15411

113741

ADDRESS BY ELMER B. STAATS
COMPTROLLER GENERAL OF THE UNITED STATES

BEFORE THE
AMERICAN SOCIETY OF CIVIL ENGINEERS
SECOND CONFERENCE ON
COMPUTERS IN CIVIL ENGINEERING

THE BALTIMORE CONVENTION CENTER
BALTIMORE, MARYLAND
JUNE 10, 1980

COMPUTERS IN CIVIL ENGINEERING IN THE WORLD OF TODAY AND TOMORROW

I am pleased to have the opportunity to address this conference and to commend the American Society of Civil Engineers for increasing the engineering community awareness to the development and use of computers to the practice of civil engineering.

Obviously, great effort must continue to be concentrated on improving the state-of-the-art of applying computers to the civil engineering field.

GAO has developed a deep appreciation of the contribution that engineers make in terms of increasing not only the quantity of goods and services we produce, but also the quality of the lives we lead. The challenges of coping with the energy crisis, controlling inflation, accelerating the rate of technological innovation, and improving our productivity impose particularly heavy demands on the analytical tools and the problem-solving capabilities of the Nation's engineers.

C12513

GAO has been interested in the use of computers in civil engineering for the past decade. In 1971 we participated in the National Science Foundation's special workshop on Engineering Software Coordination. The objective of the workshop was to develop specific recommendations for a policy concerning the transfer and utilization of computer-based technology specifically applicable to civil engineering and building construction and also applicable to the general practice of engineering. Out of that workshop came a recommendation for a National effort to develop a mechanism for the coordination of engineering software.

During 1973 and 74 we participated in a National Science Foundation study called "Definition of a National Effort to Promote Dissemination of Software in Civil Engineering and Building Construction." In 1975 the study report recommended that a National Institute for Computers in Engineering be established to promote effective use of computers and software in civil engineering. As far as I know, this recommendation was never acted on.

During the past decade, GAO has issued many reports relating to the use of computers in engineering projects. Issues have run a broad gamut from improving the safety of our Nation's dams to the use of computers in building design. Our latest report discusses problems architect-engineer firms experience when they use or try to use computer aids in Federal design work. This report shows that computer-aided engineering methods open new areas for improving building design and lowering building costs.

Today our Nation has more capabilities in science, technology, and engineering than we ever had before. However, we are using only a small percentage of our computer and engineering expertise. By more fully using computers, civil engineers could greatly improve the well-being of their companies, and help our Nation solve some of its more pressing problems in energy, and reverse the productivity slump of our Nation's workers.

Engineers have been using the computer since the early 1950s, when structural engineers began applying the computer to structural analysis problems. Over the years, a great number of computer programs of all types have been written for building design engineering applications. Yet, the computer's role in the design process has changed very little. It is still used primarily to solve mathematical engineering analysis problems, much the same as it was used in the 1950s. Use of the computer where the full potential of the interactions of man, software, and hardware systems are realized has not yet been achieved.

On the other hand, the computer has rarely been applied to architectural design work. While many firms have terminals and use computer time-sharing services, not many firms have actively tried to use the computer to do design work.

In recent years there has been increasing pressure to save both time and money in the development of new facilities. At the same time there have been pressures to conserve energy, to consider life-cycle costs when acquiring new facilities, and to improve the ability of buildings to fulfill needs and national objectives. Design professionals state that all of these concerns tend to lengthen the time it takes to design a new building as well as increase the total cost of design and construction.

The energy crisis of 1974 and the realization that we must conserve energy have sharply affected building design. The clear design objective now is to reduce the energy that will be consumed by the structure over its entire operating life. It is our perception--a perception shared by many others in the field--that the building industry in the United States can make better use of computers to design, construct, and operate energy-efficient buildings. Such buildings will consume substantially less energy without any basic impact on the building users. Also, they will conserve more energy by conserving building materials, thereby saving some of the energy consumed in the production of building materials and supplies.

The ways in which we construct a building or facility are changing and will probably continue to do so. These changes affect all stages: justifications, plans, designs, management of construction, and, finally, management of a structure once it is in use. Today, construction costs are skyrocketing, the quality of building design is criticized, and there is a national concern about energy consumption of buildings.

These factors exert powerful influences that point to the need for studying changes in engineering and construction practices; in design methods, emphasis, and conception; and in occupancy and use. We need to concentrate the full knowledge and experience of all segments of our society on developing insights and laying out approaches that will help our country and the world to build better environments--environments that are not only affordable but that will also improve the quality of people's lives.

