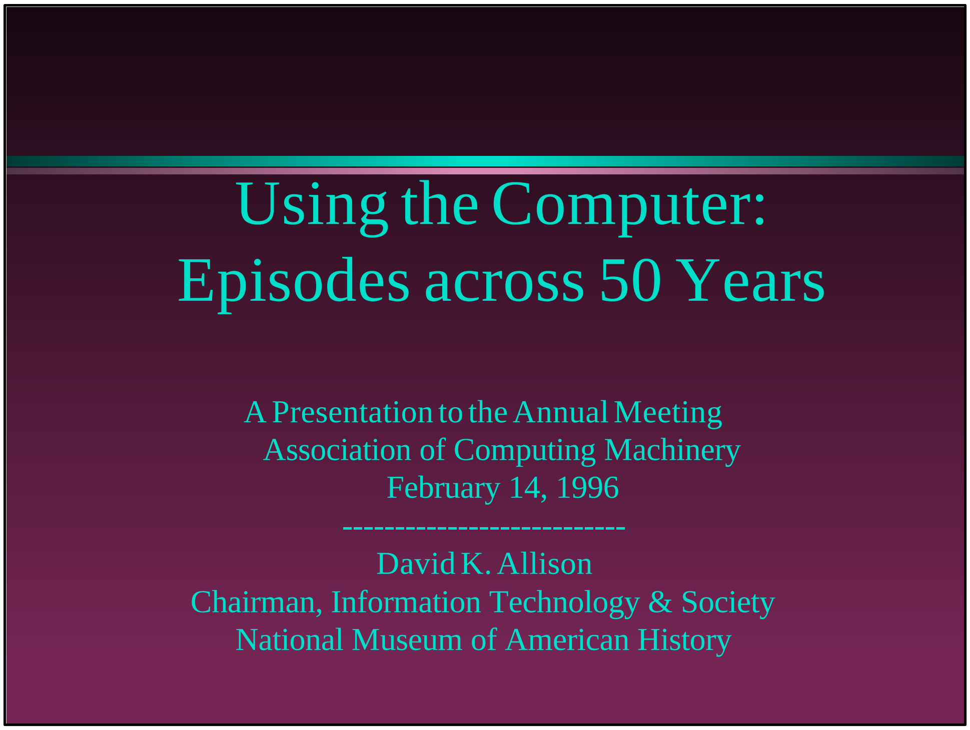


When we approach the history of computing, we frequently think of it as the history of machines. We periodize the subject it in terms of generations of designs: The mainframe generation, the minicomputer era, the PC revolution. We look at the significance in the changes in processor development, in memory capacity, in networking.

These are important subjects. But often lost among them is what I believe is a more important story: the story of the relationships between the computer and its users, and how that relationship has evolved.

Who are the users of computers? In what context--especially what institutional context--do they use them? What is the interaction between user, computer and institutional context? How do these relationships change over time?

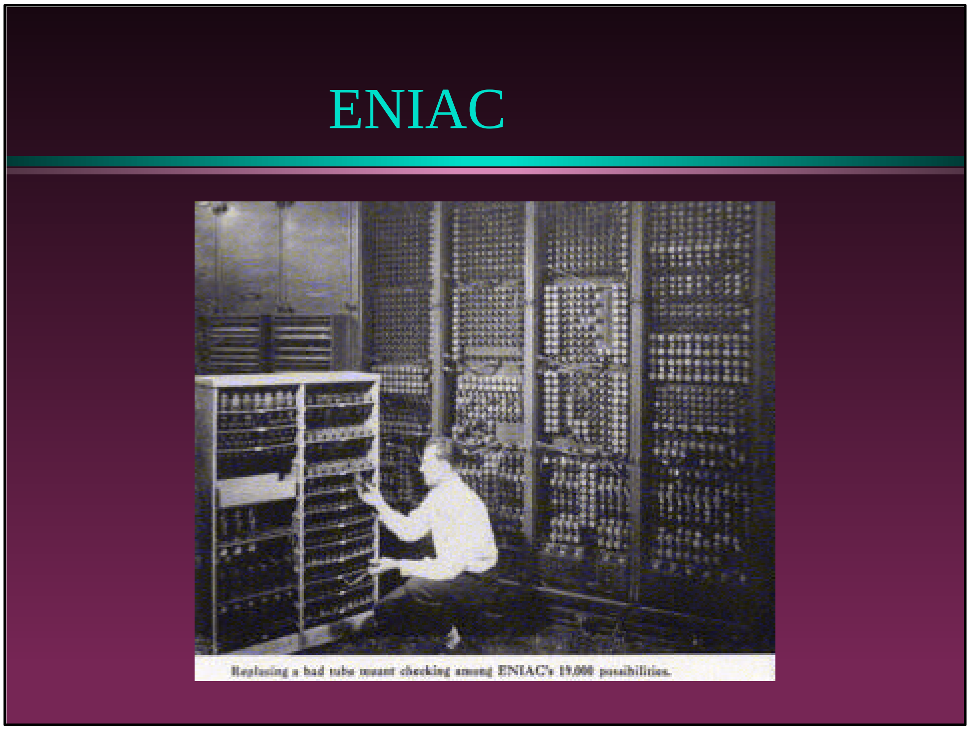
In my presentation today, I will explore three episodes with you, looking at the computer from the user's perspective. All three episodes relate to important pieces of the National Collection on the History of Computing at the Smithsonian's National Museum of American History.

Episodes

- ENIAC: Electrical Numerical Integrator and Computer
- ERMA: Electronic Recording Machine--Accounting
- Recent Applications

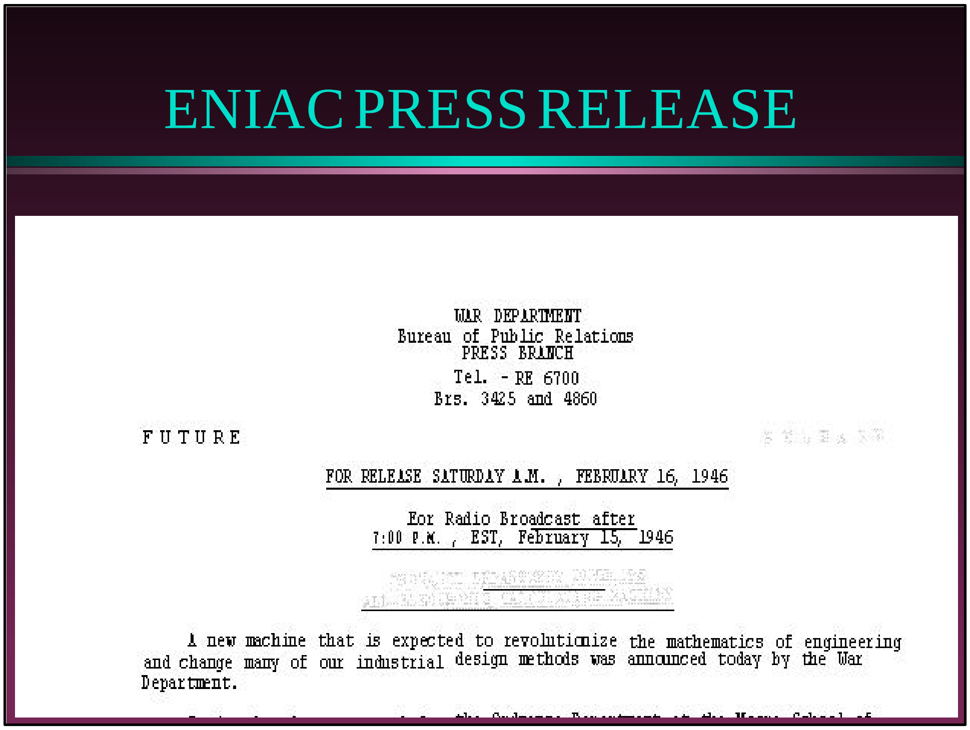
The first episode will focus on users of the ENIAC computer at the University of Pennsylvania and Aberdeen Proving Ground. The second will focus on the ERMA computer at Bank of America in the late 1950's. The third will be a sampling of computer applications in the last decade.

