha_k(i)\}$$

$$\alpha_i^- = \min\{\Delta\alpha_1(i)\ \Delta\alpha_2(i) \ldots \Delta\alpha_k(i)\}$$

where $\Delta\alpha_i(i)$ is the *ith* element of $\Delta\alpha_i$.

GRADUATE AWARD

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Research Improvement in Minority Institutions Project
Principal Investigator, Dr. Héctor J. Hernández

Creating an Object-Oriented Test Repository

Abstract: The Object-Oriented (O-O) paradigm provides a rich set of tools for software development. This paradigm has influenced the development of databases, languages, graphical user interfaces, along with analysis and design methodologies. A significant portion of software development focuses on existing systems or legacy systems. This paper is a case study on enhancing an existing test repository by using existing O-O technology. The High Energy Laser Site and Test Facility (HELSTF) test repository has a hierarchical database with pointers to data files stored on tape or disk. O-O databases support file storage directly in the database. These databases can also store other complex data such as video or test reports. This paper is a case study on utilizing O-O methodologies and tools to create a prototype repository. An Introduction Section provides a critique of the current HELSTF repository. The Background Section documents the synthesis of sometimes competing methodologies and identifies tools necessary for efficiently implementing this prototype. The Case Study Section highlights preliminary analysis and design issues. A summary of the results of this study is found in the Conclusion section.

INTRODUCTION

This section describes the HELSTF Test Repository as it exists to date (see Figure 1). HELSTF is a laser test facility where performance data are collected on various lasers through an ongoing series of tests. The HELSTF Test Repository consists of the complete set of data files associated with every test conducted at HELSTF along with the database tracking these files. A hierarchical database tracks the data files located on either disk or magnetic tape. This database tracks the set of data files associated with each test. The database also contains some background information on test, camera, and images. Additional background data is found in documents that are inaccessible from the computer system. Signal (sensor output) and image (camera output) data are the two forms of data taken at HELSTF. This paper addresses only camera data with primary focus on the infrared video sequences called images.

Computer operators run programs to digitize and decommutate analog data into data files available for analysis. Digital image files contain the infrared video sequences in a format unique to HELSTF. Decommutation is the mapping of data from its encoded multiplexed form into its decoded recorded form. They then use analysis programs to generate hard copy plots for various customers (see Figure 2). Each plot represents one frame of camera data. Only three tests are available on-line due to storage limitations. The remaining data from over 100 tests are off-line in a vault unavailable for interactive analysis and review. Restoring a complete test from tape to disk usually takes about a day.

Analysis software available for processing images at HELSTF has two limitations: a command-line interface and static frame processing. The primary limitation of the command-line interface is that the user must memorize cryptic commands to analyze and plot image data. This learning curve usually prohibits visiting analysts from using these programs. The software supports only static processing of individual frames in an image and does not support dynamic interactive manipulation of frames. A user must process each frame one by one to isolate anomalies. Infrared cameras record data at twenty-five frames a second. Processing all these frames is a very time-consuming process. With only static processing there is a possibility of overlooking anomalies easily seen when viewing frames dynamically. Problems with the current approach include:

- File-Based Repository
- VMS Specific Data Files
- Textual Database Inaccessible to Analysts
- Majority of Data Archived Off-line
- Analysis Restricted to Tests On-line
- Redundant Decommutation and Digitization
- Emphasis on Batch Processing
- Limitations of Interactive Processing Environment
- Raster-Based Graphics
- Command-Line Interface
- Static Frame Processing
- Limited Background Information

FIGURE 1

HELSTF Test Repository

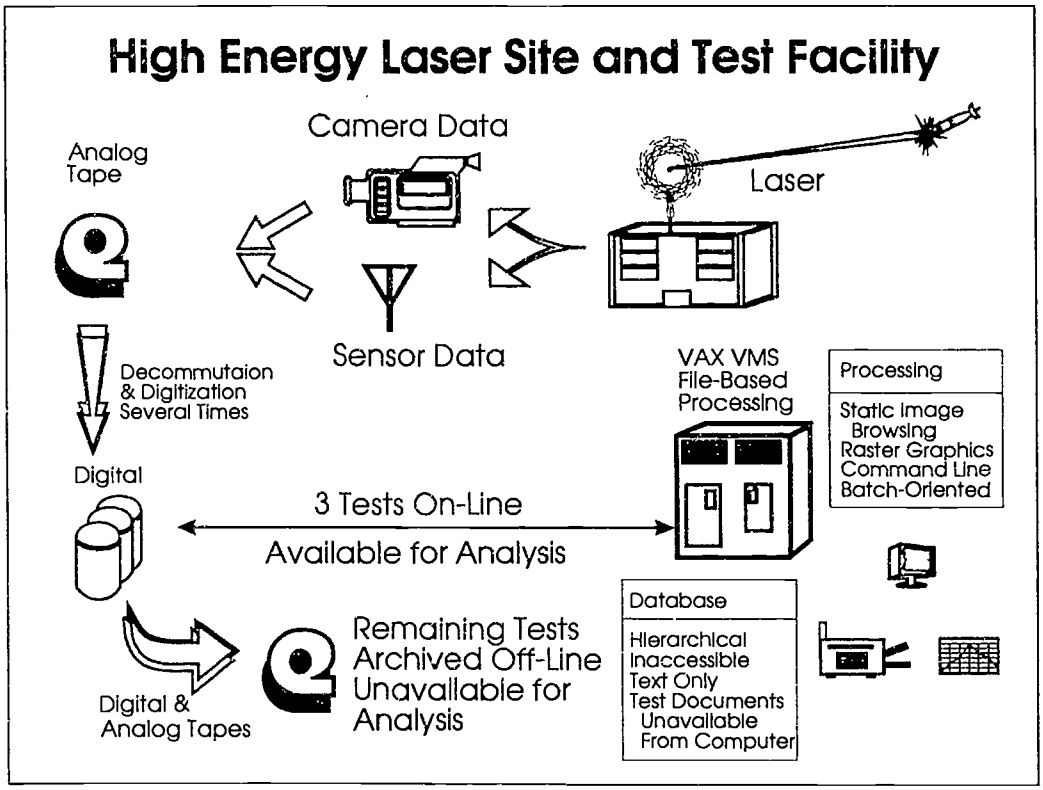
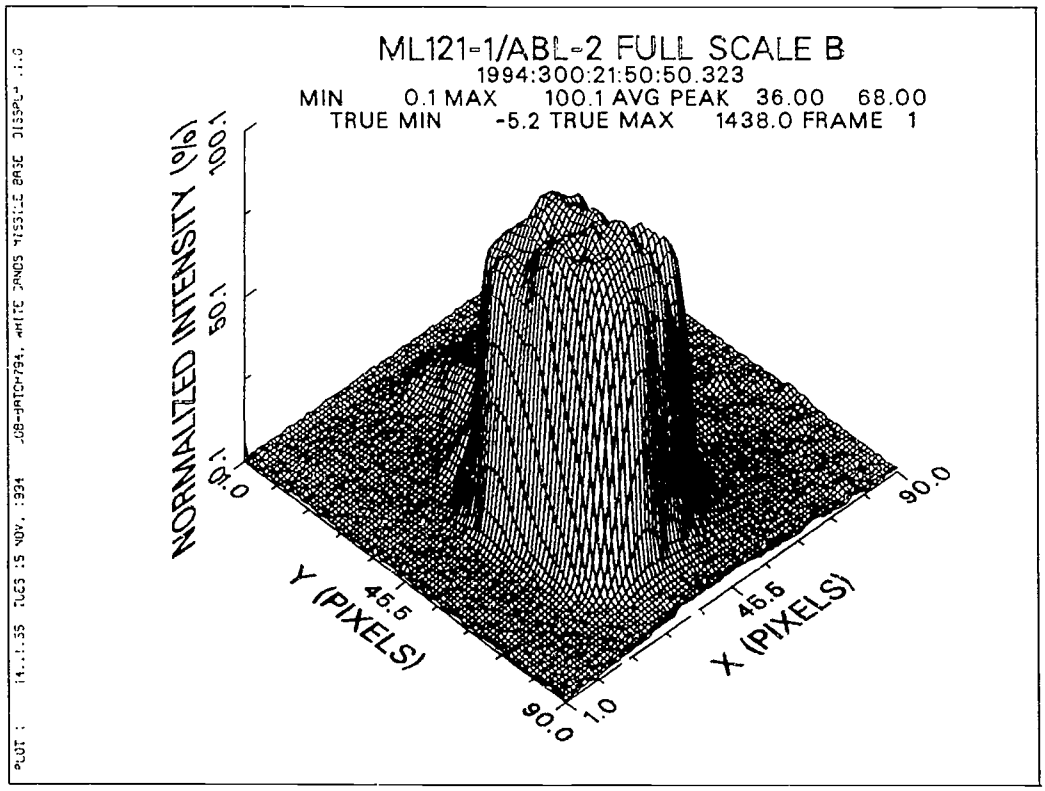


FIGURE 2

Sample Plot



BACKGROUND

The Object-Oriented Programming (OOP) Paradigm models the world into objects. This model is easier to understand because the semantic gap between reality and the model is small (see Figure 3 [6]). Program modifications are simpler because modifications often focus on a single item or object. Rumbaugh identifies the four aspects characteristic of the object-oriented approach [16]:

- *Identity* means data are quantitized into discrete, distinguishable entities called *objects*.
- *Classification* means that objects with the same data structure (attributes) and behavior (operations) are grouped into a *class*.
- *Polymorphism* means that objects of different classes behave differently under the same operation.
- *Inheritance* is the sharing of attributes and behaviors among classes based on a hierarchical relationship.

A definition of OOP can now be presented. **OOP** is a method of implementation in which programs are organized as cooperative collections of objects, each of which represents an instance of some class, and whose classes are all members of a hierarchy of classes united via inheritance relationships [1]. There may be multiple hierarchies of cooperating classes.

A goal of this project was to identify mature technology that would be useful in creating an alternate repository. The O-O Paradigm continues to influence the development of GUIs (Graphical User Interfaces), programming languages, databases, and software development methodologies. GUI, language, database, and methodology considerations are found in following paragraphs. An O-O tool must provide explicit support for the O-O paradigm: objects, classes, hierarchy, and polymorphism. Prototypes for this system were created on Sun workstations. Sun's OpenWindow Environment was chosen because of the level of support it provides for the paradigm. Figure 4 [5] shows the class hierarchy of the OpenWindow XView toolkit. The OpenWindow GUIDE tool [4] was also used to support Rapid Prototype Development [9].

