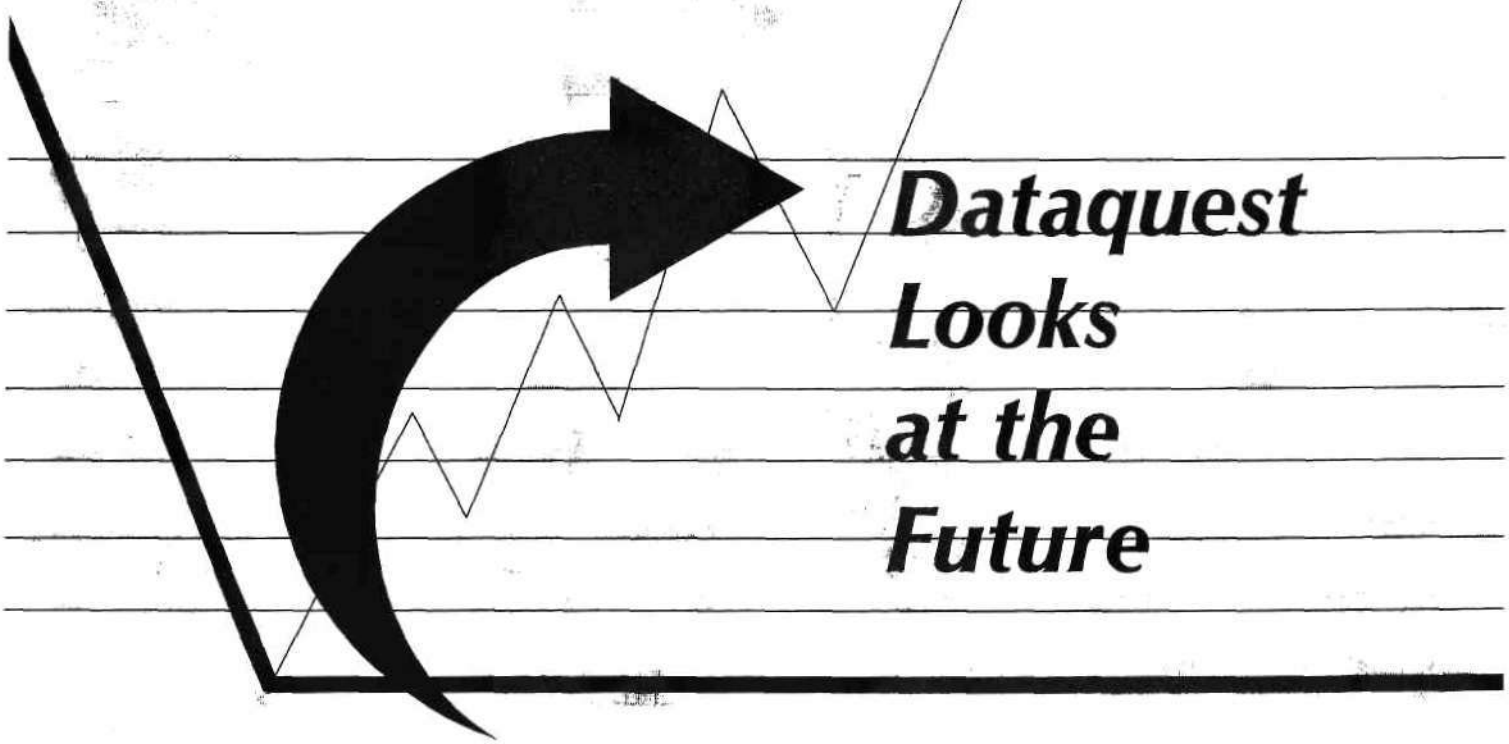
19th Annual Semiconductor Industry Conference

Conference Transcription



Dataquest Looks at the Future

December 23, 1993 - Revised Edition of November 3, 1993 Publication

137

1993 Dataquest Semiconductor Industry Conference
October 11-12, 1993
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December, 1993 - Revised Edition of November, 1993 Publication

TABLE OF CONTENTS

Conference Welcome

Gene Norrett

Corporate Vice President and Director
Semiconductor Group
Dataquest Incorporated

Mr. Norrett: Good morning ladies and gentlemen and welcome to the Hotel Nikko in San Francisco, California. Welcome to our Nineteenth Annual Semiconductor Conference.

The theme of this conference is "Dataquest Looks at the Future." We chose this theme because we wanted all the panel members, speakers, and attendees to think only about the future and what the future may bring for your individual businesses. We think that by having everyone focus on these kinds of issues throughout the course of the conference you will get a better and more lucid view of what is going to happen in the future and hopefully enable you to make better decisions.

I believe that this is the most exciting time in the history of science and technology because there has never been a time when so many technologies have experienced such continuous change at the same time, and with such tremendous speed. Specifically, I'm referring to the changes in the communications, computing and consumer systems as well as semiconductor devices. With the rapid improvement in computer power, communications technology and the accelerating drop in volatile as well as non-volatile memory prices, we believe that the revolutions in information appliances for the society have become not an annual, but a daily occurrence in our business lives.

Ladies and gentlemen, I believe that we are entering a new era— the era of the information utility. A utility is defined by Webster as something that is useful to the public. This is certainly what we are seeing today, and what we'll continue to see in the future. For example, some of the systems manufacturers in this audience today have recently created electronic check books, pocket sized global communicators, personal storage devices small enough to carry a whole lifetime of multimedia records in one's pocket, printers significantly smaller then the paper that they print on, pocket pens that can record short messages and play back using advanced semiconductor chips and a portable electronic navigation system with speech recognition. These revolutionary products are just precursors of even more sophisticated products that will be introduced in the next twelve months.

Over the next two days we will take you on a Dataquest applications trek, and like those people of the Starship Enterprise, our attendees will experience bold new challenges, and be filled with new information that will enable you to succeed in your missions of seeking success and prosperity. This is our promise to the attendees at today's conference.

To discuss these revolutionary devices, applications and systems, we have assembled the finest industry leaders in our nineteen-year history. They will share their visions and their forecasts of the developments that will change the societies of the world forever. In all, you will hear from forty senior executives from leading edge companies throughout the world. We have organized these presentations into either fifteen or twenty-five minute presentations, or on six panels covering the most exciting topics in the industry today.

Also, we have the privilege and the honor of hearing the vision of Dr. Gordon Moore, co-founder and chairman of Intel. He is our

keynote speaker today, and throughout his history with Dataquest his presentations have always been thought provoking.

Attending this conference are more than 450 people. The demographics of our conference are as follows: approximately five COBs, forty presidents and CEOs, and 180 vice-presidents and directors. These represent approximately 45 percent of the total attendees. Further, our attendees represent fifty systems and sub-systems manufacturers; fifty-four semiconductor manufacturers and foundries; fifty-two semiconductor equipment materials manufacturers and assemblers; one software maker (of course it's the largest and the most important one); three distributors; fifteen financial companies; thirteen government, users and associations; and finally, eleven members of public relations, consulting, and publications companies. This is the purpose of this conference: to bring together the complete food-chain in the electronic industry.

In the foyer today we have Dataquest staff ready to demonstrate our new and user-friendly electronic delivered services. We also have on display our semiconductor reports which are contained in the various services that we offer. These are available for purchase even if are not a current Dataquest client.

When you visit one of the booths in the foyer, please give your business card to one of the staff members in order to participate in our drawing for a semiconductor report—a value of $995. to $3995. This evening we'll be having a gala dinner cruise on the San Francisco Bay. Please dress casually tonight and bring a sweater, I'm sure we'll need one on the boat.

Concerning transportation, we have provided information in the foyer about transportation from the various hotels that we had to use because of an overflow from this hotel. We also have this information in your binder.

And now I'd like to introduce Judy Hamilton, President and CEO of Dataquest. Judy is a twenty-seven year veteran of the information technology industry. Prior to Dataquest she was a partner and national director of market development for the information technology organization of Ernst & Young. She was responsible for strategic planning, market research and communications, and obtaining and executing consulting projects on systems development and systems integration contracts, both in their New York and Los Angeles offices. Prior to Ernst & Young, Judy was vice president and general manager of Computer Science Corporation, a director at System Development Corporation, and founder and chair of Databasics, a company that she founded and subsequently sold to System Development Corporation.

Judy is going to say a few words of welcome and tell you a bit about her current management challenge, Dataquest. Please welcome Judy Hamilton.

Welcome and Introduction

Judy Hamilton
President
Dataquest Incorporated

Ms. Hamilton Thank you. I want to add my welcome to Gene's. With over 450 attendees and such a wonderful list of industry speakers I think this is going to be a great conference. I'm glad I'm here and I'm glad you're here too.

In my fifteen months as CEO of Dataquest I've been surprised that not many people outside of the technology sector that they deal with know very much about Dataquest—not even long-time clients. So I wanted to take a few minutes this morning to tell you what Dataquest is all about.

The Company is twenty-one years old. It was founded here in the Silicon Valley as an independent market research firm, and then in the early 80's it was bought by A.C. Nielson and in 1985 became part of Dun & Bradstreet Corporation when D&B bought A.C. Nielson. We're a leading provider of market research and market analysis to decision makers in high technology fields. About eighty percent of our business is with the vendors of technology, the other twenty percent is to financial institutions, banks, consulting firms, and Wall Street.

We have six lines of business. In addition to semiconductors which account for about one-fifth of our business, we cover computers and peripherals, document management, telecommunications, software, and services—both traditional maintenance services and professional services such as out-sourcing and systems integration—the parts of the industry in which I spent most of my career. Many of you may know our services sector by the name Ledgeway, which was a company of about $5 million that we acquired several years ago. We've been gradually phasing out the name Ledgeway and I guess we got rid of it finally last winter when one of our clients in Europe told us that there were three contenders for a big consulting contract—X, Ledgeway, and Dataquest.

In addition to our subscription services we provide direct reports, consulting—both custom research and strategic consulting—and conferences. In addition to conferences like this one that are tied to a service, we have standalone technology conferences. For example, earlier this year we had 980 people at a technology conference in Budapest and you may be interested to know we're planning two in China in early December—one in Shanghai and one in Beijing—and we expect to have about that number of people there.

We have a total of about 450 employees with three offices in Europe, two in Asia, and two in the United States, plus some sales offices. We believe that to be a global company you hire people who are from that country to run the local offices. As a matter of fact, this morning we have with us Yamane Masahiro who runs our Asian region. He spent thirty years with Mitsubishi in the semiconductor sector of Mitsubishi, and many of you may know him because of his work on the board of WSTS.

We think we have several strengths that differentiate us. First of all, we are second in size only to our sister company, Gartner. Second, the quality of our research and analysis is second to none. Dr. Judy Larser who is here with us this morning, heads up our research area and works with our analysts to maintain our research standards.

We think the breadth of our services is particularly important. For example, when we wanted to do a report on Latin America this summer we were able to go into all six segments and produce a report that crossed over the technology segments and gave a broad view of technology in Latin America. We think the worldwide integration and scope of our company makes us quite different. Half of our business is in the United States, one-quarter in Europe, and one-quarter in Asia.

Finally, we think our relationship with Dun & Bradstreet is a real plus. In addition to being able to use Dun & Bradstreet information such as economic trends, we're able to piggy-back on a lot of their efforts. For example, they've just recently opened an office in Russia. As a result, we're able to evaluate what we can and should do in the Russian market without having to legally establish an office there.

These are some of the initiatives that we're taking right now. First of all, we're looking for continual product improvement, what the Japanese call Kaisan. We just finished a three-month process where we've reviewed every product from the ground up—customer input, content input—we killed some old products, and we introduced some new products. Instead of just taking customer surveys periodically, we have introduced a continuous customer feedback process through cards inserted in the back of all our publications. In addition, we have started doing more focus groups as part of our continuous customer feedback process.

We're looking at increasing our accuracy and timeliness all the time, and working on providing more frequency of information to you. Starting about a year and a half ago, we put in place a published schedule to customers about when we would produce our materials, and we monitor this very carefully in order to be as on-time as possible.

We're continually looking for ways to increase our flexibility and ease of use. We've just recently unbundled some of the reports so that you can buy a report separate from subscriptions.

Also, after a couple of false starts, we are firmly into electronic delivery and you can see our CD-ROM and our PC-based Market View products outside in the foyer. The CD-ROM product is in beta-test right now with nineteen clients.

We continue to expand geographically. As the Asian market continues to grow, we're putting more analysts in Singapore, and in addition to Latin America, we're emphasizing pilot studies in China and Eastern Europe.

And of course we're continually looking at process improvements. Last year we totally replaced our internal hardware and software systems—going to a client-server environment. We now feel that we're able to apply technology to some of our processes like inquiry and order processing that will make it go more smoothly for you.

Now how do we measure ourselves? The Number One measurement for us is client satisfaction. As I said, we've been taking those feedback cards from the backs of our books and measuring accuracy, timeliness, quality, value, and overall opinion. I was interested to see a magazine article in the Electronic Business Buyer recently which had surveyed the users of several market research firms and given them grades of only between C- and B. We got a B- and when I looked at it— that survey was taken in January—it didn't vary much from what we were showing ourselves at that period of time. The good news to me is that we have steadily

improved in our customer satisfaction every month since January. Our grade now would be B+ and of course we're not going to quit until we get to an A+.

The second most important measurement after customer satisfaction we think is employee satisfaction. We have our turnover down to below industry norms, and quite acceptable. More importantly, we took a survey, as we do periodically, and seventy-seven trends out of about eighty have improved and are over industry norms. We feel that we are in good shape from an employee satisfaction standpoint. Of course we won't stop working to improve, but we feel good about where we are.

Finally, we and our parent company look for financial performance from us and I can tell you that Dataquest is now a very financially healthy company.

That's enough about Dataquest at this point. I'll be around for the next day and a half and I'm looking forward to meeting as many of you as possible and getting your feedback.

1994 Forecast- The Silicon Cycle Continues

Gene Norrett

Corporate Vice President and Director
Semiconductor Group
Dataquest Corporation

Ms Hamilton: Now I'd like to formally introduce Gene Norrett. Gene is the Corporate Vice President and Worldwide Director of the Semiconductor Group. He's responsible for market research and analysis in the U.S., Asia and Europe. Prior to this position, he was the vice president of marketing at Dataquest and he was responsible for all the strategic planning. He's been with Dataquest since 1982. Before that he was with Motorola for fourteen years in a variety of management and marketing positions. He has a B.A. degree from Temple and an M.S. in Applied Statistics from Villanova. Ladies and gentlemen, your host for the conference, Gene Norrett.

Mr. Norrett: Thank you, Judy. I believe that we are at the most interesting and exciting times in the history of science and technology. Not only because of the incredibly new and exciting systems products that are coming to us at an ever increasing rate, but also because of what's happening in the world of semiconductors.

My talk today is going to focus on the silicon cycle and where we are now in the cycle with the idea of trying to help us get some idea about what the future may bring. I'm sure you have heard the saying that if you don't study the past you're doomed to repeat it. Hopefully by looking at the past here, we may get some idea of about what is in store for us in the future.

We will also add to this information, the information that we get from our colleagues at Dun & Bradstreet corporation, and information from our worldwide network of analysts. Today we are seeing orders that are not as strong as they were six months ago, but are still very strong, and we are also seeing lead times shrinking.

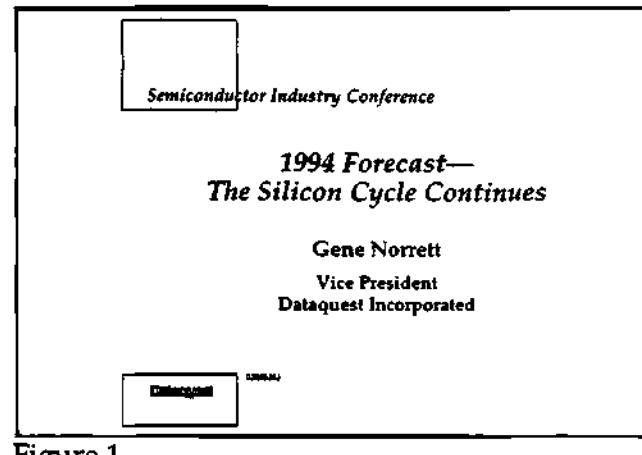


Figure 1

There are some people that are increasingly concerned about this shrinkage of lead times and also concerned about this slowing of the orders. From where I sit, the fundamental business out in the marketplace is still very solid. My presentation here is going to delve into looking at these issues with the hope that we'll be able to get a clearer vision of 1994, and then a snapshot of 1995.

Here is my agenda for today. First I want to look at the recent history of the semiconductor industry and then talk about what's happening right now. Next, I want to share my assumptions on our forecast, talk to you about

our forecast, and then give you some of my conclusions.

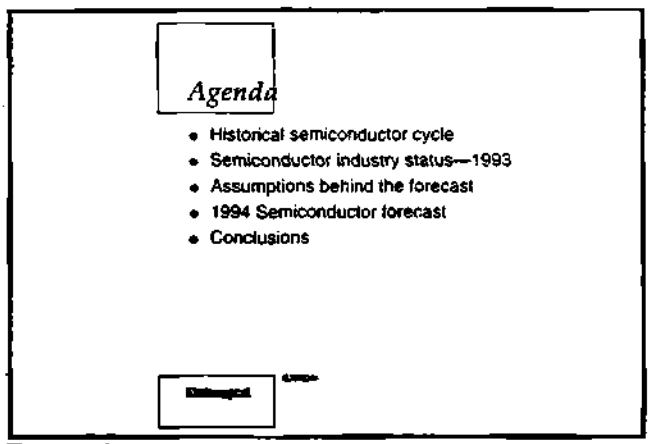


Figure 2

What I'm showing here is a twelve-month rate of change of the semiconductor shipments in the four major consuming regions of the world for the years 1986 through 1993. I could have easily gone back to 1968 when I joined the industry and was abruptly greeted by my first recession in 1970, but I don't want to go back to prehistoric times and relive that recession plus the one in 1975 and the one in 1980 and '81. I'm sure these recessions will bring back painful memories for some of you in the audience.

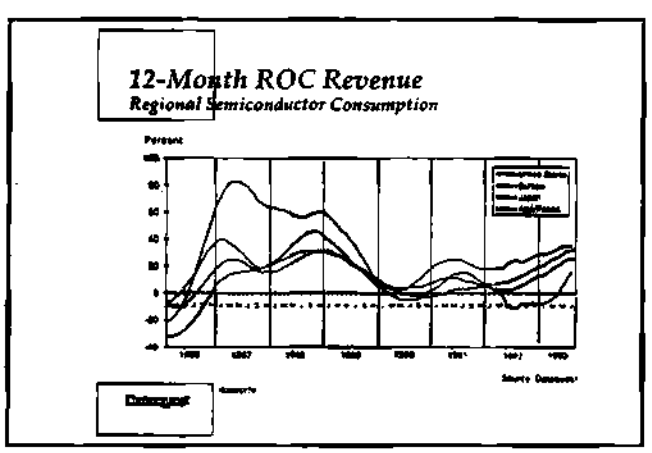


Figure 3

This chart starts with 1986 and shows the beginnings of a recovery from a very deep recession in 1985. This recession was caused by a significant slowdown in the then emerging personal computer industry. One might ask why did the personal computer industry slow down? Good question. Our information showed that new plant and equipment expenditures peaked in late 1984 and declined throughout 1985. The expenditures for new plant and equipment didn't pick up until the end of 1987. Also, interest rates were very high at that period of time and moving down though throughout that period of '85 and '86. I believe that this recession was precipitated by high interest rates and a commensurate decline in capital spending. I'm sure that you will remember the U.S. semiconductor industry had a significant amount of its workforce laid off—an estimated 20%.

This recessionary period was followed by high growth years in '87, '88, declining but still good growth in 1989. At the end of 1989, the longest expansion period in the U.S. history ended and so the did the PC and semiconductor industry cycle. In 1989 the computer industry started a three-year slide and what ensued was a most painful computer downsizing. The next up-cycle for the U.S. didn't start until the second quarter of 1992 when many computer manufacturers dropped prices significantly and the PC industry took off again.

Coincident with this PC boom, the semiconductor industry flourished and at the end of last month, September, we now have the U.S. chip industry sailing along at its lofty level of 35% over a year ago. Later I will show you our forecast of 1994, but what I want to tell you now is that we believe that there is a slowdown coming but it's not going to be precipitous. We do expect the current silicon cycle to continue through 1994 and we see a slowing of the growth rate in 1995.

Now I want to turn your attention to 1993 to look at our regional forecast. We see widely varying growth rates, with Japan being the weakest—certainly no surprise. It's remarkable though that the largest market for semiconductors today—the U.S. market—has shown such tremendous strength and is

growing at a rate faster than the third largest region in the world, Asia Pacific—a much smaller market. We believe that this U.S. growth is coming from many sectors in the electronic industry, too many sectors to enumerate here, but I want to call your attention to the most significant and largest sector today, the personal computer industry. We're forecasting 18% growth in PC shipments through 1993, and 20% growth in workstations, with the fastest being the X86 architecture. Also we are seeing an 11% increase in networking systems—LANs, WANs and internetworking. We are pleased to have with us today John Chambers, Senior Vice President of Cisco Systems, a leading internetworking manufacturer. He is going to give us insight on what's happening in this very critical industry of networking, and what are his forecast of the semiconductor needs for these systems.

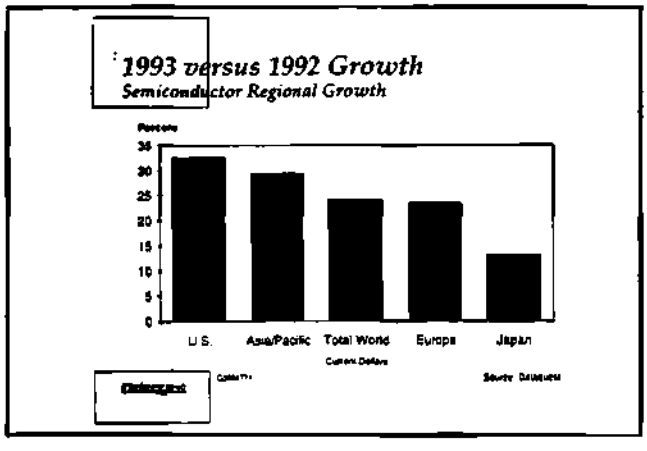


Figure 4

Asia Pacific's semiconductor consumption has risen almost 30% with a major portion of this consumption going into personal computer systems and boards, pagers and telephones, disk drives, and consumer audio and video systems. As long as the U.S. business continues to put hardware instead of people to work, the Asia Pacific region should continue to grow nicely.

This region is being supercharged by inter-Asia trade and by the high economic growth in China, which is absorbing record levels of PCs, pagers, as well as consumer products. One of our Chinese analysts, having just returned from a business trip to China, told me that in many of the companies and government meeting rooms there are signs that say no pagers or telephones are allowed because of the interruptions of the meetings. That kind of shows you where technology is moving in that country.

Dan Heyler, Manager of our Asia Pacific Research will give us his latest analysis and forecast on Tuesday. Because of the need to follow that part of the world in much more depth, we're going to be adding more people in 1994, as Judy mentioned.

Turning for a second to Europe, despite many of the macro-economic problems that Europe has had, the European semiconductor business and their customers have seen record levels in their backlogs and inventories. Europe is being driven, of course, by computing—just as in the United States—as well as communications and consumer products. European bussinesses are updating their factories and offices in order to be more competitive in the world. This process must continue because their competitors are moving very, very fast and and increasing their investments in new plants and equipment. We're very pleased to have with us here today Pasquale Pistorio, the President of SGS-Thompson, who is going to give us his European view of the worldwide industry. We look forward to hearing Pasquale speak.

Lastly we see that Japan is lagging the other regions due to the lower levels of investment by businesses and consumers. Also, we have observed that Japan is lagging the rest of the world in the usage of PCs and as a result they have not enjoyed or participated in the boom of personal computers and peripherals. Junichi Saeki, Director of our Japanese computer and peripheral research is going to talk to us about why there is this difference and give us his insights tomorrow about what he sees is going to happen in that industry.

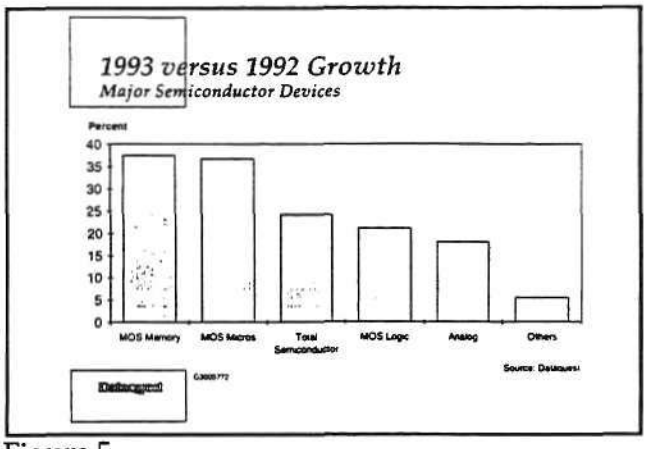


Figure 5

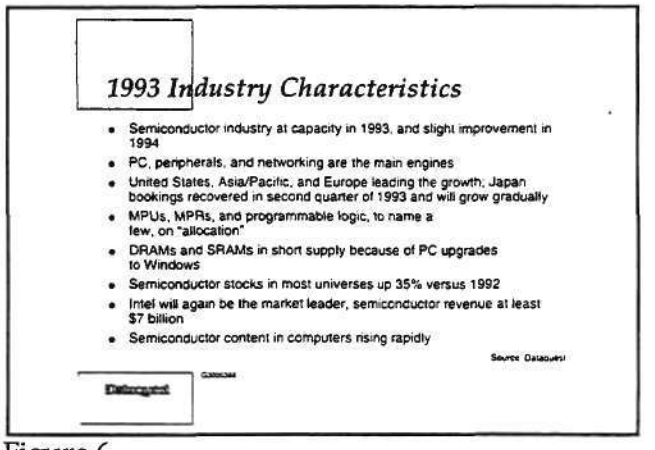


Figure 6

Now lets take a look at the major devices in 1993. The twin towers of MOS memory and microcomponents are the leading products in the industry today. Four megabit DRAMs and 32-bit microprocessors are the engines for this year. For example, we see 4-megabit DRAMs growing over $4 billion, where the whole industry in 1993 is going to be up $16 billion.

Because of under-investments last year in rapidly expanding sub-micron geometry devices, and specifically dynamic RAMs, many of the electronics manufacturers in the audience had to scramble for their allotments. This same condition was also true for thirty-two-bit microprocessors. In 1993 these devices are going to grow by approximately $3 billion. So with these two types of devices, 4-megabit DRAMs and 32-bit microprocessors, we have $7 billion in revenues, just short of 50% of the total growth this year. I call this story the "haves and the have-nots."

In the MOS Logic category, driven by a plethora of embedded control applications, PLDs have had the highest growth rate at 40%, followed by cell-based ICs and gate arrays at 19%. Analog still keeps turning out good growth at approximately 18% as mixed-signal devices find new sockets in all parts of the industry. Specific areas of strength that we see this year has been in cellular phones, fax/modems, analog braking, sound cards, and so forth.

Due to cautious investments by many semiconductor manufacturers and the accelerating growth of the computer peripherals and networking, we have seen a scenario of tight capacity in many sub-micron geometry devices. This year we will see the growth in the industry approximately of 25% and high levels of profits. One manifestation of this growth has been the semiconductor stock prices which are up over 35% in the universes of many security analysts, specifically Dan Klesken of Robertson and Stephens and Tom Thornhill of Montgomery Securities.

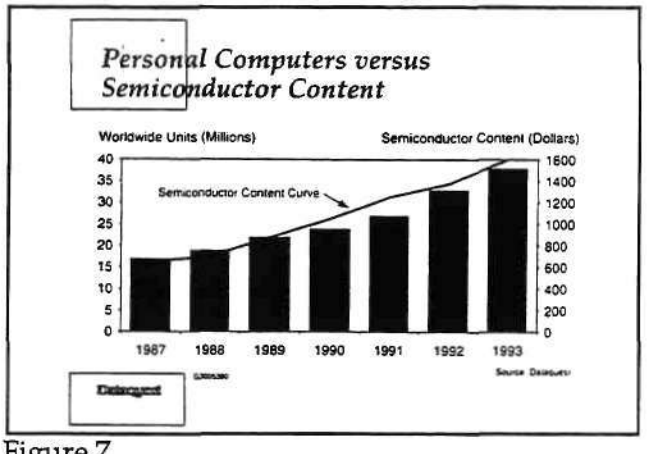


Figure 7

Also in 1993 we have seen the semiconductor content of systems rising very rapidly, especially in the low-to-medium sized portable systems. This slide shows the seven-year history of some research we've done. Here I show Dataquest estimates for worldwide PC

shipments and semiconductor content. In 1993 we expect approximately 38 million units to be shipped worldwide, with the leading-edge systems having about fifteen hundred hours of semiconductors. This content curve has had a compound annual growth rate of just over 15%, and we forecast content to increase faster than PC unit shipments as manufacturers strive to produce more differentiated, higher valued systems in order to survive among intense competition in this industry.

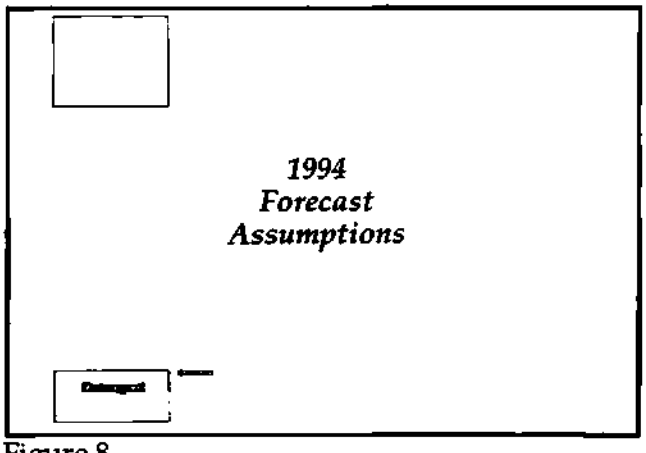


Figure 8

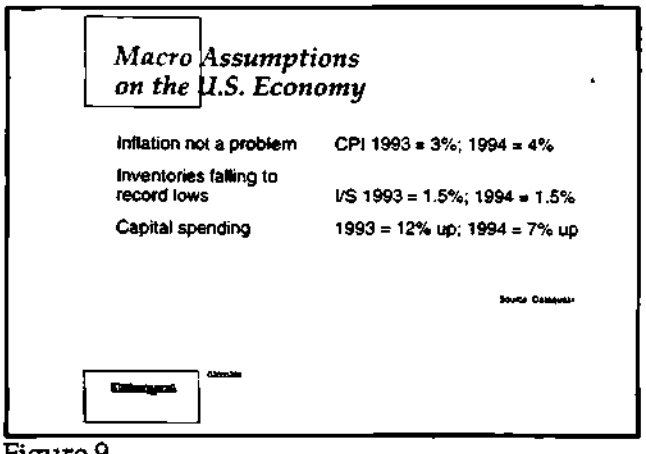


Figure 9

Historically there never was a perfect correlation between any one macro-economic variable and the electronic industry. However, we know from our research that as the industry has become more pervasive, the electronic share of U.S. capital spending has increased very rapidly over the last eight years. For example, in 1985 the ratio was about 25%. In 1993 we expect electronic expenditures to be about 45% of the total, having increased very rapidly after the 1990 and 1991 recession.

D&B's estimates show a less rosy outlook for capital spending 1994, up approximately 7%. But on a positive side, inflation is expected to remain low as are inventories-to-sale ratios for all manufactured goods. Further, we're assuming that semiconductor capital expenditures will grow about 20% next year and mostly in sub-micron geometry devices. This will certainly help the tight industry conditions that we've had this year. Recently many of the larger manufacturers of chips have announced expansion plans that are going to help with the shortages we've seen.

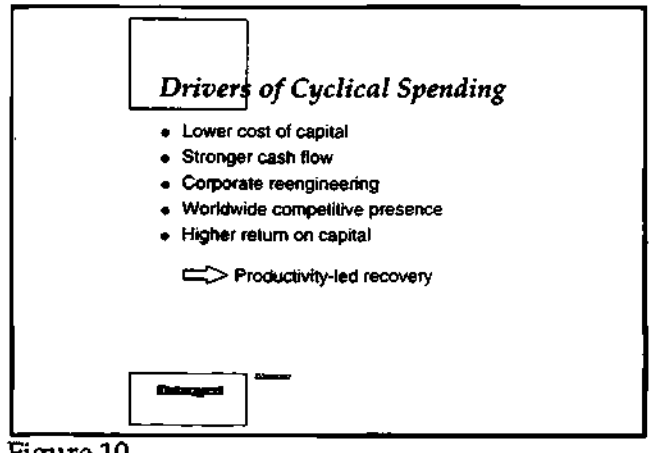


Figure 10

An interesting worldwide trend today is that the U.S. and European businesses are leading the world in putting technology to work. This is due to the lower cost of capital, making it cheaper for companies to invest in the information technologies. Today the rates are at historic lows and we expect them to remain that way throughout 1994. We believe that the U.S. has the advantage today in the cost of capital and productivity. Why else would Honda and Mercedes plan to build, and are building, their factories down South if it wasn't for this cost of capital and productivity?

Also U.S. businesses are continuing to downsize and re-engineer, resulting in stronger cash flows and higher corporate profits. One statistic worth noting is, operating earnings, adjusted for inventory profits and depreciation allowances, rose in the second quarter to an annual rate of 7.7 %. This would have been one percentage point higher had it not been for IBM's large loss in that quarter. The need to stay ahead of international competitors has lead many U.S. companies to invest more than their competitors. This is especially true in semiconductors and personal computers.

U.S. manufacturers are investing heavily in Asia-Pacific where they have the brightest outlook and a more level playing field than other regions of the world. All these factors have resulted in a productivity lead recovery, providing us with a guarded but optimistic outlook for 1994 for electronics and semiconductors.