Although these three cases are very selective, they do reflect broader usage in several interesting ways. The Aberdeen case, for example, illustrates the initial development phase of main-frame computer use by scientists and engineers engaged in national security problems. The Bank of America case represents early business use, when computers were moving out of the framework of the military-industrial sector. And the recent cases represent the flowering of the electronic information age, in which computer technology is becoming infused into all parts of American life.



Sometimes we talk of innovation in terms of "technology push" and "demand pull" to distinguish the source of new ideas. In those terms, ENIAC was created because of demand pull. The Computing Laboratory at the University of Pennsylvania was responsible for generating ranging tables for US Army artillery. They were getting further and further behind in their calculations. John Mauchley, Pres Eckert and their team, proposed developing an automatic calculating machine to speed up the process. Although the project was costly and risky, the Army approved. Without this special situation, it is doubtful that the Army--or for that matter any organization in the United States--would have sponsored the development of a machine like ENIAC at that time.

This special origin is important. The context for creating ENIAC, and the effect of the postwar sponsorship of computing by the defense establishment established the framework for the initial development and use of computers in American society. How different they might have been had they emerged in a time of peace and declining government influence, such as we have today!



ENIAC PRESS RELEASE

WAR DEPARTMENT
Bureau of Public Relations
PRESS BRANCH
Tel. - RE 6700
Brs. 3425 and 4860

F U T U R E

FOR RELEASE SATURDAY A.M., FEBRUARY 16, 1946

For Radio Broadcast after
7:00 P.M., EST, February 15, 1946

A new machine that is expected to revolutionize the mathematics of engineering and change many of our industrial design methods was announced today by the War Department.

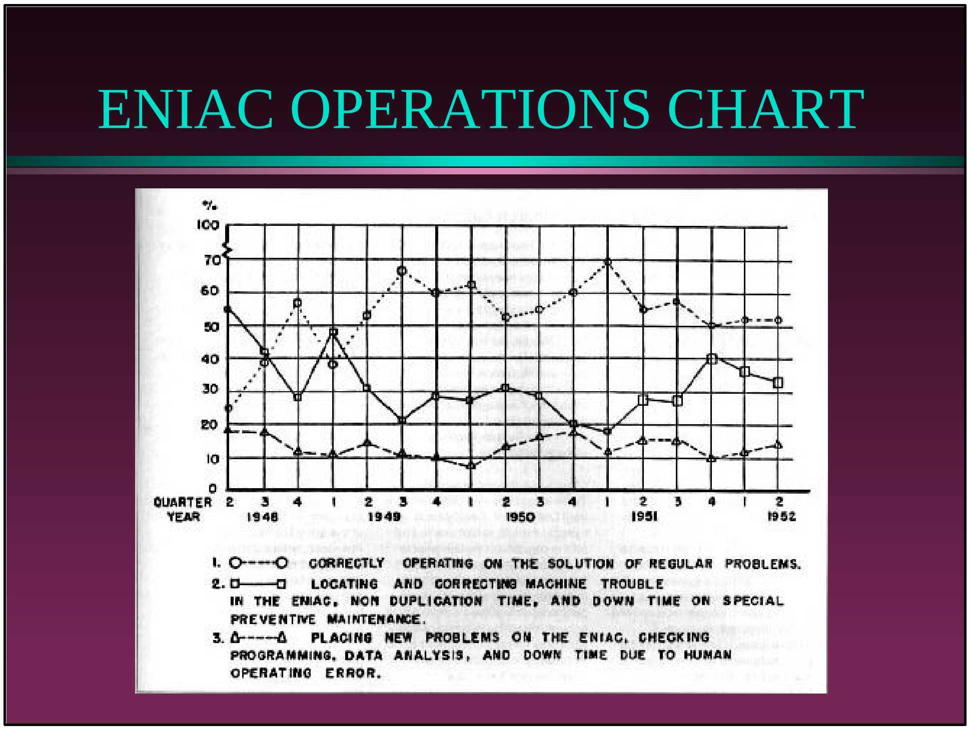
The original USE proposed for ENIAC was a high priority, well-defined computing task. But even during its initial phases, the developers considered numerous other purposes. By the time they completed ENIAC, the urgency of computing ballistics tables occasioned by the war had passed. Thus when the developers introduced the machine to the public, they emphasized that it could also be used for many functions besides the task for which it had been created.

One of the first press release stated broadly:

A new machine that is expected to revolutionize the mathematics of engineering and change many of our industrial design methods was announced today by the War Department...

Although the machine was originally developed to compute lengthy and complicated firing and bombing tables for vital ordnance equipment, it will solve equally complex peacetime problems such as nuclear physics, aerodynamics and scientific weather prediction.

These are bold claims, which seem quite optimistic. During the years of its operation, did ENIAC really live up to this promise in how it was actually used?



To a large extent it did. It certainly proved to be much more flexible than should have been expected from a machine designed and built hurriedly under the threat of war. ENIAC was actively employed throughout its ten-year lifetime to compute a wide range of valuable results. However using it was always a struggle.

In a recent article in the Annals of the History of Computing, W. Barkley Fritz provided a good summary of ENIAC's operational history. From 1945 until January 1947, it ran at the Moore School at the University of Pennsylvania, where it was designed and built. Then the machine was moved to Aberdeen Proving Ground, where it operated from July 1947 until October 1955.

Pres Eckert had prided himself on his engineering expertise and his ability to get long-life from the tubes he used in ENIAC. But because there were so many tubes, ENIAC was never highly efficient in its electrical operation. This table shows the operational history of ENIAC from 1948-1952. During that time, it never operated more than 70% of the time, and the norm was closer to 50%. Things never go much better. One reason, apparently, was that engineers would turn the computer off at least once a week, and this tended to cause tubes to blow.