An Object-Oriented Programming Language (OOPL) is a requirement for OOP. Table 1 [1] shows the support C++ provides for the object model. C++ has the following advantages that have made it the most popular OOPL: extension of C for retention of C expertise; commercial support from multiple sources; multiplatform

FIGURE 3

Semantic Gap

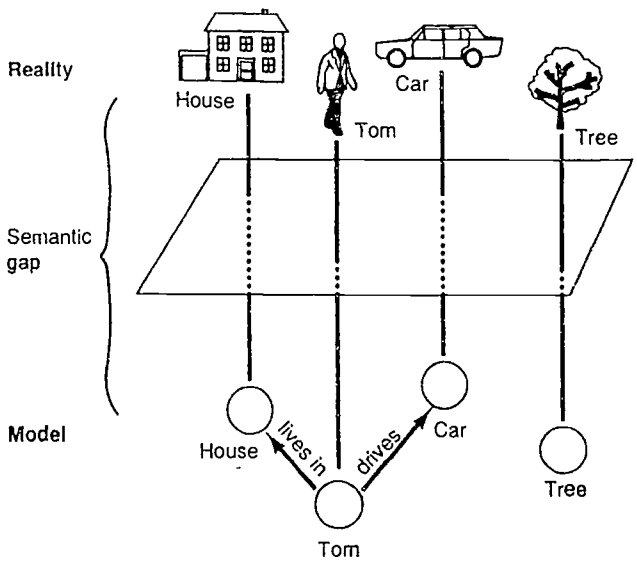


FIGURE 4

OpenWindow XView Class Hierarchy

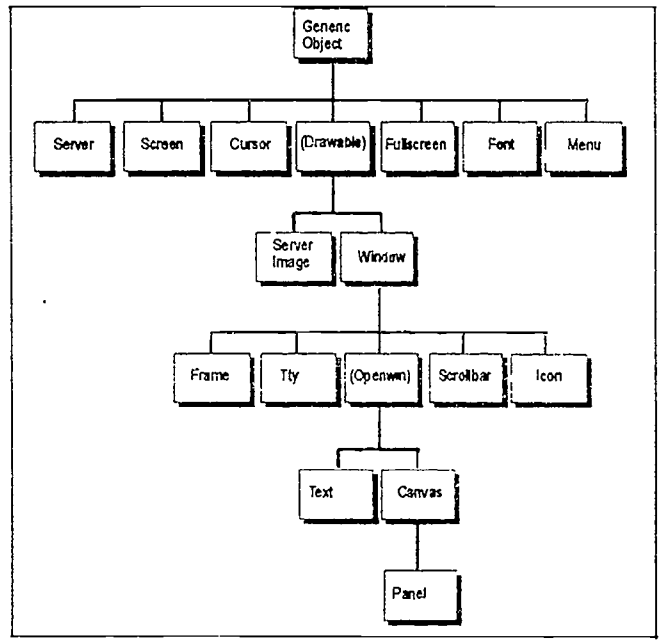


TABLE 1 C++ SUPPORT FOR OBJECT MODEL

Abstraction	Instance variables	Yes
	Instance methods	Yes
	Class variables	Yes
Class methods	Yes	
Encapsulation	Of variables	Public, protected, private
	Of methods	Public, protected, private
Modularity	Kinds of modules	File (header/body)
Hierarchy	Inheritance	Multiple
	Generic units	No
	Metaclasses	No
Typing	Strongly typed	Yes
	Polymorphism	Yes
Concurrency	Multitasking	Yes (defined by class)
Persistence	Persistent objects	No

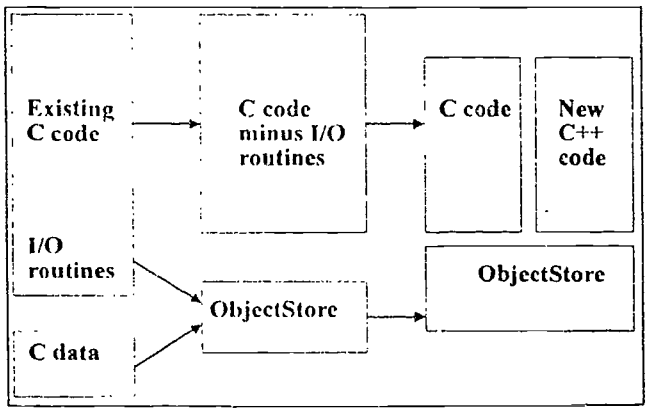
support; nonproprietary; free from Freeware Foundation; supports early error detection; and of foremost importance is its run-time efficiency. C++ was chosen for this project for these reasons.

ObjectStore was selected because it is an Object-Oriented Database Programming Language (OODPL). An OODPL extends an OOPL by adding persistence [2]. The database adds persistence to C++. An OODPL directly addresses the impedance mismatch problem programmers face when using popular Relational Databases Management System (RDBMS). A programmer must store all data as tables when using an RDBMS. Unfortunately most complex data are not in table form. The impedance problem refers to the problem of transforming complex objects into these table-oriented structures. ObjectStore stores any C++ object (complex or simple) directly in the database without any restructuring of the data. This provides an alternative to the popular persistent storage options, namely: an RDBMS or files (see Figure 5 [12]).

ObjectStore also provides: client/server operations over a network, concurrency control for shared data, relationship facilities for modeling data, collection management facilities, query support, security, and administrative tools [10]. The developers achieve performance goals by targeting applications that are data-intensive and perform manipulation of complex objects [7]. These applications exhibit the following characteristics: temporal locality, spatial locality, and fine interleaving. ObjectStore's patented Virtual Memory Mapping Architecture (VMMA) can dereference pointers for both persistent and transient objects at equivalent rates [11-14].

FIGURE 5

ObjectStore Migration and Utilization



A formal methodology is appropriate for initial OOP efforts. This forces a programmer to explicitly consider all aspects of analysis and design while formulating a personal approach. Formal Object-Oriented Analysis and Design (OOAD) methodologies vary in both scope and application. Monarchi and Puhr [8] suggest a formal evaluation scheme for these methodologies. Table 2 shows the personalized approach utilized in this project which was synthesized by selecting references addressing all relevant OOAD issues. The primary reference was Booch [1] with supplemental material from Coad [3] and Rumbaugh [16]. Coad provides guidance for placing classes and attributes and also identifying interface classes. Rumbaugh provides information on identifying base and utility classes.

OOAD methodologies often blur analysis and design. Object-Oriented Analysis (OOA) focuses on the creation of semantic objects in the problem domain. Object-Oriented Design (OOD) focuses on the solution domain objects necessary for the implementation of the OOA model (see Figure 6 [8]). Booch OOD is an iterative method-

TABLE 2 PERSONAL APPROACH FOR UTILIZING OOAD METHODOLOGIES

	OOAD Issue	Reference
1. OOA Process (Problem Domain Analysis)		
(a) Identification of:		
Semantic Classes	[Issue 1]	Booch
Attributes	[Issue 2]	Booch
Behavior	[Issue 3]	Booch
Relationships:		
Generalization	[Issue 4]	Booch
Aggregation	[Issue 5]	Booch
Other	[Issue 6]	Booch
(b) Placement of:		
Classes	[Issue 7]	Coad
Attributes	[Issue 8]	Coad
Behavior	[Issue 9]	Booch
(c) Specification of:		
Dynamic [Control] Behavior (i.e., message passing)	[Issue 10]	Booch
2. OOD Process (Solution Domain Design)		
(a) Identification of:		
Interface Classes	[Issue 11]	Coad
Application Classes	[Issue 12]	*
Base/utility Classes	[Issue 13]	Rumbaugh
(b) Optimization of classes	[Issue 14]	Booch
3. Representations		
(a) Static [Structural] View:		
Objects	[Issue 15]	Booch
Attributes	[Issue 16]	Booch
Behavior	[Issue 17]	Booch
Relationships:		
Generalization	[Issue 18]	Booch
Aggregation	[Issue 19]	Booch
Other	[Issue 20]	Booch
(b) Dynamic [Control] View:		
Communication	[Issue 21]	Booch
Control/Timing	[Issue 22]	Booch
(c) Constraints:		
On Structure	[Issue 23]	Booch
On Dynamic [Control] Behavior	[Issue 24]	Booch
4. Complexity Management		
(a) For Structural Complexity	[Issue 25]	Booch
(b) For Behavioral Complexity	[Issue 26]	No Ref.
(c) Representation of:		
Static Structure	[Issue 27]	Booch
Dynamic [Control] Behavior	[Issue 28]	*

Note: * = No Sources Available

ology where one first implements real world semantic objects (OOA) and then creates supporting solution objects (OOD). Prototypes are critical for testing analysis and design assumptions. Iterations continue until all real world objects and supporting solution objects are complete.

Booch OOD supports multiple, orthogonal views of the world. Figure 7 [1] shows the Booch model that is the basis for Booch OOD. The Booch OOD process has the following steps:

- Identify the classes and objects at a given level of abstraction
- Identify the semantics of these classes and objects
- Identify the relationships among these classes and objects
- Implement these classes and objects

Diagrams and templates describe each view of a real world model. The logical view focuses on class and object definitions in static and dynamic situations. Additional templates and diagrams describe dynamic execution. The static physical view concentrates on the placement of code in modules. Process architecture addresses the execution of processes in the dynamic world. Figure 8 [18] shows

FIGURE 6

OOA and OOD Objects

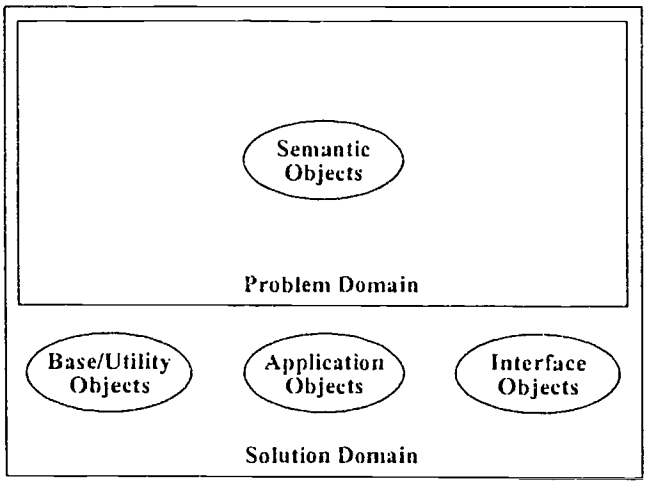


FIGURE 7

The Models of OOD

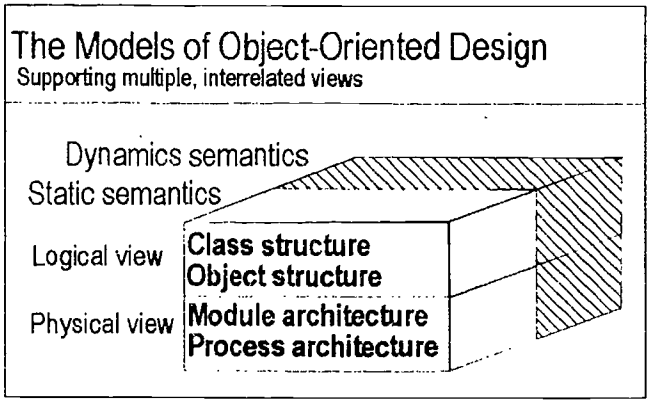
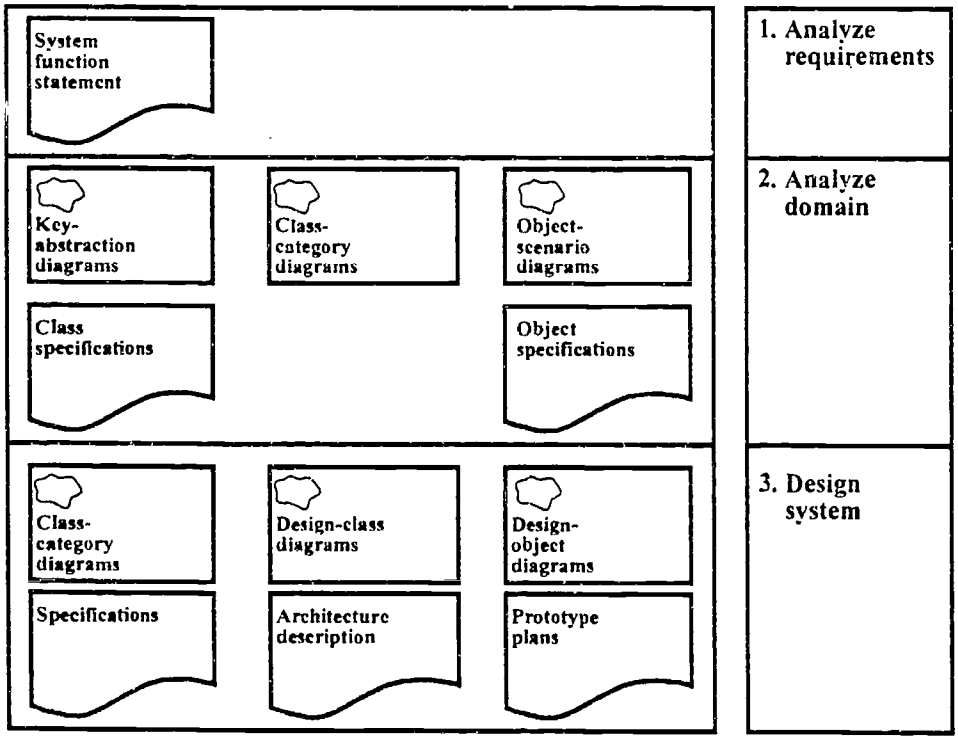


FIGURE 8

Road Map of Booch Method



the road map and deliverables of the Booch method where cloud icons identify diagrams while templates and documents are missing this symbol.