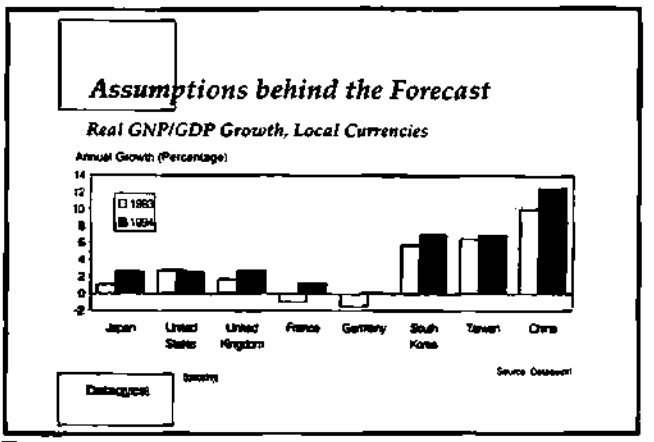
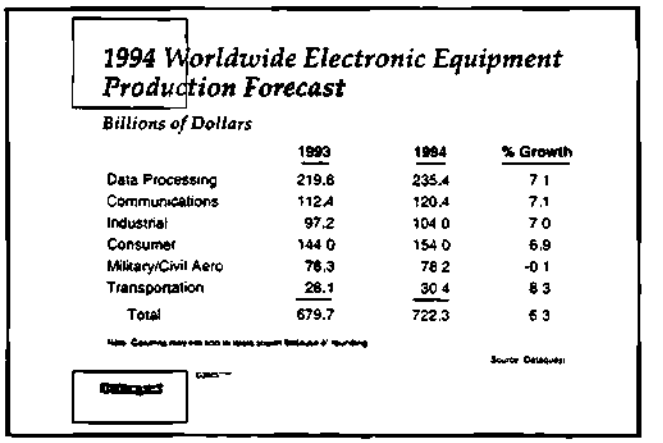


Figure 11

I'm not going to go into this table in depth; suffice it to say that we're looking for increasing GNP and GDP growth for most of the major countries of the world. In thinking about forecasts, we also ought to consider the fact that the overall economies will be healthier in 1994 than they have been in 1993.



	1993	1994	% Growth
Data Processing	219.6	235.4	7 1
Communications	112.4	120.4	7.1
Industrial	97.2	104 0	7 0
Consumer	144 0	154 0	6.9
Military/Civil Aero	78.3	78 2	-0 1
Transportation	28.1	30 4	8 3
Total	679.7	722.3	6 3

Figure 12

Now I want to talk about the electronic industry and our forecast. Overall we're forecasting the electronic industry shipments to grow at approximately 6.3% which was about the same rate in 1993. To give you a perspective in looking at cycles, the industry grew at about 3.2 % in 1992.

The largest, and of course the most significant sector, is the data processing industry. As I told you earlier, we expect desktop and portable PCs, client/servers and open architecture workstations to continue to be the drivers. These systems are having good growth rates but are forecasted to grow more slowly in 1994. Since these systems control approximately 35% of total semiconductor consumption, we expect the semiconductor growth in 1994 to be a little slower than what we've seen this year.

In the emerging products categories within the data processing industry, we look for the highest growth segments to be PDAs, subnotebooks, X-Window terminals, color laser printers, color copiers, solid state drives, and PCMCIA cards.

Consumer electronics is number 2 in terms of size. Our projected $10 billion growth will come from large screen TVs, (larger than 13-inch), laser disks, embedded CDs, personal stereo systems and 16-bit video games, digital compact cassettes and smart appliances.

Communications is forecasted to grow approximately 7%, the highest growth markets being Ethernet and Token Ring cards, modems, voice processing equipment, cordless and digital cellular phones, pagers, FDDI and ATM cards and fax machines.

As many users of technology focus on increasing productivity at the desktop, we're forecasting for the 90's a more rapid increase in semiconductor content in the electronic systems than we've ever seen in the last twenty years. In 1994 we expect more sound and video cards, frame grabber cards, LAN cards and higher memory content.

With this increasing content and continued globalization, we can expect the industry to at least maintain it's historical growth rates. Over the period 1992 to 1997 we forecast that the compound annual growth rate of the semiconductor industry will be 12%. This growth compares favorably well to the growth seen in the period 1986 to 1992. Over this period we estimate that the industry grew at 13%.

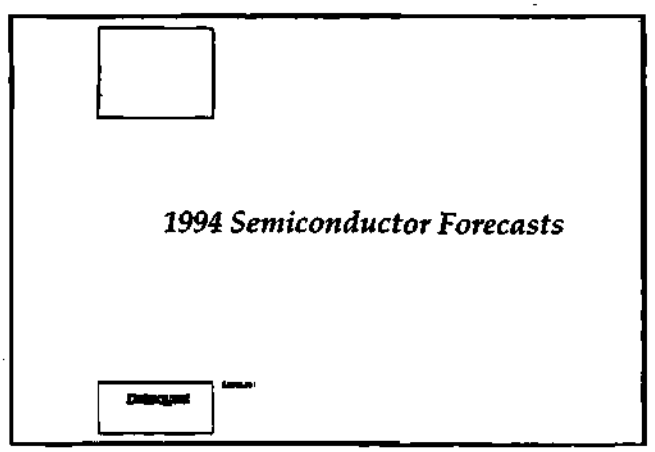


Figure 13

Here, I've given you an eye test, showing our quarterly estimates for 1993 and 1994. Basically, we see the total semiconductor growth rate for 1993 at about 24%, considerably above anybody's forecast one year ago. And we're forecasting a worldwide growth rate in 1994 of approximately 15%. The U.S. and the Asia Pacific regions will again be the big gainers for the same reason that we saw in 1993. For Japan we show a dollar growth rate of 13% for 1993, a -1% in real yen terms and we think that this region in 1994 will grow about 9%.

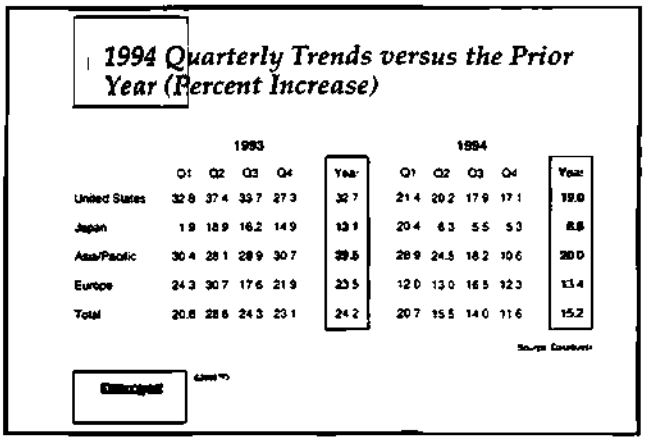


Figure 14

Japan's recovery, of course, is going to be driven by consumer, data processing and the communications market. And we expect the European market to grow in real terms by 13%, driven by the very large telecommunications industry, data processing and consumer. As you can see, we are looking for increasing quarter-to-quarter growth through 1994 with a slowing of the growth as we go out of 1994. This will be the result of slowing capital equipment expenditures and increased semiconductor pricing pressures as a result of the expansion of the factories.

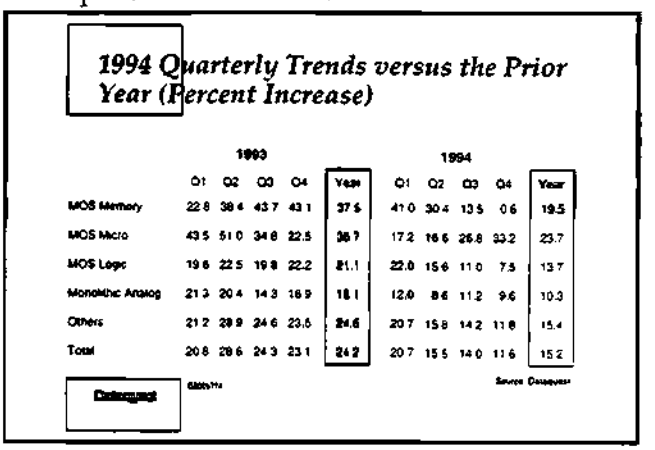


Figure 15

Looking at our forecast from a product point of view we expect more price pressures to come in the 4-megabit DRAM area due to increased capacity. For all memories we're expecting very good growth in 1994, but slower than we saw in 1993. The micro devices growth will also be a little weaker in 1994, but this category will still lead all the major product categories. Digital signal processing (DSP), CISC and RISC 32-bit microprocessors will have the highest growth. For example, we're estimating DSP at approximately 45% and CISC and RISC devices at more than 30%.

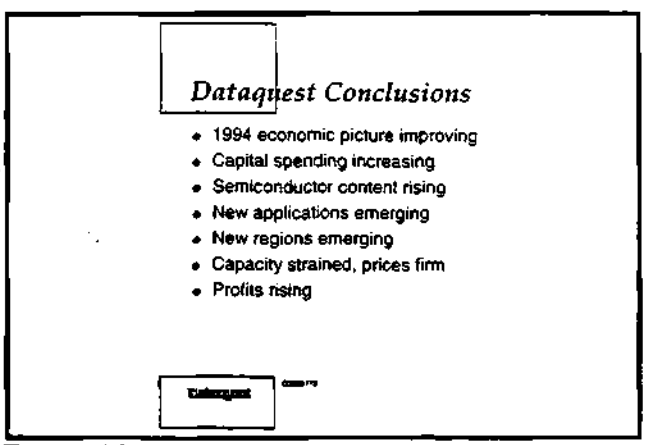


Figure 16

These are the years that I like to stand up here before you. It's fun for us and it's fun for you. Yes, of course we've had tremendous challenges in 1993 and we will continue to have these challenges in 1994. As we look out into 1994 we see another good growth year coming. But as we look out into 1995, we're looking for a slowing in that period of time. We think that the silicon cycle will bottom in 1995, but who's to say that the cycle can't be extended out beyond 1995? Remember all those forecasters who said the Berlin Wall would never come down, or that there never would be peace between the PLO and Israel, or that U.S. semiconductor manufacturers would continue to loose market share? These things also caused quite a surprise, and I'm sure that if we do see 1995 stronger than what we're now thinking, or 1994 stronger than what we're now thinking, we can also think to ourselves about those other forecasters.

Thank you for your attention, have a great conference and a great year.

KEYNOTE SPEAKER
Which Semiconductor Industry?

Gordon Moore
Chairman of the Board
Intel Corporation

Mr. Norrett: Now I'd like to introduce our keynote speaker for today's conference. Dr. Moore is co-founder and currently Chairman of the Board of Intel Corporation. Before founding Intel, Dr. Moore was Director of Research and Development for Fairchild Semiconductor, a company that he co-founded in 1957. He is currently a director of Varian Associates and Transamerica Corporation. He is a member of the National Academy of Engineering, a fellow of the IEEE and a Trustee of the California Institute of Technology where he received his Ph.D. in chemistry and physics. In 1990 he received the National Medal of Technology from President George Bush. Gordon loves to fish and he has three other credits that he doesn't talk about very much. Over the last twenty-five years Gordon has worked for the same company, lived in the same house and had the same wife. Three very laudable credits to his name. Please welcome Dr. Gordon Moore.

Dr. Moore: Well thank you Gene it's a pleasure to be here today, but I am preparing to move into a new house. The last time I spoke was on October 17, 1987, and while I was speaking I couldn't quite understand what was going on. People were mumbling and they were getting up and going out of the room and coming back in—I thought I must not have anything very interesting for them. I discovered later that while I was talking the Dow had fallen over 200 points, on it's way to a 500-plus fall that day. I hope I don't have the same effect on the market today.

Semiconductor technology is really the key electronics hardware technology. It has the tremendous advantage of being scaleable and capable of absorbing essentially unlimited functionality. I'll contrast it to some of the other important technologies. For example, flat panel display technology which clearly is key in many of the products we're considering. But once you've gotten to a certain level of resolution, certain screen sizes, it frankly doesn't do much good to continue to expend the technology in that direction because no one can take advantage of it.

Similarly, or somewhat differently, a technology such as magnetic storage on hard disks—which has been scaleable, capable of taking advantage of the technologies, increasing the information density with phenomenal regularity—still doesn't have the breadth of applicability of semiconductor technology where you can perform a wide variety of different functions while taking advantage of the advances in technology. The semiconductor technology, in its unlimited way, is not approaching any real limits yet; it's not yet a mature industry, and I think the rapid rate of change is going to continue.

The areas of change are going to come from the same things we've seen in the past, the ability of the technology to absorb more and more functionality and the quantitative changes of just absorbing more function. Decreasing the cost of function over a period of time makes real qualitative changes in the impact of the technology and the way we live.

Looking back, it's hard to believe today that we went out to try to sell the first integrated circuits some thirty-two years ago. They weren't embraced enthusiastically by the customer. The customer of the semiconductor industry at that time was principally the circuit designer in the systems companies, and he didn't take very kindly to somebody coming in and telling him his job was going to be incorporated on the chip and that essentially he was going to be made redundant in so far as the system was concerned. We didn't get around that problem until one of Bob Noyce's big contributions to the semiconductor industry occurred—he said "Okay, we'll sell you the complete circuits for less than you can buy the individual components." All of a sudden we got some significant acceptance.

Well, semiconductor technology has moved beyond that. We not only have picked up most of the circuit design, but the logic design, the system architecture. These functions increasingly come onto the chip as we have the ability to make more and more complex circuits. I see that continuing to be the case as our industry continues to drive down the cost of electronic systems.

This situation has expanded the applicability in a lot of directions I think none of us would have anticipated a few decades ago. Now your automobile engine is controlled by microprocessors—something that certainly I wouldn't have predicted in the 60's. In fact, to give you an idea of how good I was at predicting things, in the early days of integrated circuits I turned down the idea of semiconductor memory as being something that would never be practical so we at Fairchild didn't even file an patent on the idea. The economics just never seemed like they were going to make sense.

What I want to do here today is look at some of the changes that are occurring in the markets, the technology and economics of the semiconductor industry, and then identify some of the various strategies that companies have evolved (and will continue to evolve) to respond to these changes. My point is that when looking at the semiconductor industry, a simplistic view of the market is probably dangerous at best, and because of the wide range of applicability of the technology, I think one must take a finer view than looking at it as a single entity.

First of all, let's look at what's happening in the market. Esentially, I see what everyone else does, an impending collision of three very important parts of the civilized world. Computers, communications and entertainment all rushing together with some significant consequences.

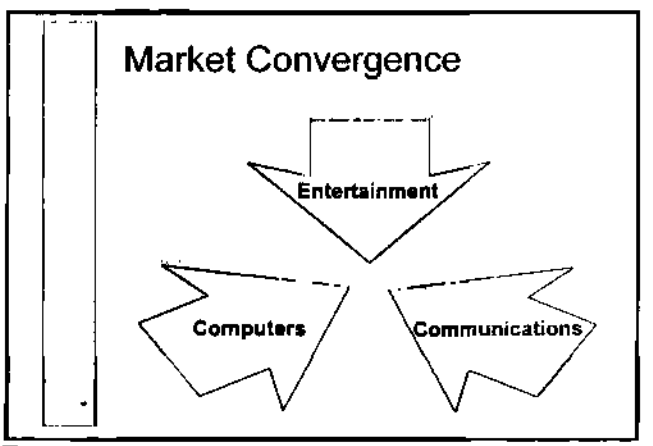


Figure 1

My idea of what happens next is that after the implosion we will have an entire new view of the industry coming out the other side, and frankly my visibility through a nuclear explosion is not very good. I can see the pieces coming together, but what comes out the other side though is going to be very hard to determine. I think there are a lot of people working on that today, and I hope many of you have a much clearer view of it than I do.

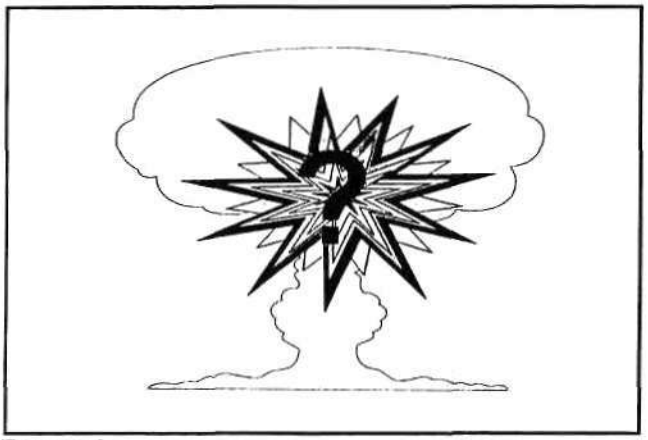


Figure 2

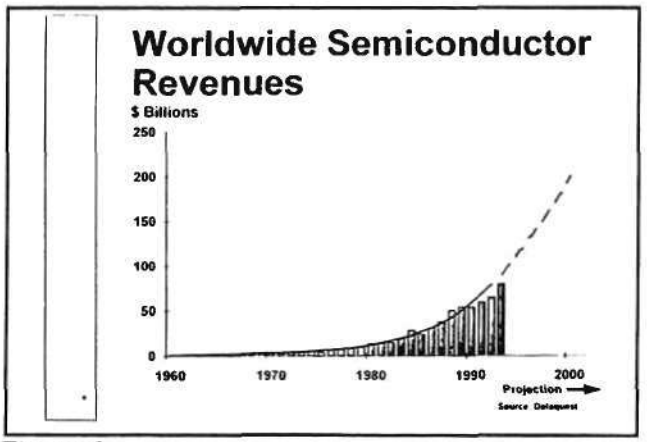


Figure 3

I notice the numbers of alliances and partnerships growing by leaps and bounds. In fact, I saw a newsletter recently that identified well over one hundred of these arrangements between major companies, particularly in the computer and communications areas, and some in cable TV and so forth. I know that this list wasn't complete because it didn't have any of the ones that Intel was involved in, and I can assure you, we also have our fingers in several of those pies. I think we're all indulging in something I'll call a "group grope," hoping that if we don't understand exactly where this is going, by working with our partners maybe we can all figure it out together. Certainly my vision of this isn't clear. I am, however, convinced that the impact of this convergence is going to be far reaching on society, and is going to present many huge business opportunities for the companies and entrepreneurs that can identify them.

The semiconductor industry has been a growth industry, and I've plotted it further back in time than you saw previously, and have drawn a line to show what has happened historically. It turns out to be reasonably close to the numbers that Dataquest has projected long term, predicting a market for semiconductors approaching $200 million by the end of the decade. Now I certainly hope this proves to be the case.

If we look at it in a finer grain, looking at more recent history, I've identified the portion of the market that is specifically related to desktop computing, and I was surprised to see what a small percentage of the total it is. Now clearly it was a major part of the growth over the last few years, but it's still only estimated at about 22% of the market in 1993. To me what this shows is the underlying strength of the broad market for semiconductors since the PC has clearly been the major engine of growth in the computer industry, and the one that I typically associate most strongly with the general advances of digital electronics.

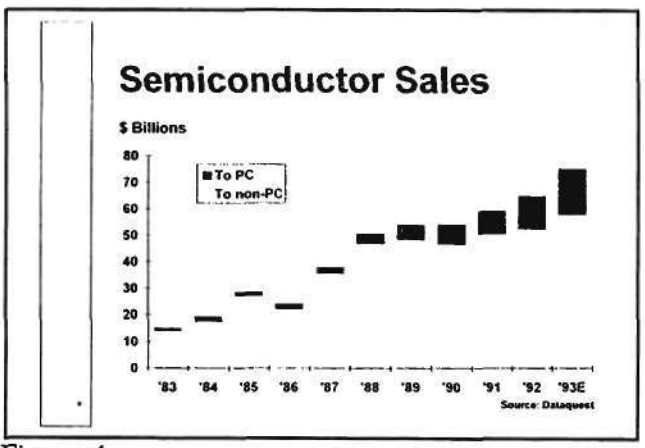


Figure 4

Well, let's look at what has happened to the technology over the last several years. Here's another case of convergence. In the 60's, the direction of semiconductor technology wasn't always certain. There was a new idea coming

along, if not every week, at least every few weeks, and it wasn't clear which of these were going to be the dominant technology or which were going to be important. I can remember arguments. Would MOS be one-third of the market? Bi-polar two-thirds, or would it eventually be the other way around. And new ideas, new device types, new structures, essentially changing the market direction—but these have kind of all converged now and I think the mainstream of the semiconductor industry is clearly MOS, CMOS in particular. This I guess is one sign of maturity of the technology.

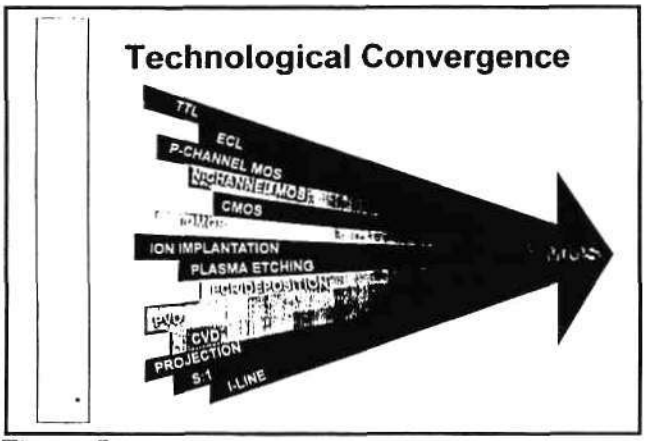


Figure 5

On the other hand, while we may all be going in the same direction, we're still moving very rapidly in that direction, and you can see that in the increase and the complexity of devices. You've all seen curves like this one—it's amazing to me how we have maintained our progress along these exponentials as long as we have. This shows both the DRAMS and the microprocessors—Intel's microprocessors in particular, since I can get things out of them more easily than other people's. But they all sprinkle more or less along the same lines.

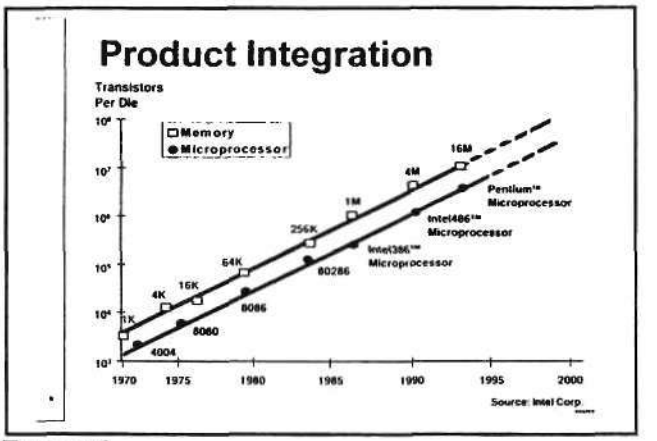


Figure 6

As the technology has grown, the processes have become more complex where the twenty mask processes are not unusual today. I look at this and it's hard to remember that one of the strong arguments for going to MOS over bi-polar was that we could do it with only four or five masks instead of the seven or eight that bi-polar required.

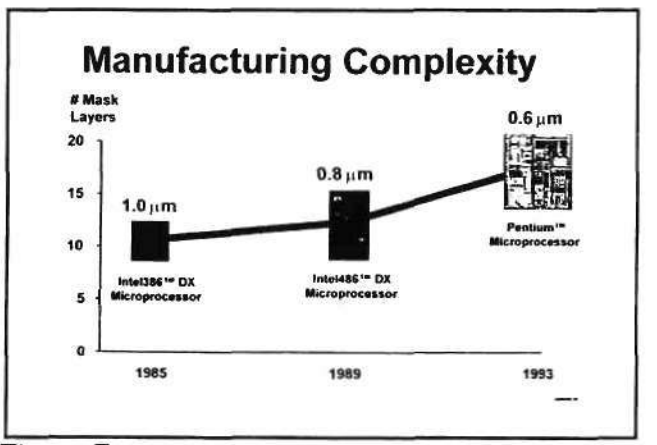


Figure 7

We are seeing this increase in complexity here, process complexity and device complexity both, but with no apparent slowing of the rate of which the industry is proceeding. One area of exponential growth that presents a problem though comes from the economics of the business. Here we have a divergence rather than a convergence.

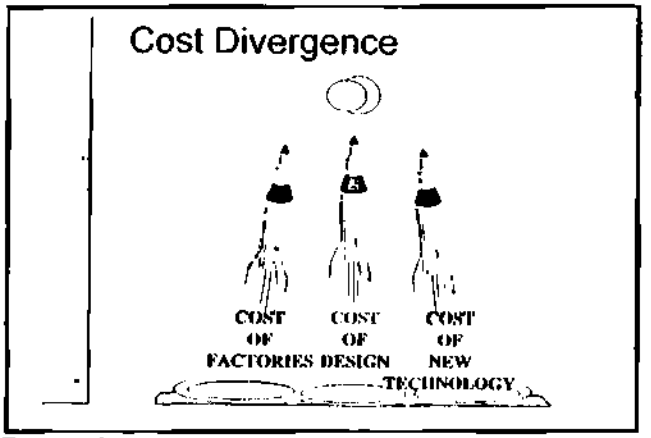


Figure 8

This has certainly changed the industry in many ways. Recently you have not seen many new full service start-ups in the semiconductor industry. Each of these areas has been growing dramatically. If I look at the minimum cost to the practice of modern technology, by minimum cost I mean the minimum building, one each of the pieces of equipment necessary to process something, not enough to make a significant number, but if you want to make one wafer this is really the kind of investment you have to look at. You can see you're well over $100 million at the levels of technology we're looking at at this stage of the game—clearly enough to make anyone wanting to get into this area think twice about it.

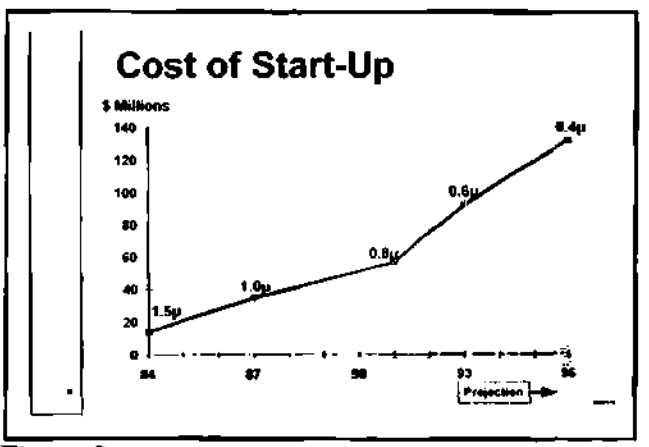


Figure 9

And if you really want to produce something, the average investment for a significant factory again is showing very rapid growth where you see at the half-micron technologies, we're looking at something approaching $200 million per thousand wafers per week. Or $200,000 per wafer, per week if you'd rather look at it that way.

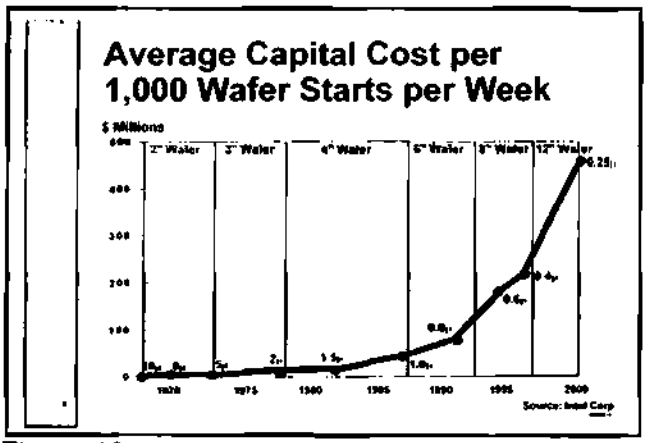


Figure 10

Moving on to next generations of technology where this really goes to high levels. Now I'm not sure I believe 12-inch wafers but I didn't used to believe 8-inch wafers either and it doesn't change too dramatically based on the wafer size. At least it didn't from six-inches to eight-inches, which surprised me rather significantly—but this is the reason you're seeing billion dollar plus factories committed these days. In order to make a reasonably balanced facility, one that manufactures several thousand wafers a week, say 4,000 or 5,000 wafers a week, the levels of technology we're investing in today, you usually end up with a billion dollar factory. In fact, it gets increasingly difficult to hold it below $1.5 billion.

If you see what this does to the cost of wafers, the largest single cost has become depreciation. I've shown this data previously and at the four-tenths micron generation, the data I had shown it as being above 50% of the wafer cost. I haven't checked back with my people to find out if they've discovered how to get more out of the equipment or how to spend more on non-equipment related items. In any case, the contribution to our cost comes from depreciation of the equipment which is really

continuing to rise, but it's not just the production costs.

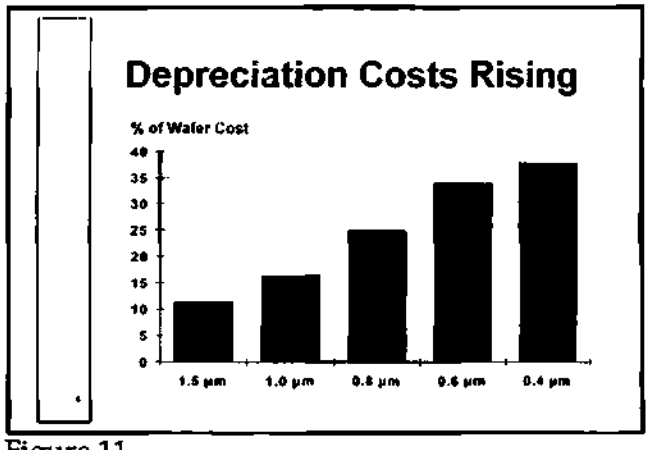


Figure 11

The research and development to develop a new process also grows dramatically. Now this shows a very large step between the six-tenths micro and the four-tenths micro. Again, I'm using Intel data in this case and it turns out, we built a new facility for our four-tenths micro that tends to weight it down a bit. Now I haven't put any scale on this because I think I might frighten you, but I'll give you some numbers you can use to put your own scale on it. We develop a new generation of technology about every three years. Our present R&D spending is about $900 million a year and about a quarter of that is on process R&D. You take those few together and you see it's many hundreds of millions of dollars to develop one of these new generations of technology and put it in production, making it a pretty darned expensive business.

Looking at the third rocket I had there, is the cost of defining and developing a new product. In this case, a new generation of microprocessor. And you see again we have a curve that's on a very rapid growth path. You can only afford increasing development costs that look like this if you're serving a market that's growing very rapidly. So the level of investment is dependant on maintaining the rapid growth in the markets that we've seen.

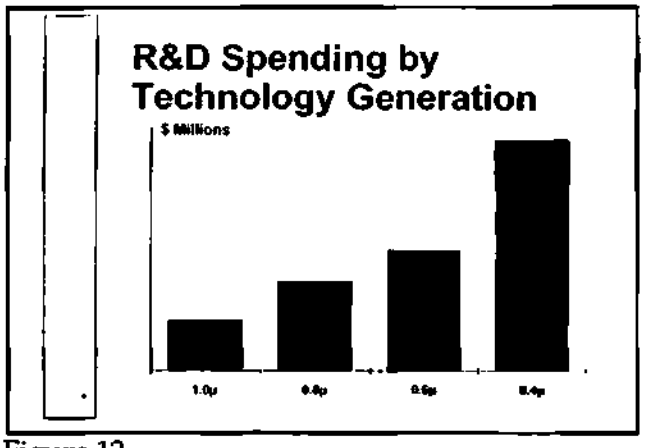


Figure 12

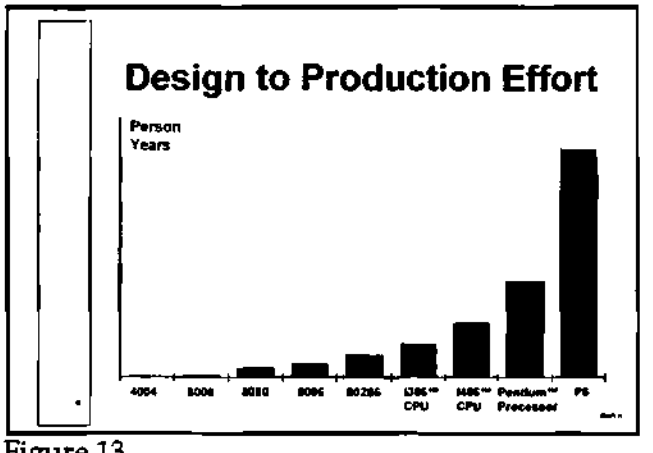


Figure 13

I think that any limitation in how fast we pursue the technology is not going to result from physical limitations—being able to make narrower lines or thinner layers, or anything like that—it's going to be an economic limitation, and the rate we can afford to invest as an industry may not be enough to maintain the rate of progress we've become accustomed to.

Well, as a result of these various forces, the semiconductor industry has really developed a variety of different strategies to participate. I thought maybe I'd review a few of these—I've listed them under several categories and would like to say a few words about each one.

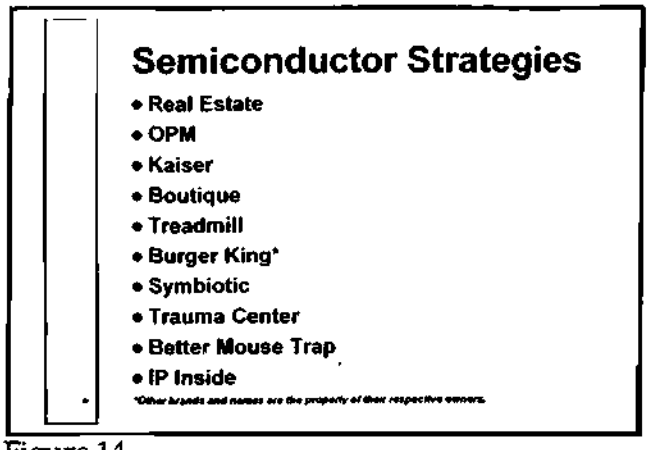


Figure 14

The real estate strategy is something that many of the companies have used for some time. Typically, we have sold procesed silicon for about a billion dollars an acre, and it hasn't changed much in the time I've been in the industry. In fact, I used to think that was the reason the Japanese were so effective in this business is that they are used to prices in downtown Tokyo. Some processors may be a few billion dollars an acre, for—for DRAMS it's gotten down to $500 million an acre—but it's been about that range ever since I've been in the business, not adjusting for the inflation or anything else.

So people have tended to build factories, price products and sell them based upon the real estate value of the silicon. It's been a high volume, modest margin kind of approach to the business. OPM could mean other people's money like it does typically in the investment community. I use it here though to mean other people's mistakes. Companies have based businesses on utilizing the capacity people built and found out they didn't need. Essentially exploiting the fact that people had made the capital investment and were willing to sell it's output for less than it would cost the company that wanted to use it to put in it's own facility. This has been a very useful strategy over the last several years. The fabless semiconductor companies are based on that kind of a premise, that other people will continue to build factories so they don't have to make the investment. I think it's a strategy that works better for a modest sized company. The bigger you get, the bigger mistakes the people you depend on have to make and I think that's a tenuous way to proceed, at best.