ENIAC CONCLUSIONS

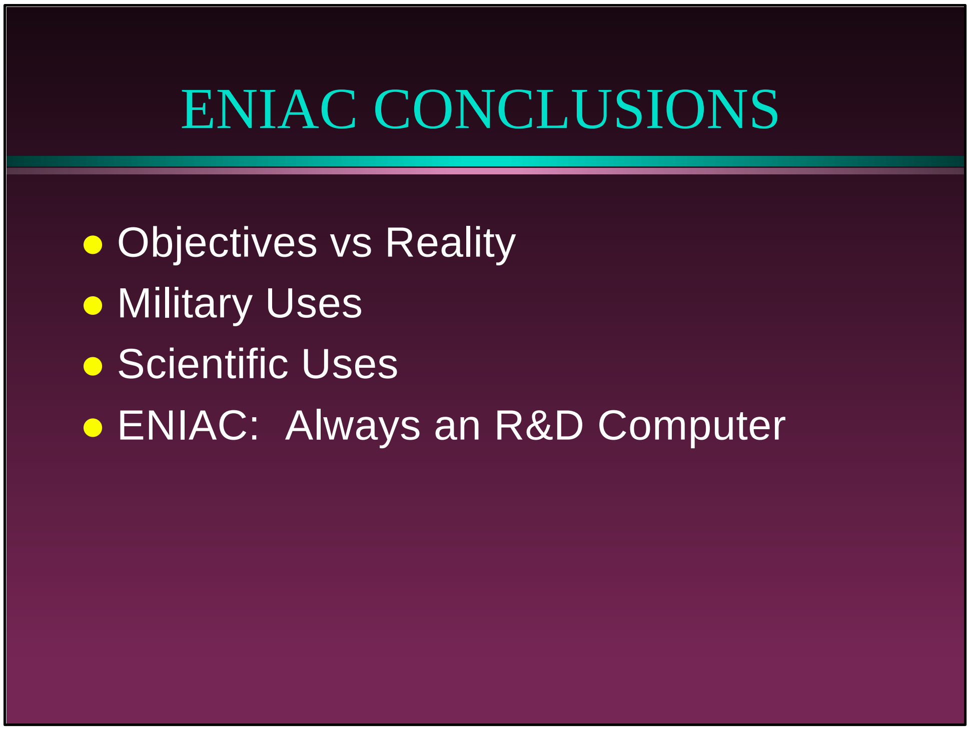
- Objectives vs Reality
- Military Uses
- Scientific Uses
- ENIAC: Always an R&D Computer

Three points characterize the operational history of ENIAC.

First ENIAC was built as a machine for use by the US Army for military purposes. These user requirements not only determined the nature of the machine, but also affected the course of the early history of computer development in America.

During its lifetime, ENIAC solved about 100 unique problems. The computer's biggest user by far was the Computing Division of the Ballistics Research Laboratory, as might be expected. Seventy percent of the problems originated inside the Ballistics Research Laboratory. Fully 25% of the work ENIAC did was development of ballistics tables: the job it was originally designed to do. Over 50% of the problems ENIAC solved had to do with numerical integration of nonlinear differential equations.

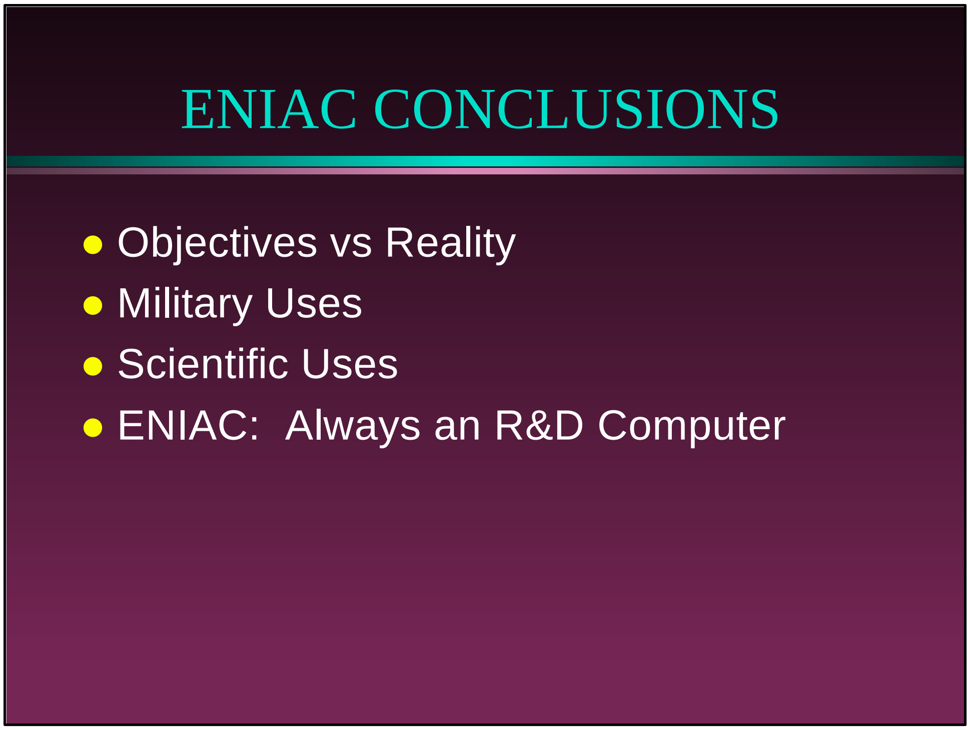
Perhaps the most important effect of ENIAC on scientific users was its fostering the growth of computational solutions to scientific problems. As ENIAC and later computers automated calculations, numerical solutions to problems began to be used much more widely in science. This profoundly affected research in many fields, such as hydrodynamics, meteorology, and oceanography.



Secondly, ENIAC was primarily a machine for scientific computing that could be used effectively only by computer professionals.

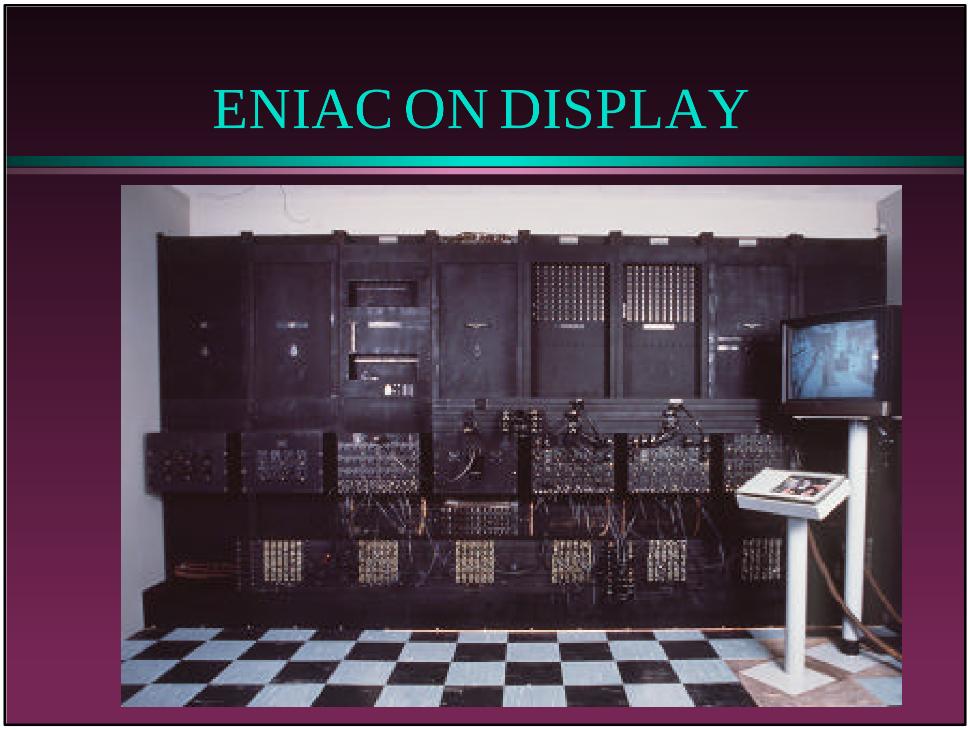
The design of ENIAC, its historical context, and its use throughout its history situated it as a machine for scientific computing.   Although it was quickly surpassed, it was far more powerful than existing computational techniques.

Soon after designing ENIAC, J. Presper Eckert and John Mauchley left the University of Pennsylvania to design a computer for business. As they realized at the time, this would be a very different proposition from designing ENIAC, and not just because the technology was now advanced. The characteristics of the users would also be very different. For successful operation, computer designs need to be as sensitive to the nature of the people who use them as they do to the technical state of the art.