CASE STUDY

This section is a case study applying one iteration of Booch OOD to the HELSTF Test Repository problem. The purpose of the Requirements Analysis Phase is to establish system requirements. In the Domain Analysis Phase, one models the logical view of the system. In the Design Phase, one maps the logical model to physical structures. This case study focuses on the first iteration of each phase.

REQUIREMENTS ANALYSIS

A System Function Statement (SFS) identifies system requirements. Revisions to this document continue with each iteration of the Booch process. A Pressman Software Requirement Specification [15] provides an outline for the SFS since Booch specifies no formal structure for this document. Initially this document includes general design goals for the new system as outlined in this section. Figure 9 shows the proposed HELSTF Test Repository. This repository takes advantage of the latest hardware and O-O technology. The proposed system is a visual database environment for browsing test data.

The proposed environment has a bit-mapped window-based interface that supports dynamic image viewing. Figures 10 and 11 show sample screens representing this interface. Operations support is limited to a one time archival of all data onto on-line media. A CD-ROM jukebox provides cost effective network based on-line storage. An entire test would be placed on two CD-ROMs. The application would be database-oriented containing the following complex test data: graphical images, documents, video segments, background information from the current database, and actual data files. All data

FIGURE 10

Sample Screen 1

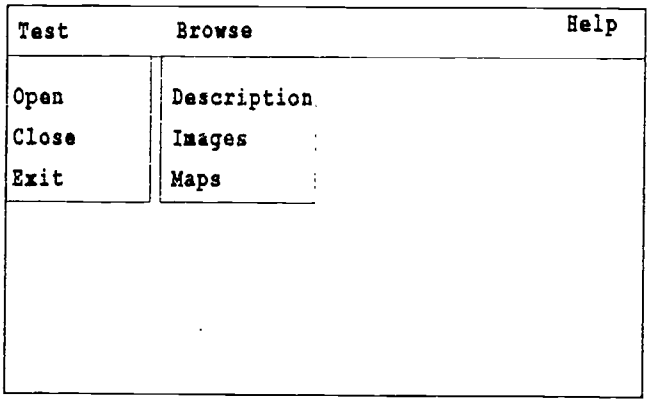


FIGURE 9

Proposed HELSTF Test Repository

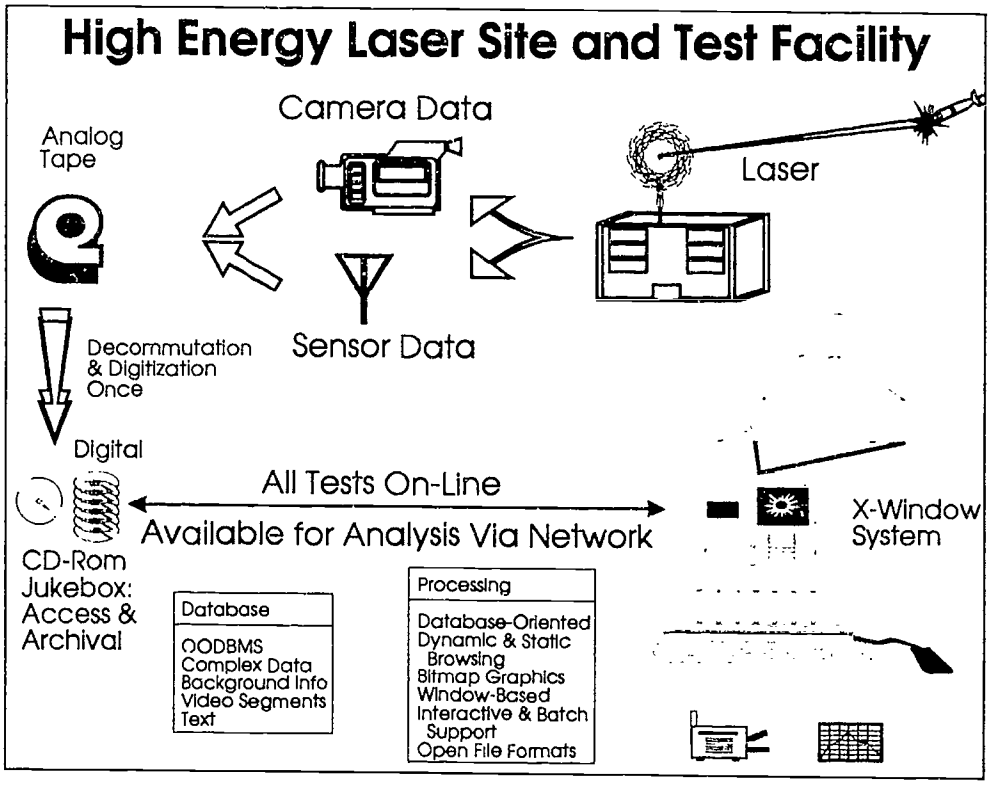


FIGURE 11

Sample Screen 2

Image	Browse	View	Help
Open	Description	Play	
Close	Camera	Rewind	
Export	Image	Step	
Print		Frame	
Exit			

would be exportable in industry standard file formats for analysis with commercial analysis programs. Dynamic playback of data with a VCR-like interface would support rapid detections of certain anomalies less discernible when viewing frames statically. The software analyst moves on to the Analysis phase only after the customer accepts the proposed environment. The advantages of the new repository are as follows:

- Complex Data Repository
- Industry Standard Data File Export
- Textual Database Information Available to Analysts
- All Data Archived On-line on CD-ROM Jukebox
- Analysis for All Tests
- Decommutation and Digitization Once to CD-ROM
- Emphasis on Interactive Processing
- Enhance Interactive Processing Environment
- Bit Map Graphics
- Windows Interface
- Dynamic (VCR-like) and Static Frame Processing
- Comprehensive Background Information

Domain Analysis

Figure 12 [18] shows the six steps in Domain Analysis where one models the logical view of a system. Figure 13 shows the logical (semantic) class diagram that is the result of applying steps one through four. Each cloud in this

FIGURE 12

Road Map of Domain Analysis

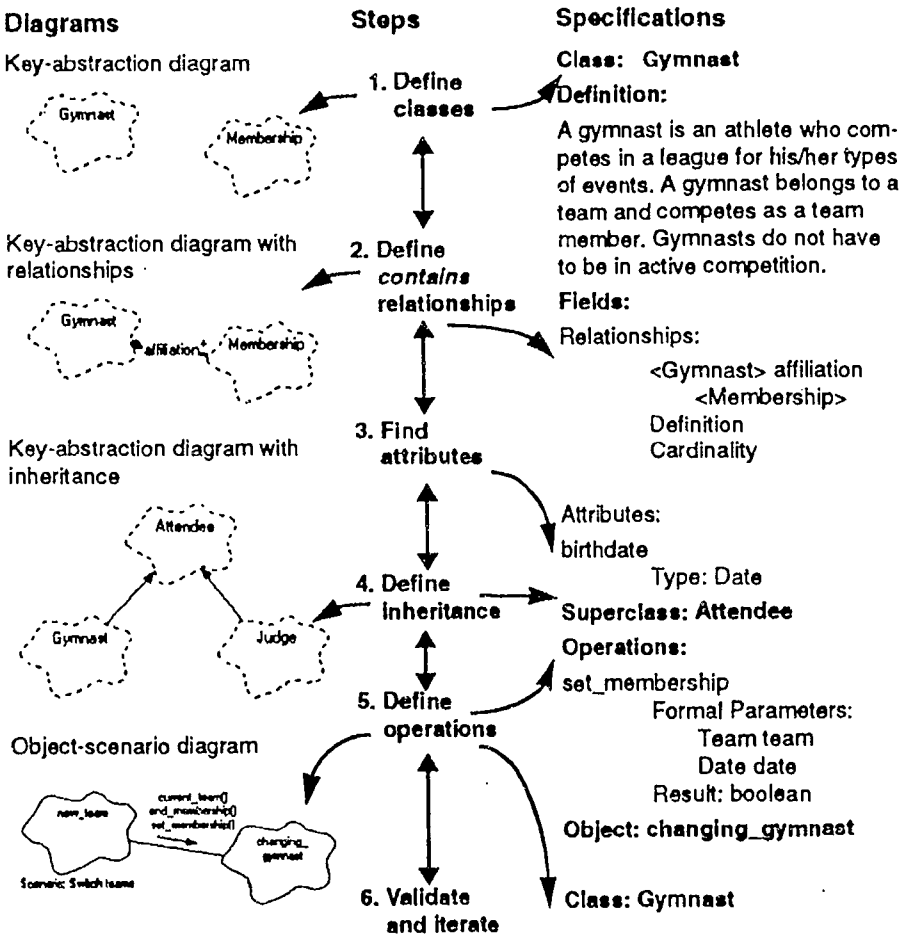


FIGURE 13

Class Diagram for Test Data Category

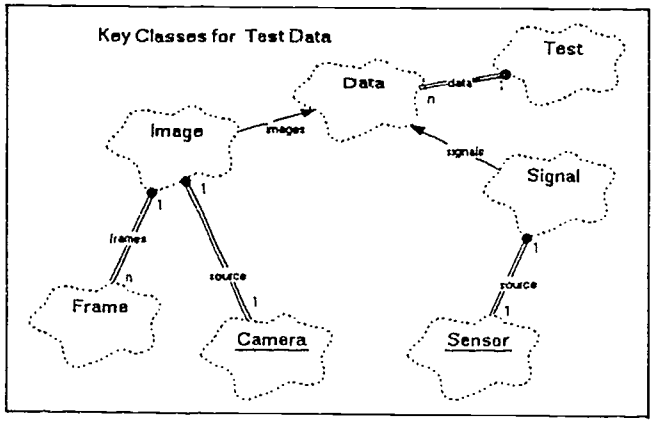


diagram represents a class. A class template further specifies each class (see Tables 3 and 4). Each template contains details necessary for implementing a class in any language. The diagrams and templates define the following contains (has a) relationships: a test has data; an image has frames; an image has a camera; and, a signal has a sensor. Templates also specify the attributes of each class. Test attributes include: an id, a date, an initiation time, a start time, etc. After defining attributes for each class it is important to define inheritance relationships and superclasses. If several common attributes are found in classes it may indicate the existence of a superclass. The data class is a super class that contains attributes common to all data. In Step 5 one defines operations for each class. Table 4 shows the types of operations that a class must

TABLE 3 EXCERPT FROM CLASS TEMPLATE FOR TEST CLASS (1 OF 2)