The Kaiser strategy—for those of you not from around here, Kaiser used to run around with trucks that said, "Find a need and fill it." This has been a successful strategy in a business that has the large number of special market niches that the flexible technology allowed, where people can find an opportunity, one that may have been neglected by the bigger participants or by all the participants in the business. They carve out a very nice marketshare and develop a good business in one of these niches. Clearly this is a successful strategy that has been employed by many of the successful start-up companies and has allowed several of them to grow to significant size.

I'll contrast it slightly with my next strategy, the boutique approach, which is to have some real special capability that people want. They plan on staying in that special area, but develop unique expertise that no one else has. This might be gallium arsenide amplifiers or some special linea r functions that really require some arcane knowledge in order to participate in. Again, a lot of the small participants have carved out places like that.

We've also seen the treadmill strategy. This is one that I think several of us got involved in—particularly in areas such as the memory business where you try to run to the next generation and be a little bit ahead of the people coming along behind—and everyone is on the treadmill trying to keep up. This can be a very high investment strategy, and one where if you miss one step on the treadmill you're likely to find yourself in the position of chasing someone else who's driving the treadmill. It has, however, been the strategy of those who like to live life on the leading edge of pursuit.

The Burger King strategy. This is the have it your way—tell me what you want and I'll build exactly what you're after—strategy. The

driving force behind what was called the ASIC business, really the customer-specific applications business of building custom circuits for whoever wanted them.

The symbiotic strategy—this one will find something where there is a big market and build the things to go around it. I would say that semiconductor chip sets have been built very much on that sort of a basis. They know the processors that are going there, and the processors require certain functionality around them. Companies that have specialized in this have built a very nice symbiotic business that develops as the processors go along.

The trauma center—you stop the bleeding. I have three big factories that I have to fill up with anything available—I guess this is the other side of the OPM strategy. This can be a very destructive influence on some of the other players in the market on occasion, but it's something that has been repeated over and over again. For one reason or another the investment has been made and you have to look at ways to minimize the negative impact of the investment on the company that made it.

The better mouse trap strategy is a fairly obvious one. You know, it's sort of the standard engineer's approach, and as long as you can find a better mouse it works fine. It's essentially identifying an application that people haven't seen previously, and getting there first with the product.

And the last stragegy, intellectual property inside. I guess it's a nirvana—it's seldom achieved, and it creates great envy among the other industry participants. It's a hard position to get into, we're lucky now that we have essentially a position like that in our microprocessor architecture, but it's not a position that is very easy to carve out and it takes a lot of luck along the way.

Each of these strategies really requires different capability emphasis—different core competencies on the part of the participants. I've tried to lay them out to see which kind of core capabilities are emphasized by the various strategies. If you look at this, you see that what you have to focus on differs significantly by the strategies that you're going to pursue.

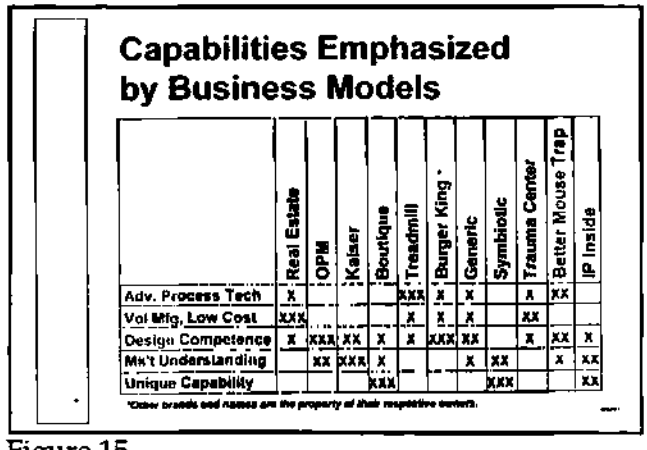


Figure 15

Now, very seldom does a company pursue one of my several strategies as their sole approach. It's usually kind of a mixture of the two, but companies end up with dramatically different emphasis on where they expect to get their competitive advantages, and what their internal capabilities are. In my opinion, the net result is that because of the way we've evolved, you end with a variety of different semiconductor companies—really almost different industries—and lumping us all together is a very simplistic and dangerous way of trying to track what's going on.

Let me look at a few other trends here now. First, capital spending as a percentage of revenue—this is for the top twenty-four companies. An interesting thing here is that the percentage of revenue in capital has dropped off the last few years. In fact, if it hadn't been for the Koreans who are spending a very high percentage of their revenue, this would have dropped significantly more.

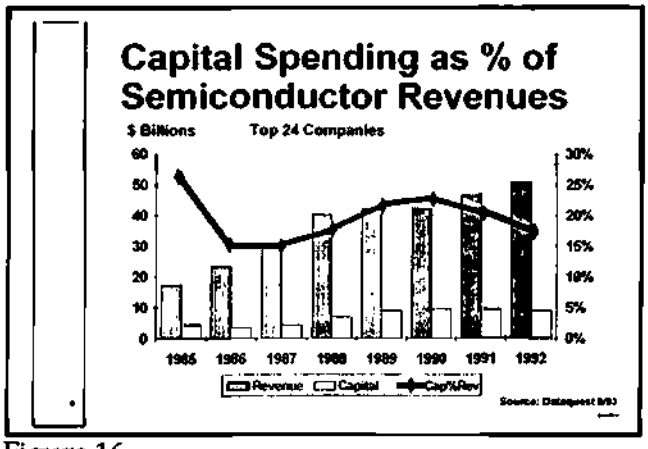


Figure 16

If you believe the increase in capital intensity I talked about earlier, showing the increase and depreciation cost of the wafer for example, this level of investment supports a slower industry growth looking forward. If you believe the growth extrapolations for the market demand that we've shown, it suggests shortages looking forward. That is, the rate of investment with the increased capital intensity has not been large enough to support the projected growth in the industry. I think this gives us cause to sit back and say, do we really believe the growth or is something else going to happen here?

A few conclusions. I think the technological direction of the industry is maturing. CMOS is the mainstream, but the technology still has a very long way to go. We're not closely approaching physical limits at all. I can see how we'll take the next couple of generations—I've never been able to see more than a couple of generations ahead, so by my simplistic view, the technology is moving as fast as it ever has.

I think the market is going to change dramatically. I really think we're going to have almost chaotic conditions in the market as we try to work through which new products are going to make this technology most useful to the user; what kind of devices we're going to carry around; how they're going to communicate; what functions are they going to perform; is entertainment going to be mixed in with business applications? There's a lot of sorting out here to do, there are going to be a lot of trials, and a lot of things that don't work on our way to finding the ones that really prove to be very important devices.

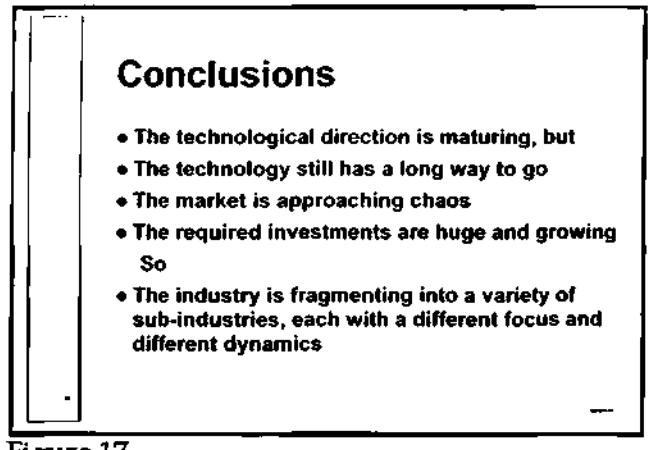


Figure 17

I've got to think back to my getting into the watch business—my $15 million watch here. When Intel got in the watch business we looked upon that as a way to get a personal electronic system with every person. We were thinking of all kinds of functions that would end up on the watch. By the time we got out of the business, the chip cost less than the pushbuttons to set the time on the outside of the case. We completely mis-estimated how that was going to work. Looking forward, I think we're going to see a lot more of that.

The required investments are huge and growing. This is something we have contended with for some time, but I don't see the direction really turning around. So the industry is fragmenting into my view of variety of subindustries, so that the local conditions for each of these subindustries makes sense. Each of those has a different focus and different dynamics. I think it should make very interesting material for these conferences for many more years. Thank you.

I'll be happy to take questions.

Questions and Answers:

Question: Gordon, there's a lot of discussion lately about these giga-fabs, these billion dollar fabs—but if you're building microprocessors that are selling for $900 apiece, and are 8-inch wafers, and if you get reasonable yield you get your money back very, very quickly. So they are very expensive but they're a very good investment too.

Mr. Moore: I'd love to be able to fill those with $900 processors frankly, but with $60 processors it's not quite so easy.

Question: What is your outlook regarding Moore's law on semiconductor price for performance decline?

Mr. Moore: Moore's law gets used for a lot of things for which it wasn't originally intended. Originally it was just the increase in complexity with time—the continued increase in complexity still will give us significant decreases in performance. To continue my real estate analogy, we may be selling a billion dollars an acre on silicon but we increase the development density all the time. As we make things smaller and smaller, we pack more in the same amount of area, decreasing costs, and most of that cost decrease gets passed on to the end user. I see this continuing for some time. Looking forward, it's not difficult to see another one-hundred-fold decrease in the cost of electronics, but that will take us quite awhile. I think another one-hundred fold decrease in the cost with a commensurate increase in the complexity of the chips is going to have just fantastic impact on the kind of systems that can be built.

Now I've exhausted the questions, right? Okay, thank you.

Merchant Market Success Strategies

Dr. Michael J. Attardo

Senior Vice President; General Manager,
IBM Microelectronics

Mr. Norrett: Our next speaker is no stranger to what Gordon called "group grope." He has a number of alliances that Jim Picciano talked to us about last year. Jim reports to Mike Attardo and we're very pleased to have the top guy with us today. Dr. Michael Attardo is an IBM Senior Vice President and General Manager of IBM Microelectronics Division. Over his distinguished twenty-six year career at IBM he has served in a number of engineering and management positions prior to his present position as Senior Vice President. Dr. Attardo has B.S., M.S. and Ph.D. degrees in metallurgy from Columbia University. He is a member of the board of SIA. I asked Mike to tell us some of his strategies for how he is going to pursue the merchant market, and I'm sure that he has thought through this thoroughly, and is going to craft his words very carefully so that he won't tell you exactly what's on his mind but still share some very interesting thoughts with us. Welcome Dr. Attardo.

Dr. Attardo: Thank you very much Gene, and thank you ladies and gentlemen. It's certainly a pleasure to be here in San Francisco with you today. I'd like to talk a little bit about the challenges facing semiconductor companies attempting to be successful in this very competitive and global marketplace. These challenges come with a price and bring a host of problems, but you know what? After the rough road is done, it will be well worth the effort. I think after you look back over the next two days, you'll see that we are indeed in a very bright industry.

Now when Gene first asked me to speak to you today he assured me that there was a great deal of interest in where IBM Microelectronics is going. About a year ago, we announced that we'd entered the merchant marketplace and that we'd introduce leading edge products and be a serious and innovative player.

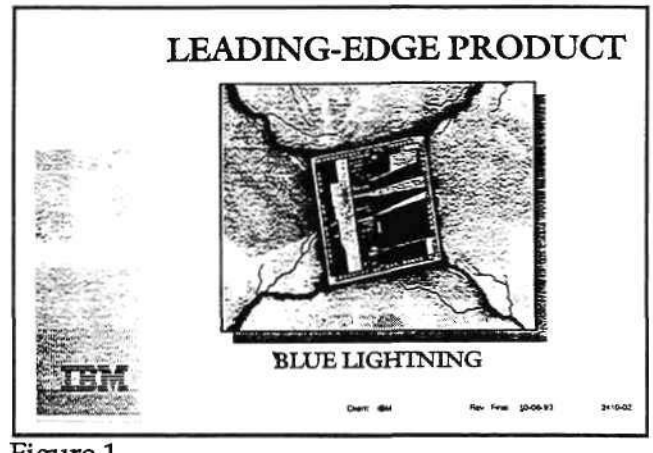


Figure 1

Though we've much to do, we have indeed lived up to that promise. The market we entered about a year ago was growing and dynamic, and we saw ourselves as uniquely positioned to take advantage of that growth. To make that happen, we have significantly streamlined our organization to be competitive in a global sense. We've capitalized on existing alliances and have sought new ones. And, we've shifted our product line, building our reputation as a total solutions technology business. We've been building a worldwide marketing infrastructure. Our objective is to earn a larger piece of the market and the

growing industry, one with room for many players.

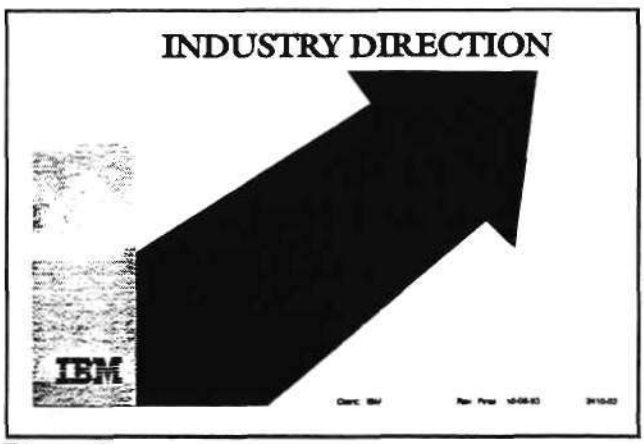


Figure 2

So where do we invest our money and what is our strategy? I boiled the list down to three main ideas that I'd like to share with you. The ideas at the heart of our IBM Microelectronics strategy are first, supplying the customer with high value-added function.

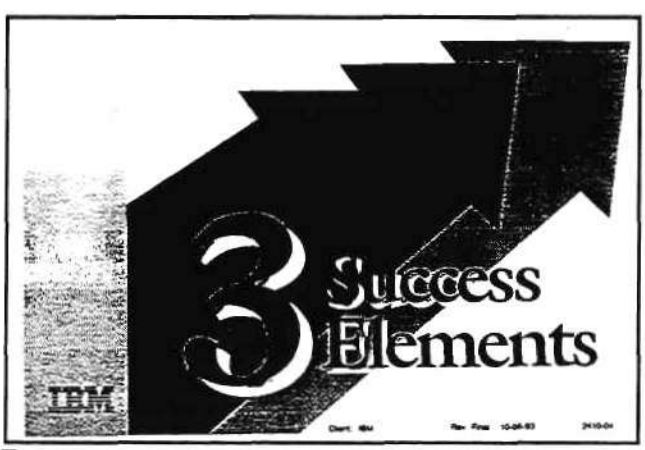


Figure 3

Second, alliances and joint ventures will play an even bigger role tomorrow than they are playing today. Third, those enterprises that own superior designs and architectures will gain a larger share of the existing and emerging markets.

If the past is any indicator, the future is brighter for the manufacturer who falls into the value-added category. The move toward value-added and away from commodities as a primary focus is a change driven, in part, by a slide similar to what Gordon Moore showed, that is the convergence of computers, communications and consumer electronics.

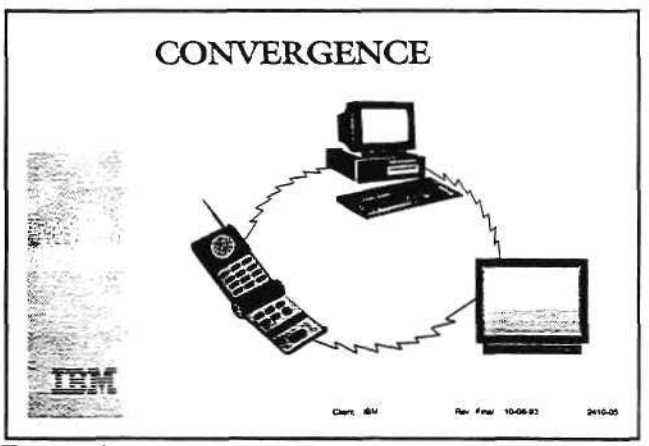


Figure 4

The first personal computer served basically two main purposes, word processing and spreadsheets. But the convergence of technologies puts us on the brink of an almost endless world of information and entertainment—a world of new and creative solutions for businesses and customers. What does it mean when it comes to system requirements? It means higher performance, higher function, lower cost—it means smaller, thinner, lighter—and it means low power and portability. It also means subsystems on a chip, module cards that are increasing complex, and it means more multi-chip modules. Component suppliers will become subsystem suppliers, and they will want to do that because that's where the profit is going to be.

Making that a reality leads me to my second point, alliances and joint ventures. Today, as Gordon pointed out, the cost of developing a new process technology is approaching a half a billion dollars every three years, and likewise the cost of putting on line a competitive factory to make that technology is approaching $1 billion every three years. These costs quickly get your attention and make it crystal clear why so many players in this industry are teaming up and forming alliances and joint ventures.

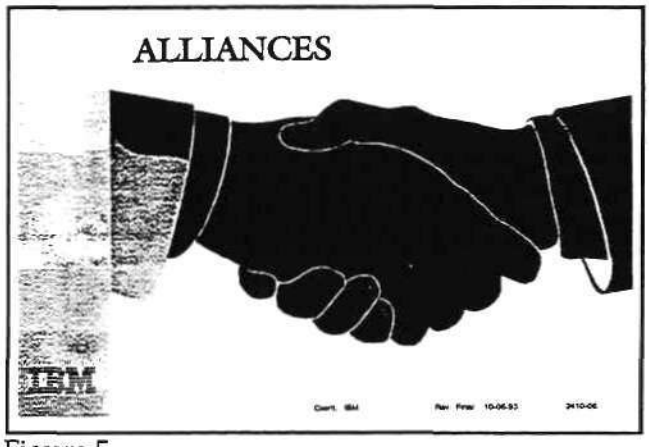


Figure 5

For example, at IBM we have agreements with Seimens for the manufacture of 16-megabit chips in Europe. We also have an agreement with Seimens for the development of the 64-meg DRAM which we are currently spreading samples of in Europe and in the United States. Further, we have an agreement with Toshiba and Seimens in the development of our .25-microprocess technology for our 256-meg DRAM.

Through such alliances, we will continue to be a process technology leader at the lowest possible cost through the quarter microdesign rules. The list of alliances is a long one and certainly includes a lot of you here today. I anticipate that list will grow as we move through time.

Many of these alliances and joint ventures will produce superior product designs—and that leads me to my third point. The best illustration of that today is the Power PC. IBM teamed with Motorola and Apple to develop a family of microprocessors aimed at shattering the notion that RISC is strictly a workstation-based technology.
Figure 6

We want our new microprocessor family in millions of computers, not only desktops, but palmtops and all the way up to large computing systems. And not only in computers—but portable phones, automobiles, or any other product that demands a processor. We want to operate in Mac, Windows, OS/2 and UNIX environments and all other major operating systems. In other words, we want to be mainstream.

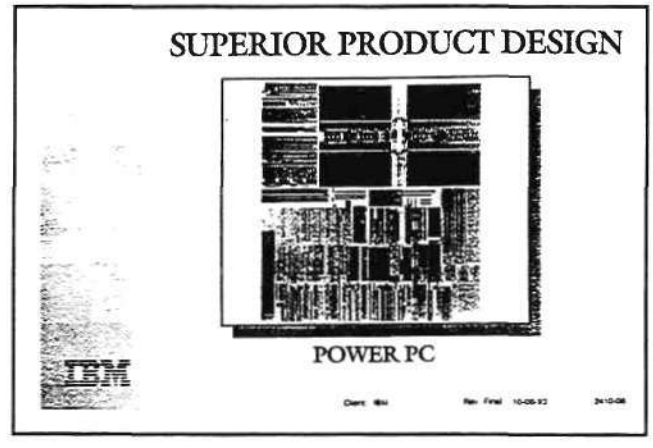


Figure 6

The core of the global computer revolution is not the computer. It's the enormous power of the microprocessor. The Power PC microprocessor family has what it takes to be one of the principal players in the industry. By the way, the 601 is now available in volume production. And the next generation in this series, the 603 was shipped for testing just a couple of weeks ago in sample quantities to IBM's Personal Power Systems organization in Austin, Texas. The Power PC has impressive cost and performance benchmarks, and major IBM microelectronics customers have already publicly endorsed the Power PC.

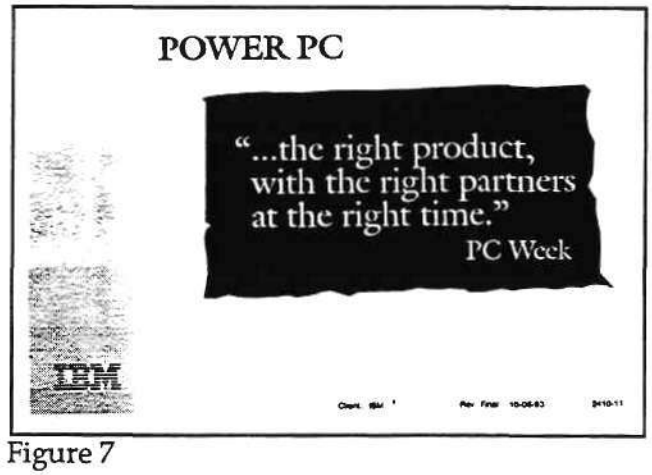


Figure 7

They include Groupe Bull, Harris, Thomson CSF and Apple. The processor has also earned positive attention in the press. *PC Week* called it, and I quote, "... the right product, with the right partners, at the right time." *Byte* magazine honored Power PC technology at this year's spring Comdex with its Most Significant Technology award.

On the product side, Apple has announced its Mac line will be exclusively powered by the Power PC. Last month IBM introduced its first Power PC based RS/6000. That announcement ushered in a new era of computing capability, giving our customers the ability to do things they could only previously dream about.

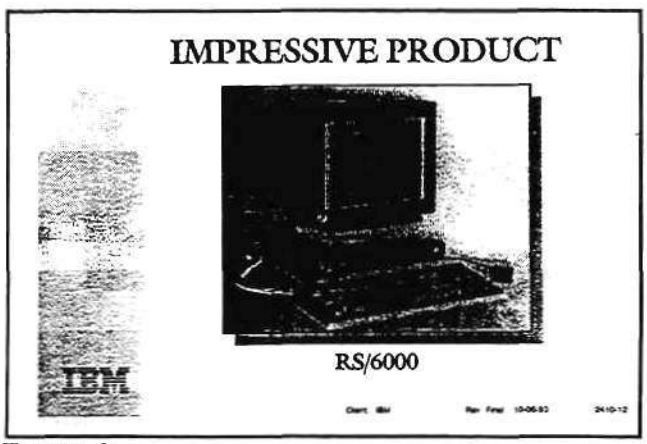


Figure 8

Why? Because this processor offers higher power, higher performance and lower power consumption than any other processors. And it's the most flexible and scaleable RISC architecture in use today.

Now I don't want you to think the Power PC push means we're not interested in the X86 architecture anymore. We are actively pursuing two opportunities within the microprocessor market. The Power PC is our strategic platform and emerging market opportunity. On the other hand, the X86 is today's industry standard platform and today's market opportunity.

We are putting effort in both the X86 and the Power PC markets, and we intend to do so as long as our customers want us to. By the way, we recognize that the Power PC won't be successful unless it is accepted by operating systems and applications developers. There will be an announcement some time in the next few months giving more specific direction on our operating system efforts. To refresh your memory, IBM has said AIX will be available for the Power PC, Sun has said that Solaris will work with the Power PC, and Apple System 7 and Taligent have publicly committed to the Power PC too.

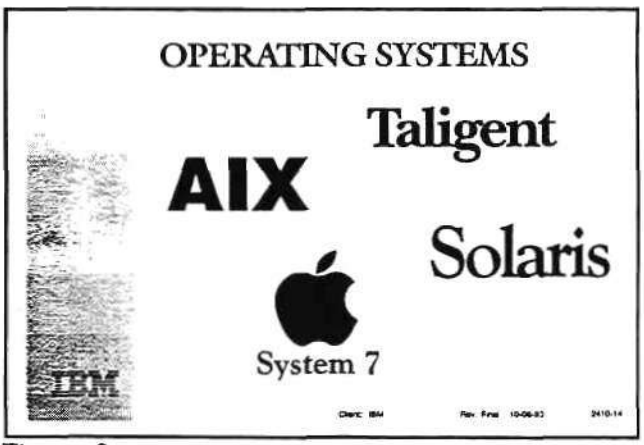


Figure 9

And what about Windows NT? Here is the best answer I can give you right now on NT. Our objective is to have all popular 32-bit operating systems ported to Power PC, and to provide migration to 64-bit operating systems, as well. And now, what about independent software or vendor support? Through Power Open, more than forty ISV's have already pledged they will pursue native mode application recompiles—and additional support is pending. Before the end of the year, we would like to make those names public.

All our work in both the X86 world and the Power PC world is solid proof of one of the commitments we made when we entered the merchant market. Namely that we would have a steady stream of competitive product introductions. Since then, in addition to the X86 and Power PC processor announcements you have seen from us, 16-megabit DRAMS, and a family of powerful leading-edge data

compression products. Leading edge application specific integrated circuits, embedded controllers based on our Power architecture, PCMCIA cards, digital signal processors, and M wave and communication adapters, bringing voice messaging system technology to the PC. And, they have all come at a steady clip in a short period of time.

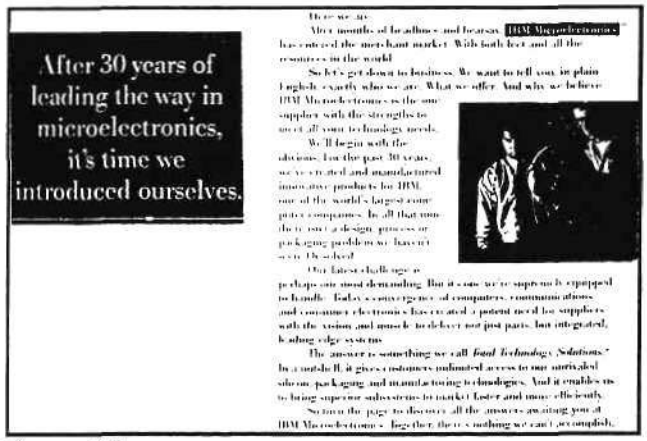


Figure 10

Just as important as introducing new products is getting our name out there so people know we're in business and we're serious. And that is why we changed our name last month from Technology Products to IBM Microelectronics. It gives the customer a much better feel for who we are—an organization that provides microelectronic products, subsystems and services to a wide range of customers.

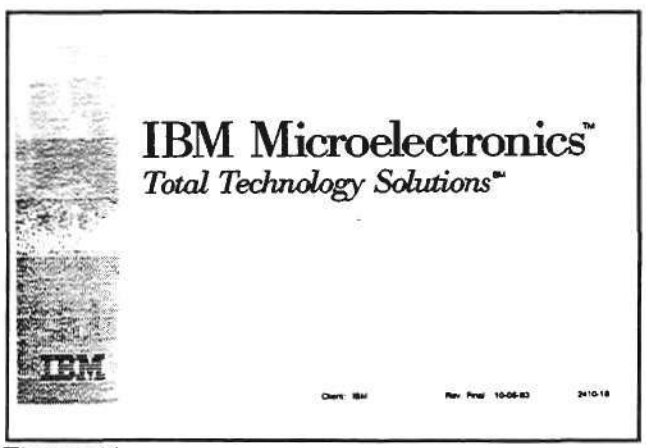


Figure 11

With our design technology coupled with our leading semiconductor technology, supported by the necessary worldwide manufacturing purchasing and distribution capability, we can easily offer systems builders, on a one stop basis, the kind of semi-conductor and subsystem solutions they need to be successful players. And this is important—customers now have access to our unrivaled silicon, packaging, and manufacturing technologies. We will concentrate on our core business, doing what we do best, providing total technology solutions to all our customers inside and outside IBM.

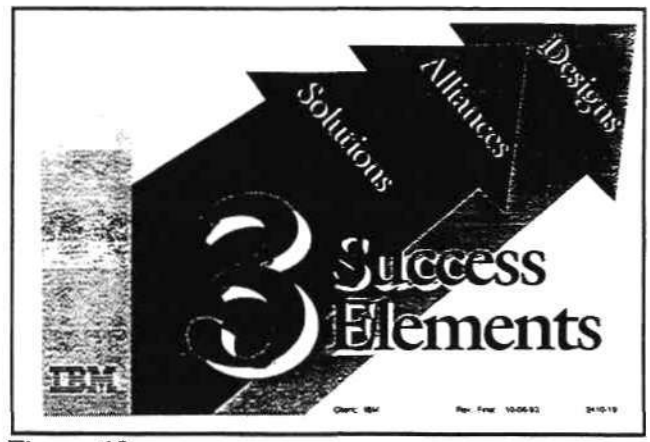


Figure 12

As you've seen this morning, we are serious about this effort. In making that clear, I've talked about a three-pronged strategy that I believe will lead to success in the merchant market arena.

First, we will deliver integrated leading-edge, value-added solutions. Second, we will find smart, aggressive partners for joint ventures and alliances. And third, we will bring to market superior product designs for a very broad range of applications.

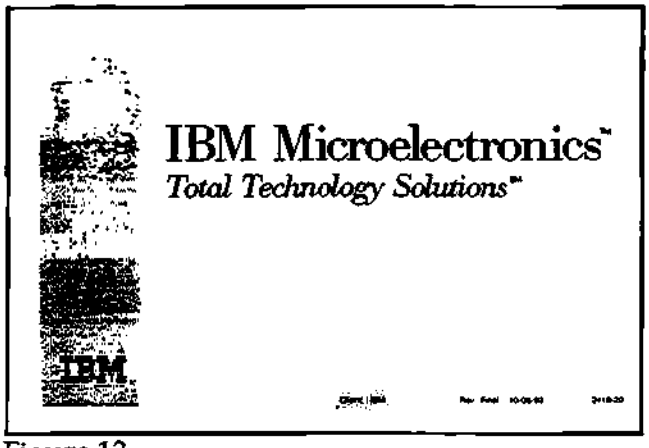


Figure 13

At IBM Microelectronics, we are uniquely positioned to capitalize on all three elements of this strategy—and I am excited about the possibilities over the next few years. Thank you all for all you're doing in terms of creating a very exciting environment. I thank you very much.

I'll gladly answer any questions that you might have.

Questions and Answers:

Question: The question is, is there any major differences on strategy for serving demand in Asia and Europe, versus North America?

Dr. Attardo: I can tell you that we've started to build our infrastructure both in terms of manufacturing reps and distributors in North America, and just started that effort in Europe and barely begun in the Far East, so that effort is embryonic at this point in time.

Question: What challenges do you anticipate in managing your alliances and forming new alliances?

Dr. Attardo: I can tell you, that we have several major alliances, as I have touched on, our alliance with Seimens in manufacturing in Europe, and Seimens with joint development with the 64-bit development program that have been very successful. We have German people in our factories and we have Germans in our advanced semiconductor technology center in Fishkill, and have encountered no problem with cooperation. If you look at those people, they look as if they were working for one company. We had a similar experience with Toshiba in those same facilities, and the cooperation there has been outstanding. On the other side on the alliance issue, we have a design center in Austin, Texas in which people from Motorola, IBM Microelectronics, and the Advanced Workstation Systems Division are all working side-by-side and we have yet to see any significant problems—just tremendous synergy among people doing the work in developing those processors. So overall, I would say that we have seen nothing but good things evolve over the alliances that we have put in place over the last couple or three years. And, they have gone a long way toward saving us capital dollars as well as development dollars.

Question: Doctor Attardo, over the years, IBM has been one of the leading companies in the world at developing manufacturing processes and technologies, and in some cases you've actually spent very significant sums of money with tool developers to bring new processes and tools into the fab world. At IBM Microelectronics, is that task going to be primarily shifted to consortiums and alliances like Sematech, or will you still try to maintain a competitive advantage by doing tool development on your own?

Dr. Attardo: We are doing very little tool development on our own. We have put very significant amounts of money in SVGL over the last three years, but that work is terminated, but I think we've given that company a good kick start at this point in time, and it has the potential to make lithographic tools that are second to none. I think that our effort has contributed to that as well as the Sematech effort, and I think some of the leading edge companies like Intel and Motorola are at the threshold of buying some of those tools. But in terms of us footing the bill exclusively to provide technology leadership as we move into the year 2000 and beyond, our finances will no

longer permit that. But we still will have to work in conjunction to Sematech to allow us to maintain that leadership. Although the expenditures we have made over the last five years, in terms of the alliances with Seimens and Toshiba, we believe will keep us at the leading edge of processor technology through the end of this decade.

Thank you Gene.

Multimedia and Microelectronics: Building the 21st Century Partnership

Robert M. Kavner
AT&T Group Executive,
Communications Products Group
AT&T

Mr. Norrett: Okay, we are about ready to begin our second session on applications and semiconductor devices. Our next speaker is Mr. Robert Kavner. Robert Kavner is the Executive Vice President & Chief Executive Officer for the Multimedia Group. This sends a message to all the watchers of AT&T, that AT&T is responding very quickly to the changes in the marketplace. Multimedia as we know is on everybody's mind here and around the world, and for a company the size of AT&T to react as quickly as they have, tells me that they have their eye on this industry and are responding.

Mr. Kavner has many years of experience at AT&T and has distinguished himself as one of the direct reports to Mr. Allen, the Chairman of the Board. Mr. Kavner, prior to joining AT&T, spent eighteen years with Coopers and Lybrand, and is on the board of directors of five corporations. He is a very busy man, and we are very pleased to have him here with us today.

Mr. Kavner will give the audience some idea of how the confluence of the computing, communication, and consumer industry will create new opportunities, and talk about how the products that come from this confluence will be determined by the value added in the semiconductor chip.

As you know, in the past we've had speakers from AT&T, Bill Warwick, and Curt Crawford, talk about where they see the chip industry. Bob is going to be coming at it more from the systems perspective down to the semiconductor devices. Please join me in welcoming Mr. Kavner.