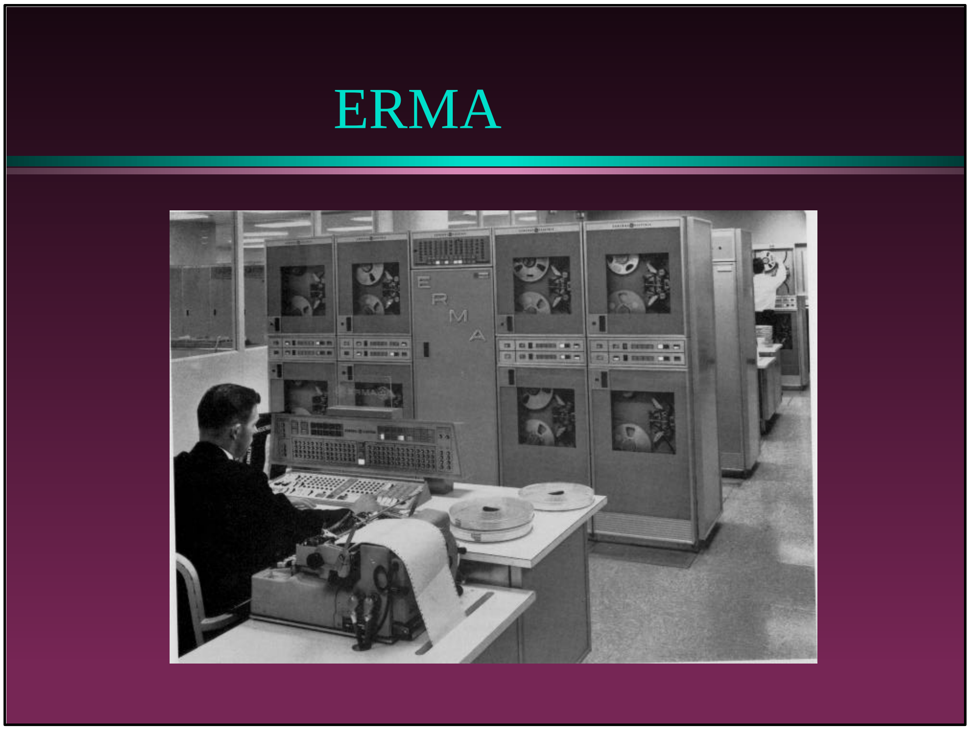


Thirdly, ENIAC was always an experimental machine, never a true production machine. The principal operators had to be engineers devoted solely to making it work. And they mostly had to adapt to the machine's peculiarities, rather than being able to make it suit their needs.

Although ENIAC operated for a decade, it remained a unique device that was an experimental, not a production computer. Parts were custom made and procedures were defined and developed specifically for this machine. Working with ENIAC in the early days required a painstaking process of defining a mathematical problem in terms that allowed a basic rewiring of the machine to solve it. The process was complex and time consuming. Adding to the difficulty was the fact that the job was worth the effort only for complex mathematical equations that generally had to be solved over and over for different data sets.



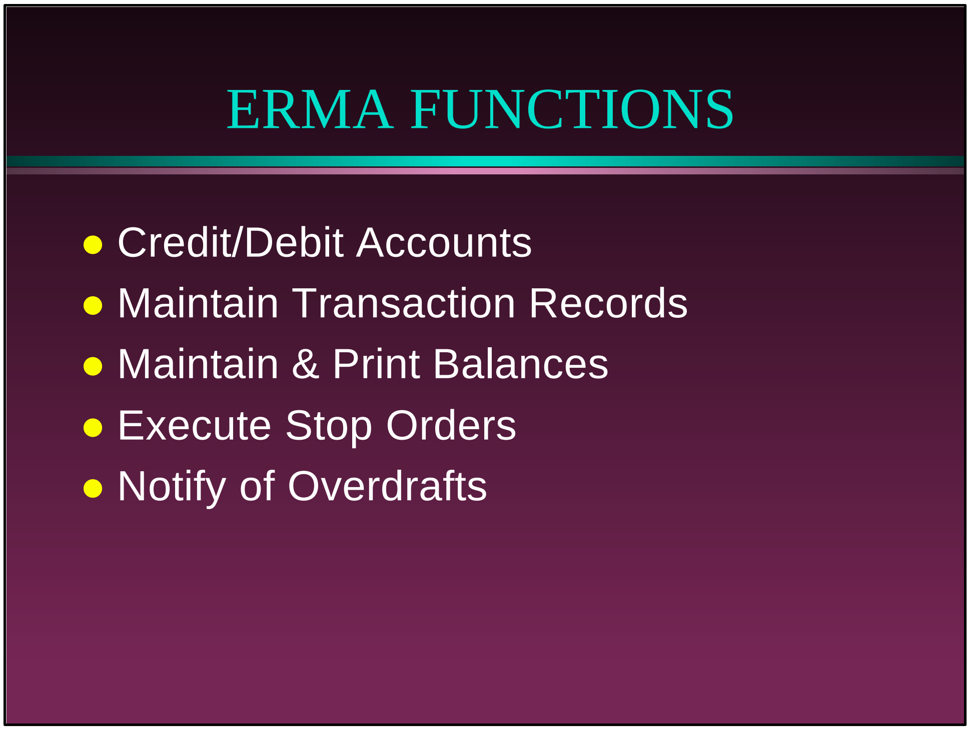
From the perspective of a museum curator, ENIAC should be displayed in a way that illustrates its origins and initial operation. We tried to do that in our display of ENIAC in our Information Age exhibition at the National Museum of American History. First we situated it at the end of an extensive presentation about World War II technology. And we put it in a room setting that gave visitors at least a general sense of the size and scope of ENIAC as a machine. Among our problems was finding someone who could still do the World War II era black wrinkle painting to touch up the sections of the computer that needed restoration! These display problems of the computer may seem unimportant to understanding the user perspective--but they are not. How users relate to a machine that fills a room is quite different from how they relate to something that sits in their lap. Among the most important changes in the history of computing are the changes in size and scale of computers.



ENIAC was spawned by a crisis in computing ballistics tables. My second episode, ERMA--the Electronic Recording Machine--Accounting, also arose from an acute crisis: in this case rapidly rising user demand in the banking industry. Unlike the case of ENIAC, the ERMA system was designed to be used not by the staff of a research and development laboratory but by ordinary bank personnel.

Between 1943 and 1952, check use in the United States had doubled from four billion to eight billion checks written each year. Manual processing of checks was becoming increasingly problematic. In a 40 person branch bank, for example, at least 7 people were employed as full time clerical workers, most of them bookkeepers responsible for processing checks.