Class name:			
	Test		
Documentation:			
	Definition:		A test is an event in which a particular laser is fired and results are recorded in order to evaluate laser performance.
Visibility:			Private
Cardinality:			n
Hierarchy:			
	Superclasses:		none
Uses for Implementation:			
	Image		
	Signal		
Public Interface:			
	Fields:	images	
			Relationship: <Test> images <Image>
			Definition: An image is camera data recorded for a specific test.
			Cardinality: A test may have many images.
			Containment: By value
		signals	
			Relationship: <Test> signals <Signal>
			Definition: A signal is the output of a sensor recorded for a particular test.
			Cardinality: A test may have many signals.
			Containment: By value
		test_id	
			Attribute
			Type: String
		test_date	
			Attribute
			Type: Date
		cmd_lase	
			Attribute
			Type: Irig_Time
		lase_start	
			Attribute
			Type: Irig_Time
		duration	
			Attribute
			Type: Milliseconds
		status	
			Attribute
			Type: String
		target	
			Attribute
			Type: String

TABLE 4 EXCERPT FROM CLASS TEMPLATE FOR TEST CLASS (2 OF 2)

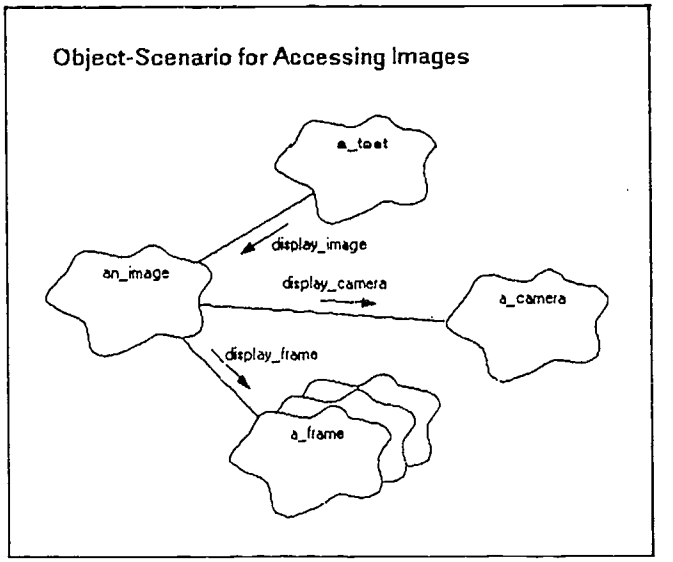
Operations:	create	
	remove	
	set_test_id	
	set_test_date	
	set_cmd_lase	
	set_lase_start	
	set_duration	
	set_status	
	set_target	
	test_id	
	test_date	
	cmd_lase	
	lase_start	
	duration	
	status	
	target	
	add_image	
	add_signal	
	remove_image	
	remove_signal	
	image	
	signal	
State machine:	No	
Concurrency:	Sequential	
Persistence:	Persistent	
Operation name:	create	
	Member of:	Test
	Result:	boolean
	Concurrency:	Sequential
Operation name:	remove	
	Member of:	Test
	Result:	boolean
	Concurrency:	Sequential
Operation name:	set_test_id	
	Member of:	Test
	Formal Parameters:	String Test_id
	Result	boolean
	Concurrency:	Sequential
Operation name:		set_test_date
	Member of:	Test
	Formal Parameters:	Date test_date
	Result	boolean
	Concurrency:	Sequential
Operation name:	set_cmd_lase	
	Member of:	Test
Formal Parameters:	Irig_Time cmd_lase	
	Result:	boolean
	Concurrency:	Sequential
	Concurrency:	Sequential

provide: creation, removal, attribute definition and access are common to every class. Class diagrams are important in defining static data while processes define dynamic manipulation of objects.

An object-scenario diagram is a representation of how objects interact in an application. Figure 14 shows how an analyst would interact with this repository: a test would

FIGURE 14

Object-Scenario Diagram



be opened; an image would be selected; frames would be viewed from this image; and finally background data like the camera class could also be viewed. This diagram is useful in assessing completeness and validating the design. Up to this point the design is architecture independent. Mapping of logical classes to specific architectures occurs in the design phase.

Design

Figure 15 [18] shows the steps and deliverables of the design phase. The final product of this phase will typically be a prototype. Table 5 shows the Prototype Plan for the first iteration. The initial goal is a prototype displaying how this proposed test repository will operate. The prototype will use dummy data from the ObjectStore database until the customer approves the interface. An Architectural Description document describes the computer, operating system, language, database, GUI, and any other architectural information. In the second step the focus is on establishing base/utility objects, application objects, and interface objects. Class diagrams and templates document the classes. The third step involves the actual implementation of all classes in some programming language. The final step is the refining of the design in response to user feedback.

Figure 16 shows the prototype interface for the proposed test repository. Several windows correspond directly to classes shown in Figure 13. The Test window shown in Figure 17 provides access to test objects. Once an image is selected then an Image Control Window provides VCR-like access to the frames in the image (see Figure 18). Manipulation routines for image viewing are exported from Xrastool, a program for manipulating ras-

FIGURE 15

The Map of Booch Method Design

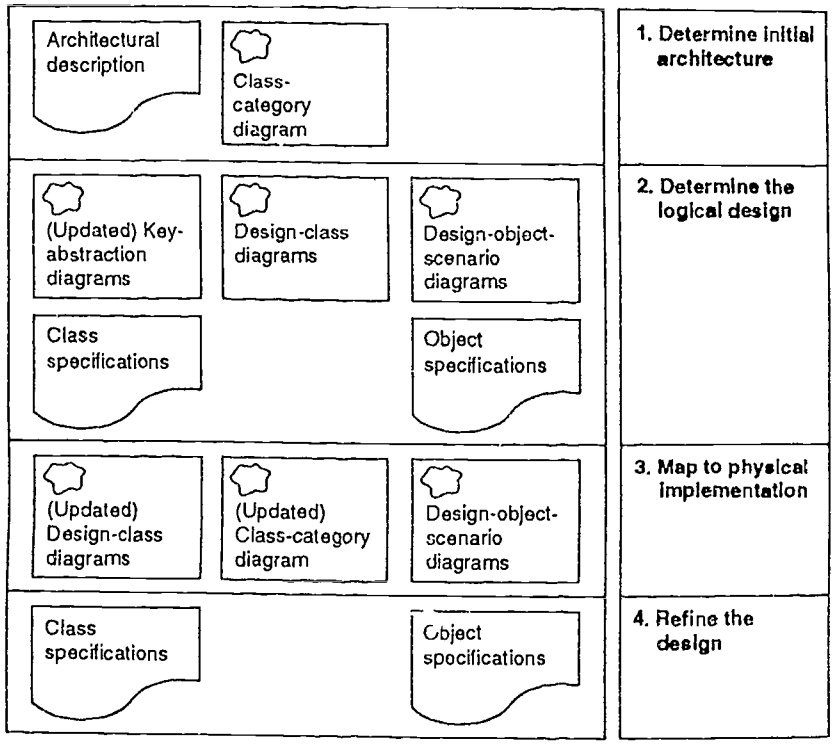


TABLE 5 PROTOTYPE 1: BROWSING INTERFACE

Goal:

Provide an interface illustrating how a database can be used to browse key abstraction elements defined in domain analysis.

Classes to be implemented:

None, the prototype will illustrate how test objects can be browsed.

Previously implemented classes to use:

None, the C data structures used for handling graphic objects in Xrastool (A Browsing Tool) will serve as the basis for design of Domain Analysis classes. In latter iterations, the transient C/C++ types and classes will be stored as persistent objects within the ObjectStore Database.

Key mechanisms to be implemented:

Window-Based Interactive Interface
No Operations Support Requirements for Accessing Data On-line Storage
Illustrate Complex Objects Which Can Reside in OODBMS
Provide Access to Background Information
Illustrate an Export Option
Provide Dynamic Image Browsing

Inputs:

Dummy Test Data.
Dummy Image Data.
Dummy Camera Data.
Dummy Test & Image Background Data.

Outputs:

Browsing Window for Test and Background Data.
Browsing Window for Images with Stub for Export Option.
Browsing Window for Image Background Data.
Browsing Window for Camera Data.

ter images. Figure 19 shows this program interface. A set of background information viewing windows is shown in Figure 20. Various other utility windows are shown in Figure 16. They provide a list of tests, a list of images, error information and other utility functions.

CONCLUSIONS

An improved HELSTF Repository can be developed by using existing methodologies and tools based on the Object-Oriented Paradigm. The Object-Oriented Paradigm facilitates development by collapsing the semantic gap between "Real World" objects and modeled objects. Object-Oriented Analysis and Design Methodologies like Booch OOD provide a formal approach for efficiently generating object-oriented software. Object-oriented programming tools include: languages, databases, Graphical User Interfaces and generators, and CASE software. Object-Oriented Programming is not a silver-bullet and it does not create true software components but it is a viable technique for developing software. The ongoing influence of the paradigm seems secure with the commercial success of C++. Component software may not be fully realized until comprehensive network models like COM (Microsoft), SOM (IBM), DOE (Sun) or CORBA (Object Management Group) are universally adopted [17]. ObjectStore addresses many issues currently considered by these models and as a result the product is relatively expensive.