Mr. Kavner: Good morning. In the half hour I have with you I want to accomplish a number of things. I'd like to give you a sense of AT&T's strategy—what we are doing and what we're not doing. I will give you a sense of how we view partnering, and the role partnering will play at AT&T in the future. I'd like to give you a context on our microelectronics business. This is a growing business—in '93, 40% of our volume outside AT&T—that will cross over the fifty percent mark in by the end of the year. We are driving that business to be customer focused, and it's obvious to those of you on the semiconductor side that it's not just selling the component, but selling the full solution support, including tools. So I would like to give you a sense of where we are there. Then fourth, an insidious objective I'd lay out, is something about the human eye. I think that is one of the subtle drivers that is affecting the confluence of industries. The human eye has been excluded from the network world, very dissimilar to the human ear. Today, we can have hearing instantaneously with whomever we want anywhere in the world. We are entering the period where the technology and capability will allow the human eye to travel the same course as human ear.

For a human being to see and hear concurrently is a very powerful change in social dimension. All of you here are paying a very fairly pricey conference fee, but you could have stayed at home and listened to these presentations.

Instead you chose to go through everything you went through in order to be here, because there is something about your eyes that works. Even though I am speaking your eyes are legitimizing. Your eyes are giving you bits of information you wouldn't have had. And obviously there is the social context that this forum provides. So those are my four objectives.

I have set up a video that we put together. There are many different models and questions in people's minds of "where are we going?" So we made a video for our own people to describe the world that we would like to be part of creating. Its objective was to give the 350,000 people in AT&T a sense of our vision, our strategy and tactics. We have promulgated this video throughout AT&T and asked all of our people using quality tools to make sure that their work, development, or marketing programs are designed to get us on that path. I'd like to show the video because it does give you a sense of what we see as the world that we would like to be a part of creating. Many of you are customers, and we also buy a lot from many in this room so this is a video that describes the nature of the relationships that we'll have. Here's AT&T mission statement. It's mapped against a matrix that I'll flesh right after the video.

It's a broad mission but one that deals with AT&T's core competencies of bringing people together even though they are apart. So, with that, I'd like to give you this nine minute video. Sit back and enjoy it. There's even a little plot -you can figure that out, and then I'll come back and talk about some of the technologies that are needed in order to make that video come alive. Will you go to the next slide and roll the video.

(Video)

This is the mandatory slide of conversions—a little bit more fleshed out than what Gordon showed. But the underlying principles are exactly the same, that there is a great movement of industries, and that industry boundaries are no longer relevant. For this first time in our hundred year history we have developed relationships with other companies and other industries. And these other industries are not just customer supplier relationships. We are finding that many people in these industries have very similar strategic intents. As a company, we have identified a number of applications areas that we would like to concentrate on—and partner with others. I would like to spend a brief amount time on each one of these to give you a sense of what we mean by it and elements of what it will take to be successful.

Network computing, distributed computing, client/server computing, microprocessor based computing, however one describes it, is fundamentally a new way of computing. There is a very large need for clarity around communications protocol that could link multimedia terminals together. Again, our heritage is linking terminals together. This is an area established with very rigid specifications and communications protocol for moving large bandwidth information, whether data, image or video, so we need rigor in terms of protocol conversion.

High speed global networks are going to be essential. Today, AT&T's underlying network is digital—a fiber network. The local access networks in the United states and around the world for the most part are narrow band. In the Western world, the PTT's or local exchange companies are narrow band, high quality, two way. In the less developed part of the world, information has a long way to go to travel. Cable exists in many parts of the globe, but this is wide band, mediocre quality, one way. So both local access providers need to travel, of course, so that they have high speed broadband networks that tie into an AT&T global network environment that exists today. Many technologies will drive this. Some of you are involved with them, like the CAPP technologies, ADS Cell, ISDN networks today and full fiber deployment to the home or to the curb.

Scaleable processors are a major subject for many of you here today. I think that every microelectronics company is driving their processors to be scaleable for small as well as very large things. In terms of messaging and wireless, we have at AT&T a processor that we are marketing called the Hobbit. It is not a processor for every application, but is essentially a processor for communications intensive environments. We are a very big user of Intel processors, and we scale them right up to the massive parallel computers that NCR brings to the marketplace.

Wireless communication is a $40 billion dollar a year market today, and is growing at almost twenty percent a year. Signal compression and processing is critical to this industry in order to take full advantage of the available spectrum that is out there. There is a growing need in the United States for Kodak [inaudible] technology, and we have a number of products in our microelectronics business that have signal compression capabilities. Low power, high speed processors is where our Hobbit chip lies today. Being miserly in the use of power is very important—to get maximum horsepower for a minimum amount of energy usage. We're promulgating our Hobbit architecture to many systems suppliers around the world, and you will see them as AT&T system business based on the Hobbit processor.

Intelligent networking and mobility management is very essential in the wireless world. We have an agreement with Macaw to merge their wireless operations in AT&T's operations. Our aspiration is to bring wireless networks to the reliability and service functionality of our wired networks so that you have a fully switched environment. There has been much said whether our intent is to go around the local exchange companies, but that is not our intent. For many years to come, most wireless will go from your cellular to the local exchange, and then up into our wide area network and then down, possibly through wireless again. This gives the customer a very important value which is mobility.

In '94 you'll hear a lot more about messaging, and I think there will be more and more conferences on messaging. In our network today, a large percentage of the calling volume is messaging. Leaving a message on an answering machine, leaving a message in your office environment or leaving the message in the network and having the network bring the message to where you are—whether voice-mail, e-mail, or fax. And this is going to grow considerably. Messaging requires lots of digital signal processing technology, particularly in terms of compression. As more and more information goes into a message, we will want to compress it to send it in the most efficient way through networks, and then decompress it on the other side. We have a lot of technology in that area, and high speed, low power communications oriented ICs are critical in this world.

Image and speech recognition also is very important whether it's handwriting, gestures or voice. We have a love affair with the human voice and we see it as the ultimate user interface into the digital world. We want to be able to say what's on my calendar today, or I'd like to send this message to Bob, and have the terminal understand. Then we can eliminate keyboards and mice from many applications so that the interface is our instruction set from natural language. We and other companies are working very hard in that area. To the extent we can break the barriers in terms of ease-of-use so people can use digital networks in natural form, this market is going to grow. Natural language may be one of the most subtle gating agents in the entire digitaization of the network world.

We are also putting store and forward capability into our network. In 1994 we'll be bringing this out in our Easy Link service where you can send a message into the network. For example, you could say, "tonight I'm going to sleep early and at 5:00 am can you put the

scores of the Phillies and Atlanta game into my terminal?" Then you send that message into the network and the network goes to your service that provides you sports information and brings it down to your terminal. Applications will be available beginning in '94 that will let you send messages into the network to the proper environment and bring it back through the network to your intelligent terminal.

In terms of visual communications, you saw several applications that show when you combine the ability to hear, and the ability to see, it brings the applications very much to life, and without them these applications do not exist. If you look at visual communication market segment today, it's small, it's under $1 billion—but it is going to be a monster business the more we are able to bring our eyes through networks. Obviously, it requires building out of networks, it requires an integration capability and there are a number of companies, some in this room, who are working on the skill set of providing the customer the ability to do the integration. We need to help whoever's next in the food chain with an integrated solution and interoperability standards.

Voice and audio processing is where digital signal processing resides. There are many different products that are needed in this area. Echo cancellation, for example, so you can be in crowded rooms and you can speak into a terminal and all the surrounding sound is eliminated—or you can hear but no one else can. That is very important in terms of privacy. Other application areas are encryption so that the information comes across the network in a secure mode and then be de-encrypted at your terminal.

These are the major application areas that we're working on. You can see we just gathered a number of pieces randomly from the press about the kind of alliances that are occurring in industry. I do believe that it is not just us working in the dark. I think people do understand what's on the other side of that explosion on Gordon's chart, and I think some of us are working on paths in order to get there. But it's going to be a team sport, and many companies will be collaborating in different forms as this evolves.

I'll end my formal remarks here and handle any questions that you might have.

Questions and Answers:

Question: Video conferencing is not currently in high demand—beyond headshot pictures, the speaking heads, right?

Mr. Kavner: What will grow the market? Again, my view is we are on the cusp of major change there. It wasn't too long ago that to put in a video conferencing system you'd spend a couple of hundred thousand dollars. Now you're talking about $20,000. AT&T and Intel are pushing this very hard. We'll be down a couple of thousand dollar price points by using a standard PC. We are connecting PCs to PBX environments so the PC can be your terminal, and people are getting more comfortable with having collaboration meetings by having a camera on their screen, and using their monitor as a terminal. So I think dropping price points are one issue, and the integration of technology is another. I would hope that people in this room will bring us monitors where the camera is in the screen. I think that a lot of air travel, car rentals and hotel stays will be affected by people being able to accomplish some of what we want to do by traveling. I think the 90's are going to bring it into a very meaningful application environment.

The Organization of the Future

Dr. Robert Johansen

Senior Research Fellow and Director
New Technologies Program
Institute for the Future (IFTF)

Mr. Norrett: Our next speaker is Dr. Robert Johansen. He's a Senior Research Fellow and Director of the New Technologies Program at the Institute for the Future based in Menlo Park.

Bob has worked for more than 20 years in the fields of telecommunications and computing. He has focused on the business, social and organizational effects of new systems. Dr. Johansen's ongoing research involves field studies, needs assessments, expert panels and market research in a wide variety of forms.

Dr. Johansen has a B.S. from the University of Illinois and a Ph.D. from Northwestern University. Please welcome Bob Johansen.

Dr. Johansen: Good morning. I am your change of pace for the morning. As Gene said, I have been charged with taking you on a 35,000 foot fly-by of the organization of the future. I'm going to take this as an opportunity to summarize some of the things we think we know about the organization of the present, but also to stretch your thinking about where the organization of the future might be going—and thinking of it as a context for the types of products that you all are working on.

The title of my talk is "The Organization of the Future" but the sub-title is really the title. I'll begin with what we know about the organization of the future. Then I'll talk about what we're learning—in other words what we think we know. Finally, I will introduce the topic that troubles me the most, what we can't imagine. It turns out that the future that you are creating and making technologically possible, is creating an organizational future which is very difficult to predict.

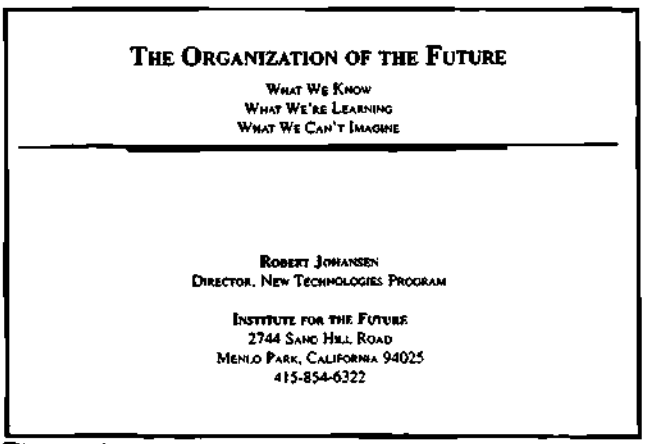


Figure 1

I was fortunate enough when I did my doctorate at Northwestern to be there at the early stages of the creation of the Arpanet (now Internet), and I know there are people in this room who were involved in creating some of the technology that was part of that. My role was as a sociologist trying to understand how this might affect communication among people, and what the implications of this amazing packet switch network were for people. I can remember at the first meeting, the RCCC in Washington, where Arpanet was introduced. I was on a panel with Doug Engelbart and several others who had the crazy idea of people communicating through computer networks. We were talking about that notion and exploring some of the early implications and an impassioned young man in the back of the room stood up and said that he thought that electronic mail was a misuse of CPU.

Now, in fact, I think he had a point. When you think back to the early days of the Arpanet, no one really anticipated that it would be used so heavily for electronic mail and messaging. It was a data exchange network which became an interpersonal exchange network.

Now to give you a sense of how we are covering this ground at the Institute or the Future. IFTF was founded 25 years ago as a spinoff of Rand. It's intentionally small, there are about 25 of us in the group. It is a non profit group. We are very interdisciplinary—we try to have one of each academic discipline in the group—and we emphasize people who do research at the borders of disciplines.

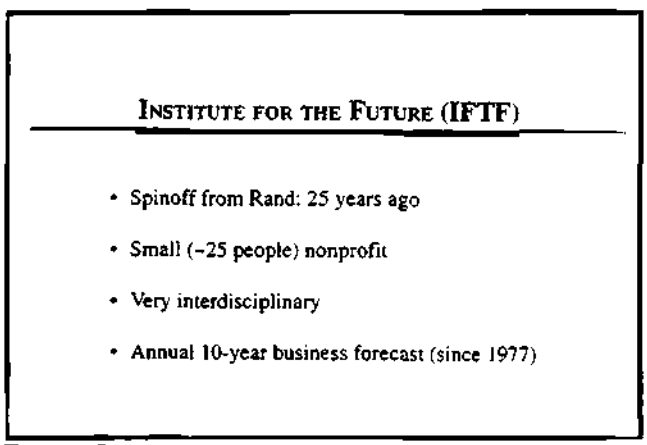


Figure 2

We do an annual ten-year forecast of the business environment. The Institute of the Future is located in Menlo Park on Sand Hill Road in the area that's now called the Wall Street of Silicon Valley because many of the venture people are located there. But we are also exactly on the San Andreas fault. This has given us a sense of humility which many futures groups have not had. The ten year forecast which I am going be drawing from today is our 16th ten year forecast. The forecast is done in January of each year, and is the only document in our group to which everybody on the staff contributes. As far as we know, we're the only futures group that's ever outlived its forecast. One way we do that is by not predicting the future.

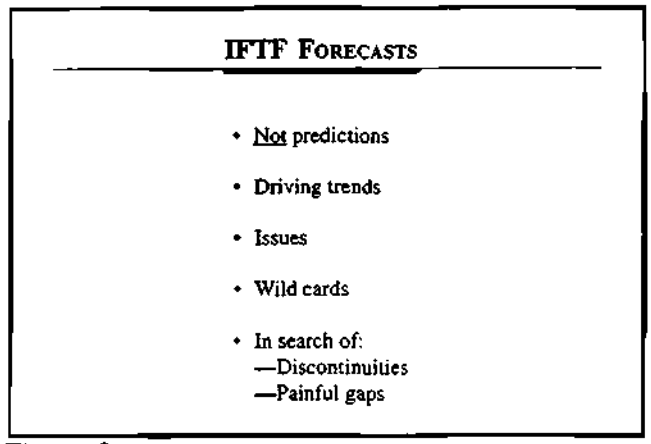


Figure 3

Although you can't predict the future you can identify driving trends. Underlying factors like demography, (which is quite predictable) through economic trends, labor trends, and national trends. And you can identify what we call issues. To us, an issue is a threat or an opportunity that presents a company with choices. We spend much of our time identifying issues.

We also look at wildcards which are low probability events—those events that if they should occur will have high impact. If you think about the late 90's, there are many more wildcards. In fact, somebody asked me just recently, what are the big issues in the 1994 ten year forecast? I flippantly said, there aren't any issues, they are all wildcards. We're in that kind of a future, and what we try to do is look for the discontinuities—the painful gaps such as I'm going to give you a sense of today.

So, there are three things I promised to tell you: what we know, what we think we know, and what we can't imagine about the organization of the future.

What we know is that for the foreseeable future, we're going to be living with flatter network style team-driven organizations. That's pretty much a given, there's no way around that particular kind of organization. We saw a very big set of trends coming together here that involve pace of change, demography, economy,

restructuring, all coming together on the social side with a platform of technologies making things possible which weren't possible before. You have an organization for the 90's, which is a team oriented organization.

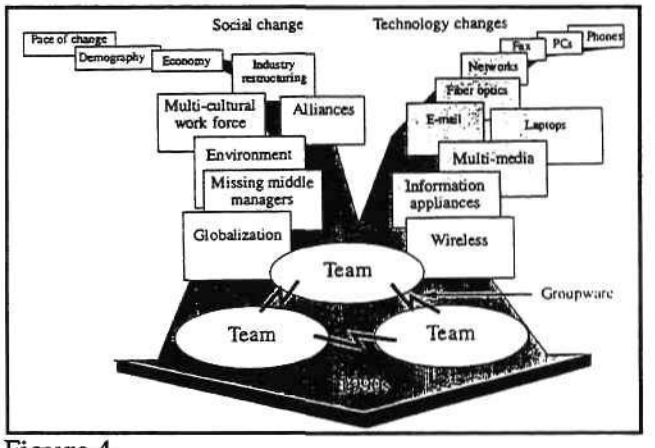


Figure 4

By teams we mean small ad hoc, cross organizational, time driven, task focused, work groups. Everybody uses business teams now—you might call them projects or task forces—but they are the basic unit of measure for the organization of the 90s. Groupware is the most common term now used in the market place to describe the information technology to support this flatter, team-based network style organization and its collaborative work groups

The organization itself looks like this. It has a web of outsource people and includes the traditional work place. The office buildings of the past where we used to have departments, used to have a clear organizational line where the work occurred at a work place. Now we have an emerging work space which is part place part buildings and part virtual space, with not just full time employees, but peopled by this outsource web of specialty organizations and specialty activities. If you look over the last decade, there are a number of sectors, such as those listed here, that are growing at a rate of at least 4 times the growth of the labor force in the United States. We will see massive growth in this outsource web, and massive dependence on it by the traditional organizations. Most of the large companies are becoming smaller—and this is not just a recent trend from the recession—it's actually a 25 year trend in the U.S.

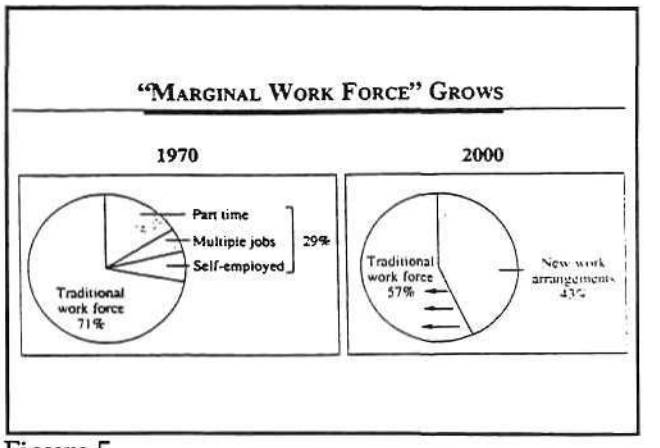


Figure 5

What's happening is the web of outsourcing companies are turbo-charging the current organization, and providing the actual work space, which is mixing with the traditional work place. Now this a sure thing—as sure as anything you can say about organizational change. My colleague Andrea Saveri looked back at 1970 Bureau of Labor statistics and found a set of things that were described as part time work, multiple job, self employed—that kind of thing—and it was a relatively small proportion of the work force. In fact, many of the current categories of work that we have now weren't even listed in 1970. By the year 2000 we expect these categories will approach one-half of the total work force. Where traditionally people were employed for a career, and if you performed well you would continue to rise through an organization and spend your whole career there—now there are very few companies in the U.S. or world-wide that can make that promise and actually keep it. In fact, what we have now is a mix of new work arrangements—some temporary, some part time, some permanent—but quite different from what we had in the past.

What did all the middle managers who are changing roles or leaving companies in the wave of downsizing or rightsizing do? They used to provide organizational memory—a

sense of control. They also facilitated work processes. They were a conduit for communications up and down the hierarchy. They weren't particularly good at communicating horizontally unless they happened to carpool, play golf, or bowl with someone which might facilitate cross organizational communication. Middle managers worked up and down. They took care of coordination and did the people stuff—they were the ones who did worry about career tracks and paths and whether people were doing well. And, of course, they knew how to work the system, even if it meant bending the rules a bit.

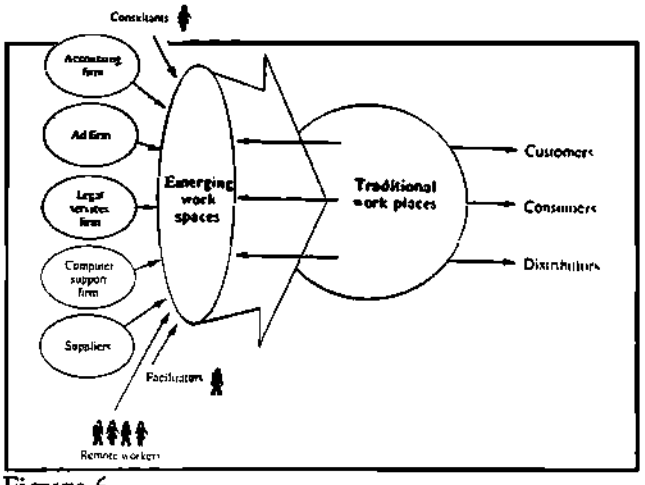


Figure 6

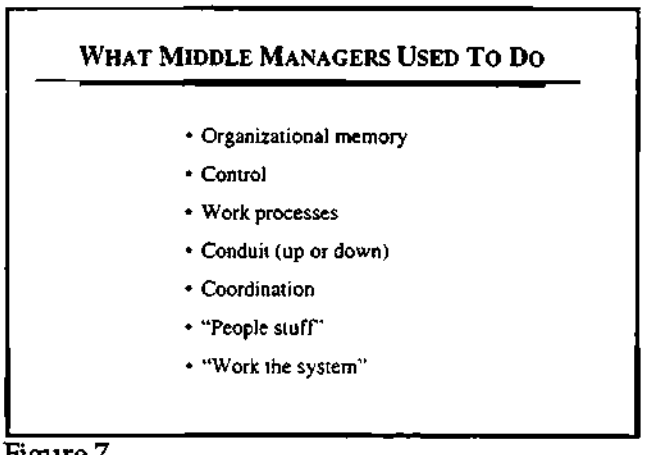


Figure 7

We know that in the organization of the future these functions are disappearing because of the changing nature of the labor force. You now have fewer managers, managing more people who have more diversity and less commitment to the organization—which also happen to be more scattered geographically.

Now to a social scientist, that is an equation that doesn't play. You cannot have fewer managers managing more people, with more diversity and less commitment. It just doesn't work. So what we need are new forms of corporate loyalty, new forms of glue to hold these organizations together—and this is the list from which the needs for your technology of the future will grow.

I remember Gordon Moore saying almost 20 years ago, that user needs are "ex post facto observable," which I thought was a marvelous phrase. As you think out in the future, this is even more true because user needs growing out of these kinds of functions are very difficult to predict.

Let me move on then to what we think we know—and that is that we're in an emerging global world. We think we're learning to work in a global market place, to work cross culturally. One of our projects over the last year was to study high performance global teams and global organizations at many of the best companies in the world, and to try to pull out rules of thumb about cross cultural work.

What we've found is that we think we know how to work globally, but on a day-to-day level, it's much harder than Business Week or Fortune makes it look. In fact, there are many problems working at the cross cultural global level—we think we know how to do this, but we really are just learning how to make it work.

We developed this map in our book, *Leading Business Teams (Addison-Wesly).* and it says there are options for working in the distance, and they roughly break out this way. You have same time-same place, which is the face-to-face meeting—we now see various kinds of technology developing to support this kind of meeting. At the other extreme you've got different times-different places—the

asynchronous media if you will. We have E-mail, voice mail, and technologies like Lotus Notes—the infrastructure for asynchronous communication.

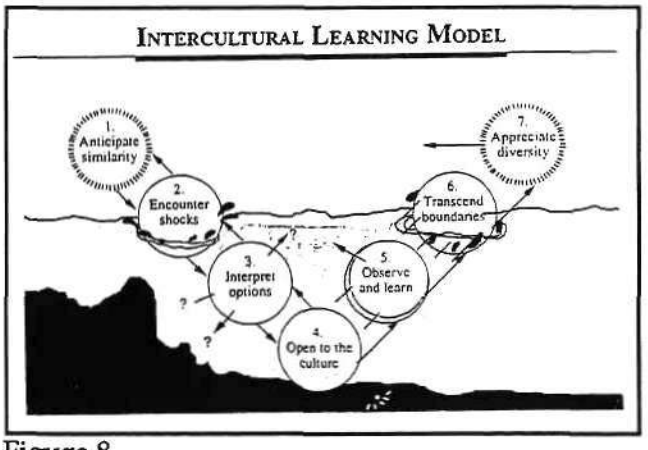


Figure 8

Over here you have same time-different place—video conferences, video at the desk, conference calling—those sorts of things. Then you have same place-different times which could be a team room, an international trader's room following markets, and the like. Now this is the central access of today's information technology where you want the flexibility of the different time-different place, with the familiarity of the same time-same place. What you really want, though, is any time-any place—the ability to be mobile, to go anywhere and to respond at any time. Of course there are different visions about this. One of my colleagues Paul Saffo likes to say that happiness is the any time-any place office—and hell is the every time-every place office. We're on the cusp of that kind of change now, learning what this means. We know that video conferencing technology has taken off—there are now 10,000 two-way video rooms in North America—it's taken roughly 20 years to be an overnight success, but it is occurring. With no marketing, audio conferencing still grows at a rate of 20 to 30% per year. That's very healthy and suggests a platform to build on, but we really don't know yet which medium is good for what.

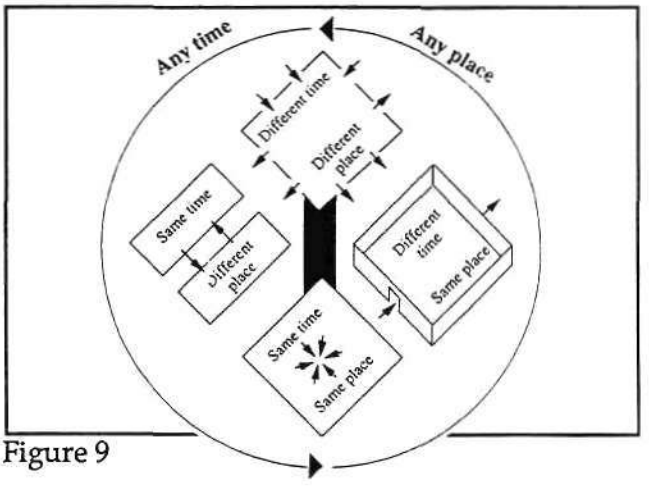


Figure 9

We also know there are intense human dramas that are played out through these media, and we're only beginning to understand them. This map comes from our research that looked at cross cultural teams where we found there is a tendency for teams to go through this kind of cycle. At the beginning, they anticipate similarity—that the engineer from Japan will think in the same way as the engineer from Silicon Valley—and are shocked when they realize that even though engineering is a common culture for them, there are differences in assumptions.

If an opening to the culture doesn't occur then there's a spinoff here, toward the bottom of the V. If you don't believe this occurs, just look at the number of expatriate communities in foreign cities around the world where Americans cluster with each other because they can't fit in with the culture in which they are working. Still, if everything works, there can be a pursuit of learning, a transcending of boundaries, and an appreciation of diversity. The theory is that this just doesn't happen once—it is an ongoing cycle—complex, messy and involving some very real differences in the cultures of how people work.

If you combine this with the process of choosing which medium to use in cross-cultured work, our sense is that you just can't predict how it will play out. Most people assume that the more bandwidth and the richer bandwidth the better, and the closer we can

come to face-to-face the better. This assumption is not necessarily true. For example, there is research from England on the detection of lying by audio only versus video, and audio-video versus face-to-face. What this research concluded was that it's easier to detect lying over audio only, than it is over audio-video or face-to-face. This suggests that people who are good at lying, also tend to be good visually. It also suggests as we create this multi-media world, we will have a more complex sense of which medium is good for what, and that face-to-face is not necessarily the ultimate in human communication—it's just one in a series of options.

Finally, let me conclude by talking about what we can't imagine. This was sparked by our study on global work and global cross cultural teams. It was also sparked by another book I'm working right now with a novelist about life after layoffs where we're going out and collecting stories of people working in companies after re-engineering.

What is life like after re-engineering for the people who are left, the people who have been spanned and layered? What is life like in that emerging organization of the future after the middle managers are gone? We're just beginning this exploration and starting to get a sense of what this organizational corporate life that occurs partially in virtual space and partially in physical office buildings, will be like. Our conclusion at this point is that it will be very different from what we know today in ways that are very difficult to predict.

Let me give you a sense of how this plays out. Our study looked across a range of different types of diversity, and we found more differences among the culture of different functional areas than we expected. For example, in many cases there were more differences between engineers and advertising people than there were between Americans and Japanese.

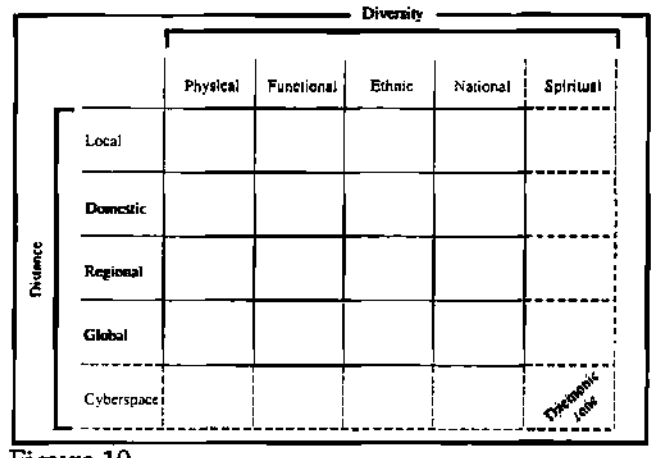


Figure 10

There are, of course, ethnic diversity issues. And, although most of us don't like to think about it, there are intense spiritual diversity issues still very much alive on the planet. As we were writing our book about cross-cultural collaboration, we realized that even as we were writing, there were 50 places on the planet. where cross cultural killing was occurring—all because of tensions regarding spiritual diversity.

We also looked at the distance dimension and how it is growing. We have local distance, within a certain area or a campus. Then we have domestic differences within a country, and if you're a country like the U.S. you see intense diversity within our borders. Then there are regional differences—we studied the NAFTA countries in particular. We did field research in Mexico and Canada and also looked extensively at the European Economic Community. Finally, we looked at the classic global teams.

As we went down the spectrum, we realized there is another element of distance that is a dotted line, at best, in relationship to conventional concepts of distance—the shift from the conventional work place to the virtual work space, to the any time-any place concept. The word that has of stuck to the wall to describe this, is the word "cyberspace," which William Gibson coined in 1984. Cyberspace is defined by Gibson as a shared consensual hallucination made possible by electronic network interconnection.

What we noticed as we looked across the range of these companies working in this range of diversity, and in this range of distance, was that if you looked at the extremes you ran into some fairly strange behavior which we've started labeling the Daemonic zone. For those of you who are familiar with Greek mythology, this goes back to the Daemon who was the son of Zeus, the source of spiritual energy—and not necessarily evil energy, it could be good or evil. That is what we're seeing at this intersection where you have the creation of electronic communities of people with the potential to form types of organizations that never existed before. One of the hottest words in Silicon Valley is the word community, and companies exploring how to use networks to develop community, a telecommunity, if you will.

On the other hand, there is potential for strange behavior coming out of all this that has been characterized in the cyberspace or cyberpunk literature as edge surfing—a different kind of behavior pattern than what you've been used to with corporate e-mail. If you look at the data about labor force trends that I mentioned to you earlier—where more people are laid off and stretched in more ways than they've ever been stretched before—you have the potential for a very disgruntled, very impatient sort of work force. Combine these factors with a very difficult to control electronic environment of cyberspace, and you have the making of intense social organizational dramas over the next decade.

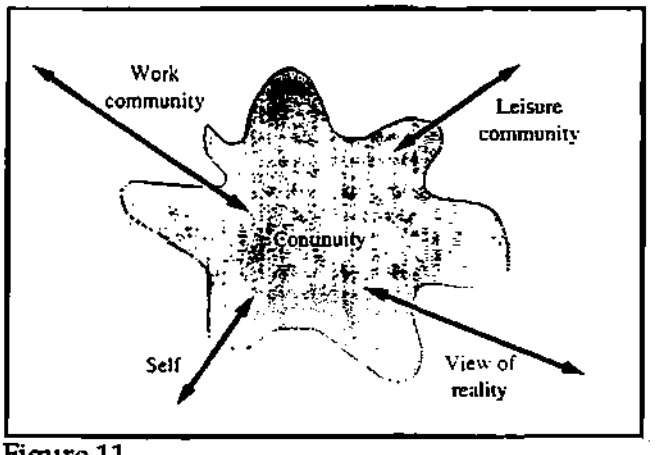


Figure 11

Now we think all of this boils down to a quest for continuity. If you think about the linkage of work communities, and here you can see a whole class of technologies coming about to provide continuity in the work environment, called workflow systems. We've tracked 45 different products doing that in today's market place. Combine that with the any time-any place notion of the leisure community—then bring in a couple of perspectives such as how does your self concept relate to your notion of continuity, your notion of balance, your notion of being able to make sense out of a very difficult organizational environment? And finally, what's real, what do you define as real? These elements were stimulated by some work that I did in Japan where these four elements are much more integrated than they are here. That the concept of the self is more closely tied to the work community, to the leisure community, and that the view of reality is overlaid directly with the corporate view.

Now we won't have a situation like Japan here, but the notion of continuity will be very much with us. If you think about the organizational climate of the present and the near future, the word chaos comes to mind. But, the potential for technology such as that all of you are working with, is for us to add to the chaos a significant element of human choice, and a significant element of balance, and a significant element of trying to bring together disparate activities and bring them back to humanize the organization of the future.

If I had to end with one vision of user needs for you all to think about, it's how can the technologies which you all are working on be brought together to provide a sense of continuity?

Now, I'd like to open it to questions. What I've tried to do is to summarize where I think we are and what we know, which is that we will be living with a flatter network style, team-based organization and a very different notion of the work force—that much is a given. In terms of what we think we know, even though we're

learning how to use information technologies globally, there are still some very real unanswered questions about how that will play out. Then finally, what we can't imagine—but we really have to—is what will life be like in this virtual organization that our technologies are allowing us to create?

Thank you.

Questions and Answers:

Question: Could you elaborate on the effects on our social system as wireless technologies intrude on private time—will there be a backlash against the new technology?

Dr. Johansen: I don't know of any major company in the United States that has a human resources policy that deals with the use of any time-any place technology, or the use of systems from home, or participation in global teams. We're drifting into a notion which is more accurately defined as over-work at home, than as work at home. I think that's a big sleeper social issue, we have to think through what the guidelines are for appropriate work at home and on the road. Also, what are the rights of the employee and the rights of the company? I don't think there is a way to legislate behavior in that sense, but we have to start thinking about it. Unfortunately, most of the human resource organizations in major companies in the U.S. have very little power, and very little vision to do any thing about it even if they had the power. So we're not in a position to have this coming about very quickly. There is a group set up on work family issues called the Family Work Institute and the Conference Board is doing some work on this topic. They're doing the best work I've seen on that issue, but I think there will definitely be very big issues around all of that, and most American companies haven't yet begun to think about them.