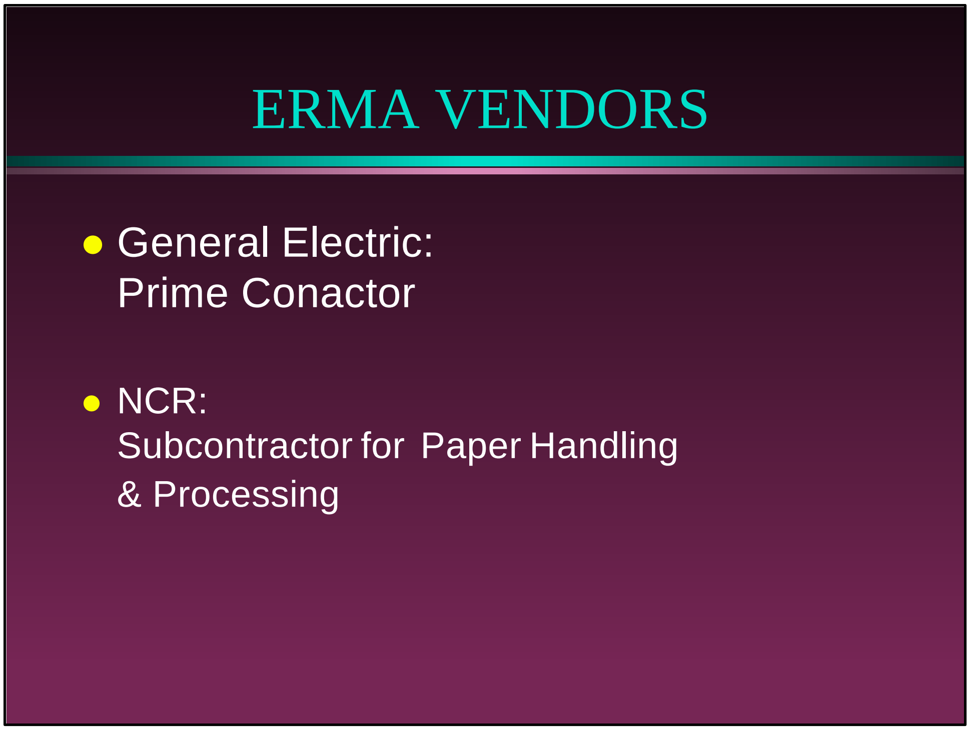
Computer automation seemed a good answer. However at the time, most attention in the young computer field still focused on large scientific computers, not on business machines capable of handling something as complex as checking.



No bank in the United States felt the pressure to modernize more than Bank of America, California's leading bank. In 1950, S. Clark Beise, senior vice president of Bank of America, contracted with Stanford Research Institute to develop a system to automate check processing. After initial discussions, the two decided that they should develop a system that accomplished five basic functions:

1. Credit and debit all accounts
2. Maintain a record of all transactions
3. Retain a constant record of customer balances for printing
4. Respond to stop-payment and hold orders
5. Notify the operator if a check caused the account in question to be overdrawn.

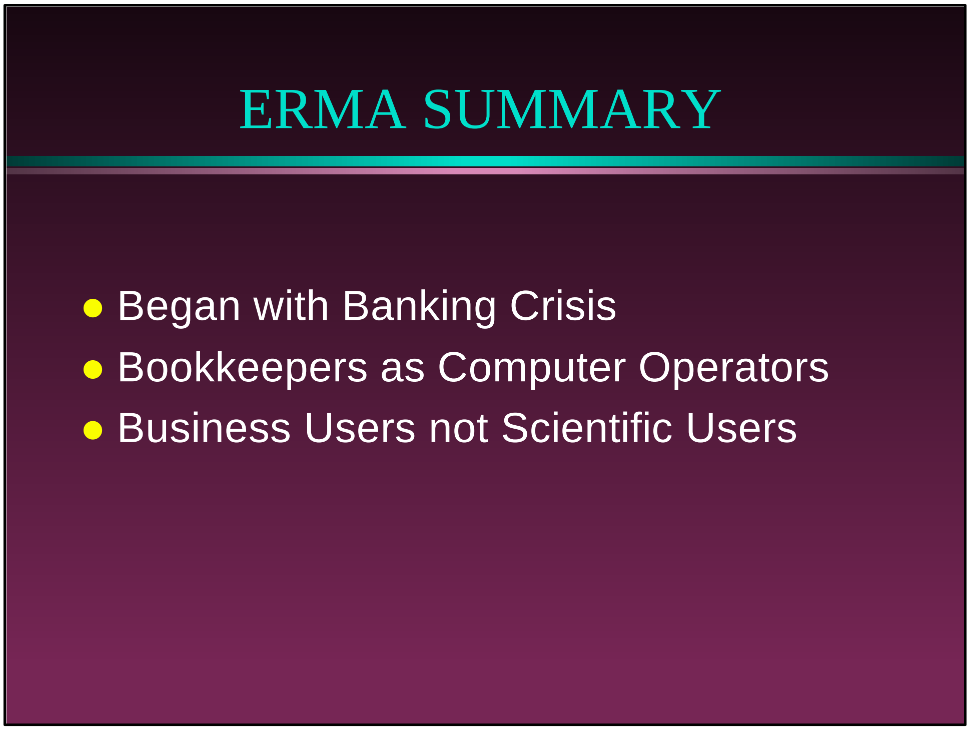
Over the next several years, SRI developed a prototype system that would meet these needs. A critical innovation was the use of magnetic ink on checks to record accounting numbers so they could be read automatically. In developing their approach, Bank of America and SRI worked closely with the American Banking Association and other banks around the United States. Thus the Bank of America standards were ultimately adopted for use on checks throughout the country. SRI completed its prototype in late 1955.



Once the SRI prototype was finished, Bank of America had to manufacture a series of production machines based on the design developed by SRI. In 1956, after evaluating proposals from IBM, RCA, Texas Instruments, and General Electric, Bank of America chose GE--a new entry into the computer field. As a subcontractor to produce the check sorter and encoder, it chose National Cash Register. The system was completed and first put into operation in late 1959.

Implementing the system had a major impact on customers: each had to have a new account number. Nearly two million checking accounts were involved, so this was a huge endeavor. Moreover now customers wouldn't be able to use other's blank checks: they could only use their own. Banking was beginning to change from an industry defined less by personal service than by efficient computer systems. That trend has continued to this day.

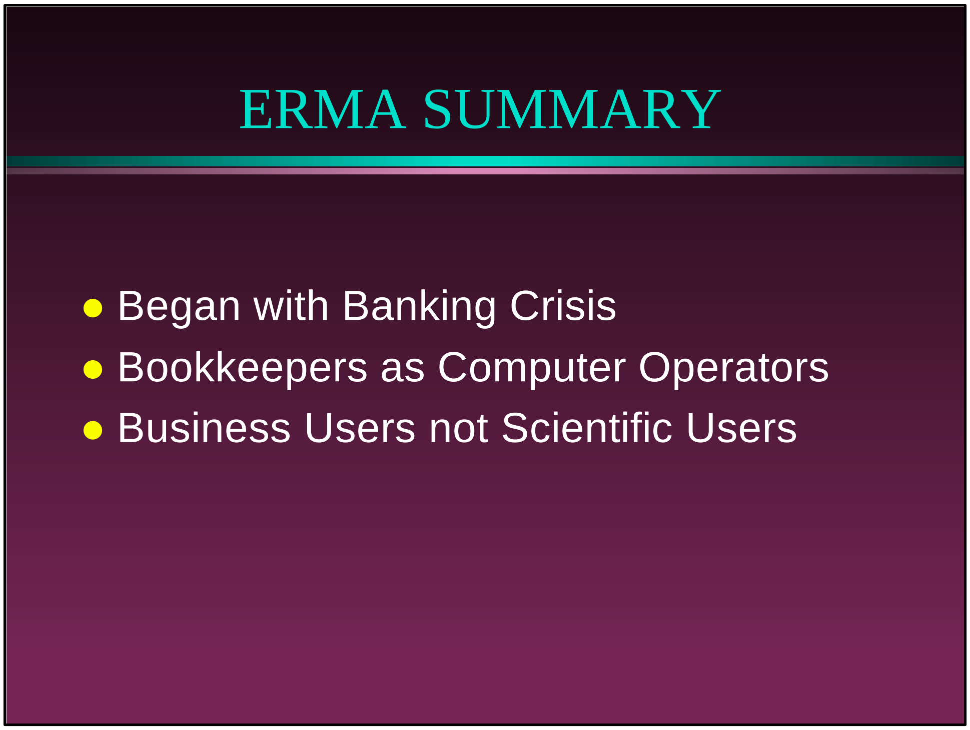
The greatest effect of the system was on banking bookkeepers. In its initial publicity, Bank of America stated that with ERMA, nine employees could do the job that previously took fifty people. They were quick to point out that no one would be fired due to the initial implementation. But clearly the principal goal of the system was to reduce labor costs and errors while speeding check processing.