FIGURE 16

Prototype Screens

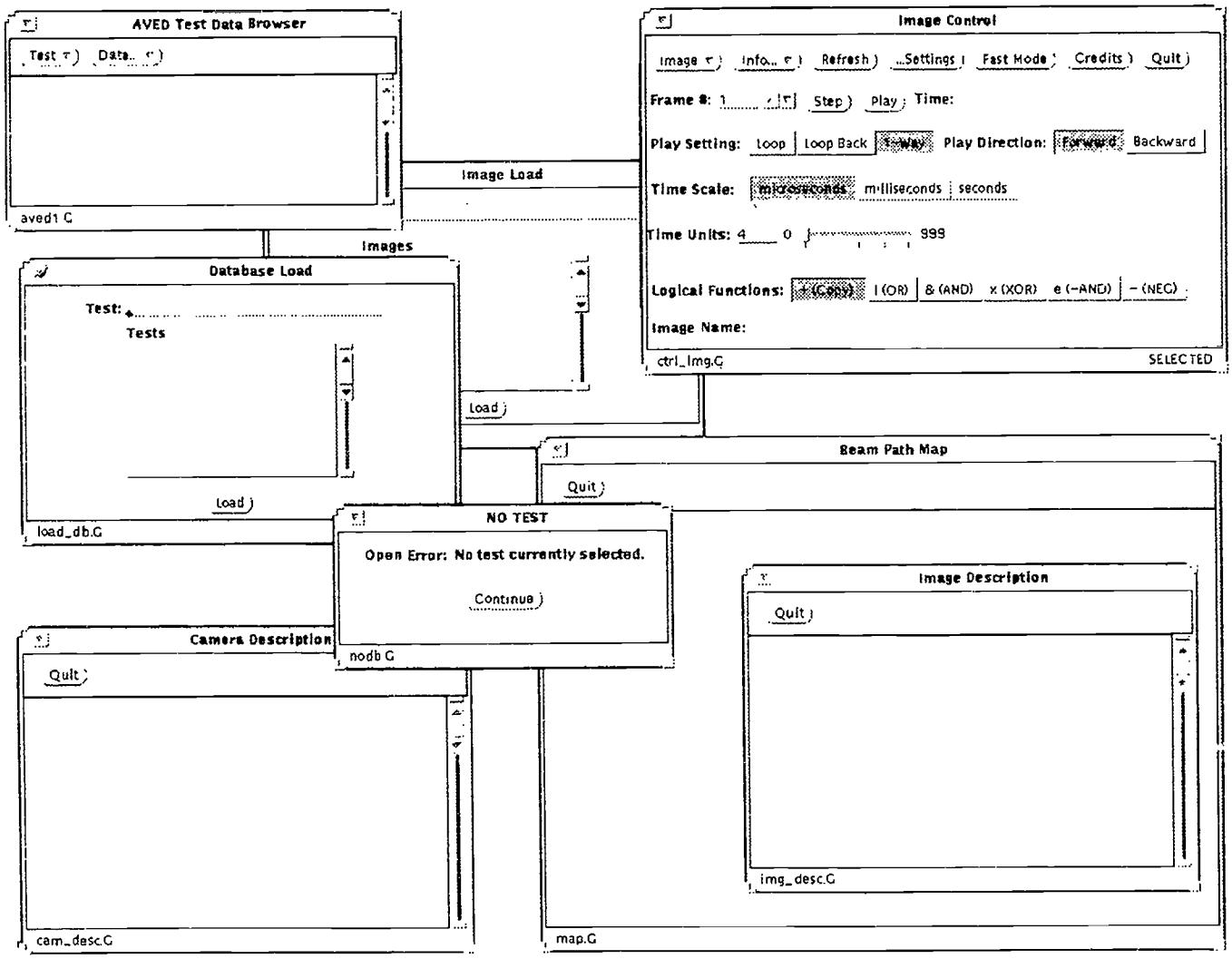


FIGURE 17

Test Window

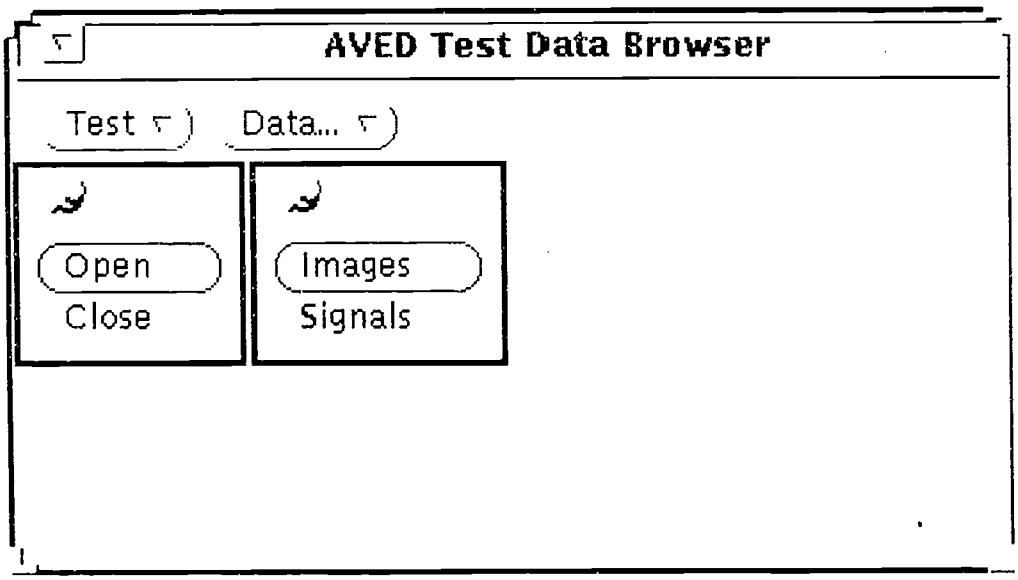
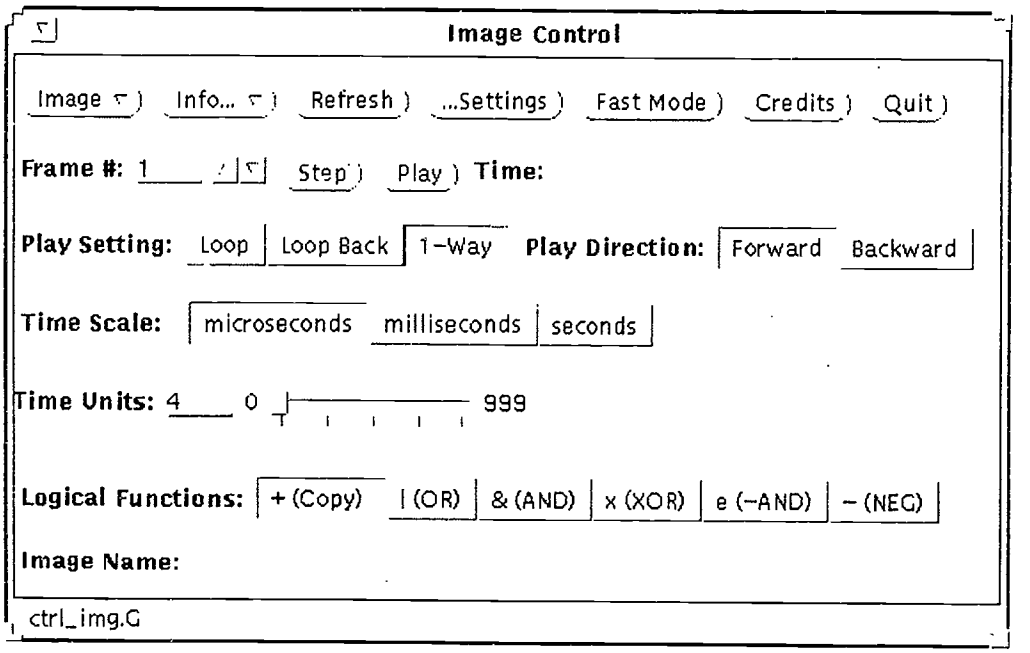


FIGURE 18

Image Control Window



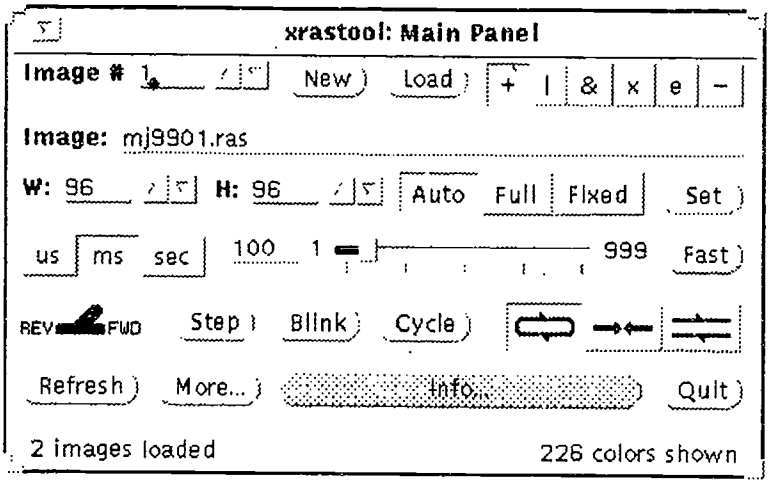
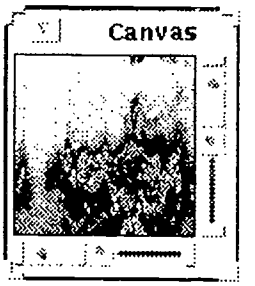
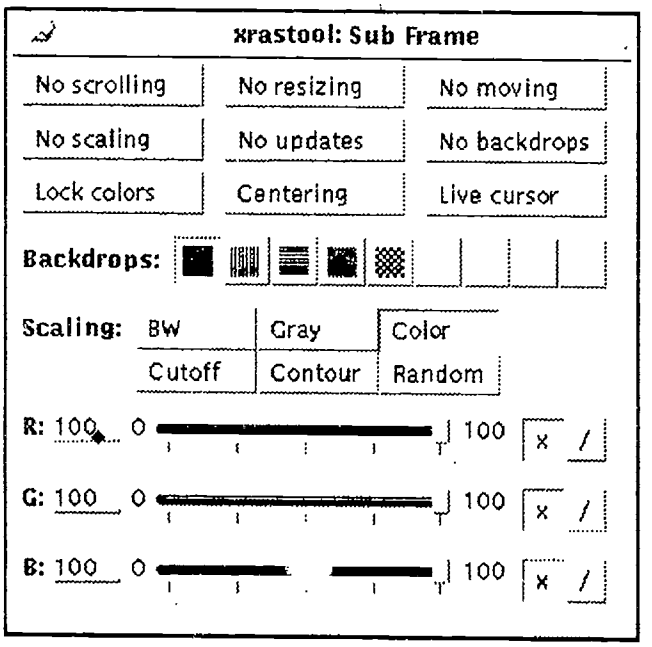


FIGURE 19

Xrastool Application





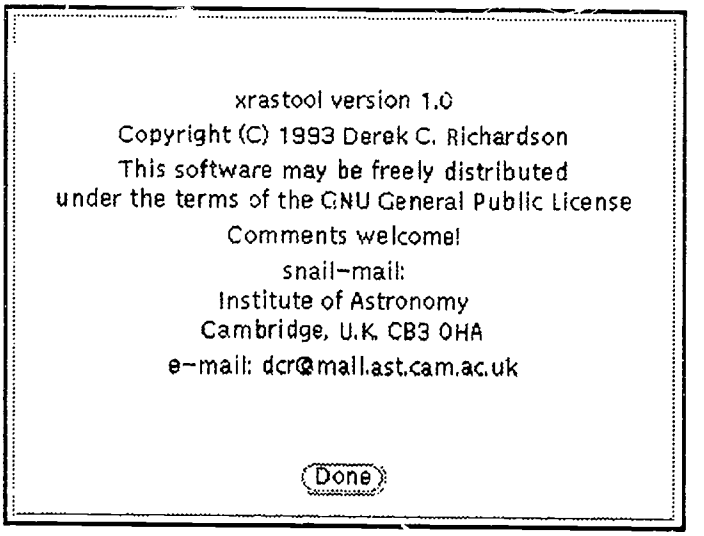
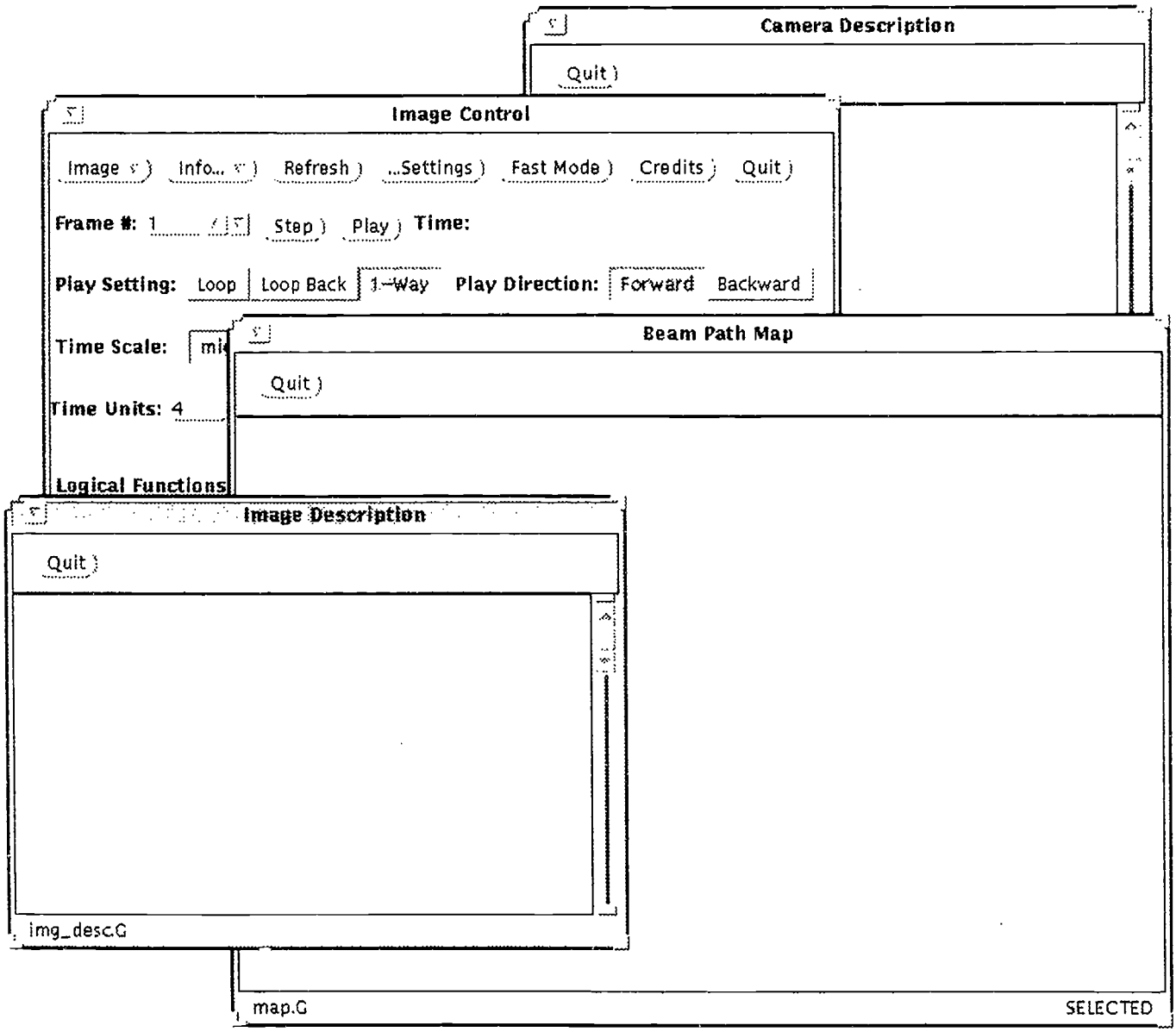