Question: I spent about five years at Apple which was an interesting company because they have E-mail for everybody and a bulletin board system where you can post things. I saw human resources policies change based on discussions that went on there, for example—they cut out water in order to cut costs—and people were so angry about it so they brought the water back. And even changes like profit sharing, where people wanted to have an impact on policy. I'm wondering, will electronic communication serve the same role as unionism did?

Dr. Johansen: It will be different from unionism, but there will be some similarities. The work I mentioned to you about communities and community building has raised many of the same issues that came up in the U.S. in the early days of the union movement, or in the 60's with ideas such as what social change author Sol Alinsky, for example, wrote about in a book called "Rules for Radicals" on community building and community change. Those principles still have a relevance, will be discussed and will play out—but they'll play out very differently in cyberspace than they played out on the South Side of Chicago. So although they'll be different, there will be similarities and it is important to go to school on the experience of different kinds of social change activities that occurred earlier. One of the dangers, I think, is that in many cases the engineers that design cyberspace didn't live through, and so are not prepared to deal with, organizational issues or organizational change issues—so they are susceptible to remaking some old mistakes.

Question: Regarding the globalization of work force teams—what are the regional barometers of success for the globalization of the work force? What does all this mean to the global semiconductor companies?

Dr. Johansen: I think the semiconductor industry has the advantage of being of having a common work culture which many of you share by your academic background and your technical training, and that is a real strength. The downside of it is that you're clearly a global industry, and it's often difficult for engineers to

accept that there are some of these fuzzy cross cultural issues that get in the way of good clean engineering work. So, one likely issue is that you will find some parts of the country, or the world, more able to respond to cross cultural issues and more sensitive to those kinds of differences, and some cultures which will tend to be more rigid and therefore will have a more difficult time.

In general, we found that factors such as a multiple cultural background as you grow up, and multiple language backgrounds were extremely helpful, but you can't learn all the languages and cultures. So what you need is sensitivity to the sorts of cross-cultural issues that can come up in an engineering context. Most of the semiconductor companies that we've looked at in this context—and there were quite a few—had internal cross-cultural training efforts already underway.

Thank you very much.

Internetworking: Growth, Challenges, and Opportunities

John Chambers
Senior Vice President
Cisco Systems, Inc.

Mr Norrett: Our last speaker this morning will cover networking from a different perspective. We had AT&T talk about their networking plans, bringing people together visually and audibly and about the social issues of this technology. Next we have John T. Chambers, Senior Vice President of Cisco Systems.

Mr. Chambers joined Cisco in January of '91 after eight years at Wang Laboratories—the last two as Senior Vice President of U.S. Operations. He was previously Senior Vice President of Wang's America-Asia-Pacific operation and before that Vice President of the firm's Central Region in the United States. Prior to joining Wang, Mr. Chambers spent six years at IBM. He has an MBA degree from Indiana University, and a law degree and two other undergraduate degrees from the University of West Virginia.

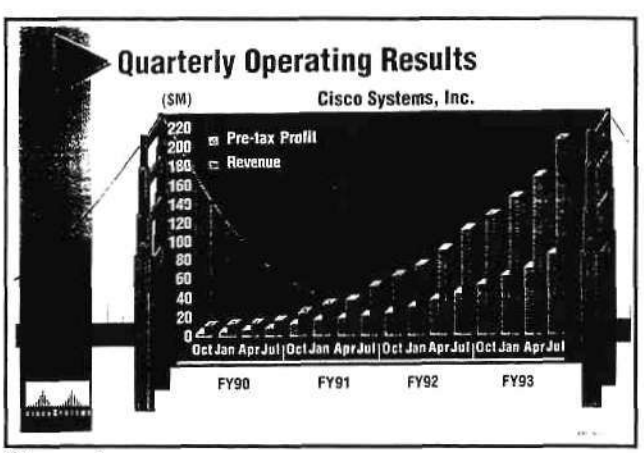


Figure 1

John will try to help us understand what's going on in the world of internetworking and how this new, very fast growing industry will present large opportunities for the people who supply to that market. Please welcome John Chambers.

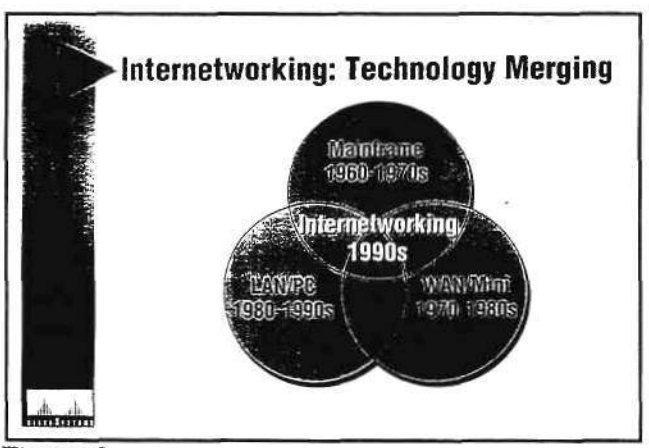


Figure 2

Mr Chambers: If you look at the challenges in front of us in internetworking, it has many of the same challenges that the computer industry saw during the 60's, 70's, and the 80's. There were opportunities for growth, and opportunities for challenges as well during that time period. I wish I could tell you that when we started out as a company seven years ago, we clearly understood what role internetworking would play in terms of the strategic importance the technology would play in the computer industry and information processing industry. Very candidly, we did not. We started out like many companies here

in the valley—we wanted to grow and expand as fast as we could so we could survive.

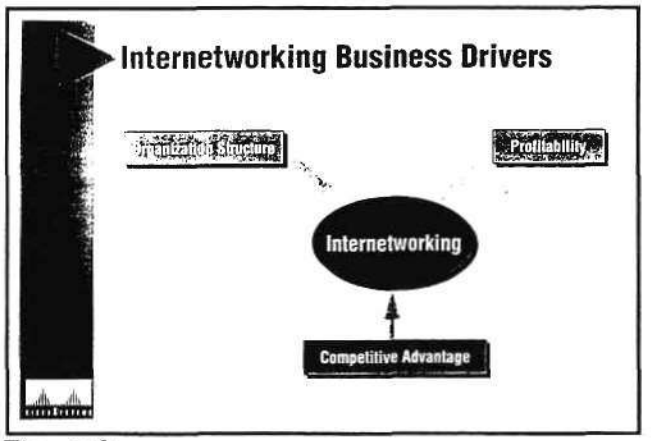


Figure 3

After a period of time, however, a number of our customers shared with us that Cisco had moved from being a tactical vendor whose products tied together various workgroups in their organizations–to a strategic vendor. From a strategic vendor perspective, our customers were saying they would make us one of the two-to-five key vendors in their company in terms of how they went about planning their information processing strategy.

That took us by surprise. One of the companies articulating this change in status was Philip Morris. They said, "we made a tactical decision in one division of Kraft. Now, all of the sudden, we're networking the world and when we plan our future we're going to plan it with internetworking being one of the key component parts." Ford Motor Company said it the same way. They have five key strategic partners: IBM, DEC, AT&T, Cisco and SynOptics.

EDS, another major company who traditionally does not form close working relationships in their strategic business unit—the networking group—has only one major partner in the networking arena—Cisco. I would like to say that all of the Fortune 100 companies have made that same decision, but only about half of them have.

In terms of growth, the industry started first here in North America. This was followed, almost literally, one year later in Europe, and then one to two years later in the Asia-Pacific area. But what actually occurred during this time was that the seeds for our growth, started in the information processing industry. In the 60's and 70's the action, and the profits, were in mainframes, where the vendors who had the best products could gain the majority of the market share. During the 70's and early 80's it was mini-computers that really drove the industry. Then, in the 80's and early 90's, it was PCs and LANs. What we're finding now is that it is internetworking—tying all those networks together—that is driving corporate productivity and information processing.

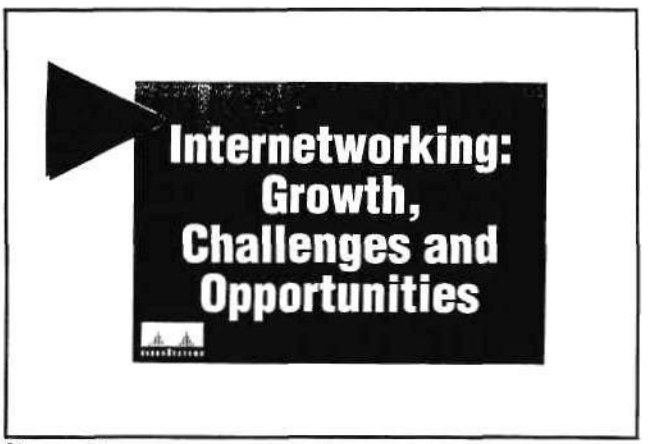


Figure 4

Over 70 of the Fortune 100 companies have made a decision to purchase Cisco technology, but probably 90 to 95 percent of those 70 companies have made decisions with the key strategic vendors in mind. When you talk about the network and how important it is to a company like Hewlett-Packard, you're talking about one of the largest data networks in the world. They have over 90,000 end nodes attached, and that doesn't count their access points. They have over 1,200 subnets, and six terrabytes of information pass through their network on a monthly basis. So we are finding that companies are becoming increasingly dependent upon the network for future success. The people at Hewlett-Packard said to us, "very often we cannot move to the new generation of

workstations we want, or bring on the new applications for those workstations until we remove the barrier that the network presents to us today." So the internetwork is both the strategic advantage and the challenge in many of our customer environments.

If you talk about the business drivers that are pushing internetworking, there is a flattening of organization structures worldwide. Almost any type of account that we call on worldwide is trying to get fewer and fewer layers in their organization, expand the span of control, and eliminate the middle level of management more quickly because of the combination of computers and internetworking. In short, they have set up a truly paperless system. At a large aerospace manufacturer, for example, not only does internetworking allow workgroups to communicate across their networks, it let's them cut the plane up into sections and form teams from various engineering, manufacturing, sales and finance groups to work on various sections. You see many organizational structures change in this kind of scenario, and in order to change you have to share information.

Other examples. Take a large pharmaceutical company who has people around the world, but wants to find a way to tie them together and get them to work together effectively. The bank that used to process a loan in 24 days and now does it in one day, cutting their bad loan loss ratio in half. The large automotive company who used to have a separate network for every single key division within their company, and now ties these networks together into one single group. Or a large conglomerate who manages its cash from a central location worldwide for over 50 different divisions. These are the business forces that are driving the technology and social changes today.

When you look at who are going to be the key players in the internetworking industry in the future, there are three primary considerations: product leadership, customer satisfaction, and strategic partnerships.

In terms of marketing positioning, there are a large number of players coming into the industry. Market share depends upon how you measure it–by number of routers or by dollars of revenue. This slide gives you a snapshot of how the industry used to be separated in the area of high-end systems, mid-level systems, and low-end systems in the North American market.

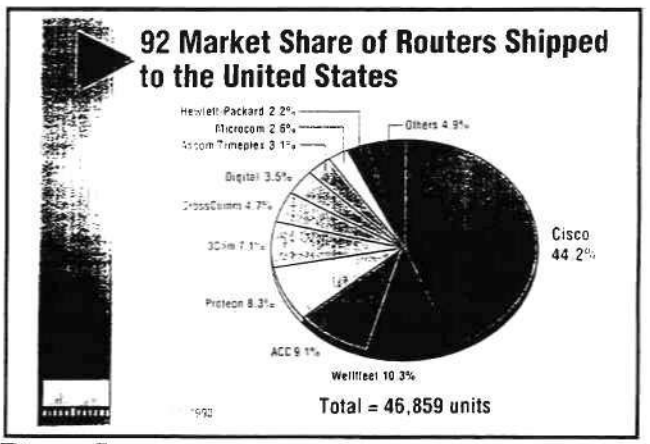


Figure 5

However, we're finding the market is changing as more and more vendors get into this arena. Going back three years, there were four or five players who were really focused in this market. Today there are probably 50 to 60 players, and you'll see companies on that chart constantly change. But you also see a growth rate that has been 10 fold in the last three years (and the profits that went along with the growth) — hence all the interest in this arena.

One of the challenges we jointly face is anticipating what the growth rate is going to be in the future. Dataquest has been one of the more accurate forecasters of this, although they're still on the conservative side. The challenge that we face is that if you look at these numbers you see the market growing about 50% in '93, 32% in '94, 23% in '95, and 12% in '96. We have a goal to grow our productivity by 10% per year. So anticipating the accuracy of this trend and whether it will be as abrupt as the main industry analysts anticipate is the key challenge for us. We generally forecast 8% to 12% growth per

quarter and we react after that. But candidly, that's the same projection we had for last year and the year before when our markets grew at 90%, and the year before that when it grew at 79%.

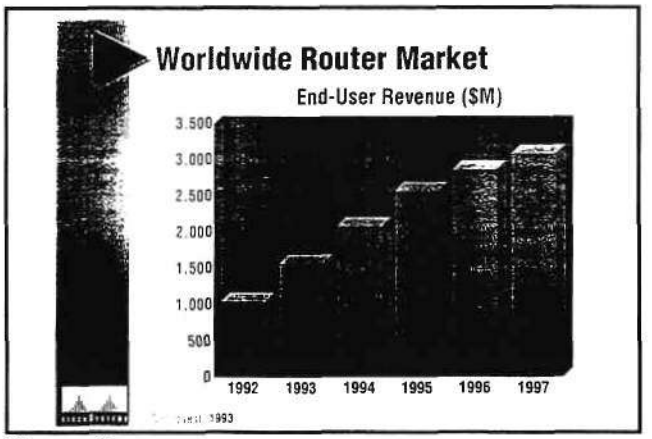


Figure 6

What is driving the industry growth is the requirement to share information among various groups, and we've seen this requirement across all industries. It used to take us four years to install a hundred routers to connect 10,000 workstations. We now routinely install a hundred routers in a month. It took us six years to build our first thousand-router network (typical thousand-router networks will often connect up to 100,000 to 200,000 individual workstations). Now we're seeing an explosion in this area. To the best of our knowledge there are only 250 or so hundred-router-plus networks in the world, and there are only two thousand-router networks in the world. Again, this is primarily a phenomenon of Fortune 100-type companies on a worldwide basis. There are 50 situations we're looking at the could be over a thousand routers. Once you remove networks as the bottleneck in the ability to transfer information and get the response time that IBM SNA networks require, the implications for the workstation market are dramatic.

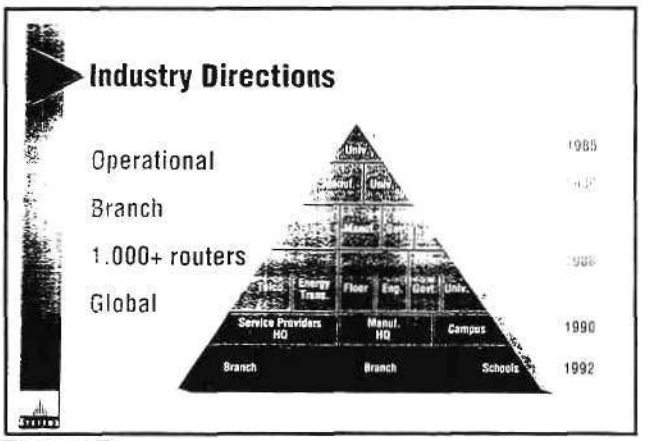


Figure 7

But support is a key factor for success here. Everyone says that, but when the network functions as the computer, and when a large aerospace firm, for example, runs all their manufacturing plants off of a network and there is no paper backup, and when that network goes down because of a quality issue that involves us or one of our partners, support is very important. Recognizing this, we've increased our support in the last two years by a factor of 10.

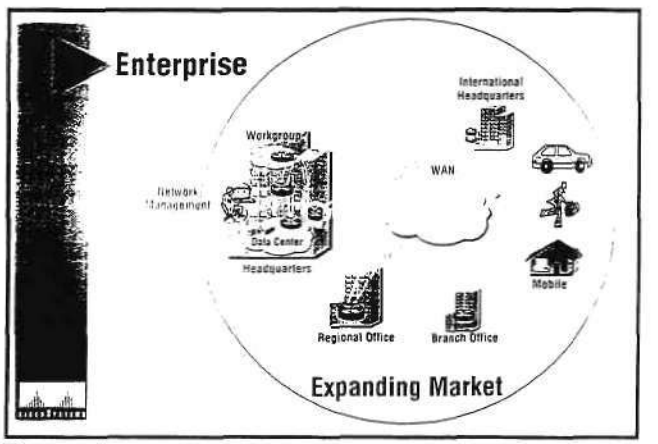


Figure 8

Since we started working with Ford, we've had about 13 or 14 problems, half theirs and half ours. At one point for a period of about 45 days, Cisco and Ford put over a hundred people on that account who went through a new network design and educated employees. Once you established an account as a partner,

you are a key determining factor in their ability to continue to grow with you or not.

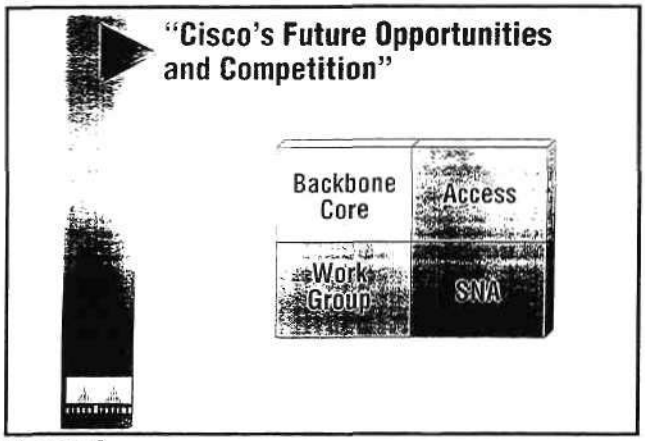


Figure 9

I'd like to talk briefly about the market components, or market segments, in the core, or backbone segment of what you call the wide area network. Networking together the various components in a distributed processing environment produces a requirement for more processors of various performance capabilities. It also requires programming, additional memory, and large bus structures.

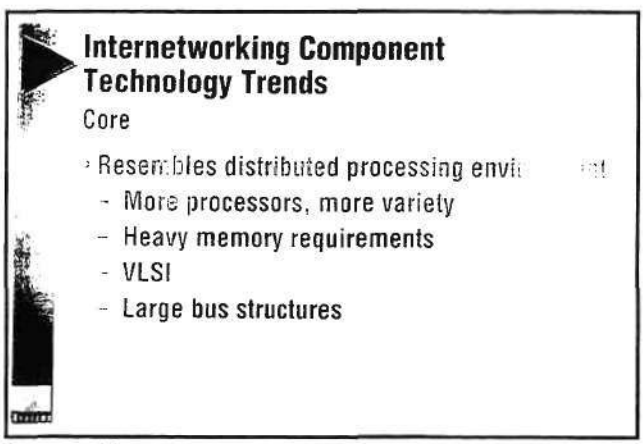


Figure 10

The access market for smaller internetworking systems is probably the fastest growing area. The access marketplace is growing at least 100%, and possibly as fast as 200% per year. It's also the area where, unlike the core or backbone, your key decision criteria are performance, functionality, total cost of ownership, and support. You're seeing a lot of vendors enter into this arena. Here you need medium performance processors, but at a very low cost.

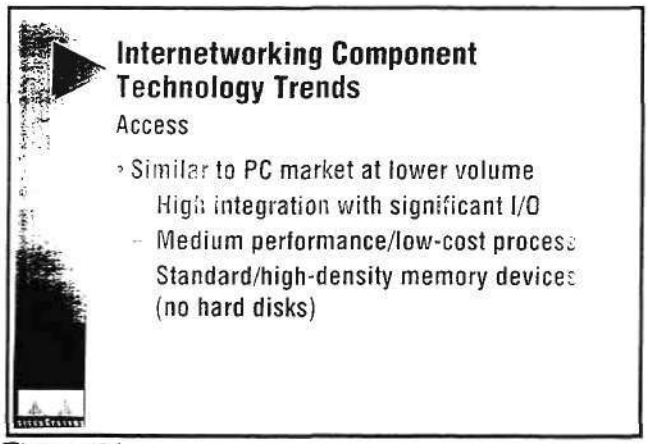


Figure 11

The workgroup area, where you tie together a whole building floor by floor, is probably the area where you're seeing the most overlap of technologies, and is the most challenging for us, our partners and our competitors. What you're seeing is routing functionality becoming very tightly tied to hubbing functionality as well as becoming very tightly tied to LAN and wide area switching functionality. Both from a fast ethernet and from an ATM perspective.

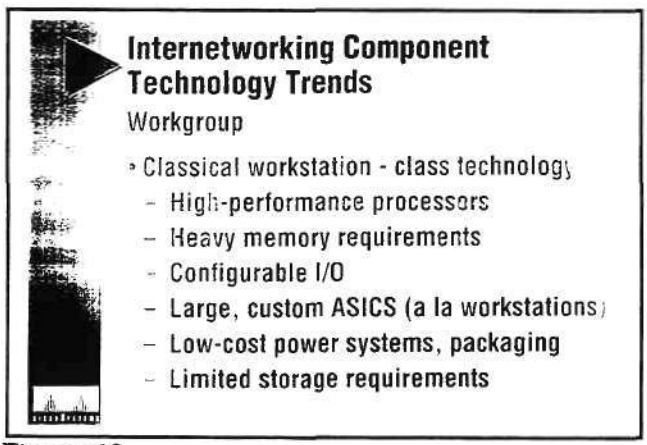


Figure 12

Finally, there's the IBM SNA arena. Two years ago there were very active discussions with our large customers of whether to overlay an SNA network with a TCP/IP network as well as

other types of networks. Then the answer was "absolutely not." Today, you have to do it. But the key is how do you keep your same application response time on that network and assure that the SNA side of the house gets the same level of service they did before you combined the networks. This one is more of the typical applications—much more a software than a hardware challenge in terms of its development.

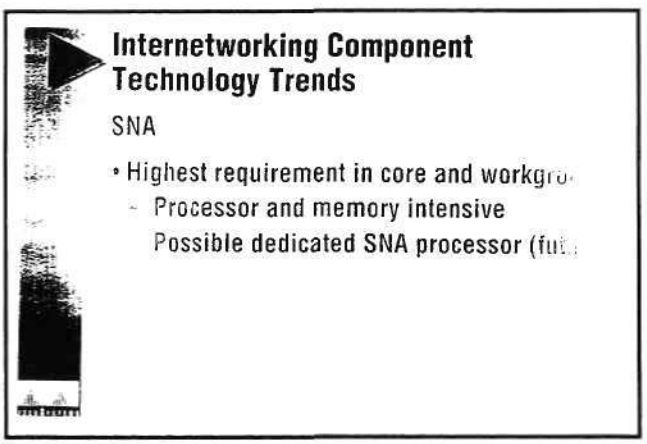


Figure 13

So if you were to overview internetworking technology, it's following many of the classical computer marketing trends. It's different from PCs, however, in that it is a dedicated application. But we are literally seeing an explosion in the cable and wireless area. One of the challenges we face is determining who the key players are in this area and what role we can play within that environment. However, we also believe that homes will be networked very shortly. In the United States, and also in many countries worldwide, there are a number of tests occurring in the consumer information network arena, and the players in this arena are very key.

We started off originally with a commodity strategy. We really looked at DRAM and flash and EPROMs etc., and we lined ourselves up with one to three vendors who we considered best in class, either from a processor or technology perspective. However, as we got a little bit smarter, we realized there were some tremendous advantages that could be had from partnering, and we began sharing information and with our key suppliers on a quarterly basis—going back and forth with a report card type of structure, looking at things like what levels of service/response are we achieving and how well are we anticipating component pricing trends.

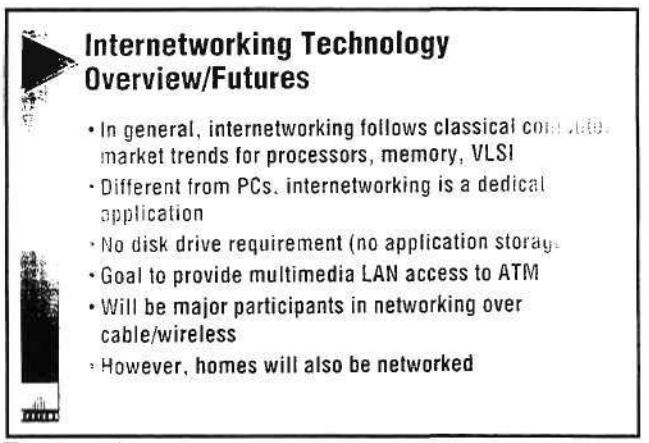


Figure 14

What we're doing right now is attempting to expand the concept of the virtual factory to where we all understand the advantages of concurrent engineering and manufacturing working together, while simultaneously sharing the information from a demand pool and sharing common systems with our key suppliers. The minute demand is put on us, our suppliers know.

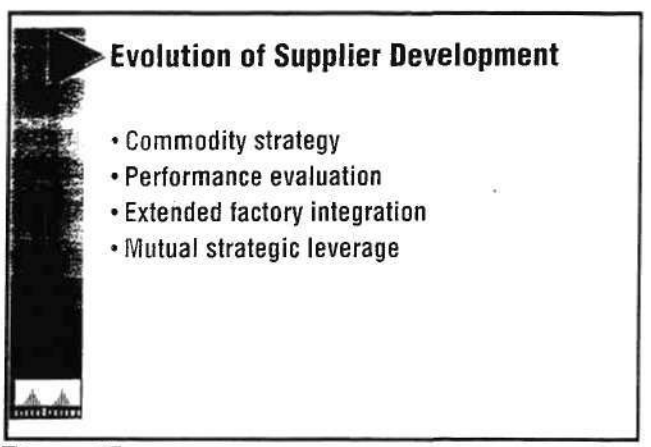


Figure 15

And finally, as we complete this concept, assuming that we do it reasonably well, we'll

begin to look at how we truly take the core competency of our key supplier partners, and our routing competency, and how can we combine that to form joint competitive advantage? That absolutely will happen in the next two years.

One of our mutual challenges is how do we focus on that concept of concurrent engineering and manufacturing. We're really an assembly shop, so how do we make our key suppliers truly part of our own organization? Do we share information openly and quickly between the organizations to take advantage of the core competencies of both functional groups?

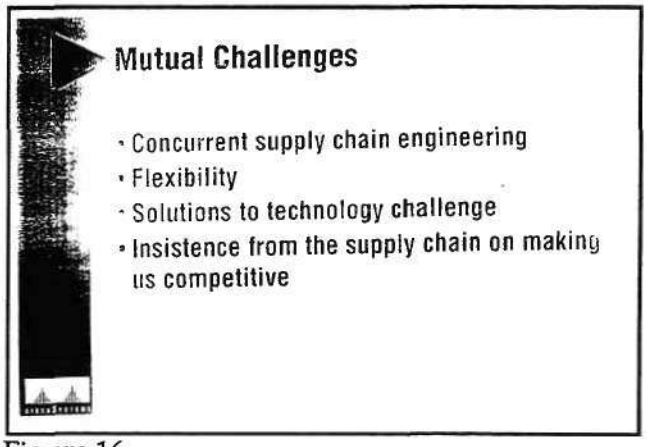


Figure 16

Flexibility is key to us. I'd like to tell you that I can forecast this industry looking out one to two to three years, but our forecasts from our sales organization does a good job 120 days out, and after that their forecasts are terrible. Even tougher is the mix. Our forecasts within the 120 days is plus or minus 5% to 10%, but the mix between use of an old technology, high-end, mid-level, and low-end systems, and the various component parts, varies as much as 30% to 50%. Yet what our joint customers expect from us is very quick delivery. Our lead times have been cut to 35% of what they were just a year and a half ago. And within the next year or two, you'll probably be on a one-week time basis for most of the products in this industry.

In the remote access market for small internetworking systems we anticipate the prices dropping between 15% and 30% per year because of the price sensitivity of this market segment. At the high-end, price protection of existing products is key. That means the high-end customers will pay a much heavier premium for support.

We also tend to be a company that's very direct, and we like to select partners and customers who are also direct to help influence us. We meet three times a year with a subset of our customers who have the reputation for being both technologically advanced, but also having the image of being the most direct with the vendor. And we listen to them for 12 hours about where they see the industry going, and what suggestions do they have for new products and solutions that we can offer them.

So partnering of many kinds is key. Those companies that don't understand how to partner will be left behind, regardless of their size. We've done well in some partnerships, and candidly we've really messed up some other. But if I were to say what are the common ingredients in a strategic partnership that really works it is that you must define a win/win situation up front that is also a win/win deal further out as well. It works best also where there's a common vision of where the industry's going and the role that each partner plays within that.

Third, as corny as it sounds, it's the chemistry. It's how the two companies inter-relate in the exchange of information. Our attitude is that if we can't be number one in an area, we will partner to do it. That's true, not only from a supplier perspective, but from a hub perspective, where the hub vendors represents 60% of the market. It's also absolutely true from a telco perspective. In this industry, partners are going to play a key role, not only in product requirements and utilization of the products, but also in the retail and systems integration side of the house.

You find a similar approach here with about half of the companies on that list who made a strategic vendor decision. The other half have made a tactical decision that they may not be able to maintain. But if you look where the industry's going there are many combinations. Telco's, BT with MCI, for example. With switch vendors, Alcatel with Sprint. Also, there are mobile phones, with AT&T and McCaw, the US West/Time Warner combinations, and more. All these will have major networking implications and workstation implications in terms of distribution.

As you expect, the barriers to entry in this industry are getting higher and higher, both for new companies coming in and for established companies coming over. This is why I think you will see fewer and fewer key players that will play across the whole gamut of these four market segments. You'll find companies getting more and more into niches, and some consolidations will take place.

Perhaps the toughest change, however, is that of building a culture that adapts to change very quickly when you're already successful. That's something that many companies in the industry have not done well before and ,candidly, we're struggling as we go along.

One point you can make about technology is that as an industry moves from a tactical purchasing decision to a strategic decision, you often see a few key players growing very rapidly and the other players growing below the industry average. I think that's absolutely going to occur in this industry, and you began to see some of the movement along that line in the events of the last two quarters.

In terms of growth worldwide, the market almost invariably starts here in the United States—almost inevitably first in universities and then in manufacturing. The same thing is true in Europe and in the developed countries. Europe tends to lead Asia-Pacific by one to two years, where we are focused on the Japanese market place. I think most of us know that their spending on information technology is one-half of what is spent in the U.S., and yet many of us have not been very good in the past at getting that same market share there. So, we're separating it into a separate theater of focus. Latin America is also booming. It's our fastest growing arena at the present time, along with Japan.

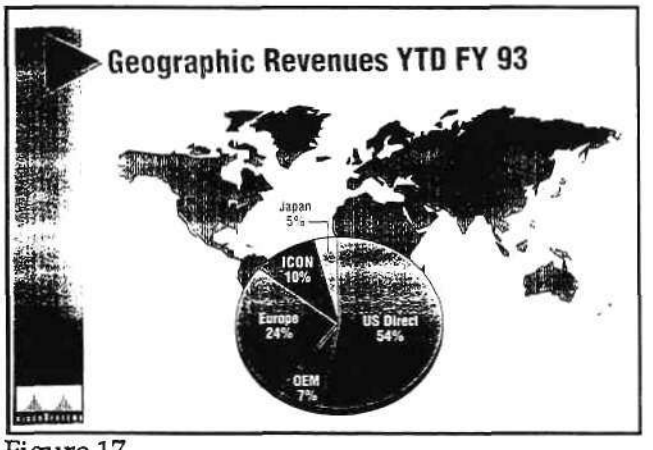


Figure 17

In Europe, we've not seen the slowdown that other companies have, but with unemployment in so many of the countries well above 10%, nothing comes easy. The large deals tend to hold us in, in terms of our growth, and that is how we see the market on a worldwide basis.

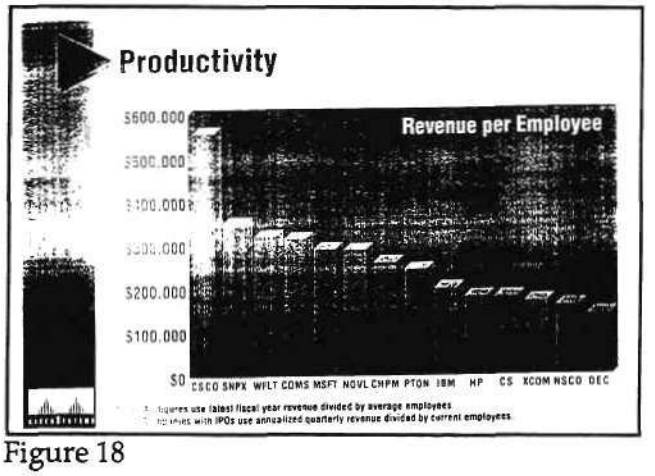


Figure 18

Productivity is key, and we think it means survival in the industry. Our gross margins are good—about 5 to 8 points better than our

competition. What accounts for our profitability is this productivity number, which is simply the revenue divided by the average number of employees over a period of one year.

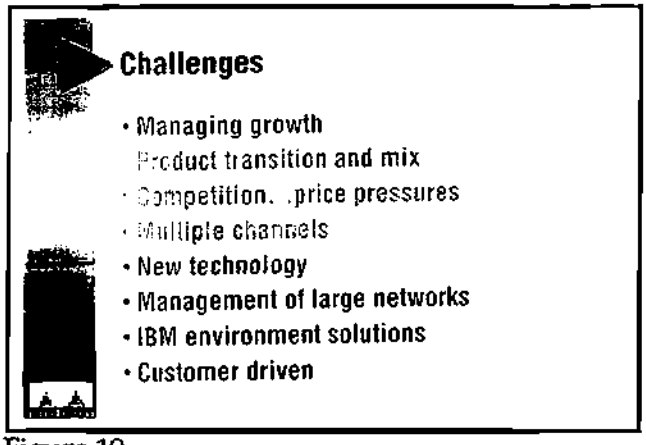


Figure 19

In summary, probably the biggest challenge we face in this industry, and it's true of all of the internetworking vendors, is just managing the growth. How do you tell people who have been very successful that they must change, and change rapidly or get left behind. We're on our third generation of management at Cisco—many people don't realize that. We've changed most of our key managers three times, we've gone through the founder scenario, the tight central management scenario, and the decentralized management type of approach. And getting people to adapt to change, even though we've been successful, is tough.