Affordability, now and in the future, is closely related to productivity. Improving the quality of life by enlarging and refining the building industry depends largely on affordability and on the quality of plans and designs. Thus, we should increasingly strive for better design and look for ways to increase productivity.

The reasons for setting such goals are substantial. It is essential that we realistically evaluate the impact of design and construction on the economy of the country as a whole.

The building industry is one of the largest in the Nation. Almost 5 percent of the American work force is employed by or is dependent upon this industry for its livelihood. It accounts for nearly 10 percent of the Nation's annual gross national product. In comparison, the automobile and steel industries, combined, contribute about 5 percent.

The building industry impacts heavily on national policy objectives and Federal programs. It plays a key role in several major national goals, such as stable economic growth; reduction of energy consumption; housing; and development of public transportation, education, health, sanitation, and recreation facilities. I believe you would agree that the use of computer technology in your industry greatly enhances your ability to accomplishing your goals.

Over the short period of 30 years, the computer has made amazing advances. Computers have evolved from very large to very small machines, from very expensive to very inexpensive machines, and from vacuum tubes to integrated circuits on silicon chips. Since the chip logic started a revolution within the computer industry, many new products have been made possible. The impact on society has been tremendous. Microcomputers or processors are used in watches, calculators, automobiles, sewing machines, cash registers, and ovens, to name but a few examples.

Extensive growth, refinement, and expansion of advanced technology are accompanying the introduction of computers into a widening variety of activities. Designers, prominent among those seeking ways to improve their techniques, are turning to the computer, and numerous products are now being designed with its assistance. For example, computer aids are being used extensively in the design of circuits, missiles, motors, automobiles, and telephone equipment.

Notable savings and increases in efficiency and productivity have been achieved through the use of computer technology in design. Diverse applications and functions can be accomplished at speeds and with accuracies that far exceed unaided human abilities. The end is not yet in sight, as the variety of computer uses continues to broaden and becomes accessible to even the smallest organization.

Civil engineers must move to more efficient use of computers to help them design and draft or lose out. It is the only way to be competitive. Engineers using manual methods are using an obsolete technology. For example, it costs about $15.00 to produce a final drawing manually but only about $3.00 to produce the same drawing with a computer.

Why then, don't more civil engineers use computers to design and draft? I believe it is for three important reasons:

1. The lack of computer programs (software) aimed specifically at the practice of civil engineering and building construction.
2. The lack of information or cost comparisons to demonstrate how much money can be saved by automation.
3. The high costs of computer hardware. In the past, computer systems cost from $50,000 to several million dollars. Civil engineering firms usually are small and have little capital, and are thus unwilling to make such a large investment.

Computer costs have now come down and can free all types of engineers from monotonous tasks which will give them more time to be creative. With computer-aided design and/or computer-aided drafting, engineers can sketch designs on terminal screens and let computers create final drawings. They can have the computers assemble their parts on circuits and simulate the way they actually would work. It's an important step toward "paperless" production since the computers convert design into coded form to run automated machinery in manufacturing.

Today, advanced research is going on in computer analysis of photographs that is expected to facilitate the future study of natural resources, medicine, and engineering.

Research on industrial pollution on forests, cancer diagnosis, and the detection of stress in building construction are three areas where the computer may be applied.

The primary emphasis of one research project is on measuring light, which directly provides information from atoms and molecules as in the field of spectroscopy.

Up to now, "the reading of pictures by computers" technique has been limited mostly to remote sensing by satellites and some medical and technical engineering calculations.

As we noted before, the computer marketplace is rapidly changing. Hardware costs have decreased dramatically. More computer programs (software) are becoming available for use by civil engineers. Computer programs have been developed for sophisticated computer graphics systems to translate structural engineering and environmental data into pictures. The graphics display can show the preliminary design with and without interior lines displayed. The system also creates a computerized drawing of the building and displays it in whatever position or background scene the designer chooses. The programs in the system can also estimate a building's annual energy consumption, given occupancy and geographical location.

According to recent computer magazines, there are more and more engineers working on software development. Surveying and mapping software is now fairly sophisticated, and in recent years software has been developed for pipe routing and some flow diagrams.