FIGURE 20

Image Background Windows



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GRADUATE AWARD

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NSF Directorate for Engineering
Principal Investigator, Janet C. Rutledge

Noise Reduction Methods for Speech Enhancement

Abstract: Most listeners have difficulty understanding speech in the presence of noise. Hearing-impaired listeners, in particular, face special difficulties that are often exacerbated by interfering noise. Attempts to suppress interfering noise have achieved only marginal success, limited by the unpredictability of the noise and the capabilities of current technology.

This paper reviews the application of digital signal processing techniques to the speech enhancement problem. Several speech enhancement methods are discussed. Differences between single-microphone and multiple-microphone methods are examined, with emphasis placed on internal signal representation, real-time implementation, and application issues. Finally, preliminary results are presented for a new parametric single-microphone approach.

INTRODUCTION

Most listeners (particularly those with hearing impairments) have difficulty understanding speech in the presence of noise. Much of this difficulty may be attributed to masking of consonants, which often resemble short-duration bursts of random noise. Numerous signal processing algorithms have been proposed to address this problem. Several of these algorithms have difficulty distinguishing between noise and consonants, and consequently remove both. Furthermore, inaccurate estimates of the noise (which is often assumed to be stationary) can cause some algorithms to create audible artifacts which further mask consonants. The objective of the present study is to develop a new approach capable of accurately distinguishing between speech and noise in portable communication systems.

This paper will review the application of signal processing algorithms to the noise reduction issue. Speech enhancement algorithms using both single and multiple-microphone configurations will be reviewed. The capabilities of these methods to improve intelligibility will be discussed, with areas of improvement suggested. Finally, a novel parametric single-mierophone approach is proposed, which reduces noise by compressing noisy speech onto a series of wavelet bases.

BACKGROUND

A. Differences between single-microphone and multi-microphone approaches

The differences between single-microphone and multiple-microphone approaches have been motivated primarily by intended applications. Multiple-microphone approaches use the correlation between noise signals from spatially separated inputs to enhance noisy speech. In applications affording use of spatially separate inputs (e.g., noisy cockpits, automobiles, and some industrial environments), this approach has been shown to improve intelligibility [1] [2] [3]. Single-microphone approaches, which rely on statistical models of speech and noise, are more appropriate for compact portable systems (e.g., mobile telephones, digital hearing aids) and other applications for which this spatial information is not available. Several single-microphone techniques showing promise for real-time application are reviewed in the sequel.

B. Single-microphone noise reduction methods

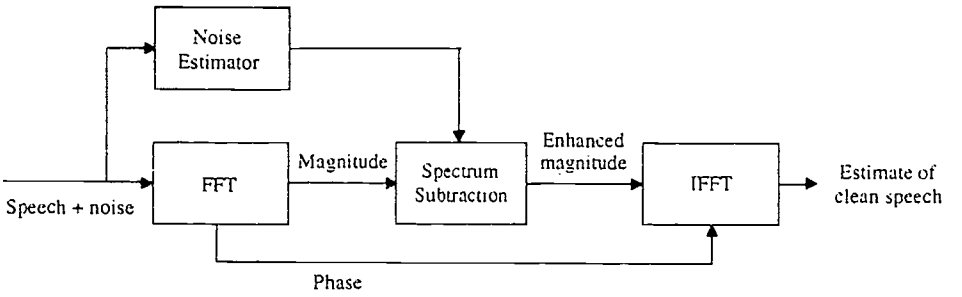
1. Spectral subtraction

The term "spectral subtraction" is used to describe a number of related techniques ([4], [5], [6]) which estimate the spectrum of clean speech by subtracting estimates of the noise spectrum from the spectrum of the noisy speech (see Figure 1). The noise spectrum, which is assumed to be stationary, is estimated from measurements taken during non-speech intervals. Noise spectrum estimation errors are manifested in the output spectrum as randomly spaced magnitude peaks of short duration. These peaks produce a sound often referred to as "musical noise," which degrades the intelligibility and quality of the output speech.

The INTEL method of spectral subtraction [4] has been used successfully in industrial environments to reduce worker fatigue from noise exposure. Another

FIGURE 1

Block diagram of Spectral Subtraction



method reported by Boll [6] was shown to increase intelligibility of LPC-coded speech in noisy helicopter cockpits. None of the methods have been shown to increase the intelligibility of uncoded noisy speech for human listeners.

2. Wiener filtering

A second approach uses the optimum noise-reduction filter developed by Wiener for stationary random signals corrupted by uncorrelated additive noise [7]. The filter is described by the transfer function

$$H_{Wiener}(e^{j\omega}) = \frac{S_{ss}(e^{j\omega})}{S_{ss}(e^{j\omega}) + S_{nn}(e^{j\omega})},$$

where $S_{ss}(e^{j\omega})$ and $S_{nn}(e^{j\omega})$ are the respective discrete-time power spectral densities of the speech and noise signals. Precise implementation of the Wiener filter (which is non-causal) requires *a priori* knowledge of signal and noise parameters. In most practical situations, where these parameters are not precisely known, estimates derived from simple models (like those of spectral subtraction) are used in their place. Alternately, a sub-optimal time-varying approximation may be implemented with short-time spectra.

3. Bayesian parameter estimation

More recently developed single-microphone noise reduction approaches have employed two Bayesian parameter estimation methods: maximum *a posteriori* (MAP) estimation, which maximizes the conditional probability density of the clean speech, and minimum mean-squared error (MMSE) estimation, which provides the expected value of clean speech for the given noisy speech [7].

Lim and Oppenheim [8] used MAP estimation to construct all-pole estimates of noisy speech, which were used iteratively to obtain time-varying Wiener filters. Ephraim [9] later developed a similar system which used hidden Markov models (HMMs) to derive the Wiener filters. Both methods force usage of a single sub-optimal estimator; a drawback circumvented by various forms of MMSE estimation used by other researchers. These estimates of clean speech parameters ($\hat{s}$) were taken as weighted sums of expected parameters, conditioned on the noisy speech y and each of M hypotheses H_i as:

$$\hat{s} \equiv E\{s|y\} = \sum_{i=1}^{M} E\{s|y,H_i\}p[H_i|y]$$

The estimation approaches differ primarily in their emphases on time ([10]) or frequency ([9],[11],[12]) domain parameters. The MMSE approach was also used by Quatieri and McAulay to estimate clean speech with a sinusoidal model [13].

C. Multiple-microphone approaches

Many of the techniques reported for reducing environmental noise have employed adaptive noise-canceling (ANC) systems [14]. The ANC system (see Figure 2) receives two input signals; a primary signal (x[m]), consisting of speech in additive noise, and a reference signal (n_R[m]), consisting only of a second noise signal correlated to the noise of the primary channel.

The reference signal is passed through an adaptive FIR filter (see Figure 3) which estimates the primary channel noise component and subtracts it from the primary signal to produce an estimate of the original speech. This speech estimate is fed back to the adaptive filter, which adjusts its weights to provide a minimum mean-squared-error estimate of the noise.

FIGURE 2

Block diagram of ANC system

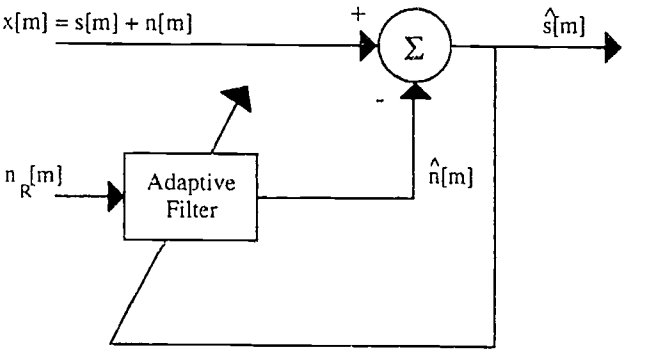


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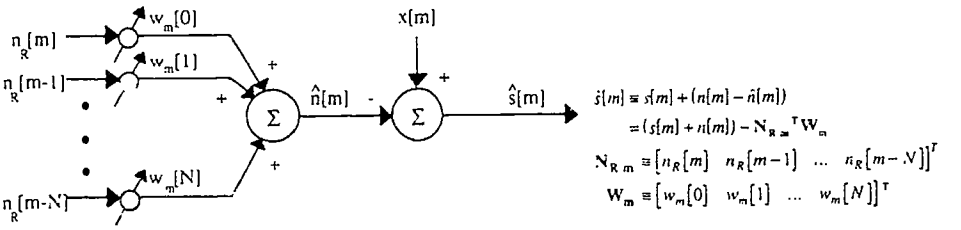
FIGURE 3

Block diagram of Adaptive FIR Filter



The task of reducing the error in the speech estimate may be alternately viewed as the task of selecting a weight vector minimizing the quadratic cost function

$$J(\mathbf{W}_m) \equiv \mathbf{W}_m{}^T\mathbf{R}_m\mathbf{W}_m - 2\mathbf{P}_m{}^T\mathbf{W}_m + E\{n[m]^2\},$$

where $\mathbf{R}_m \equiv E\{\mathbf{N}_{R,m}\mathbf{N}_{R,m}{}^T\}$ and $\mathbf{P}_m \equiv E\{n[m]\mathbf{N}_{R,m}\}$. One widely used iterative method for weight-vector selection is the LMS algorithm [14], which performs a stochastic gradient descent of the cost function's surface in weight space. Successive weight vectors are found by moving in opposition to the gradient; i.e., setting

$$\mathbf{W}_{m+1} = \mathbf{W}_m + 2\alpha\hat{s}[m]\mathbf{N}_{R,m},$$

where α, the *learning rate* of the adaptive system, is less than 1. Convergence is dependent on the choice of α, which determines the size of the steps (and speed of adaptation) taken in descent of the error surface. In portable systems with frequent movement, the fast adaptation rate required can result in weight misadjustment, especially at high listening levels where $\hat{s}[m]\mathbf{N}_{R,m}$ is large. Practical compromises between misadjustment, adaptation speed and filter length are discussed in [2].