ERMA exemplified several important trends in the history of computer use.

First, unlike ENIAC, ERMA was an innovation for business use, not scientific use. As the computer moved more broadly into society, business uses began to predominate. As I said earlier, they probably would have predominated even in the initial development of digital computers had it not been for the extraordinary intrusion of World War II and the Cold War into the development of what is primarily business equipment.

Second, the ERMA system was designed for innovative forms of input. In the early computers, innovation was primarily in processing and storage of information. Input and output was done in a basic and routine fashion, usually via punched cards. But as computers were integrated in different settings, innovation was also needed in input and output. The most important innovation in input in ERMA was the MICR code.

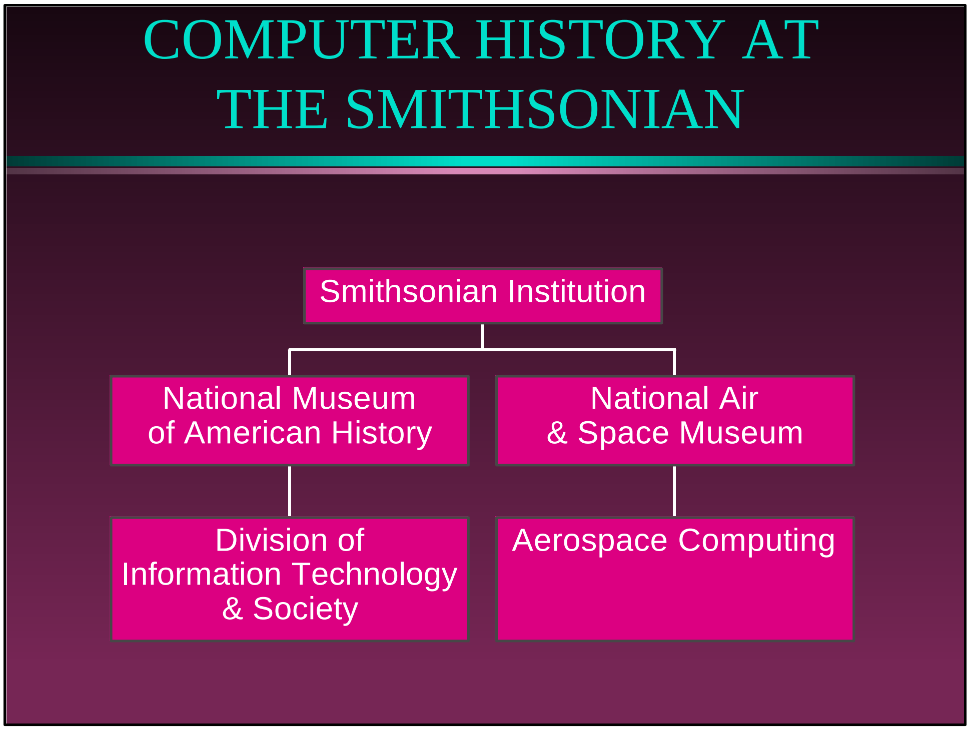


Because of complexity and cost, MICR codes have not spread much beyond the banking industry. However a later innovation of a similar sort--the bar code, has spread widely from the grocery industry where it began to applications in many areas of society. Bar codes on all sorts of objects today remind us of the extent to which our lives are now mediated by machines.

This point relates directly to the user role. ENIAC could be operated only by engineers. ERMAs principal users were data clerks focused more on the information they processed than the machine processing it. They symbolize a new generation in computing defined in terms of users, not in terms of hardware.

When the Smithsonian collected pieces of ERMA for the national collection, we elected NOT to collect the major computer components of the GE computer. Our largest problem was space. We simply don't have room to store many large computers. We already had sections of other main-frame computers of that era, and it did not seem necessary to collect pieces of the General Electric machine used in ERMA. However we did collect sections of the NCR dollar amount encoder used by bookkeeping clerks in processing. [Show image] This station allowed clerks to encode the amount of the check in magnetic ink on the check itself, just as the account number had previously been recorded.

We believed that this station symbolized the change that was going on in banking much better than technical components of the host computer. For now the lives of a large segment of the American workforce was changed from an operation managed by humans to an operation in which humans and machines worked together in an integrated system.



ENIAC in the 1940's marks the beginning of the computer industry in America. ERMA in the 1960's is an example of how computers began moving into American big business. By the 1980's, computer processing was entering virtually all areas of American life. An information grid based on networked computers was becoming as important to our society as the transportation grid and power grid.

It is impossible to keep track of all the uses of the computer these days, and quite difficult to establish an effective means for tracking even most significant users. At the Smithsonian we are tracking the history of computing at both the National Museum of American History and the National Air and Space Museum.

One systematic program that is helping us accomplish this objective at American History is the Computerworld Smithsonian Awards program. The program began in 1989 as a collaboration between the Smithsonian and Computerworld, a leading newsweekly of the Information Technology Industry. Award Nominations are gathered from Information Technology leaders for outstanding applications of computing technology in the ten different areas shown above.

Although they are not comprehensive, these ten areas are quite broad. They indicate the range of areas in which computer technology now affects our society.

Since the program began, the Smithsonian has collected information on over 1,500 pathbreaking applications of information technology. Information about them, images, video tapes, and artifacts are all deposited in the Smithsonian collection. In addition, we are providing a real-time archive on the World Wide Web http://innovate.si.edu. Tens of thousands of people have begun to access this data.

The collection documents a wide range of major applications of computer technology. What are some of the most significant stories we are tracking?

MAJOR APPLICATIONS INCLUDED

- American Airlines SAABRE System
- Emergency 911 Telephone System
- NASDAQ Stock Exchange
- Online Information Services: America On-Line & Compuserve
- Federal Express