Programs exist for every engineering discipline, but locating them and evaluating, and adapting them for individual purposes is sometimes more difficult than to write a new one. We do need a central clearinghouse for programs.

Perhaps, the most encouraging sign for the civil engineering community is the increase in civil engineering students and graduates that are familiar with computer science.

The new graduates will be less resistant to using the computer in their work. Even more important will be that the new graduates, being familiar with both computers and engineering applications, will be able to develop the needed software.

Finally, the new capabilities of the desk-top computer will bring, I am sure, many changes to the small civil engineering firms. Today, desk-top computer systems are available for as little as $20,000 and the personal or build-it-yourself computers are under $1,000. And with preestablished software program packages, few additional computer personnel will be needed.

Until recently, the United States was perceived at home and abroad as an enterprising, innovative and highly efficient nation that enjoyed the highest standard of living in the world. Our productivity practically doubled during the first two decades following World War II. As a result not only were we able to achieve much better living conditions, but also believed we could afford extensive foreign aid plus ambitious domestic programs. Unhappily, the trend of national productivity has faltered during the past decade. In fact, recent statistics indicate that in 1979, U.S. productivity not only showed no improvement, but showed an actual decline.

The cost of our recent productivity stagnation has been enormous. It has cut deeply into the growth of our Gross National Product and caused an accelerated pace of inflation, a weakened position in international trade, greater social tensions, and--most troublesome of all--reduced confidence in ourselves and our institutions. We are all aware of the importance and implications of this last problem. Now we must respond through a concerted effort in both the public and private sectors.

This awareness is recent. Not long ago our greatest challenge was to convince the executive branch and the Congress that the decline in productivity improvement was a significant economic problem. This has changed. Fortunately, the stagnation of our productivity is now recognized in both Government and business circles.

The two most recent annual reports of the Council of Economic Advisers stressed the importance of productivity.

Top administration officials have spoken out on the problem. In January, President Carter warned that the productivity slowdown has "reached serious proportions," and that "with productivity growth at a low ebb, living standards will not rise as fast as they have in the past two years."

We now also find unprecedented interest in productivity on Capitol Hill. The Joint Economic Committee has called our sluggish productivity growth "the most important factor contributing to our present economic malaise," and numerous committees and members of Congress are speaking out and calling for action on various productivity aspects.

Let us for a minute or so take a quick look at how foreign competitors are using engineers to design new ways to do things to increase their nations' productivity.

Looking inside an automobile assembly plant, a visitor looks past lines of moving cars, down aisles the length of a football field, and sees no one. Here and there are small groups of workers watching, in case the machines and computers do something wrong. Occasionally, one spots an employee actually touching hands to the car that is being made.

But, this is an exception. Ninety-seven percent of the work in the Datsun Motor Company's Zama plans is performed by computers and machines, making it the world's most automated car assembly plant. On an average day more than 1,300 cars come rolling off the production line. On an average shift, the plant is run by about 70 workers.

Instead of people, there are robots, computers, and automation, doing the work and bringing the parts together. Roofs are welded tight to the body and doors are bolted on without anyone even bothering to watch. Tiny television cameras tell computers when the parts supplies are dwindling and new batches are rolled automatically into place.

In the past two decades much of the Japanese superiority in everything from television sets to steel sheets has been attributed to the supposedly happy, little worker who loyally does his company's work and plays golf on the company's course in off-hours.

But this may not be so. Japan now is replacing those cheerful workers with computers and machines or assigning them to watch and repair the automated tools. The result is a steadily rising productivity that is the envy of all the industrial world.

An authority on Japanese industry for the Economist magazine recently surveyed the state-of-the-art in Japan and compared a Japanese car factory with the British Leyland factory. He found that the productivity per man in Japan is four times greater than in British Leyland and it probably will double within the next 5 years.

However, precise productivity comparisons are hard to find. In surveys that compare car manufacturers according to units turned out per worker, Japan is shown to have an embarrassingly large lead over both American and European companies. But the comparison is crude and inexact because much of the work done inside the factory in other nations is done in Japan outside the plant, by subcontractors.

Japan usually is acknowledged to be far in front of its competitors in one of the major ingredients of productivity: investment in new automated equipment. It may or may not have a lead in the science and engineering of robotics, but its application of these inventions is widespread. Faith in the value of new equipment and computers is a cardinal principle in Japan.