In terms of product transitions—the nice thing about being a strategic vendor is you're very often tightly locked into the account. The tough thing is then they want you to share your product plans for the next two to three years. When you make a product transition you can freeze the market for a period of time, and we haven't had to face that before. Getting that mix right both for us and our suppliers has been key, because competition is coming at us from every direction.

There are a lot of price pressures, particularly on the low-end. I think all of us understand the implications of multiple channels. New technology, for example. What role will ATM, ISDN and other technologies play in internetworking? They will probably play together. How do you stay customer driven? That's what got us where we are, so how do you keep that mentality as an organization?

So those are the challenges that I see in this industry. If there are any questions at this time, let me address them.

Questions and Answers:

Questions: As a responsible industry leader, how do you plan on growing the industry through strategic alliances and joint development?

Mr Chambers: I would like to tell you that the reason we made the decision on strategic alliances and the partnering is because we're good corporate citizens. It wasn't. We did it because we think it is survival in this industry. We're going to really separate these four market segments into components where we can do part of them ourselves. We will use joint development for other parts, and we will acquire product lines, even from some fairly large players, to move through our channels. It is in our best interest to make the network not be the bottleneck for other computer technology component parts.

Question: The second question is, do you foresee routers used outside the traditional corporate environment?

Mr. Chambers: Absolutely, yes. If you look at where most of our business comes from it is in the largest 100 corporations or universities or telcos.

But, so we see the market moving into second-tier companies, and to the home market very quickly. We're trying to figure out a constructive way to leverage our competitive advantages into that new market, and looking at how that's going to come about from both a

mobile perspective and, candidly, from a telco and cable perspective.

Question: Why do we not see disk drives in the internetwork technology component part?

Mr Chambers: We think they will go on the computers. Remember that we're coming from a single application perspective—we primarily do packet switching—so we put most of our stuff in memory. I think you will see the data and the disk drives put on a number of various devices throughout the network—they just would not reside at the router level. Most of our customers have told us they wanted a dedicated application set at the router level. It's too strategic to their future to put other applications on it, or combine it with other functions such as PC functions, file server functions, or even mainframe functions.

Thank you very much.

The Promise of Pictures... Is Productivity

Richard M. Beyer

President, Communications and Computing Group
National Semiconductor

Mr. Norrett: The next speaker is Rich Beyer, President of National Semiconductors Communications and Computing Group. It's my pleasure to have Rich here to talk to us this afternoon.

The Communications and Computing Group is composed of the Ethernet Division, the Wide Area Networks Division, the Advanced Networks Division, and the Embedded Control Division. Mr. Beyer brings to National his considerable general managerial experience and international marketing acumen in telecommunications and computer applications. Prior to joining National Semiconductor, Rich held executive management positions at Rockwell International, Alcatel, ITT Business Communications, Burroughs Corporation, and was a management consultant with Booz, Allen & Hamilton in New York.

Mr. Beyer holds a B.S. and M.S. degrees from Georgetown University, and an M.B.A. degree in marketing and international business from Columbia University. Please welcome Rich Beyer.

Mr. Beyer: Good afternoon, everybody. Abraham Lincoln said "we must not promise what we ought not, less we be called on to perform what we cannot," over a hundred years ago—it may be even more pertinent today. Recent history gives us no lack of promises not kept. Solar energy, battery powered automobiles, quality television, you can think of many yourself.

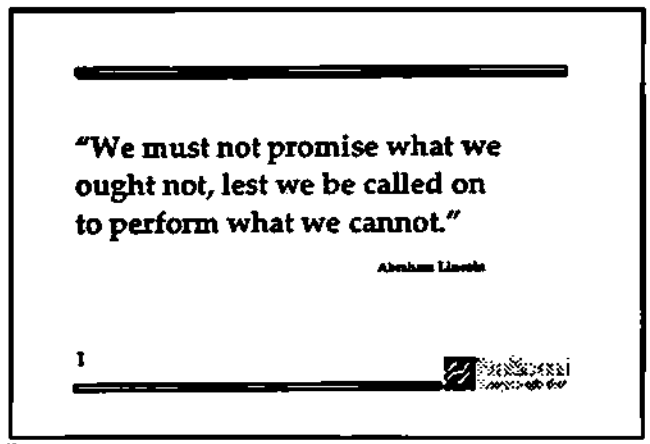


Figure 1

Politicians of course have raised the promises not kept to an art form. Some suggest even Lincoln might alter his behavior and his vision if he were alive today, but he was an amateur compared to modern politicians. Remember George Bush's "read my lips and no new taxes," remember Bill Clinton's promises before the election?

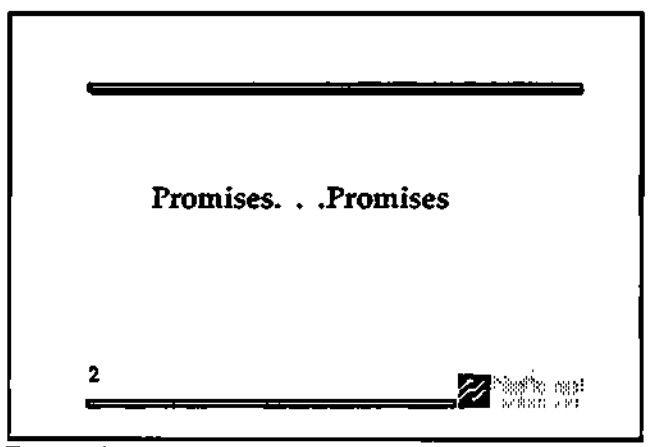


Figure 2

If history has taught us anything, it is that we should not promise what we cannot deliver. So what does this have to do with the topic of my presentation today? Video conferencing on the desktop—the video phone.

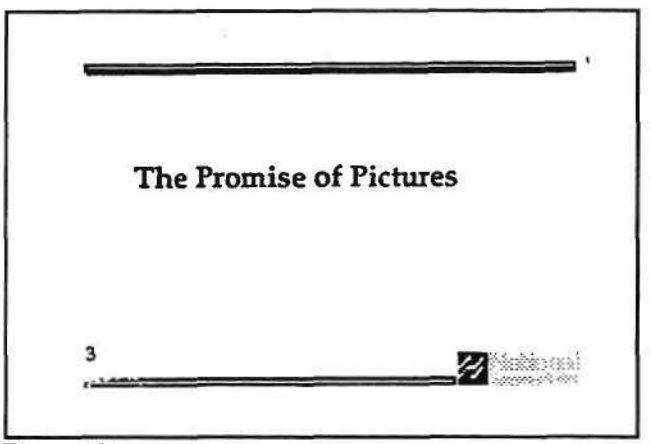


Figure 3

Every since Alexander Graham Bell patented the telephone in 1876, it has been our technological dream to see, as well as hear, the people that we talk to.

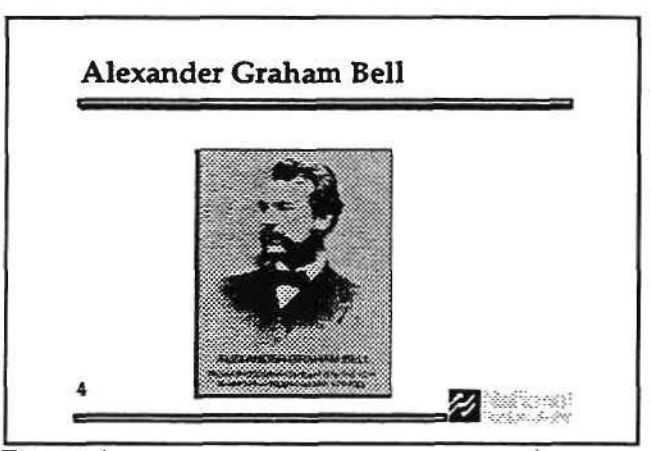


Figure 4

I think Bob Kavner from AT&T spoke to that issue this morning. Today, there are about 400 million telephones worldwide with 155 million of them in the United States alone.

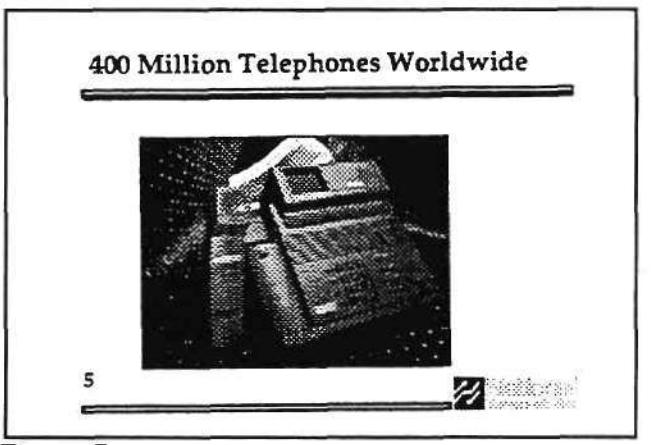


Figure 5

We Americans make more than 800 million phone calls every day—but so far, at least in the mass market, promises but no pictures.

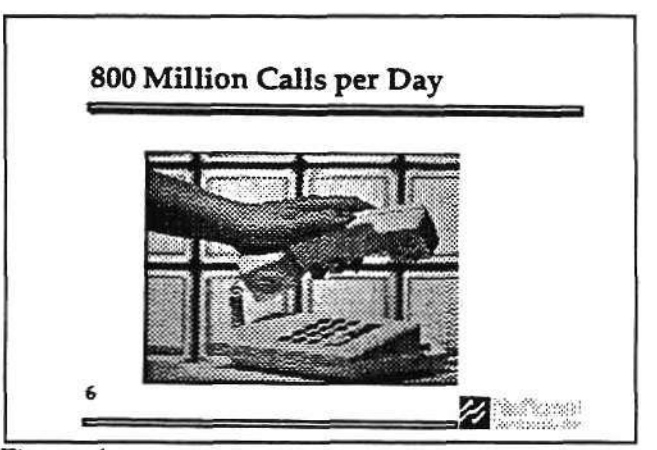


Figure 6

"But wait!" you say. "The video phone exists." It's true it does exist—and it is a far cry from the one that AT&T introduced when I was a high school student in New York City at the New York's Worlds Fair in 1964. According to AT&T, today the video phone model 2500 has sold tens of thousands. Sure, the price is relatively high, more than $1,000, and you really have to have more than one of them to be able to effectively use them. And the quality of the image isn't particularly good at this point, and it only works on analog lines so the majority of businesses are not able to take advantage of the technology—but it's an ambitious product and it does exist.

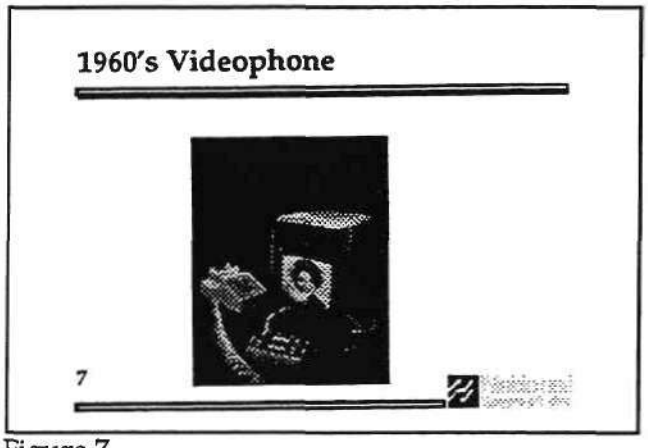


Figure 7

But I maintain the promise of video phones, the promise to change our lives is still not kept—but just wait.

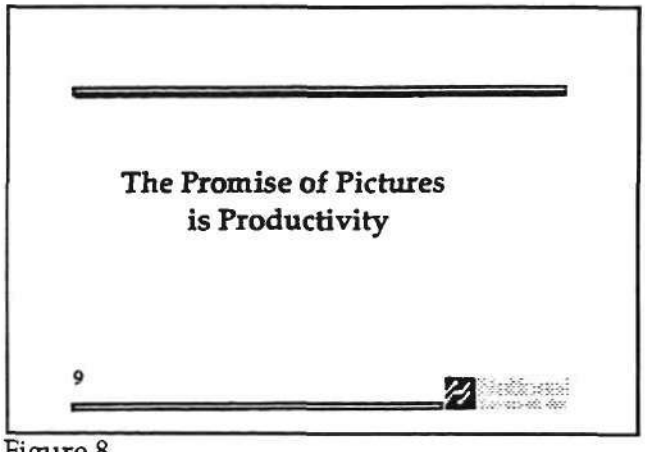


Figure 8

The promise of pictures is rooted in the promise of an explosion of business and personal productivity that could dwarf many of the trends that have come before. As we all know, there is a technology operating that does let us see the person that we're talking to, that does save time and increase productivity.

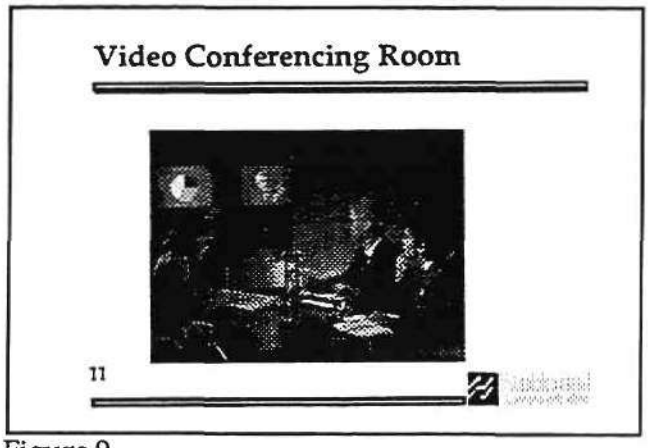


Figure 9

The technology of video conferencing in specialized video conference rooms has been around more than ten years. Since 1988, the hardware cost of equipping such a dedicated video conference room has gone from over $250,000 to about $25,000, and the price of transporting a call has also dropped dramatically. The tariff on a San Francisco to New York call has dropped from about $300 an hour to only $30 an hour today.

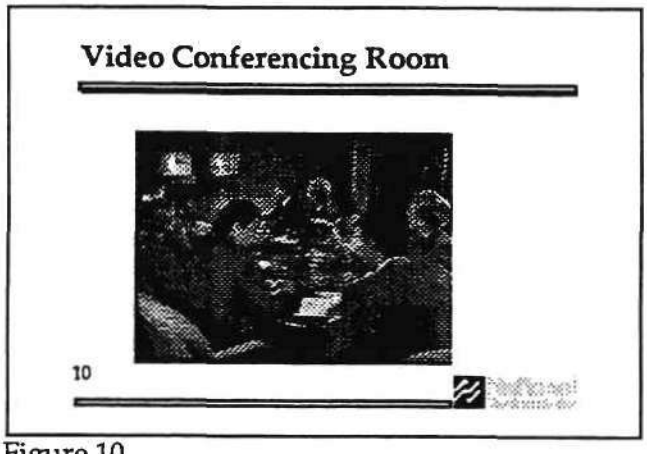


Figure 10

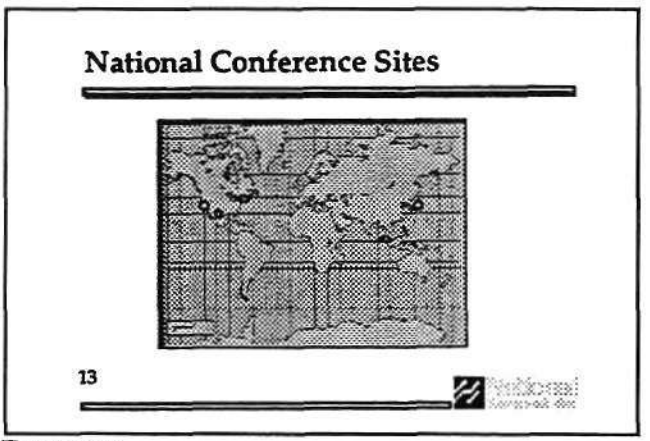


Figure 11

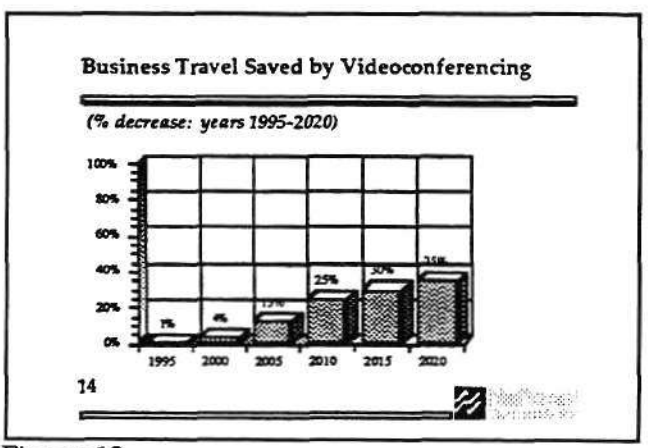


Figure 12

At National, we have dedicated video conferencing rooms in California, in Utah, Texas, Maine, Maryland, Scotland, England, Germany, Singapore, Hong Kong and Japan. And in spite of the expense, which is billed of course to the using departments, these rooms are very popular. You must reserve a room at least several weeks in advance and you run the risk, unfortunately, of being bumped if an organization that has a higher priority has a need to use the room. Our company is not alone in this respect. Our research tells us that many companies are in fact using video conferencing today. But I'll bet more of you in this room have taken business trips in the last six months than have used video conferencing rooms—I'll also bet this is going to change significantly.

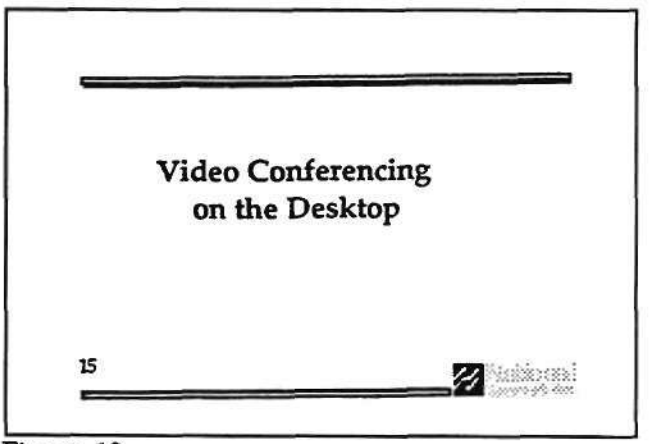


Figure 13

A New Hampshire consultant, Ernest Thorvi [phonetic] has predicted that video conferencing will in fact eliminate one in four business trips by the year 2010. He further predicts that it will eliminate one in three by the year 2020.

While some people feel that this notion is a bit far fetched, and rest assured the airline companies and other travel oriented businesses are praying he's wrong, most everyone agrees that video conferencing will have a major impact on the way that we conduct business.

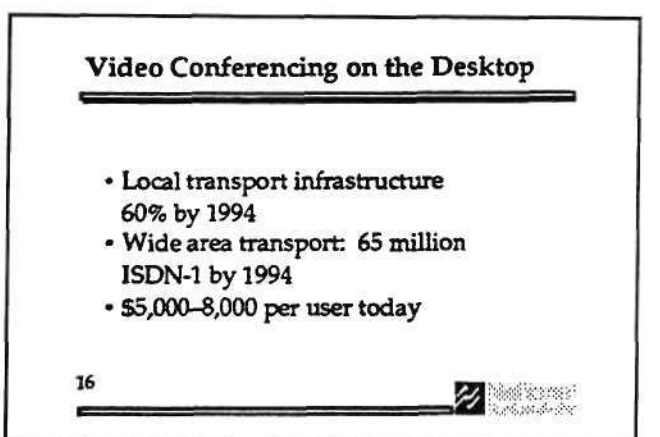


Figure 14

We can use travel cost reductions to justify buying a video conferencing system but the real benefits, the real savings will come from increased productivity and communications. For the full benefits of video conferencing to be realized in our business, video conferencing

must be available more broadly so it can be used it more spontaneously. For that to happen, it must move to the desktop—that movement is now in progress.

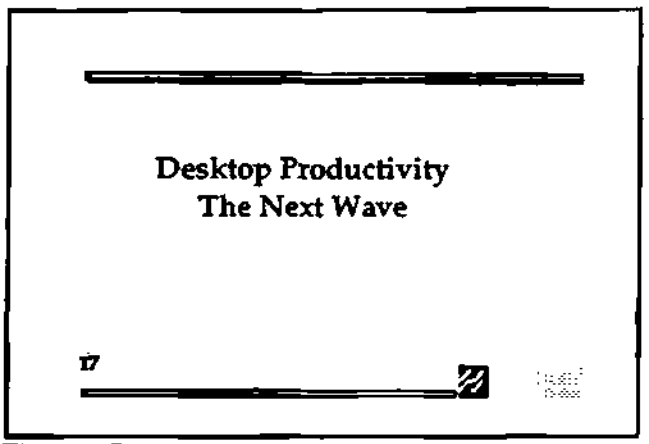


Figure 15

Technology is rapidly enabling high quality video with low cost video cameras, high resolution color video monitors, fast video capture at 30 frames per second, and the required audio amplifiers, mixers and codec. The local transport infrastructure is also in place—with more than 60% of potential users connected by the end of 1994—and the wide area transport infrastructure is also falling into place with more than 65 million ISDN capable lines estimated to be in service by the end of 1994. But, it's still too expensive.

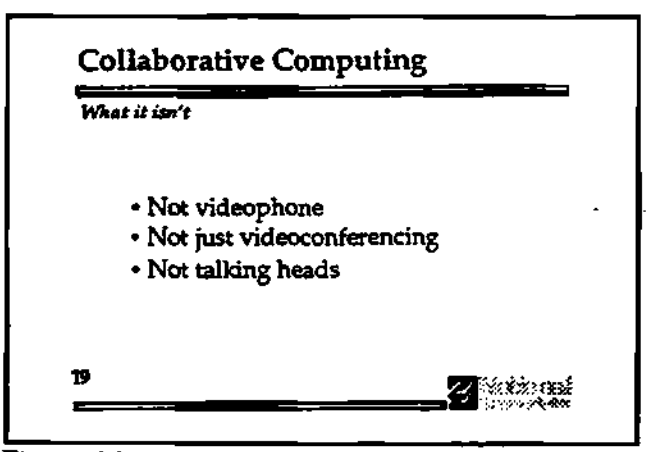


Figure 16

The hardware and software to implement the video conferencing PC today runs up to $8,500 and the basic rate ISDN tariffs, which vary widely even just around the United States, are still excessively high. These transport prices are falling, however, and we anticipate that in 1994, 6B channels will cost less than $50 an hour.

Now let's talk about the concepts of desktop computing and collaborative computing.

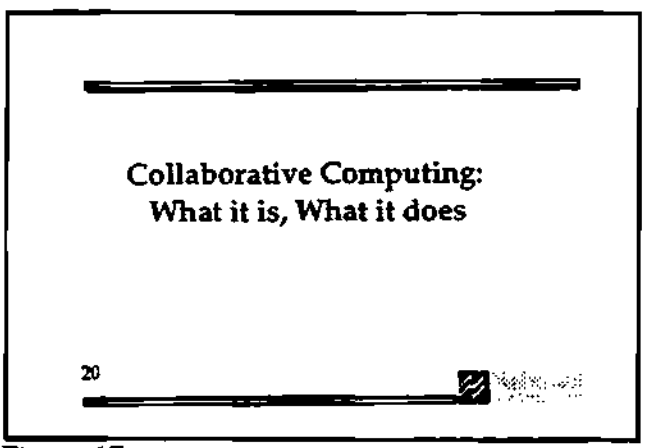


Figure 17

The introduction of the personal computer in the early 80's brought a major increase in personal productivity. You could manipulate data on a PC far faster, and much more accurately, than with pencil and paper—and you didn't have to wait for the MIS department to take care of your requirements or to add or change software. In the mid-80s, the introduction of networking of these PCs brought another increase in personal productivity—you could share your data with others in your work group or in other parts of your company. I believe we're on the verge of implementing yet another wave of desktop productivity, at National we call it collaborative computing. Before I get into what it is, let me make several things clear.

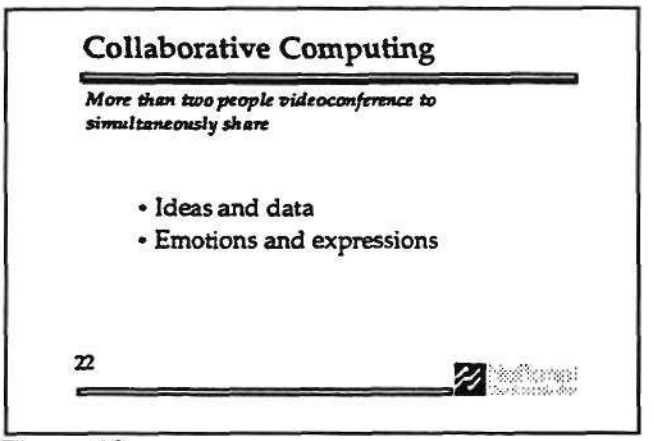


Figure 18

Collaborative computing is not a video phone—it is not limited to video conferencing—and collaborative computing is not what people refer to as just talking heads.

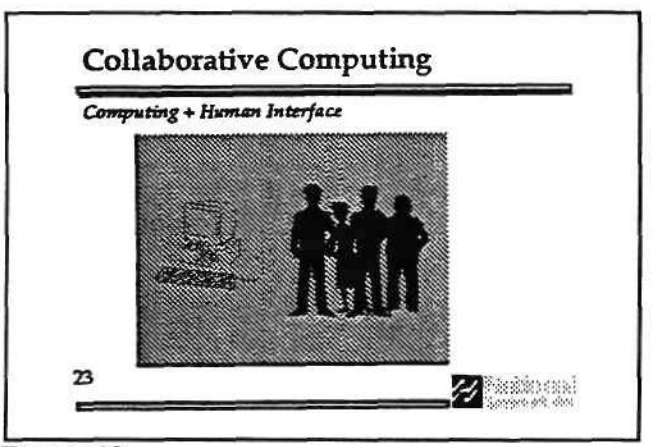


Figure 19

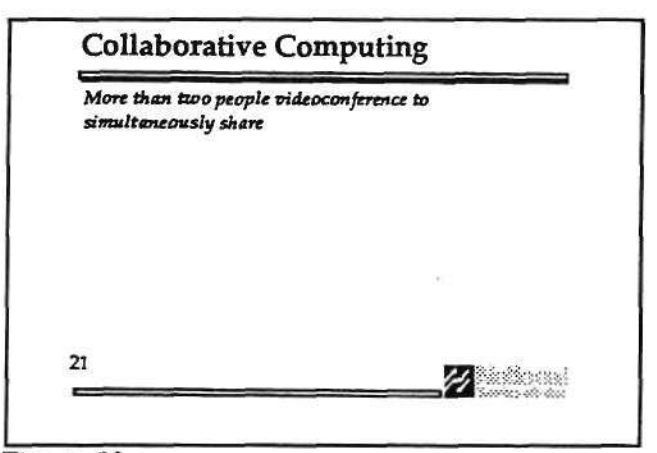


Figure 20

Our definition of collaborative computing is work group video conferencing, where two or more people simultaneously share both intellectual ideas and hard data. The ideas are shared by the words, emotions, and expressions that people use while they're talking—the data is shared by these same people manipulating graphics, spread sheets, databases and other types of documents in real time. About 80% of most meetings key on human interaction.

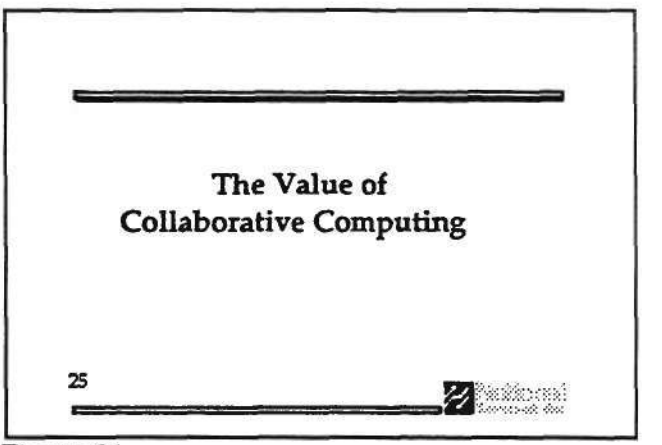


Figure 21

When people talk, or argue a point, they use facial expressions and tone of voice to convince and to get others to accept their arguments or to adopt their point of view. In other words, collaborative computing improves productivity by combining the power of the computer with the richness of the human interface. Are there practical implications and applications for this? You bet there are.

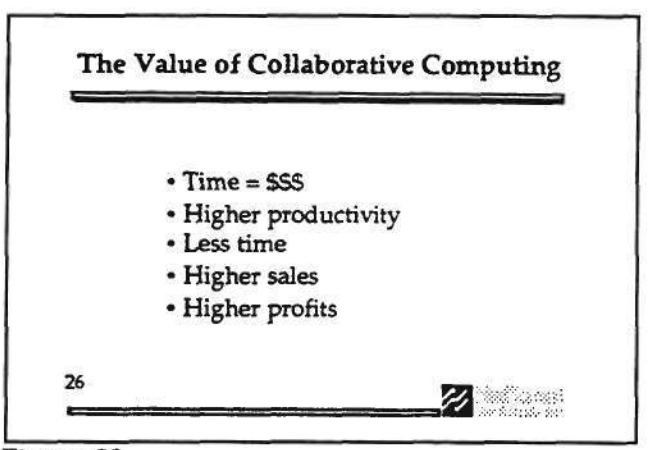


Figure 22

Let's take a look at just one.

[VIDEO]

That simulation is one segment of an asynchronous video that National recently produced to show the world how we'll be helping to enable this next wave of productivity. While the characters in the video were presented with a relatively simple problem to solve, making a change for a client, I think their interaction demonstrates that there's an enormous value in simultaneously working together over distances and being able to change and manipulate the same information.

We in this room may have to adjust our mindsets to really accept collaborative computing since it's not the paradigm with which most of us are familiar. In our video conferencing, we're used to talking heads and, at best, a single video image of a piece of paper. At our desktops we usually don't sit around with three or four people exchanging information—I can't remember the last time I sat at my desk doing that kind of a project. But there are many people in our organizations who do just that. How would it affect your company, or ours, if a person working on a chip design in Tel Aviv could simultaneously share that work through audio and video communications with coworkers in Santa Clara and Hong Kong and virtually anywhere else in the world?

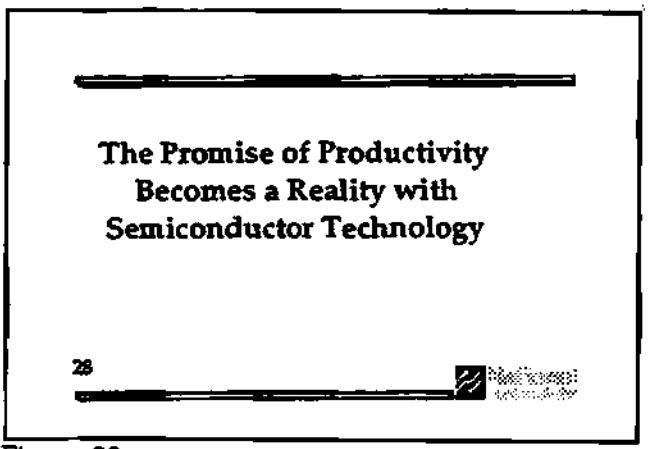


Figure 22

How would it affect productivity if each of them could make simultaneous comments and changes based upon their individual skills? And how would it affect our bottom line? Well, what used to take days or even weeks will now be able to be done in minutes—and clearly time is money—so, that's how it will affect our bottom lines.

So where will we get the experience to achieve these great time and money savings? The promise of increased productivity through collaborative computing is still not a reality for the mass market.

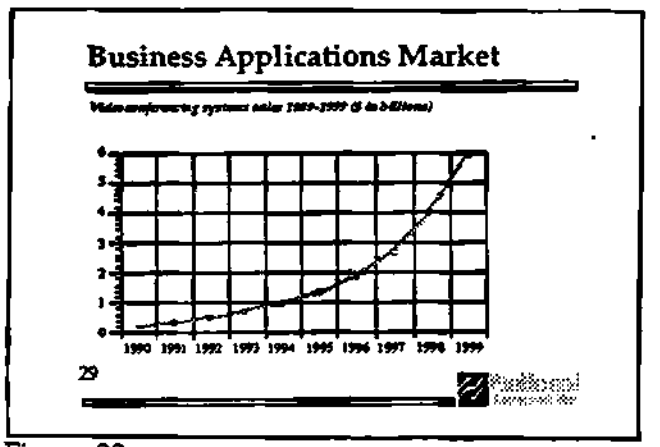


Figure 23

Today, as I said earlier, rudimentary PC to PC video has been announced by a number of companies, but the image is small, blurry, appears at a slow rate of change, and won't allow multiple parties to interact and change the information on the screen simultaneously. So, its very limited application still costs about $8,500 per workstation. The full application of collaborative computing at reasonable prices, however, is well on its way—thanks to technologies in development in the semiconductor industry.