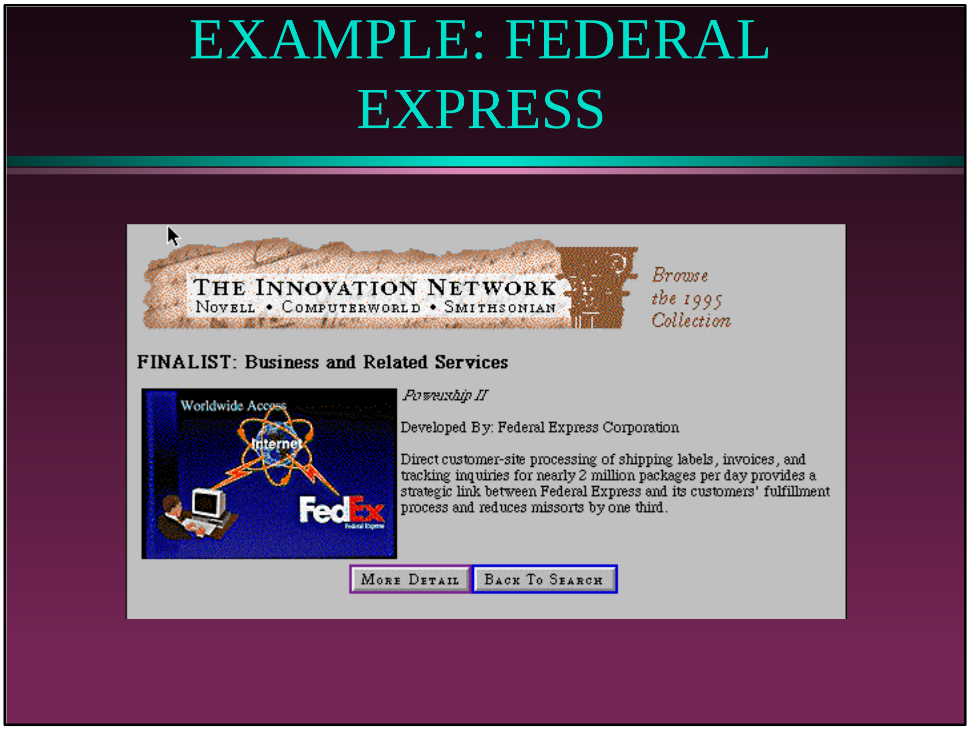
They include such applications as:

• The American Airlines SABRE system, among the largest and most active transactional databases in the world.

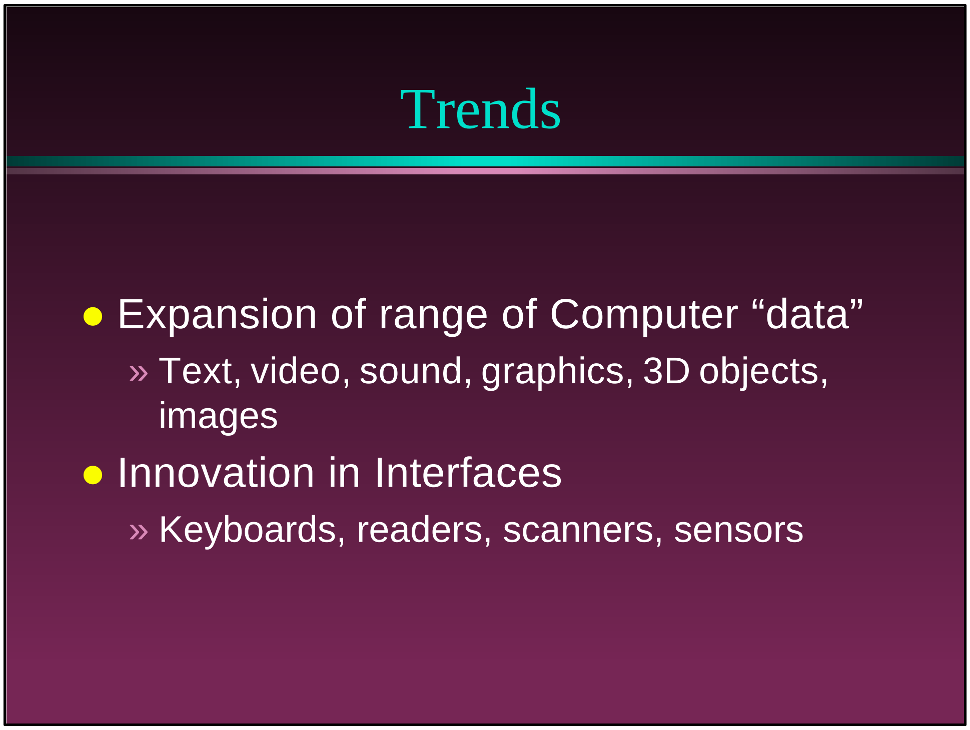
• The Emergency 911 telephone service. It is arguably the integrated computer and communications network that has had the most significant impact on the lives of ordinary citizens

• The NASDAQ stock exchange--the first trading floor without a floor;

• Public network services such as Compuserve and America On-line, which are bringing on-line information and internet access to millions of home and small business users.



- Federal Express' computerized express mail system. Here is a business that couldn't exist in its form without modern computer/communications networks. They enable the company to track millions of individual objects along the path from pickup to delivery. Federal Express' computerized express mail system. Here is a business that couldn't exist in its form without modern computer/communications networks. They enable the company to track millions of individual objects along the path from pickup to delivery.



What are we learning about computer applications from our Awards program?

The nominations indicate that the most important change in recent decades has not been in their processing power or the size of computer memories or even the drop in cost. It has been the increase in the range of information computers can process and the variety of user interfaces.

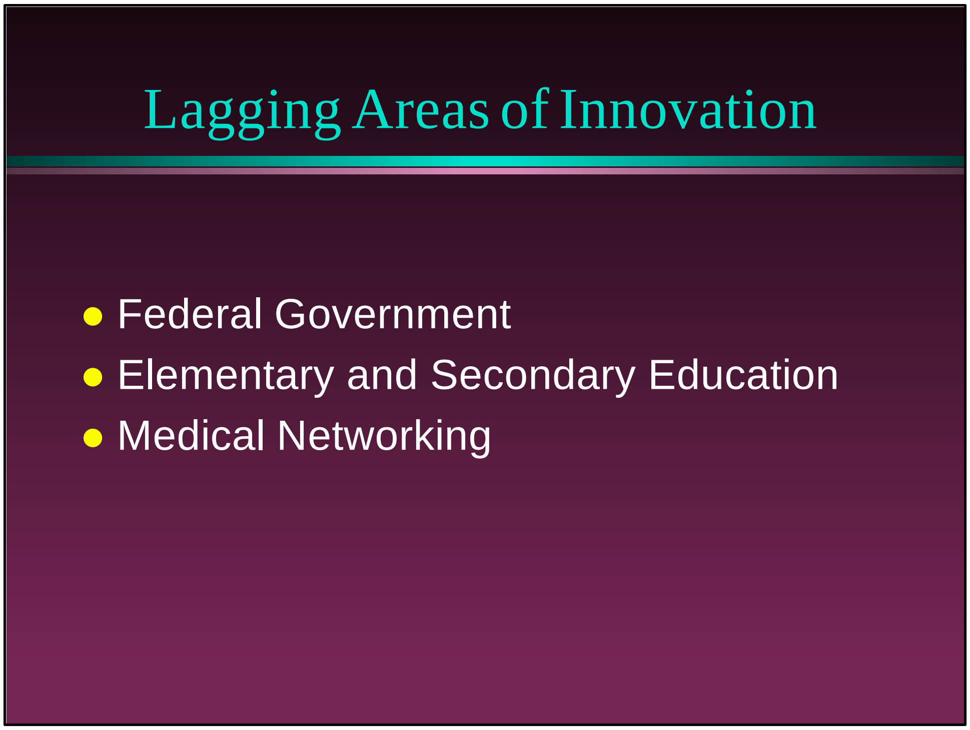
Computer "data" now encompasses not only numbers and text, but also pictures, video, sound, graphics, three-dimensional shapes and all sorts of images: fingerprints, DNA maps, barcodes, etc.   Virtually anything that humans sense can now be expressed with a digital representation. I don't know yet of digital smell or tastes interfaces, but if they don't already exist, then I expect they soon will.