Technology provides the basis for change in a nation's productive process which results in higher productivity. Technological progress works through a sequence that starts with research and development (R&D), then uses R&D results for innovation, and finally culminates in new capital equipment and processes which incorporate the benefits of R&D and innovation.

All three aspects of technology--R&D, innovation, and capital investment--unfortunately have suffered declines or stagnation. Fortunately, the news media and other influences have aroused an awareness of this decline.

Because of this awareness, reversing the Nation's declining technological structure is an issue that has received much attention, and it appears that some needed changes are coming into being.

One of the first and foremost is reversing the declining emphasis on research. New programs and increased funding for scientific research and development were proposed by the Executive Branch in the proposed Federal budget for fiscal year 1981 (FY81), beginning in October 1980. The budget reflects the innovation concerns of the Administration. President Carter said in his budget message to Congress on January 28 that the budget continues to "reverse the trends of the last two decades and provide for major and sustained increases - above the rate of inflation - for research and development programs." The new Federal budget reflects an increase in scientific research and development of 12 percent for FY 1981. Presidential science advisor Dr. Frank Press says that the 12 percent figure translates to a 3 percent real growth.

The use of engineers and computers in research and development and other functions faces an increased role in the new budget and in future years. The Office of Management and Budget reports that Federal (R&D) expenditures for FY 81 are expected to total over $5 billion, a $445 million increase over FY 80.

A combination of three Federal agencies will attempt to encourage industrial innovation and productivity over the long term in new initiatives in the areas of computers, automobiles and energy. In the computer area, special efforts will be undertaken in 1981 by the Department of Defense and the National Science Foundation to increase the strength of experimental computer science in academic institutions with a $6 million program. There will be an interagency effort to study microelectronics and submicron science and technology in a $51 million government program in very large-scale integration technology.

In the area of capital investment, the advice and assistance of the private sector was unquestionably key in the passage of the Revenue Act of 1978--which encourages capital investment through a reduction in corporate tax rates, an improvement in the investment tax credit, and a reduction in the capital gains tax.

Even more directly in the arena of cooperative efforts, several agencies have programs that are worth noting.

The Department of Commerce has developed a number of approaches to help private sector productivity. The domestic policy review, initiated a year ago, specifically called on private sector "experts" from outside Washington to deal with the apparent slowdown in industrial innovation in the United States.

Commerce's Cooperative Technology Program intends to use a similar approach. With the Department of Commerce acting as a catalyst, researchers in industry and academia will be brought together to resolve common technological problems in order to help speed up the innovation process. The key mechanism in this program would be the establishment of a cooperative technology center, by joint action, as a not-for-profit corporation to carry out R&D and innovation. This program is like the 1975 proposal for a national institute to develop and share computer software in the Engineering field.

Another example: Some Department of Energy cooperative projects are showing promise toward improving coal extraction productivity. The Department and private companies are working together to develop a shaft boring machine which will impressively reduce the time required to bring a mine into production.

These cooperative efforts are in the right direction--and more are necessary. Perhaps we should look again at the need for a technology center to develop and share computer software in the civil engineering field. Technological growth is too important to the Nation to be allowed to flounder because of the complexities of the modern economic environment. These complexities can be addressed only through the participation of both Government and the private sector.

CONCLUSION

Engineers have designed the equipment and improved the techniques that have stepped up our productivity. The engineer translates scientific principles into working technology and modifies the technology to accommodate human and material resources. Engineers are productivity change agents. It is hard to overestimate the contribution that the engineering profession has made to the performance of our economy and to the well-being of the United States.

The realities that we in the United States face as we enter this decade require an even greater contribution from groups such as yours. Rigorous and concerted efforts from a large number of engineering disciplines will be required to help us use all our scientific and technological know-how more efficiently, and to better develop new and innovative ways to do things. If the United States is to increase its innovativeness and improve its international competitive position, engineers must develop and use more computer methods to compete in this arena. This is the free enterprise response to international competition.

If engineers are to respond to the challenges of the eighties, they must improve their capabilities and use their computer resources wisely. This requires training and cooperation. Ambitious and extensive as the current efforts are to improve the use of computers in civil engineering projects, much remains to be done. Developing more computer software for the practice of civil engineering along with training of the current staff will be a long and arduous task. Much also remains to be done to bring the enormous power of today's computers to the civil engineers who work for small engineering firms. I urge you to work diligently at this conference to exchange ideas and information about all possibilities of applying computers to the engineering field. Thank you.