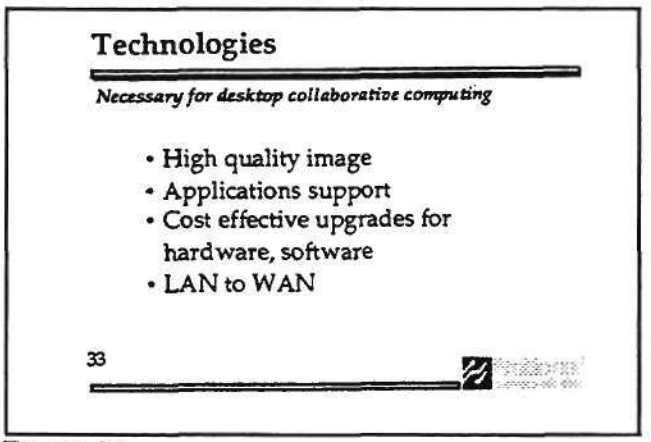


Figure 24

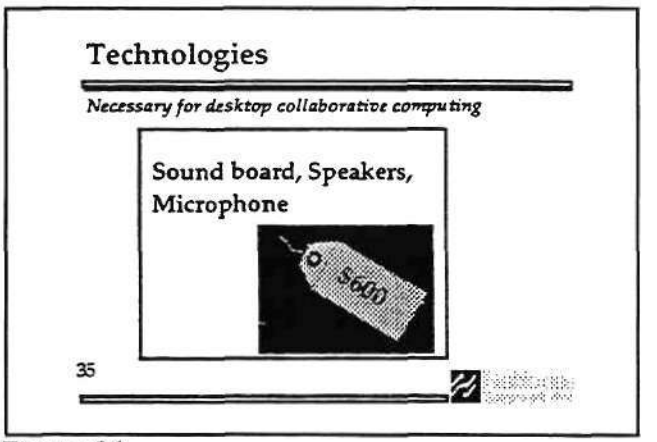


Figure 26

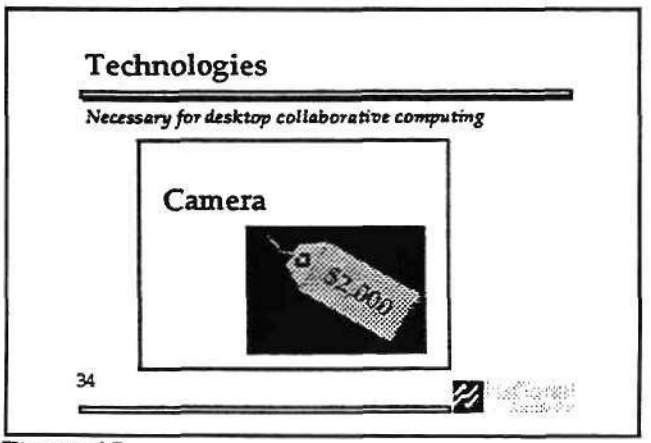


Figure 25

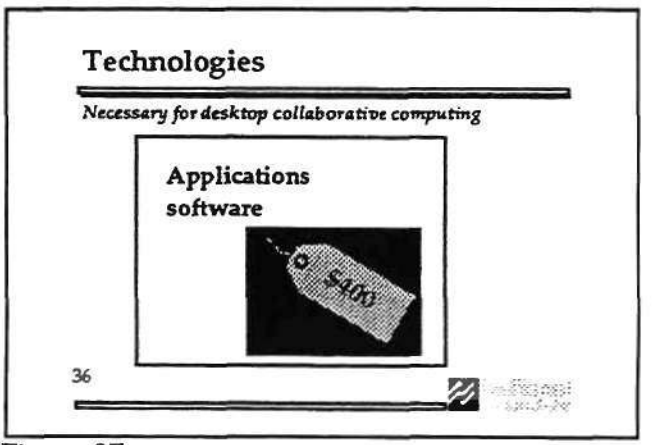


Figure 27

Before we address these technologies and capabilities, however, let's look at the opportunity.

This innovation is not really of interest unless it addresses a sizable, and what we all believe to be, profitable market. What do you think about a market of $6 billion in just a couple of years?

A market research organization predicts that worldwide sales of video telecommunications equipment will go from about $500 million last year, to over $6 billion in 1997. This slide shows National's forecast for desktop nodes using this technology—from 100,000 nodes in 1995, to 300,000 in 1996, to more than 600,000 in 1997.

And, yes, as you saw in the AT&T video this morning, there will be a significant consumer market for video conferencing. Eventually the technology will be so affordable as to allow that huge market to develop—but I'm not going to go into detail on the consumer market today.

Suffice it to say, as you saw in that video this morning, we will see a day when remote teaching, medical advice, home entertainment, home shopping, even family reunions are accomplished with video conferencing. What I'd rather do is to shift from applications and markets now, to the technology that will turn the promise of productivity into a reality.

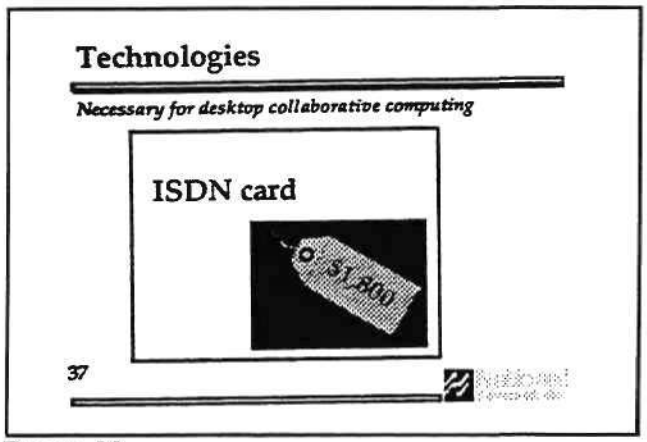


Figure 28

Desktop collaborative computing requires the combination of many capabilities.

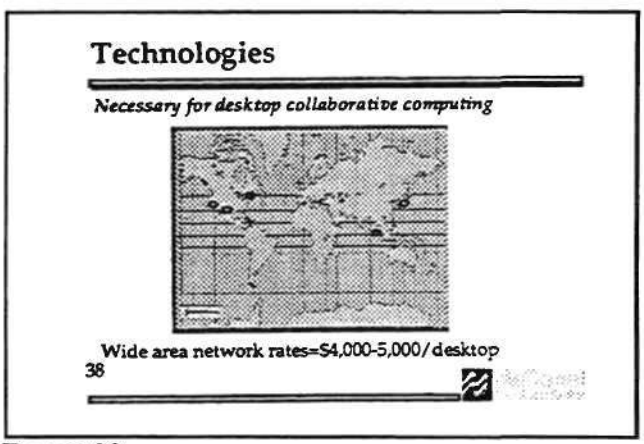


Figure 29

It requires interoperability with existing systems, high quality video images, application support, cost-effective upgrades and cost-effective hardware and software components—and a LAN to LAN network infrastructure that supports multi-party video conferencing and real time data sharing. In fact, collaborative computing will only come to life when it can be done across the wide area network.

Let's turn today's typical PC into a video conferencing PC and see why the costs today are still too high to achieve major acceptance.

First, I need a video codec application software and a camera—cost today, almost $7,000. Then I need to upgrade my PBX to switched 56 kilobit or ISDN capability—cost per individual work station about $500. Then I need an ISDN card to provide the additional bandwidth required for video conferencing—cost about $1,200 per work station. Finally, I need to consider the wide area network transport costs to convey this information, conduct these conferences across cities, states, and countries even worldwide—cost about $1,400 a month for one primary rate interface circuit. The bottom line is that about $8,500 additional cost per desktop PC, plus $30 to $300 per hour for transport costs, is simply too much an investment for most any company to make. Especially when all they get for that investment is low quality video conferencing.

So what will it take to provide high quality cost effective multi-party video conferencing? One of the things semiconductors do well, which everybody in this room realizes, is to turn complicated and expensive into simple and less expensive. We will help these costs plummet through integration. We will play an enabling role in bring this technology to market. Intel, Hewlett-Packard, IBM, AT&T and others have recently announced their plans to contribute their skills to the evolution of desktop video conferencing. At National we will offer innovative technology by 1995 that will help bring the cost to up grade a PC to high quality collaborative computing to about $2,000. We will take the functionality now on a sound card, video card, and network connection card and integrate that functionality into a single board. That integration will virtually cut the cost in half—and that board will eventually cost no more than a thousand dollars. We will offer high quality asynchronous services network solutions that will connect desktops to the public network.

Earlier I showed you a simulation of collaborative computing. Now I'd like to show you a demonstration of its enabling technologies produced without any edits or special effects. I should point out before the video starts, that the rolling line you'll see on the computer screens is not the result of the

technology but rather the normal result of shooting a video monitor with a video camera.

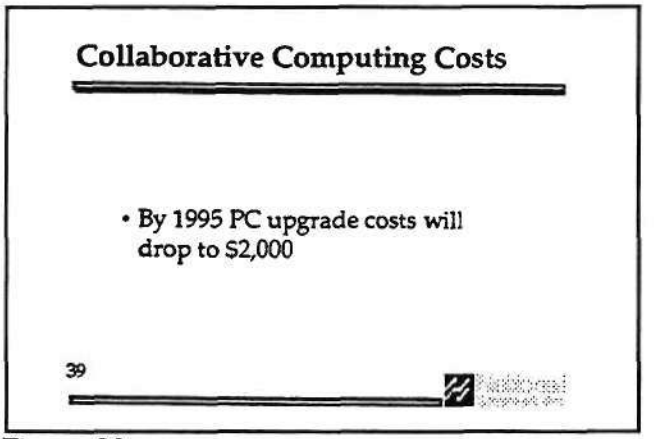


Figure 30

[VIDEO]

We produced that real time video to demonstrate that our asynchronous technology is, in fact, here today. To do this we had Mike, Andy and Andrew sitting in the same room, but they could have been in any part of National's campus operating over our local area network—but as I said before, the real capability, the real explosion in desktop video conferencing, will come when we can operate over the wide area network, which we believe will be possible by 1995.

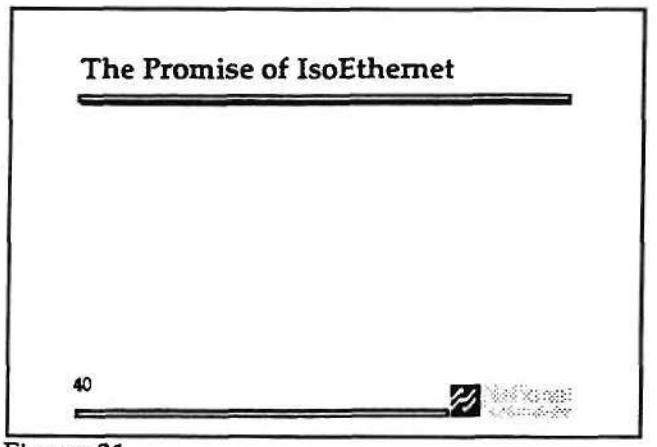


Figure 31

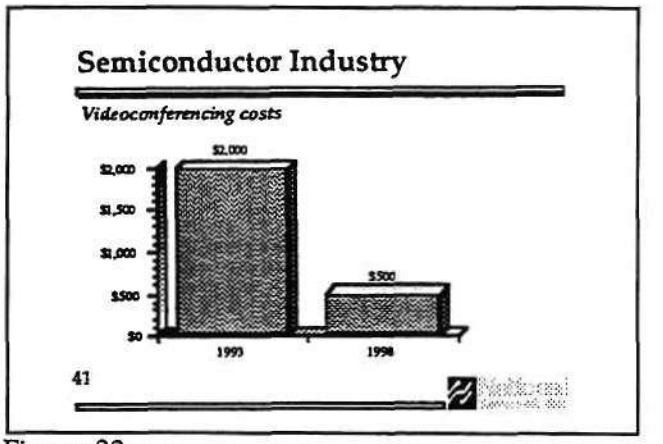


Figure 32

We feel that National's asynchronous services, including the iso-ethernet technology just demonstrated, holds the greatest promise in the short term to provide high quality, full motion, multiparty collaborative computing. In the future, it's a given in the semiconductor industry that we can dramatically reduce costs over a relatively short period of time. As I said, by 1995, we'll offer video conferencing solutions for about $2,000. This will usher in what I consider to be the new wave of productivity for the business environment. By the end of decade, our industry will drive the cost down to about $500. We believe at that point the consumer market will truly take off—and this will happen. It will happen because end users are looking for this capability. It will happen because PC manufacturers, LAN providers, software developers, and telephone companies all want collaborative computing to become a reality. And this is so because the end users will get productivity increases, and for the other participants in this market place, this could add significant value to their products and services. We're all marching together to make this happen.

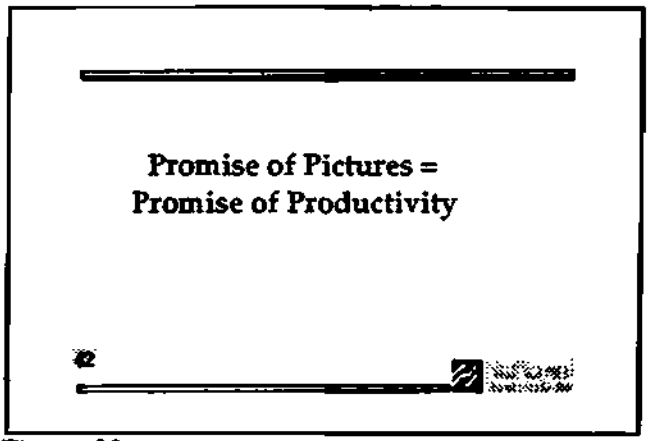


Figure 33

Success in business depends on productivity. To a great degree, productivity depends on timely communications. Before the PC, if data changed, people had to retype every letter, redraw every graph, and recompute every column of numbers. We sat in our offices and waited for the data so we could make critical management decisions—and we waited. Before PC networking, to share data people had to physically move the floppy disk containing the data to other people in their work group—and we sat in our offices—and we waited. Imagine how much more productive we can be, how much more successful our organizations can be, if our workgroups can share and manipulate data and see and hear each other in an instant from anywhere in the world. Imagine the sense of urgency that this will ingrain in our corporate cultures. Of course, the downside is that everybody will start to expect us to make critical management decisions in much less time—but that's a small price to pay for progress, and I venture to say that everyone in this room is willing to accept that challenge.

Thanks very much. I'd be happy to take any questions.

Questions and Answers:

Question: Do you feel conventional LAN technology will be good enough for collaborative networking or will the technology like ATM be required?

Mr. Beyer: I think if one says conventional LAN technology, the answer is no. I think we must expand the overall capabilities of LAN technology, but that doesn't mean an abandonment of the Ethernet protocol, for example—an iso-ethernet is an example. Faster ethernet will, in fact, be able to handle this application, although we believe it will handle it only on a very limited basis and therefore asynchronous Ethernet is far more appropriate solution. Unquestionably, ATM would handle it, but we believe that users who are interested will want to implement this capability within their organizations before they migrate their networks to ATM. So we believe that the technologies of today will be the technologies that we use to build upon for collaborative computing.

Question: Do you think this depends on telephone charges going down, and if so do you have any projections on how much they will decrease over the next five to ten years?

Mr. Beyer: Certainly the application will be driven both by the cost of the equipment and software needed to support the application, and the wide area environment, which we think is critical, will definitely be affected by the tariffing the service. I gave just a couple of indications, this technology will allow the application here in the United States to be dealt over 6 B channels and the cost of that in 1994 will probably be in the range of $50 an hour. So we believe by that point in time the price of the network costs will, in fact, enable this application to take off because the hardware and software costs will be coming down as well.

In the international environment the rates, as everybody who's dealt in the international environment or is from overseas knows, tend to come down more slowly, so I believe that international applications will happen a bit more slowly because of that cost.

The question is, will you keep your promises? National will keep its part of the bargain if the

rest of the industry works with us, I believe that the entire semiconductor industry, the PC OEM manufacturers, software developers will, in fact, make all this happen in the time frames that we speak. It's certainly in all of our best interests.

Thanks very much.

Enabling Platforms for the Digital Office

Karen Hargrove
Senior General Manager
Digital Office Systems
Microsoft Corporation

Mr. Norrett: Our next speaker is Karen Hargrove. Karen is general manager of the Digital Office Systems Group at Microsoft Corporation responsible for all systems software found in the work place products including telephones, fax machines, copiers, handheld systems and printers and for connecting these systems to personal computers running Microsoft Windows.

Karen worked with Dr. Nathan Merthold[phonetic] ******that spoke to this audience last year. Nathan is Vice President-Director of strategic planning at Microsoft, and Karen has moved over into a line function.

Prior to joining Microsoft, Karen was a member of the Digital Equipment Corporation West, DecWest as it's known, engineering team which focused on advanced hardware and software platforms.

Would you please give Karen Hargrove a warm welcome.

Ms. Hargrove: I guess I'm the black sheep at this conference because I'm not going to talk to you about hardware or chips—I'm going to talk to you about software and solutions we need in the work place today.

I'm responsible for Digital Office Systems, and what that means is software products for fax machines, copiers, telephones, handheld systems and printing systems. I don't think the workplace is just on a PC—it is much broader than that—and I think there are a number of problems we have to solve there. What I'll show you first is a concept video that we put together that characterizes what problems in the work place keep us from getting work done. This is supposed to be little funny so I'll be able to tell who is asleep in the back if no one is laughing.

[VIDEO]

Unfortunately this really is the work place that we live in, and when you're in that situation, it's not so funny. So what does this mean?

For the last twenty years, a number of companies have said we need to have a better integrated office, the paperless office, the office of the future—no kidding this time. One of the big reasons it hasn't happened is there hasn't been an architecture and platform that is open, supported by a number of different manufacturers in real partnerships, really trying to solve the problems in the workplace.

Until now, everybody has focused on the workplace as just being PCs. We have all of our data there in digital form, we have the ability to handle lots of different documents, and documents become richer every day. We use our PC as a place to store information in digital form. Now the irony of that is that once we have all our data in digital form, the only thing we can do is get it out of our PC in some analog form—that's not very sophisticated. What we end up with is people running around the office trying to make connections between the different office machines in their office environment, instead of using technology to help make it happen in a digital way.

If you look at the issues of communication and information access or delivery, even though all of us here are in the technology computer industry, if we have a document to send overnight to a broad audience of people—not just people in the industry but families, friends, people that don't have internet or a PC LAN environment—how do you send it to them? Today, it is pretty much analog. If I want high quality, I use the postal service and send the original, if I just want it to go fast, I'll send a fax then follow up with an original because fax is such poor quality.

If I want to send something editable, I'll probably FedEx a floppy or mail it, or sent up a data modem, but still, it's not very simple or intuitive, and not something you would get your family members involved in.

If I look at ways to address others phone numbers are easy, but physical addresses can get very confusing. Internet addresses, for example are hard to explain to people outside the industry. So we want addressing that is very simple. But what you need to solve these problems are platforms—and it starts with the hardware components, the chips, the VLSI and DSP functionality, for modems. Then, to then enable these platforms to be flexible instead of hard wired, you need to layer on a modular software architecture.

You also need to think of not just the PC industry any more—to make this a reality the office will be a mix between computer companies, telecommunication companies, and office machine equipment companies—so that the platforms can transcend these three different industries.

So the foundation is the hardware technology. Recently there has been a number of new chip set introductions for office machines—both embedded and handheld systems. So that's a core fundamental basis.

Then on top of that, is something that we call Microsoft At Work. It's a technology and software architecture for providing software and communications among all of these devices in the office. It draws on the networking capabilities that you heard the speakers talk about this morning, and uses the chip sets that are going into embedded systems to make them real platforms.

All of this requires partnerships. We do software—we don't build telephones today, and we don't do chip sets—so it really takes partnerships between all three types of companies, telecommunications, office automation and personal computers in order to make this happen.

So these are the foundation for what I call enabling platforms. To give you a concrete example. When I was in New York, I was walking downstairs and I saw three gentlemen with this huge crate full of phones. My curiosity was piqued—so I asked them what they were doing with all those phones, and they said we gave a new valet service at the hotel we've ordered new phones because we need a new physical button. They replaced them all!

That's a very real example of devices that are hard coded. If you want a new feature or function, you have to get a new device. It's almost like telling the people that use PCs that if they want to run a new application, they have to go buy a new PC. So devices today really are hard wired, and providing a software architecture and a platform means that you can now write applications on top of them to customize them.

Another aspect of Microsoft At Work is the ease of use issue. I think there are still many of us who aren't able to use some of the basic functions on our office systems, and we haven't even begun to tap the rich functions and features. That is because the user interface is just not easy or intuitive to learn, so you have to learn it over and over again. So you want something that's easier to use so people become more proficient. It's interesting, if we're so good at technology, why is it that we're always

making end users adapt to technology instead of the other way around? So we want to put more focus on the end user and have these new systems adapt to them.

Then there is the issue of compatibility. I want to be able to send information many different people and have them receive it on a number of different devices—all in a compatible way.

The Microsoft At Work architecture has these five components to it. In the center is small real-time preemptive multitasking kernel. It's really small because today phones, fax machines, and copiers don't have much memory in them. So it has to be very small, real-time preemptive multitasking kernel designed specifically for communications and office machine equipment, because communications is a realtime task, and even a device such as a fax machine can be scanning, printing and receiving all at the same time.

Then we have the graphical user interface (GUI) up on the right hand corner. Either on the device or on the PC there will be a GUI and touch panel that allows you to access features and functionality rather than just a series of hard coded buttons.

Down at the bottom is the Microsoft At Work rendering technology. Today if I print something, the quality of the printout is different from the fax, and from the copier, and from what I view. But I want them all to be equivalent quality, and I want them to be the best quality and not the lowest common denominator. So this technology is a small rendering piece of software that runs in these devices and interprets displays or prints a document.

Copiers degrade because they have analog input—they can't take a digital original. In the past, we've even gone so far as to make fonts that don't degrade as badly instead of fixing the real problem of giving the copier digital, rather than analog input. So now what you print, fax, copy, see and view will all be the exact same quality.

Then there are communications—each of these devices must connect to a network—and do it in a network independent way. As you can see, there are a number of new network technologies out there, whether it is ATM, PCS, ISDN, a *******POTS system or a proprietary PBX system. Because there are many network technologies the connection must be independent of the network—this is what the Windows Telephony services API interface enables.

Communications also must be secure. Today there is no such thing as a secure fax. What we want to do is provide encryption and decryption of messages over the network. We want to provide authentication capability so you can be sure that your fax is being sent to the correct place and to the correct recipient. There have been a number of incidents in our industry where a document meant for one person was sent to another, or something was faxed to a newspaper that printed a merger agreement ahead of time, etc. We want to resolve these problems by having authentication and digital signatures so that you can be assured the document did not change from the time it was created, to the time it was received.

Finally, on the bottom is desktop software. You don't need a PC to run these devices, they're all standalone and will work by themselves with Microsoft At Work software. If you do have a PC you have extra benefits, however because with Windows we are bundling At Work software that allows you to communicate with each of these devices. We recently introduced Windows for Workgroups version 3.11 and as a start, it has Microsoft At Work fax capabilities. Fax doesn't just mean bitmap anymore—you can send any form of a rich document over a fax/modem. We will continue with future versions of Windows to add the technology to connect to all of these devices. So if you look at this, there is the desktop software that goes into

the PC, there is the real-time multitasking kernel, secure communications, the rendering and the graphical user interface that physically resides on the device itself.

On June 9th of this year we introduced the Microsoft At Work architecture and since then we've had a number of ISV conferences for hand held systems, we've been shipping development kits, and we begin shipping systems next year. So we had to introduce a concept, and at the time of the announcement, over seventy companies listed here said they were working with us to create At Work products. So this is not something we think we can do alone—we want to work with a lot of other companies to make the integrated office a reality. This office will require more of a hardware platform and we're counting on that to come from people like yourselves

Thank you.

Questions and Answers:

Question: Given the fact that a few of us still use software applications that are not Windows compatible, in addition to using Windows applications, will Microsoft At Work benefit in a stand-alone environment?

Ms. Hargrove: Absolutely. That's one of the things that I tried to bring out in the video. Let's take a specific example. By allowing people to do delayed send, and to configure their fax machines to their networks, we have been able to save MIS managers costs in telecommunications. You can save as much as 40% of the cost of faxes by sending in a delayed time and at reduced rates rather than at the end of the day.

Question: Please explain preemptive multitasking and why it is necessary?

Ms. Hargrove: If you take a phone, for example, you could have a number of different calls coming in at the same time, and need to be able to address them in real-time. Fax is even more imperative, because if you have a call coming in and it isn't answered within a limited time, the caller hangs up and the call is lost. So in the operating I need to be able to switch between a number of different tasks and functionality and be able to address all of them in real time. That's also true for running print engines at speed—some printers don't like being stopped and will abort the page being printed—so you need to keep the engine running. Incoming communications or scanning functions also can be a problem without preemptive multitasking.

Thank you.

Panel Discussion: The Future of Computing

Ken Lowe, Moderator
Principal Analyst,
Semiconductor Microcomponents Service
Dataquest Incorporated

Panelists:

Tom Beaver
Corporate Vice President
and Director of PowerPC Programs
Motorola

Dr. Lani Spund
Chief Technologist,
Enterprise Systems Division
Apple Computer, Inc.

Frank Spindler
Marketing Manager,
Pentium Processor Family
Intel Corporation

Karen Hargrove
Senior General Manager,
Digital Office Systems
Microsoft Corporation

Brad Smith
Vice President,
Worldwide Computer Systems Group
Dataquest Incorporated

J. Gerry Purdy
Vice President, and Chief Analyst
Mobile Computing
Dataquest Incorporated

Mr. Norrett: I'd like to introduce our moderator Ken Lowe. Ken is a Principal Analyst from Dataquest's Microcomponents Service. He is responsible for research, analysis and forecasting of microprocessors and microperipherals, including the controller chips, graphics, networks, and storage. Previously, Ken was the senior industry analyst in the graphics processor research area of Dataquest, and prior to joining Dataquest Ken was president of Performix Technology, a startup company that developed and marketed Windows graphics accelerator boards for the PC. Ken has more than twelve years experience in the electronics industry and we are very pleased to have Ken moderating this panel this afternoon. So I'll turn it over to Ken and let him introduce his panel.

Mr. Lowe: Thank you Gene. Good afternoon and welcome to Dataquest's panel discussion on the future of computing. This panel will focus on the major trends that are affecting the PC industry, then try to relate those to the future effects they'll have on microprocessor architectures. Now, I'd like to introduce our panelists.

From Motorola, Tom Beaver, Corporate Vice President and Director of PowerPC Programs; from Apple Computer, Dr. Lani Spund Chief Technologist in the Enterprise Systems Division; from Intel, Frank Spindler, Marketing Manager for the Pentium processor family; from Microsoft, Karen Hargrove, Senior General Manager of Digital Office Systems; from Dataquest, we have two people—Brad Smith, the Vice President of Worldwide Computer Systems Group and Gerry Purdy, Vice President and Chief Analyst from Mobile Computing.

Computer systems are in a rapid period of change with new architectures, software and form factors reshaping the industry. The microprocessor used inside the computer determines the level of power, performance and the kind of price range of the computer system. Currently, the X86 family represents over 80% of the PCs being shipped, and continues to control the majority of the market due to the base of compatible software, widespread availability of competitively priced systems, and general market acceptance.

However, times are changing. Competition is beginning to mount from the proponents of RISC processors who are proposing to offer substantially better priced performance using a different model of compatibility. Success in the future mainstream PC market will be based on the totality of the solution offered by an architecture across a range of different factors. We'll examine some of those key factors today in our panel discussion. The first question I'd like to move to is one that involves the integration of the PC with the workplace environment. Very similar to the discussion that Karen entered into earlier.

There are some very significant movements underway to integrate the way we implement communications, control office machines and perform other office functions—the way we interact with our PC. Does this panel believe this concept will be successful and if so, in what timeframe and how will that affect the trends in PC architectures. I'd like to start the responses with Dr. Lani Spund from Apple.

Dr. Spund: Well Karen and I agree that we're not going to be talking about our various products, we're going to sit back and drink some beer while you guys discuss whether Microsoft, Pentium or PowerPC, etc. is going to win the marketplace. I think my talk lends credence to the fact that Karen and I see the world coming together the same way, and the degree to which we can agree on a set of standards that gives us cross platform portability is going to be the real key to success in the marketplace. It's won't be whether Windows or Apple proprietary products win anymore, it's how we interact with one another.

Mr. Lowe: We heard from Karen earlier that in fact this type of movement has been looked at for the last twenty years, and that it hasn't

happened until now and what's changing is that now there's a single platform with a set of business partnerships designed around propagating this into the office—which really precludes multiple architectures from proliferating in the office. Does anybody have any further comments on the question? Gerry?

Mr. Purdy: Well, I think that Lani's comment is a very good one, and it's one which has to be taken forward. If I take Karen's video as the reality of the way the office works where things sometimes have complexity of blowing up when you reach the end of the day. What happens when you finally are finished, and you want to submit it to the other party? Let's say they're in a Microsoft At Work environment and the other party is in an Apple networked environment and the documents get transferred? Can they in fact electronically be received and managed appropriately on the other side? Do I do something as profound as submit everything to fax—receive the fax, OCR it and then utilize and manage it within that different environment. So we need not only the interoffice, or intraoffice, solution, but also the interconnection between networks which may be based on different architectures, and the means to make sure that protocol and processing mechanisms are in place to make it operate efficiently. We don't have that in place yet, but I think that's the challenge for the future, to have this interconnectivity—it will be a strong criteria to success.

Mr. Lowe: Karen, does your proposal involve seeing multiple architectures implemented in the officeplace and interconnectivity between those?

Ms. Hargrove: I think that the cross platform integration is important. There are many different types of machines that people have in their office from a number of different vendors. Even if we just take personal computing, a lot of people have Macs and PCs and some mixture of the two of them. In fact, Microsoft applications today are on the Mac, and it is important to share and exchange data between those two types of platforms. So cross platform integration is really important to us. We're just trying to push that further out and not just address PCs, but really take it out into more devices—the other devices in the office that we've neglected for the last twenty years, and have them be able to have that same kind of platform capability.

I'd also like to comment on whether Microsoft At Work will be successful. Who knows what will be successful, or when and how. But here's a general trend that you should think about. These other devices in the office, they are kind of computers today. They have processing power, they have memory. So you say, do we think Microsoft At Work will be successful? In a way I think that is an question independent of how are these office machines evolving? They will evolve to accept digital input. They are digitally based as far as hardware architecture today, but they are in need of some solid component technology in the form of processors, DSPs, and networking to allow them to connect up, and as you saw by that partner list, we're working with a number of companies who are looking for solutions. So the time is ripe, and I think there is an opportunity there, whether the software is Microsoft At Work, or something else. I think that will just be the start of it.

Mr. Lowe: Any further responses on that?

Mr. Spindler: The environment here is very similar to the way it is in the desktop environment, volumes drive the ability to make investments in capital and in the architecture. With the Intel architecture generating volumes of 40 billion plus units a year, we're able to take the investments that we make for fabs for the higher end PC products and apply it to these types of products as well. So what you see from Intel are fully compatible devices that are integrating the additional functionality that's beneficial in this type of environment. You'll see this with 386 and 486 core types of devices, and it becomes a fairly simple matter to move software into this

environment that does play well with the devices in the office of desktop PCs that these portable devices will be communicating with.

Ms. Hargrove: I'll add one comment to that. You're commenting only on how big the PC industry is. If you take the office machine industry and telecommunications industry, it's at least twice as big. If you combine them all, the market is much, much bigger than the PC industry. So that's just something to think about.

Mr. Beaver: Obviously my bias will come forth here as regards PowerPC and the earlier comment about how we envision that this office environment and the portable environment, the whole convergence of communications, consumer and computing which was very well articulated this morning by both Gordon Moore and Mike Attardo. Does this suggest that there are going to be other architecture within this environment—the answer is absolutely yes. Because while the office environment as it exists today is an X86 DOS moving to Windows NT environment, it's a whole new ballgame in terms of communications and the interoperability vis-a-vis wireless. And, it's a whole new ballgame in terms of portable devices because the size of these OSs that are used in office environments certainly are too large for that which exists or will be required in the PDAs. So it's not clear that it's only one architecture in that environment. As a matter of fact, I think with all of these portable OSs and all of the things that are going on in the interoperability schemes, client/server models, wireless protocols, etc., it's very much opening up the marketplace for other architectures and other choices for the user.

Ms. Hargrove: Given that comment, I want to ask Tom, what are the PowerPC based platforms or solutions that people have for fax machines, phones, copiers, all those things that I was talking about, in other words, what is Motorola doing in this area today that people can use because I know that there's lots of other products that do have applicability to those things today.

Mr. Beaver: We've been in those environments a long time with 68K cores and IOs that perform various functions, whether they are things that similar to what the General Magic people use, or what is used in laser printers, automobiles, whatever. We're no stranger to embedded control and standard cells surrounded cores. So the obvious thing that's going on in our shop is to take those PowerPC cores—whether they be the very small cost-effective ones, or those like PTEC an acronym that means Power Train Embedded Controller, PowerPC core that's being used where Ford is the volume driver. Or, taking that as a core and surrounding it with the necessary IOs, or cores like the 603— which is a very powerful part from a spec standpoint and has a good feature set and yet has a small enough die [phonetic]****** to go after the embedded market. So the answer is doing with PowerPC what we've done with the 68K microcontrollers.

Ms. Hargrove: Does that mean that Microsoft At Work should try to address PowerPC?

Mr. Beaver: Absolutely.

Mr. Lowe: Relating back to the original questions, does that mean that as we look into the future that we will have office machines controlled with a Windows look and feel interface on the front of them so that copiers, for example, are operated with a Windows look and feel on 80% or 90% of the systems, and maybe 15% will have an Apple look and feel on the front of them?

Ms. Hargrove: I'll address that. I think that the Windows interface is great for doing the tasks that we have today, for applications like Excel or Word, and the Mac interface has been great too. But now let's take a fax machine or a phone. We have many users of these types of devices that are not PC users. My grandmother would not be able to figure out a Windows shell just to be able to just make a phone call.

So you need an interface that is different, that maybe has some commonality to Windows but maybe with 3D buttons that are very intuitive. We've done a number of useability studies, and we think you don't want the same exact user interface—you want something that's very simple and guides people through. If I had time to show the rest of the video, you would see a sample user interface in use for each of the products that I've talked about today. If any of you are interested, just give me a card or look in the backgrounder that's in your notebook on Microsoft At Work that shows some of the different UI shots we've come up with through our useability testing. It's won't be the same interface as what you have on a PC today, because it's has to address different needs and different users.

Mr. Lowe: If Microsoft At Work did proliferate in the current office place, what microprocessor would be underlying it?

Ms. Hargrove: Well, in all fairness I was going to ask Mr. Spindler the same question that I asked Tom. What products does he have that I can work on today?

Mr. Spindler: We have highly integrated 386 core devices developed jointly in an arrangement we have with VLSI Technology. Announced plans for 486 based devices in the future. Ultimately, they will move up the performance treadmill that we're establishing with the Intel architecture, so solutions are available now.

Mr. Lowe: Okay. Why don't we move ahead to the next question. Moving over to a different environment, for just a moment let's address the same question applied to the home. Do we believe that the PC architectures and their types of interfaces, or some form of their interfaces, are going to proliferate through the new era of digital entertainment systems, communications systems and information products that are going to be introduced into the home? Who would like to start that question?