A second practical limitation concerns the quality of the reference signal. Widrow, *et. al.*, [14] have shown that the maximum attainable output signal-to-noise ratio (SNR) is equal to the noise-to-signal ratio (NSR) at the reference input. In compact systems with short inter-microphone distances, obtaining a reference signal consisting only of noise is very difficult. One proposed solution [15] uses a beamforming array (see Figure 4) to improve rejection of unwanted signals. The beamformer derives its primary and reference signals from the respective sum and difference of signals from two sensors, located equidistant from the target. Signals radiating directly from the target to the sensors produce in-phase information in the primary channel. Off-center signals, having differing amplitude and phase, produce a reference signal which is used to reduce their amplitude.

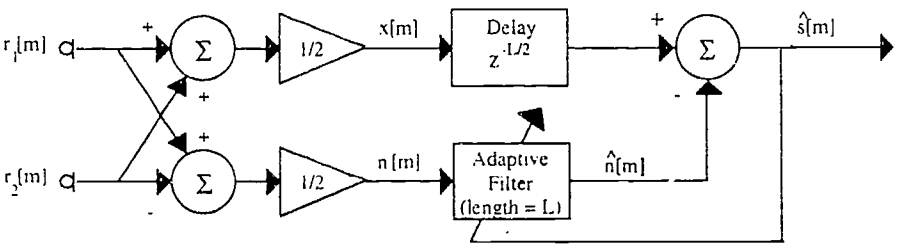
Studies conducted by Peterson [16] and Greenberg and Zurek [17] showed that the benefits of beamforming systems decreased as the direct-to-reverberant energy ratio at the microphones decreased. The presence of reverberation impairs beamformer performance, as reverberant target energy received by the reference channel tends to lower the reference NSR, and reverberant target energy received by the primary channel tends to obscure the true location of the target source.

D. Evaluations of Existing Noise-Reduction Algorithms

Earlier reviews of the existing literature [18] [19] [20] report that none of the methods mentioned above are capable of providing consistent improvements in intelligibility. In a recent study, Levitt, *et. al.*, [21] evaluated the capabilities of four noise reduction algorithms to improve speech intelligibility in digital hearing aids. The noise reduction algorithms, which included adaptive noise canceling, short-time Wiener filtering (using *a priori* spectral information), low-frequency spectral subtraction, and

FIGURE 4

Griffiths-Jim Beamformer



sinusoidal modeling [22], were evaluated by both normal-hearing and hearing-impaired listeners. The results of the study indicated that:

1) Adaptive noise canceling provided significant intelligibility gains which decreased in the presence of reverberation and subject head movement.
2) Wiener filtering increased intelligibility for half of the hearing-impaired listeners, and reduced intelligibility for all of the normal-hearing listeners.
3) Spectral subtraction and sinusoidal modeling removed both interfering noise and crucial high-frequency cues, thereby improving SNR (and perceived quality) without improving intelligibility.

The first three methods evaluated by Levitt, *et. al.*, attempt to preserve aspects of the speech waveform, while removing features unique to the noise waveform. This waveform representation of signals is used in many speech processing algorithms.

THEORY

A. A parametric approach to noise reduction

A second approach commonly used in speech recognition systems maps portions of the speech waveform into a set of time-varying parameters. The parameters may then be used to synthesize a modified version of the signal (as with the sinusoidal model mentioned above) or used as input to subsequent processors. The parametric model's capability for resynthesis lends itself well toward solving the problems met by the waveform representation, in that:

1) No short-time stationarity assumptions are required: processing may be modified as needed on a frame-by-frame basis.
2) Distortion may be more easily controlled, since the output waveforms are synthesized by the noise-reduction system.
3) Parameters derived from distorted or noisy data may be input to intelligent signal processing algorithms for purposes of enhancement or restoration.

B. The Minimum Description Length (MDL) criterion

A new approach proposed by Whitmal and Rutledge [23] uses the Minimum Description Length (or MDL) criterion recently applied by Saito [24] to reduce additive white Gaussian noise in digitized image and geophysical signals. The description length, defined as the length (in bits) of a theoretical binary codeword used to describe both a noisy signal $x \in \mathbf{R}^N$ and a model thereof, is expressed as

$$L(x,\theta_{m,k},m,k) = L(m,k) + L(\theta_{m,k}|m,k) + L(x|\theta_{m,k},m,k),$$

where $\theta_{m,k}$, the model of the signal, is constructed with k members of orthonormal basis m [25]. Given a library containing M varieties of orthonormal bases (i.e., wavelet packets and local trigonometric functions) with minimum information cost [26], Saito's algorithm selects the basis and coefficients providing optimum compression of the signal and rejection of the white noise (which compresses poorly in every basis). Assuming equal probability of basis selection, the approximate minimum description length (AMDL) is given by k* coefficients in basis m* such that

$$\tilde{L}(k^*,m^*) = \min_{\substack{0 \le k \le N \\ 1 \le m \le M}} \left(\frac{3k}{2}\log N + \frac{N}{2}\log\|(\mathbf{I} - \ominus^{(k)})\mathbf{W}^{\mathrm{T}}{}_m\mathbf{x}\|^2 \right),$$

where $\mathbf{W}^{\mathrm{T}}{}_m$ is the transform matrix, and $\ominus^{(k)}$ a rank-k matrix preserving the largest k coefficients. The algorithm was successfully demonstrated on both geophysical data and digitized images.

When applied to speech, the MDL algorith tends to remove consonants in the presence of noise, and imposes mild distortion on speech (particularly consonants) in the absence of noise. Furthermore, for the short frame lengths appropriate to real-time processing of speech, the additive noise tends to compress efficiently onto a few basis elements. The retained coefficients produce audible artifacts similar to the "musical noise" produced by spectral subtraction.

C. An adaptive multi-band MDL criterion

Several modifications are proposed to allow use of the MDL algorithm with speech signals. First, a quadrature mirror filter (QMF) bank employing power-symmetric FIR filters [27] is used to split the incoming signal into two bands: a low-frequency band dominated by vowels and nasal consonants, and a high-frequency band dominated by fricative consonants and plosive bursts. The MDL algorithm is then separately applied to the low and high frequency signals. The multi-band approach allows salient features of consonants to be reproduced faithfully, eliminating the distortion produced by the original algorithm in the absence of noise. Moreover, the filter symmetry causes each channel's noise component to be manifested as white noise, obviating the need for computationally intensive inverse-filtering.

Additional modifications are motivated by a relationship between changes in AMDL values and changes in the envelope of the speech waveform. Observed AMDL values have a lower bound dependent on the minimum amplitude of the speech signal, and provide reliable indication of whether the signal is above or below the noise floor. When the signal in the high-frequency band is below the noise floor, a tracking algorithm adaptively disables the band's MDL processing in favor of power spectrum subtraction (using local trigonometric bases), thereby reducing audible artifacts. A running average of spectra derived from discarded coefficients in the local trigonometric basis is used to construct an estimate of the noise.

IMPLEMENTATION RESULTS

A preliminary comparison of the capabilities of original and modified MDL approaches was conducted. An utterance of the sentence, "That hose can wash her feet," was sampled at 8 kHz, digitized to 16 bits, and added to each of three white Gaussian noise sequences to produce waveforms with overall SNRs of 0, 5, and 10 dB. Successive frames of the speech signals (256 samples, 50% overlap) were processed by each of three algorithms: original MDL, multi-band MDL, and multi-band MDL using power spectrum subtraction. RMS levels of the /o/ phoneme in "hose" and the closure preceding /t/ in "feet" were used to obtain relative measures of signal-to-noise ratio for each of the three methods. (For sentences with 0, 5, and 10 dB average SNRs, vowel-to-silence SNRs were 8.77, 13.78, and 18.75 dB respectively.) The observed SNR increases are presented below in Table 1. At all noise levels, the proposed algorithm substantially reduces the "musical noise" produced by the original MDL algorithm. This difference is reflected in the higher SNRs of the proposed algorithm.

TABLE 1 Signal-to-Noise Ratio Improvements (in dB)

Original Vowel-to-Silence SNR	18.8 dB	13.8 dB	8.8 dB
Algorith under test	Improved Vowel-to-Silence SNRs		
Original MDL	29.8	23.9	17.7
Multi-band MDL	31.0	23.2	17.1
Multi-band MDL w/HF alternate	32.6	25.7	20.2

SUMMARY

Several methods capable of reducing noise in speech signals have been reviewed. These methods, which are generally classified as single-microphone or multiple-microphone methods, often improve SNR without improving intelligibility. The need for improved intelligibility is particularly strong in portable systems (e.g., mobile telephone systems and digital hearing aids) where single-microphone methods are most appropriate.

A novel method for enhancement of noisy speech has been presented. Preliminary results indicate that the new method may be useful in applications requiring a single-microphone noise reduction system for speech.

ONGOING WORK

Ongoing work is focused on the development of intelligent preprocessing algorithms which apply time-varying, frequency dependent (TVFD) processing [28] to perceptually significant basis elements. The capability of multi-band MDL with TVFD processing to improve intelligibility in normal-hearing and hearing-impaired listeners will then be tested. The method's ability to provide reference noise estimates for single-microphone adaptive noise cancelling systems is also being investigated.

ACKNOWLEDGEMENTS

The author wishes to thank Professors Janet Rutledge and Jonathan Cohen for their support and helpful comments.

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APPENDICES

APPENDICES-Continued

APPENDIX A

THIRD NATIONAL CONFERENCE ON DIVERSITY IN THE SCIENTIFIC AND TECHNOLOGICAL WORKFORCE

September 29 - October 1, 1994
Omni Shoreham Hotel
Washington, D.C.

CONFERENCE PROGRAM

NATIONAL SCIENCE FOUNDATION
DIRECTORATE FOR EDUCATION
AND HUMAN RESOURCES

ELEANOR HOLMES NORTON
DISTRICT OF COLUMBIA

CONGRESS OF THE UNITED STATES
HOUSE OF REPRESENTATIVES
WASHINGTON, D. C. 20515

September 29, 1994

GREETINGS

Greetings to all those attending the Third National Science Foundation Conference.

As a strong advocate for opening doors of opportunity to African Americans in every endeavor, I applaud the efforts the National Science Foundation is making to enhance diversity in the scientific and technological workforce now and in the future.

The Foundation's actions in organizing workshops, seminars and job fairs shows your commitment to addressing the under-representation of minorities in the science, mathematics, engineering, and other technological fields.

I am happy to be a part of this event.

Sincerely,

Eleanor Holmes Norton

Eleanor Holmes Norton

THE DISTRICT OF COLUMBIA
WASHINGTON, D. C. 20001

SHARON PRATT KELLY
Mayor

DIVERSITY IN THE SCIENTIFIC AND TECHNOLOGICAL WORKFORCE DAY

SEPTEMBER 29, 1994

BY THE MAYOR OF THE DISTRICT OF COLUMBIA

A PROCLAMATION

WHEREAS, on Thursday, September 29, 1994, the National Science Foundation's Directorate of Education and Human Resources is sponsoring the Third National Conference on "Diversity in the Scientific and Technological Workforce"; and

WHEREAS, this conference will address the concerns of minorities in the scientific and technological workforce and will unveil an action plan that will finalize a national agenda of strategies to assure significant expansion of the limited number of African Americans, Hispanics, and Native Americans in a variety of roles in the science, mathematics, engineering and technological fields; and

WHEREAS, the District of Columbia is proud of the dedication, commitment and contributions that the National Science Foundation has made to substantially increase minorities in the science, mathematics, engineering and technological careers:

NOW, THEREFORE I, THE MAYOR OF THE DISTRICT OF COLUMBIA, do hereby proclaim September 29, 1994, as "DIVERSITY IN THE SCIENTIFIC AND TECHNOLOGICAL WORKFORCE DAY" in Washington, D.C., and call upon all the residents of this great city to join me in commending the National Science Foundation for its efforts on behalf of minorities.