Trends

- Expansion of range of Computer “data”
  - » Text, video, sound, graphics, 3D objects, images
- Innovation in Interfaces
  - » Keyboards, readers, scanners, sensors

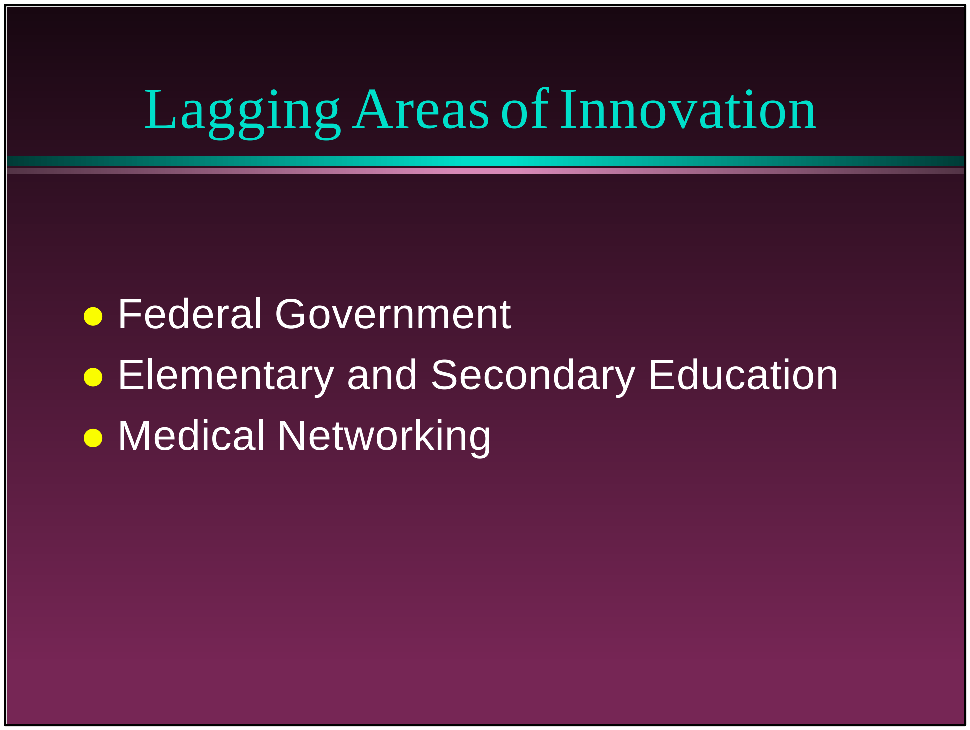
Just as the sort of "data" computers can process has grown, so have the number and variety of user interfaces. All manner of input and output devices convert entities in our society into digital representations and get them out again. It is this expansion of input and output devices as much as the growth of processing power and memory that has paced the flow of computer technology throughout society and determined its social impact. For instance, the adoption of barcodes as a common means of identifying retail products to computer systems has led to fundamental changes in that business. So has the development and use of magnetic tape strips on credit cards.

Our Awards Program highlights innovative ways new computers applications are changing society. But ironically it also puts in relief areas where application of new technology is lagging behind what it could be. It is as important to study these areas as areas in which information technology moves forward rapidly.



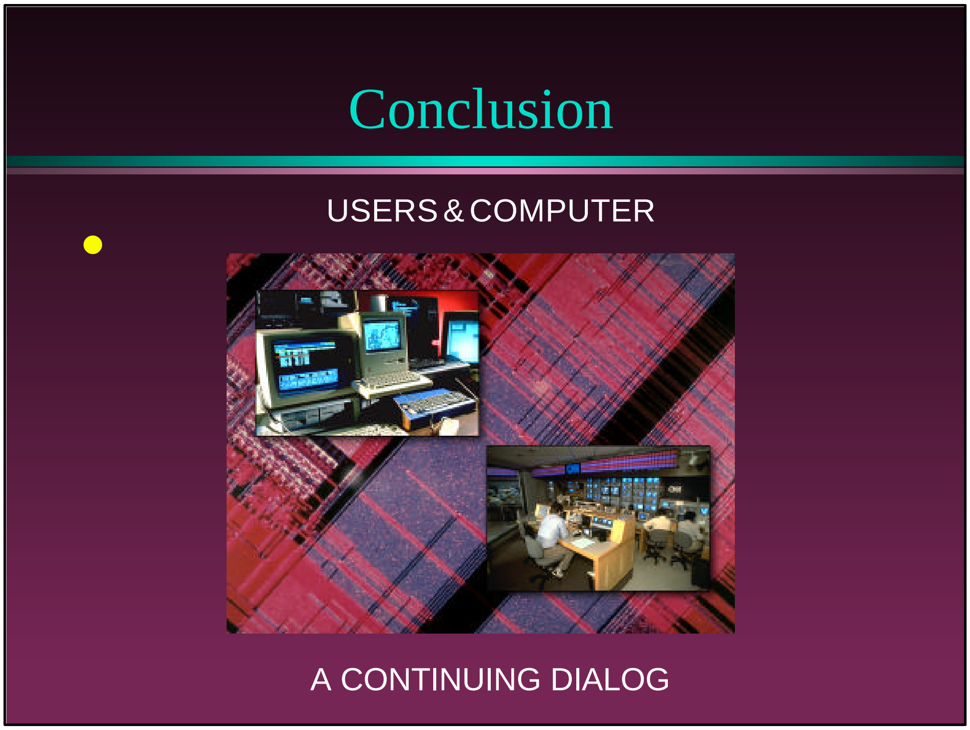
Among the least innovative users today, I am sad to say, is the federal government--exclusive of select areas in the military. The computer was born from a federal program, and some military contracts continue to drive advanced development to this day. But the majority of federal agencies have tended to lag far behind leading private sector companies in the adaptation and use of advanced information technology. Compare, for example, the implementation of new technology by the post office as compared to Federal Express. Or by the Internal Revenue Service as compared to major accounting firms. Or any of the major administrative agencies as compared to major insurance companies.

A second area of lagging innovation is elementary and secondary education. The nominations for the awards program show that Educators at all levels develop many innovative ideas for improving education. But institutional barriers tend to block the spread of innovations outside of select pockets. Factors such as poor teacher training, lack of investment funding, inertia, and lack of effective performance measures all militate against rapid adoption.



A surprising third area is medical networking. Although there has been much innovation in medial research or diagnostic instrumentation, much less has been accomplished in effective networking of medical information. Few doctors have fully automated records, case records housed in different institutions are not shared effectively, and doctors can't share information effectively with experts at remote sites.

These three cases highlight once again the role of institutional factors in shaping computer implementation. Government and Education have no easily measurable results, and productivity enhancement is often resisted--especially when it requires personnel reduction. Until recently, medicine has been a sector of society controlled more by independent small businesses than by large, integrated institutions. This has affected the pace of technical change. But as medicine changes, the technology associated with it will also change.



Across the last 50 years, the application of information technology to society has gone through distinct stages. First it was in a few areas of military affairs and science. Then it spread to financial institutions and large businesses. Now it is spreading throughout society. The spread is not even, and how it occurs depends increasingly on institutional and social factors instead of technical factors.

Let me leave you with this thought. Several weeks ago I talked to Jay Forrester, pioneer developer of the Whirlwind Computer and Core Memory. He's been away from technical computer work since 1957. He had gotten out because he believed all of the basic technical work had been done.

"Do you think you were right?" I asked.

"Absolutely," he said, "Computers today are smaller, faster, cheaper, and more reliable, but they are essentially the same machines we had 30 years ago. The important question has been--and continues to be--how we use them."