SHARON PRATT KELLY
MAYOR
DISTRICT OF COLUMBIA

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

OFFICE OF THE
ASSISTANT DIRECTOR
FOR EDUCATION AND
HUMAN RESOURCES

September 29, 1994

I am pleased to welcome you to the National Science Foundation's (NSF) National Conference, "Diversity in the Scientific and Technological Workforce." This year's conference is the third in a series of meetings dedicated in part, to the development of a national Action Plan to increase the participation of underrepresented minorities in Science, Mathematics, Engineering and Technology (SMET) careers. This year we will present the final Plan along with strategies for implementation.

As Assistant Director for Education and Human Resources at NSF, I encourage each of you to participate fully in conference activities including the presentation and discussion of the Action Plan, the Congressional Round Table. Student Research Presentations, and NSF Research Directorate Workshops on their educational programs. A highlight of the conference will be the Awards Luncheon during which we will honor student researchers and national leaders in the field of SMET education.

Again, to those of you who are joining us for the first time, as well as those of you who attended previous Diversity conferences, welcome.

Luther S. Williams
Luther S. Williams
Assistant Director

Telephone (703) 306-1600 FAX (703) 306-0390

THURSDAY, SEPTEMBER 29, 1994

3:00 p.m. - 7:30 p.m. *West Lobby Registration*	**CONFERENCE REGISTRATION**
5:00 p.m. - 8:00 p.m. *Exhibit Hall*	**EXHIBIT SET-UP/POSTER SET-UP**
8:00 a.m. - 11:00 a.m. *Executive Room*	**PROJECT DIRECTORS' MEETING** Alliances for Minority Participation (AMP)
6:00 p.m. - 7:30 p.m. *Regency Ballroom*	**OPENING SESSION** **Presiding:** Luther S. Williams, Assistant Director, Education and Human Resources (EHR), National Science Foundation (NSF) **Greetings:** Roosevelt Calbert, Division Director, Human Resource Development (HRD), EHR, NSF **Speaker:** Louis Stokes, United States House of Representatives **Conference Logistics:** Elmima C. Johnson, National Diversity Conference Coordinator and Staff Associate, EHR, NSF
7:30 p.m. *Ambassador Ballroom*	**"JUST DESSERTS" RECEPTION**
8:30 p.m. *Palladian Room*	**STUDENT ORIENTATION** (Required for all student presenters)

FRIDAY, SEPTEMBER 30, 1994

7:30 a.m. - 6:00 p.m. *West Lobby Registration*	**CONFERENCE REGISTRATION** (continued)
9:00 a.m. - 6:00 p.m.	**EXHIBIT HALL OPEN**
8:00 a.m. - 9:20 a.m. *Regency Ballroom*	**PRESENTATION OF NATIONAL ACTION PLAN** **Presiding:** Elmima C. Johnson, Staff Associate, EHR **Speaker:** Luther S. Williams, Assistant Director, EHR
9:20 a.m. - 9:30 a.m.	**BREAK**

9:30 a.m. - 11:00 a.m.	**STUDENT RESEARCH PRESENTATIONS**
Ambassador Room	Panel Session A
Diplomat Room	Panel Session B
Palladian Room	Panel Session C
Embassy Room	Panel Session D
Empire Room	Panel Session E
Congressional Room	Panel Session F
Executive Room	Panel Session G
Exhibit Hall	**POSTER SESSION A**

9:30 a.m. - 11:00 a.m.
Regency Ballroom

Forum on Undergraduate Education - An Open Dialogue

Presiding: Elmima C. Johnson, Staff Associate, EHR, NSF

Moderator: Diana S. Natalicio, President, University of Texas at El Paso

Resource Persons:
Robert F. Watson, Division Director, Undergraduate Education, EHR
James M. Rosser, President, California State University at Los Angeles
Carolyn Meyers, Associate Dean for Research & Inter-disciplinary Programs, College of Engineering, Georgia Institute of Technology
Gary Keller, Executive Director, Project 1000 of the Hispanic Research Center, Arizona State University

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11:00 a.m. - 11:15 a.m. **BREAK**

11:15 a.m. - 12:30 p.m. **NSF DIRECTORATE PRESENTATIONS OF EDUCATION AND HUMAN RESOURCE FOCUSED ACTIVITIES**

Ambassador Room	Session A Engineering (ENG)
Palladian Room	Session B Mathematical & Physical Sciences (MPS)
Blue Room	Session C Computer & Information Science & Engineering (CISE)
Empire Room	Session D Biological Sciences (BIO)
Diplomat Room	Session E Geosciences (GEO)
Executive Room	Session F Social, Behavioral & Economic Sciences (SBE)
Hampton Room	Session G Department of Education, Office of Elementary & Secondary Education, Eisenhower Mathematics and Science Programs

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12:30 p.m. - 2:00 p.m. *Regency Ballroom*	**LUNCHEON** **PRESIDING:** James L. Powell, President and CEO, Los Angeles County Natural History Museum **SPEAKER:** Clifton A. Poodry, Director, MORE Programs Branch, National Institute of General Medical Sciences, National Institutes of Health
2:00 p.m. - 2:15 p.m.	**BREAK**
2:15 p.m. - 4:00 p.m. *Regency Ballroom*	**NATIONAL VIDEOCONFERENCE - CONGRESSIONAL ROUND TABLE** **Presiding:** Roosevelt Calbert, Division Director, HRD, EHR **Moderator:** Louis Stokes, United States House of Representatives **Participants:** Ben Nighthorse Campbell, United States Senate Eva M. Clayton, United States House of Representatives Eddie Bernice Johnson, United States House of Representatives Constance A. Morella, United States House of Representatives Esteban E. Torres, United States House of Representatives
4:00 p.m. - 4:15 p.m.	**BREAK**
4:15 p.m. - 5:45 p.m.	**STUDENT RESEARCH PRESENTATIONS** Panel Sessions
Ambassador Room	Panel Session A
Diplomat Room	Panel Session B
Palladian Room	Panel Session C
Embassy Room	Panel Session D
Empire Room	Panel Session E
Congressional Room	Panel Session F
Executive Room	Panel Session G
6:30 p.m.	**BIRDS-OF-A-FEATHER SESSIONS** **See separate listing of sessions and room assignments.**
7:00 p.m. *Blue Room*	**RECEPTION HONORING NATIONAL ADVISORY COMMITTEE AND SPEAKERS**

7:30 p.m. *Capitol Room*	**PROJECT DIRECTORS' MEETING** Comprehensive Regional Centers for Minorities (CRCM)/Partnerships for Minority Student Achievement (PMSA) **(Closed Session)**

SATURDAY, OCTOBER 1, 1994

8:00 a.m. - 5:00 p.m. *West Lobby Registration*	**CONFERENCE REGISTRATION** (continued)
9:00 a.m. - 6:00 p.m.	**EXHIBIT HALL OPEN**
8:30 a.m. - 10:00 a.m.	**STUDENT RESEARCH PRESENTATIONS** Panel Sessions
Ambassador Room	Panel Session A
Diplomat Room	Panel Session B
Palladian Room	Panel Session C
Congressional Room	Panel Session D
Empire Room	Panel Session E
Embassy Room	Panel Session F
Executive Room	Panel Session G
Exhibit Hall	**POSTER SESSION B**
10:00 a.m. - 10:15 a.m.	**BREAK**
10:15 a.m. - 11:45 a.m.	**STUDENT RESEARCH PRESENTATIONS** Panel Sessions
Ambassador Room	Panel Session A
Diplomat Room	Panel Session B
Palladian Room	Panel Session C
Congressional Room	Panel Session D
Empire Room	Panel Session E
Embassy Room	Panel Session F
Executive Room	Panel Session G

12 noon - 2:00 p.m.
Regency Ballroom

AWARDS LUNCHEON

Presiding: Diana Garcia-Prichard
Research Scientist, Eastman Kodak Company

Speaker: Argie K. Johnson, General Superintendent, Chicago Public School System

Award Presentations:

Student Awards (Sponsors and Presenters)

Precollege Student Award - National Science Teachers Association (NSTA)
Marvin Druger, President, NSTA

Undergraduate Student Award - Phi Beta Kappa
Virginia R. Ferris, Executive Committee, Phi Beta Kappa and Professor of Entomology, Purdue University

Graduate Student Award - Council of Graduate Schools
Anne S. Pruitt, Dean In Residence, Council of Graduate Schools

NSF Science and Technology Education Leadership Awards (Presenters)

Educator Achievement Award
Eugene DeLoatch, Dean, School of Engineering, Morgan State University

Institutional Achievement Award
Jaime Oaxaca, National Science Board Member and Vice Chairman, Coronado Communications Corporation

Lifetime Achievement Award
Luther S. Williams, Assistant Director, Education and Human Resources

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2:00 p.m. - 2:30 p.m. **BREAK**

2:30 p.m. - 4:00 p.m. **STUDENT FORUM - "ASK NSF" (Students Only)**

Garbo Room

Session A: Precollege Students

Moderator: Joseph G. Danek, Director, Office of Systemic Reform, EHR

	Resource Persons: Wanda E. Ward, Special Assistant to the Assistant Director, EHR; Costello L. Brown, California State University at Los Angeles
Blue Room	**Session B: Undergraduate/Graduate Students**
	Moderator: Roosevelt Calbert, Division Director, Human Resource Development, EHR
	Resource Persons: Elbert L. Marsh, Deputy Assistant Director, ENG, NSF; Susan W. Duby, Program Director, Graduate and Minority Graduate Fellowships Programs, EHR
Ambassador Room	**Session C: Undergraduate/Graduate Students**
	Moderator: Daryl E. Chubin, Director, Division of Research, Evaluation and Dissemination, EHR
	Resource Persons: Thomas W. Cole, Jr., President, Clark Atlanta University; J. Eleonora Sabadell, Program Director, ENG, NSF
2:30 p.m. - 4:00 p.m.	**ACTION PLAN IMPLEMENTATION SESSIONS**
Palladian Room	**Session A: Precollege Programs**
	Moderators: Margaret B. Cozzens, Division Director, Elementary, Secondary and Informal Education, EHR; Lida K. Barrett, Senior Staff Associate, Office of the Assistant Director, EHR
Diplomat Room	**Session B: Higher Education & Beyond**
	Moderators: Terrence L. Porter, Division Director, Graduate Education and Research Development, EHR; Robert F. Watson, Division Director, Undergraduate Education, EHR
4:00 p.m. - 5:00 p.m.	**CLOSING SESSION**
Regency Ballroom	**Presiding:** Neal Lane, Director, NSF
	Wrap-up: Luther S. Williams, Assistant Director, EHR
6:30 p.m.	**BIRDS-OF-A-FEATHER SESSIONS** **See separate listing of sessions and room assignments.**
6:00 p.m.	**Student Activity: Dinner and "Twilight Tour" of the Nation's Capital**

END OF THE FORMAL CONFERENCE PROGRAM

SUNDAY, OCTOBER 2, 1994

8:30 a.m. - 12 noon	****PROJECT DIRECTORS' MEETINGS** **Division of Human Resource Development, EHR** **(Closed Sessions)**
Executive Room	Research Careers for Minority Scholars
Hampton Room	Research Improvement in Minority Institutions
Cabinet Room	Minority Research Centers of Excellence
Palladian Room	Summer Science Camps

**** Continental breakfast available in meeting rooms.**

NSF Office: *Director's Room*
Press Room: *Forum Room*
Student Lounge: *Exhibit Hall*

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