Ms. Hargrove: First of all, I think we've learned a lot on graphical user interfaces and how people use things—what's intuitive, what's not, for PCs. Some of that will apply into the other markets, whether office or home—but many won't. Take graphics and images, for example, and the graphical user interfaces versus just a lot of text that people have to read—GUIs are much more intuitive. So, there will be simple things that transcend to the office and to the home, but I don't think it's going to be exactly the same interface. Users will be doing different tasks and will require different functionality. I want my phone interface to look like a phone to me. I don't want it to be something I double click on to execute a phone number for someone. I want it be able to touch on a phone number or person and have it dial. So if I'm talking about the home, and the interface is controlling my TV, I've gotten used to remote control and it would be difficult to do double clicking or something else that is a PC Windows interface for that function. So we can learn from what we've done in graphical user interfaces, but I don't think it's appropriate to just take exactly what we've done there and apply it to devices in the home.

Mr. Beaver: I know you want some differences of opinion but I would tend to agree with everything Karen said and add a couple of other comments. I don't think there will be a cross product impact from the PC and the office environment or a more prolific use of PC-like functions in the household. The business and office will continue to want more silicon that provides robust solutions, meaning multimedia or teleconferencing, RISC processors, L2 cache controllers, wireless chips, etc., in that price point, and that silicon will continue to help improve office productivity.

In the home, however, the price point will be much different because of what the consumer will want to pay for said device. I don't need an exotic spreadsheet, I need something like Quicken or something even smaller. Or I don't need to do teleconferencing in my household, but I might want to see a little picture of the

individual I might be talking to on the TV screen. I don't need huge databases, but I need a rolodex kind of function, maybe a little more than that, especially since the price points will demand that kind of differentiation. I don't see a cross-product impact from one or the other. I think the office environment for PCs will continue to grow, but there are some data that says the growth will be absolutely phenomenal on what is going to go on in the box on top of the TV set—the wireless device that's going talk to that box on the TV set and interact with the TV and/or the PC—a kind of a client/server model within your household. So I think both areas will flourish and there will be some similarities, but also some differences.

Mr. Spindler: One thing that's important to note is that PCs have proliferated into the home already. I think a good analogy is when televisions at first were a luxury item, then it was every house had color, then everyone had two and three and they became almost household commodities. Today, we're seeing a broad acceptance of PCs in the home—they are almost a prerequisite for children growing up. I think we're going to get into how many PCs are in the home—is it two? Is it three? I know if I want to use a system at home, I have a hard time competing with my son who wants to play his games or do his typing. What we're seeing with the PC architecture, is sub-thousand dollar 486 class systems in the home and broadly used. Once that happens, it becomes very natural for those types of systems to become the integration point for the other types of capabilities that you want to bring in. Performance is valued in that environment as well. Multimedia capabilities and games chew up a ton of performance, and performance helps drive ease-of-use capabilities. The home can value that performance just as the office can, and also values access to all of the software that runs in the office as well.

Mr. Lowe: So do we see an overlap between the types of architectures and software that grow and flourish in the PC space overlapping with the consumer products that we're going to see brought into the home?

Mr. Beaver: I think there's some overlap, depending on the income. I have a Mac II at home, and so what Frank has just described is probably correct, in that there is a common computing environment being described there. The prior environment was about seven to eight million units, and in the cities that have a twisted pair Telco ******[phonetic] connection into the house, the consumer wants about a $300 to $400 to $500 device—that is about the threshold of pain that's tolerable—so I think there's kind of a demographic spending per capita income difference that one needs to look at.

Mr. Smith: I think that the Windowing environment, whether Microsoft Windows or Apple style windows, will become the user interface to all types of electronic devices—in the office or in the home. Personally, if you had a Windows interface to the copiers in our office, I might actually be able to make some copies once in awhile, but I don't think it will replace all the equipment in the home or in the office. I think it will be used to do some new and innovative things. In terms of the combination devices, whether at the office or at the home, the key things are cost and functionality. If the functionality is anything less than what is available now, if the telephone that's integrated into the PC has less functionality than usual, then people won't accept that.

Using the power of the microprocessor and the systems will advance how we interface to these machines. I also think that the home will become the client in what is a larger client/server initiative that's occurring in the world today—and that's where the PC, whatever form it takes, whether a combination device, a PC up in your kid's room, or your system. That device will become the port into the resources of the network, and that network could be back in your office, the phone system, the Internet network, a LAN or it your cable TV. I really see a huge opportunity here, and

we're in an era where we can do some really innovative things.

Mr. Lowe: Okay. Let's skip on to a new set of devices. The new genre of handheld devices that are emerging simultaneously from at least three different directions, appearing as downsized PCs, pen-based organizers, multifunction communicators. Which of these paradigms do you believe will be successful, and what impact do you believe they will have on the market for portable computers as they exist today? Gerry, you want to start this one?

Mr. Purdy: From a mobile computing standpoint, there are four classes, or types of things that people will do with handheld devices. This happens to be an Apple Newton that I have here, and we'll see a whole family of these out during the next year. First, people will be concerned with Enterprise connectivity. I may be at a lunch with a handheld device when someone says, "Let's have meeting next week about this issue," and this meeting involves people at work. So, how will I communicate that meeting back to the network? If I'm involved with a connection process through an Enterprise, how this device is used is a very important issue. Second, is interpersonal communications. If everyone in this room had a device and were communications compatible, we could send messages to each other without cellular phone signals going off in the room. Very silent, very message oriented, very simple to do, and very ubiquitous. Third, is personal information management. All the things I want to keep track of in terms of information about me and my interaction with the outside world. It may not involve connectivity, but may be simply names, addresses and telephone numbers that I keep that I want have in my handheld device. In itself, that doesn't necessarily involve any connection. And fourth, remote information access. If I want information about something, I'd like the ease of making the request here, and have the source of information be remote such that the agents and the telecommunications systems serve me and get the information I want by the way of this device. I may have to pay for it, or it may be free, depending on the structure. Services such as news, weather and sports, or more specific information such as Dataquest number.

So these things: network connectivity, interpersonal communications, messaging among millions of people, and personal information among ourselves, and remote information access to easily get information remotely—I think that's where all this personal handheld technology is headed.

Mr. Lowe: Would anyone like to respond to that?

Mr. Smith: I have a question for Gerry. If you look at the average corporation, you have a couple hundred PCs. You may need anywhere from one to four MIS people to keep those systems up and running, hold network and E-mail together, or add or delete four or five systems per month. When we move into a wireless LAN environment and everybody has these devices, suddenly you ,may have 200 to 300 connections and disconnects per day. How do you think that the infrastructure is going to manage this kind of things and do you see that as a major problem?

Mr. Purdy: I think that the whole nature of packets in wireless communication has the objective of acting as a virtual connectivity system. When I have a ubiquitous software and wireless hardware, I would hope that I have the ability to use a handheld device and have it act as if it is virtually connected to the services and networks that I have in the outside world—when in fact, 99% of the time it is not connected but using communications and protocols that gives me the look and feel of being connected. The challenge is developing the wireless infrastructure, and software support systems connected to the OSs, to allow it to happen in such a way that the user is focusing on the task instead of how to make the connection. We aren't there yet, but we're talking about the future of computing. I hope in ten years when

we have a conference like this there will be 400 people here with personal systems messaging among other people, and among remote systems. We're not there yet— but you've identified a big challenge.

Mr. Smith: So the computer and phone companies could create all these devices but there may not be a home for them in terms of the wireless connection.

Mr. Purdy: I think that's the challenge. There is so much money to be made in this area that we have the motivation to figure out how these things work for us—but we're really at the beginning of a new age and industry in terms of mobile computing. It's very much like the PC industry was in '82, '83—terribly exciting but tremendously challenging. We're just not there yet.

Mr. Lowe: Let's wrap this back around to the impact on the PC market. Right now there are several million notebook computers being shipped per year, and we're seeing the emergence of handheld devices. As the handhelds start to proliferate in high numbers, does it mean we're going to be shipping less notebooks? Or does it mean that the handheld device will be a niche product, and the notebook will go further based on incorporating so many more features. What's the impact between the two?

Dr. Spund: I think those of you who have any experience with the Newton will come to the immediate conclusion that there is something radically different between handheld devices and a mobile personal computer. The big difference is that it's an intensely personal machine, beyond anything that we would use a generalized computer for. For example, it not only learns your handwriting, it teaches you how to write better. Once you become attached to**********
one of these devices, it acts on your behalf much more as an agent than as a tool. Today, it can to connect, I do this everyday—connect seamlessly, without dialing in, and it synchronizes my calendar and gives me messages. If you all had Newtons here, I would be able to beam a copy of my presentation to your machines. Now This is the world that the wireless LAN will give you, but I will point that in order to do this you do need to have dynamic name binding, and armies of people to administer how many people are on, who can get on, and where they can get on. So, the challenge is not insurmountable, but it is something we have to address.

Question: What about the compatibility angle? If I use a Macintosh in my office, will it only work for me to buy a Newton, are there connections for X86 PCs and products that come from that base?

Dr. Spund: Well that is a software compatibility issue, not a Mac versus Windows thing. This is simply whether you have the right APIs, where the two machines can interact. I guarantee you if I put a product out today that did not have some kind of Windows API interaction, I would be nuts. And vice versa. Anybody who thinks they can own the market by having proprietary software products is wrong—people just have gotten fed up with it—users want interoperability and the longer it takes for a company to get that, the less they're going to make.

Mr. Lowe: Frank, do you agree it's a purely software compatibility issue?

Mr. Spindler: I think when we talk about new capabilities of the handheld versus portable versus desktop, we can't draw a black/white line between them. What you have are capabilities from one that migrate to the other, much like we've seen capabilities now on notebook computers that were only available on desktops. Similar types of capabilities will move into handhelds. How rapidly will that happen I don't know, but what you have is the benefit of having one architecture that will deliver up to main frame class performance in the servers to help address this interoperability and handle all of the connections all the way

down to the handheld device, making that monumental task more manageable. It certainly doesn't solve the problem, but having that common architecture gives a secure base that people developing the infrastructure, the software vendors know will be here today and well into the future.

Ms. Hargrove: I'd like to comment. First of all, your question of is this a difference device and will it affect other devices in the office—I'll bet a lot of us here today, me included, brought a portable computer with us today. If I take Gerry's analysis of the four different types of systems, I can give you an example of each one. Take Personal Information Management—how many of you still exchange business cards today? Everybody that talked to me today exchanged business cards—it would be great if you had that interpersonal information manager. How many of you made phone calls at break—it would be nice to have that in some type of communication device. How many received a fax rather than just voice from someone at home while they're traveling, even at this conference? How many of you have a pen and paper in your hand versus writing on something, and how many of you won't type during meetings because it's socially unacceptable, and noisy?

I would say there's a need to address the issue of compatibility. Compatibility is pretty important to us, but not just compatibility back to the PC, but to other devices in the office. Let me give you a few examples. The address book that I have in my handheld, let's say I have your business card on it. I'd like it to be on my phone, and I'd like it to be in my PC. Do I have to synchronize all of these? That would be crazy. What about fax phone numbers that are speed dialed? How many places do you keep one person's phone number today? Is it in your fax machine, in your rolodex, in your mind, in your PC because you entered it there to begin with? In fact, if I take entering data, we've gotten people to enter a lot of their data on the PC and so it's in a digital form, but now they need to be able to move it to these other devices, whether that be a handheld system or printer, or fax, etc.

In terms of information documents in general—you want compatibility between devices because you want to be able to send to anybody, anywhere in the world. The great thing about fax today, you can send it to anyone in the world—it just works. So information in documents needs to go across platforms. One last example is security. If we are going to encrypt information, everybody should be able to decrypt it.

Mr. Beaver: Those in the room are familiar with the term TAM—Total Available Market. I think in concert with what was just said looking at the question that asks which of the paradigms—down sized PCs, pen based organizers, multi-function communicators—do we think will be successful. What impact will they have on the market for portable computers—I think there will be a real impact. I view the down sized PCs, laptops, and portables as a subset of the PC back at the business enterprise, and it performs certain functionality.

I do notice, however, that the user now wants more of an accessory oriented device, wants to run it for a thousand hours on a couple of AA batteries and wants wireless connectivity. We mentioned earlier that these FCC protocols are going to be the Achilles' heel—I would disagree with that. I think that over the next five years we'll see more occurring in personal communication devices than we have seen in the four generations of computing that went from main frames to PCs to the client server model. PCMCIA cards exist now that do the paging function and are the network connection so you can send information to another portable device on the other side of the continent. Certainly with the Iridium Network above cellular 800 MHz frequencies up in the 1.2 gigabyte range, you can send it anywhere you like. We are dealing with all of this in concert with our partners, Apple and IBM, on the power PC, and we have all of this in mind, all

the way down in the handheld devices with very low power, all the way up to the super server space and everything in between. And, also all of the IO and the wireless technology necessary to make this mobile computing revolution happen—computing anywhere, anytime is the key.

Ms. Hargrove: I just have a question for Tom. If you think that these might affect other markets—let's just take your pager as an example—how many people in the world do you think have paper and pen and use it daily or exchange business cards versus what percentage have pagers today?

Mr. Beaver: A high percentage—we shipped about 12 million last year, that's a fairly good percentage.

Mr. Lowe: Let's move on to question number four. We have Windows NT, Power Open, and other new PC operating systems, along with emulation, that are promising to provide portability across different microprocessor architectures, thereby breaking down all the barriers. Do we believe that this movement is going to become mainstream, and will it be a sufficient to deliver us into an era where all the microprocessors are competing for PC market share on a level playing field? Frank would you like to start with that one?

Mr. Spindler: There are some common misperceptions about portable operating systems, and the first is just because the operating system may be ported to a different architecture, it does not mean that the software base of applications has been ported to that architecture—that is the most daunting task any alternative architecture will face. There is an installed base of 50,000 applications on the Intel architecture—a $50 billion investment that's been made in software by the user community—and users want to be able to run their existing software. They want to be able to run it ,and run it faster when new and better machines come out.

There are different techniques that different architectures can use on a portable operating system to run the software base. One of these is software emulation, which is where the processor interprets the instructions similar to translating. I could read a Russian novel by reading a Russian word, going to an English/Russian dictionary, translating it and then eventually I would get through it. Now it would take me a long time, and that's what happens in an emulation environment when different architectures are running the existing Intel application base. So it can run in some cases, but it runs very slowly.

Can applications be ported? Well, a significant amount of work is required by a software vendor to port an application. In fact, estimates are that 90% of the work is done after the recompile. There are issues such as bug fixes, support, product releases, and post-release support. That is a very intensive amount of activity. For what? The Intel architecture is 40 million units a year. The next highest volume architecture is the Apple Macintosh at about 3 million units a year, and the next highest is 300,000—so there's no volume base to motivate a port to a different architecture.

The next task that we face is what operating system do you port to? Let's look at Power PC, because I think Power PC is an interesting architecture that has some very strong industry players behind it. Would an ISV port to OS/2, to AIX, to System 7, to Windows NT? It's uncertain as to what the right environment is to port to, and given a market where margins are squeezed for software vendors as well as hardware vendors, it is very difficult to put a lot of effort behind something with such an uncertain future.

My answer to the question of portable OSs is an emphatic yes—I maintain that users are demanding it. I think much of this argument about 50,000 software packages, and umpteen billion installed base of ISV packages, and the emulation arguments have been overdone. I base my opinion on a study that IDC did in

June of 1993—let me hit you with a few statistics. There were 54 million application packages, exceeding $7 billion shipped in 1993—and 75.3% of the volume came from 175 packages, and those 175 packages came from 38 companies. The top five companies, the Microsofts, the Borlands, the Lotus's, the Intuits, etc., the top five companies represented 50.1% of that market. Now every one of these companies, including Bill Gates himself, has stated that his application packages will run on the contemporary OS's. They run on Apple machines, and yet he also has an OS business. I think the user community is looking for a few good word processing, spreadsheet, and database packages on their choice of platforms.

Ms. Hargrove: I have a couple of comments on portability. First of all for applications, Windows NT runs Windows applications. One thing you want to do is minimize the affect on applications, because it is tough to get an ISV to write across multiple platforms. From that standpoint, you can think of Windows NT as just an extension of the Windows platform that exists today—it will still run Windows applications. Another important thing is about wireless, especially in the area of handheld systems. It's will be important for applications that are network independent to be written. We don't yet know where the wireless market will go, and there is lots of good technology and good opportunities for different wireless networks, but it's not something that is defined today. I will have products that come out before all of this is defined, and since I'm a pragmatic person that means those applications must be written in a network independent way and be able to take advantage of the networks that do exist today—whether they are phone lines, LANs or cellular networks. They must work with those today, and then be able to be extended to other networks in the future.

Mr. Spindler: I want to respond to a couple of Tom's points. First, the performance penalty for running those applications in an emulation environment is really more like a factor of five than 40%, so it's important to realize that the slowdown is far more significant than that. The second is, in terms of raw, native performance—we have seen the first announcement of a power PC based system from IBM—and its integer spec performance is 62. That compares to the Pentium processor which has an integer spec of 67. So, this year's product in volume production, the Pentium processor, is faster compared to next year's power PC product. The other point is that the portable operating systems are niche—not mainstream. Microsoft's Bill Gates has said publicly, the mainstream for the desktop is Windows, Windows 3.1, and Windows Chicago, and that's where the bulk of the systems will be shipped and where the applications will continue to be developed.

Mr. Lowe: So what we're saying is that Windows NT is going to be relatively niche oriented and used more for servers. Apple plans to continue to ship the Macintosh system software in bulk rather than PowerOpen, which leads to the fact that we're looking at maintaining the architecture structure that we have now. Gerry, did you want to respond?

Mr. Purdy: I will take this all the way down to mobile, which is my level of expertise. I wrote down three classes of processing—server, client and satellite. In the server world, NT, OS/2 and UNIX and its flavors, seem to be well entrenched with a lot of Novell attached to all of it.

In the client world, today we run primarily Windows and System 7, that has to be 98%. If you look forward to next year from a pure market perspective, the X86 will very clearly be operating in that environment on notebooks at the desktop, and System 7 will be ported to the PowerPC. The question is, will Chicago—which operates on X86 and obviously is a primary client OS that will give us the multitasking we need—going to be ported to the PowerPC, and will System 7 be ported to X86? Will that then mean interoperability is based on the chip, which is the question you started with.

On the satellite side—today you've got five environments, WinPad and GeoWorks on the X86, PenPoint on Hobitt, Newton on ARM, and General Magic on a Motorola chip set environment. The question is, will we see the operating system vendors cross hardware platforms, and are the hardware platforms going to cross to support different OSs? We don't know yet because it's an evolving market. We still have some very interesting key questions to resolve in the architectural space over the next two to three years. It's going to be a very interesting, boiling, dust cloud environment, and many of the users may get confused, but I think we're in for some very interesting dynamic times.

Ms. Hargrove: I think it's very hard to get native performance by emulating it on any other architecture—it is really tough. If you have an ISV go in and change and manipulate their code, you get maybe a 10:1 performance degradation. If you actually interpret on the fly, it can be much higher than that, and that's with some very sophisticated tools and technology—so I don't think that emulation is necessarily the answer. To give you a specific example, take the Intel instruction set. It sets a number of flags that it keeps for executing an instruction. There isn't any comparison on a RISC architecture, so what you end up doing is for each flag that gets set, you incur another instruction hit for storing a variable somewhere that is reflective of that flag being set. So emulation will never be as good as the real thing, and we're fooling ourselves if we think that there isn't a leapfrog in performance between different processors. Maybe one version will emulate pretty well and get good performance, but emulation will always be behind the actual source code written directly for that processor.

Mr. Beaver: Yes. By the way, I conceded the point on emulation— I said 1.4, maybe it's 2x. I think Frank and Company will have to ask Insignia Solutions since I am not familiar with the 5x number. I was trying to help the cause of Windows NT and portable OSs in my scenario that 75.3% of the packages come from 38 vendors. I know that running native is certainly much better than running in an emulation. I just want to clarify one more thing because I would be remiss in not doing so. The workstation that IBM introduced this last month was a 601 based machine running AIX with MacTools, and uses a RISC processor already in production, not something for next year—the 601 is in production at 66 MHz and higher speeds.

Mr. Lowe: As the mainstream PC market continues to move from one microprocessor generation to the next, it has continued to increase it's performance demands, which spiral upward every year. Does this panel see the growth and performance demand either accelerating, decelerating or staying the same as we move into the future? How does floating point factor into that, and will there be a difference in the performance demand relating to desk tops versus portables? Brad, do you want to start with that one?

Mr. Smith: Well there are several areas where the performance will always be required—the first is the user interface—which consumes a great deal of the compute cycles of the system. When you start bringing in some of the newer technologies, multimedia, voice, integrating NTSC [phonetic]******, video, anything requiring multitasking or multiprocessing, and all of a sudden your compute demands as well as the rest of the system requirements—throughput, memory, disk size and so forth—just start to skyrocket. So I think there's plenty of fertile ground for the performance spiral, the upward spiral. I guess it depends on whether the specific application requires floating point or not, so you have to kind of look at it one application at a time.

Mr. Beaver: As we move into the future, I see growth in performance demand very much accelerating. I think Gordon handled that topic well in his talk this morning on the semiconductor content per desktop machine

being on the rise because the user demands it and/or multimedia and other things enter into it. Obviously I think RISC processors are ideally suited for this increase in performance.

Dr. Spund: Rather than restate things others have said, I'll direct my comments towards personal handheld devices. Two things differentiate them at the chip and memory layer, and that is that they're all main memory. These machines do not have IO in the traditional sense—they don't store things on floppies or hard disks—they store them in main memory. That also means that the way they search them is rippingly fast in nanosecond speed, that is 30,000 to 50,000 times faster doing searches than any IO related device. Now, knowing that, means that your flash point memory and your non-volatile memory is going to become critical because if you ever were to do anything other than sequentially search all main memory, you would like to have the index of some data stay non-volatile. Floating point is going to be the way you search this thing—in other words, floating point instruction sets will be critical to fast execution of these kinds of sorts and searches, as well as the ability to do graphics on other machines.

Ms. Hargrove: There's constantly an increasing need for performance, and I like to think that I want more power and less power. I always need more power for processing, whether that be with 3D Graphics, which at least doubles the performance that you need, or video and real time, or multiple video Windows in real time, or audio and video and data all at the same time— give me the power and I can figure out how to use it. So I always want more power. I also want less power as far as power consumption goes for the handheld system—so I want both more and less.

Mr. Spindler: I think this question is one we're all in agreement on, but yes, the user will be able to use whatever power is delivered to them and performance has been doubling, every 18 months, for the last ten years. It will continue to double at that rate over the coming years. We have P6 program which is the next generation in development, with P7 following on the heels of that. It's not black magic, it's a fundamental investment in Silicon technology and architecture.

I'll make one final comment. You don't need more power to run the old technology faster—usually you run it at a level that is satisfactory. What happens is you want to start using and doing something new that requires more capability than you've had before. So I don't need necessarily Pentium to make Word for Windows run faster—it works fine on my 486—but I might need Pentium to run interactive video ,or some new level of technology that would make my work better than before. It's that new higher form of technology that requires more increase in performance.

Mr. Lowe: Historically, Intel has been able to sell the X86 microprocessors at a higher price/performance ratio than the other architectures, though the X86 system prices don't necessarily reflect this premium. As the new RISC PCs begin to enter the market, do you believe that the price/performance structure of the X86 and RISC architectures will merge together at the system level, and eventually at the component level?

Mr. Beaver: Maybe I will surprise you, but I maintain that the implementation of RISC systems is lower cost. If you look at the block diagram of your typical PC system, certainly you have the microprocessor and the microprocessor BUS specific microprocessor BUS, it goes into the memory function, DRAM controller L2 CACHE controller. In our jargon, they're 4L3 devices, and in Intel jargon they're mercury chip sets. Coming out of that is a BUS like PCI BUS, everything below that PCI BUS is common commodity product available in the market place, whether it's a SCSI II controller from NCR, Western Digital or whomever or a PCMCIA chip set, what have you, these are commodity items. So, with the PowerPC, HCMOS very small die size, I maintain there is

a definite price advantage with RISC implemented systems.

Mr. Spindler: What end users look at is system level price and what's delivered to them for that system level price, and the PC architecture systems have consistently delivered the most favorable system level price. There are many factors that affect that. There are a broad number of players in the chip set area—OEM manufacturers, ISVs offering software, all creating a very competitive environment that results in very favorable price points to end users. I think one of the best examples is what we've seen happen recently with the Pentium processor where there already are sub-$3000.00 systems on the market today. The 486 started at a higher component price point than the Pentium processor—so the fact that we see $3000.00 Pentium processor systems which will be moving down cost curves, means some very attractive systems in the future.

Mr. Purdy: Just one quick observation—in the mobile world there's a different dimension that you have look at—MIPs per watt, because it's very important to provide high performance it at a wattage level that gives adequate battery life. I agree with Frank that there are sub $3000.00 PCs with Pentium processors but they probably have a near $1000.00 microprocessor in them, and the question that I have is who's going to win at this game? Right now about the only companies that are making money are Microsoft and Intel.

Ms. Hargrove: That's not true. I think there are a number of ISVs in the PC industry that are doing very well. I know of chips that even Intel introduced last week that are really embedded X86 compatible systems that have an X86 core, that are lower cost/performance solutions for specifically the types of products that I'm working with other partners to bring to market for phones, faxes, handhelds. I also wanted to comment and disagree with Gerry earlier when he said we don't need more performance for what we do today. I think that's really not true, how many of you want to wait to open a file, see graphics drawn on your screen, have a file transferred or have something printed? We can always use more performance and our applications will always be growing to abuse whatever performance we get.

Mr. Lowe: You know there's another angle to this question which is that in the X86 PC industry, it took years of development of a broad based clone industry to really drive the price structure down to the point that they're being delivered now at gross margins that fall well below 20%. Will this happen to any of the alternative architectures to the X86? What will drive that change?

Mr. Beaver: I think the margins in the computer OEM business will be down pretty low, I don't think the industry will do anything but hemorrhage if they stay in the 20% range, so they'll inch up and our bias is obvious with the PowerPC—we think it will help on that margin issue. For example, the PowerPC is about a $280.00 device right now. I think that the computer OEMs who are basically in the clone business are going to have to recognize that engineering as a percent of sales is going to have to stay very low, which implies the use of commercially available chip sets, internal BUS interfaces, which was my contention on PCI or ISA BUS or VME BUS or PCMCIA, and take advantage of all of those chip set offerings that are out in the market place and some of the architecture specific chips, whether they're the CACHE controllers from our shop or the CACHE controllers from Frank's shop.

Mr. Lowe: Lani, how do we proliferate the PowerPC architecture across all sorts of systems without driving Apple into a commodity business?

Dr. Spund: Well, that's a good question. First of all, that while I maintain that interoperability is critical, I want to be able to play on a level field in interoperability, but still add value on top of what differentiates the product. In other words, where you're going to see us operate and differentiate ourselves is in continuing to

be the easiest to use, easiest to configure and easy to hook up machine in the marketplace. I think you'll find that will also drive a very common interface among all of the products that we build so that they all plug and play together with absolute seamlessness. I don't mean talking about API, I mean all of our products work together, and when you take them out of the box, you plug them in, they work, and that's the end of it. I also think that you're going to find probably us differentiating ourselves in human interfaces much more dramatically than you ever thought possible, probably within the next 24 months.

Ms. Hargrove: I want to ask Tom a quick question. When will we see PowerPC chips that cost just a few dollars that could be used in embedded systems and is there a necessary volume required to be able to support that type of price point?

Mr. Beaver: Well Gerry said earlier that he'd like to see a device with very low power and yet it must get a lot of spec mark performance —that's the 603. It's a less than 3 watt part, it's in the greater than 70 spec mark range, and I would look for an introduction before this quarter is over.

Ms. Hargrove: How much will it cost?

Mr. Beaver: It will be very cost competitive, you'll like it a lot.

Mr. Purdy: Less than $100.00?

Mr. Beaver: Well you synthesize the answer. The part is very suitable in a PDA or a Personal Intelligent Communicator and the price point on that kind of product is a $500.00 kind of thing. You can work backward without my doing any pricing announcement, which I'm not able to do right now—but you can see that it will be a very competitive part.

Mr. Purdy: You might also see those chips start to show up in printer products, in fact sometimes I wonder if printers have more intelligence than the computers these days.

Mr. Spindler: I would like to make one more comment—for the price points and the margins, the first PC manufacturers have made a very successful business by driving big volumes, and they have developed around a particular business model, that's the model of the industry today and that's the model that has caused the industry to grow to 40 million units a year. Where do the add-in vendors, ISVs and the whole industry develop their products. Do they develop it to the 40 million unit a year base, or to an unknown? I think that's really the key that's will continue to make these systems more attractive from a price performance standpoint.

Mr. Lowe: I want to thank the panelists for their participation and want to thank the audience for your patience

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Introduction

Joe Grenier

Vice President, Manufacturing and Applications, Semiconductors

Dataquest Incorporated

Mr. Grenier: Good Morning. I'm a Vice President in the Worldwide Semiconductor Group and I'm going to be your host for this morning.

Before we get started this morning with more of the weighty business of the electronic industry, we heard a lot yesterday about the convergence of technologies and the driving applications and today we'll hear some more about those issues. However, what I'd like to do first is sit back and relax for fifteen minutes before we get started, and I'd like to show you some of the lighter, more interesting, more strange applications of semiconductors, which today may seem bizarre and specific, but maybe tomorrow will be prosaic and ordinary applications.

There is a bee with a chip on it. The Department of Agriculture asked the Oakridge National Lab to come up with a chip that would be an IR transmitter, solar powered, to help them track killer bees to determine their mating and foraging habits. Oakridge National Lab built a couple of prototypes. This is not the actual chip—this is a chip they used in the weight carrying test, and they found out that the chip was a little too heavy so they had to lighten it up to be around 48 mg. The project never reached fruition, however, because they ran out of funding. Now lest you think that the Oakridge National Lab just does humorous things like this, when I talked to the project engineer who did this, it turns out they're doing some pretty exotic stuff. They do approximately 35 designs of advanced chips per year and they use outside foundries to do the manufacturing. One of the things that they're doing right now is very advanced control electronics for automobiles. He wouldn't tell me what those were because it was some kind of secret project, but he did emphasize that it's very, very advanced control electronics. They're doing collision avoidance sensors for robotic arms so when the arms swing around they won't bump into anything. They are also doing read out detectors for the supercollider. Everytime I found one of these unusual applications and I talked to the people, at first it seemed like it was an unusual application, but there was always something deeper that went beyond, and I think that will unfold as we look at some of these.

Another one comes to us courtesy of CMI, Inc. in Kentucky. They've just developed a device to measure alcohol testing with the breathilizer. Now there are some proposed Department of Transportation regulations that are about to be passed that will affect nearly 7 million employees in the federally regulated transportation industry. The regulations will state that nobody can operate an airplane, truck, railroad or any other kind of public conveyance that's federally regulated if they have a blood alcohol level between .02 and .04. Now many of you know that most states have regulations for drunk driving about .08 to .1. In order to measure .02 or .04, you had to take a blood test that would require a 24-hour turn around, which means you'd have to sideline a pilot. If you suspected him of being slightly intoxicated, they would take a blood test and then wait 24 hours. You couldn't do a breath test because although breath testing has been around for 40 years, they're not very accurate. They're only good at gross levels of .08 to .1. Well, has CMI's developed a system that within minutes can detect far below .02 with accuracies

that will hold up in court. You administer the test and get an instant printout— the whole thing takes just a few minutes. There was an objection to the new regulations that would be passed because they wouldn't be feasible and nobody could do the turn around. Well, CMI has a product that can do it. There's a couple of things I noticed about this slide, however. That truck driver seems to be leaning and if you've ever seen a drunk, once they start leaning they keep on going, so I think this is probably a staged photograph. The other thing is, I think they could have used a smaller company van. I don't think this photo uses good public relations. The thought of a big semi rolling down the highway behind you with a slightly intoxicated driver disturbs me.

There are a number of other unusual applications that are coming through the medical industry. Another one is an implantable defibrillator used to control rapid heart rates, like tachycardia. This is not a pacemaker. This is a device that detects the irregular heartbeat and sends an electrical impulse to the heart to get it back into normal rhythm.

Another device is breast implants that are fitted with a microchip to electronically tag the implant to help detect the doctors and the patients locate the device quickly.

Another one — hearing aids with digital signal processing chips to help the wearer discriminate between unwanted noise. Right now, everything is amplified equally. The new chips will help discriminate sounds you want to hear from sounds you don't want to hear. For instance, if you're in a crowded room, you know we naturally discriminate, we pick up a voice and we tune out or attenuate background noise. Well, people with hearing aids don't do that as easily so this new chip will allow them to hear more accurately.

In agriculture, there are a number of things. There are microcontrollers implanted into cattle to stop rustling. Also, there are microprocessor-controlled apple sorters that sort apples into different bins by the redness or the color of the apple. The device has a chromaticity diagram in it and it compares the reflected light back from the apples to a chromaticity diagram and directs the apple into the right color bin. There are even automated chile pickers — robots that can move through the field and detect four different colors of chiles. It can also detect which ones are the right color for harvesting.

There are greeting card kiosks being marketed by Hallmark. The internal parts are an Apple CPU, an Apple monitor, a custom keyboard, and a Techtronics four-color printer and this kiosk has up to 500 designs stored in it. You walk up to the kiosk, select a design, then select the font and you can create your own greeting card When it's all done, it shoots out the card and the envelope and you mail it away. It costs $3.50 and I think that's a great deal. They also have a modem which is attached to the Hallmark office, representative or distributor which monitors the status of the ink and supplies so when you get low, a little buzzer goes off and the representative comes out to stock it up. At the end of each greeting card, there is a little questionnaire that you're asked to fill out — they're collecting real time market statistics with every card you fill out. Would anyone like to guess who are the most frequent buyers of these cards? By the way, the expectations have exceeded Hallmark's forecast by a factor of three or more. Would anybody like to guess? I don't hear anything so I'll tell you. It's young men and one of the reasons is young men don't like to walk down the aisles in drug stores to buy the regular cards because the displays are full of pinks and pastels. They're not substituting these cards with others. They're actually increasing their market by selling to young men who otherwise wouldn't buy cards. Maybe they ought to start putting greeting card stalls in hardware stores next to the tool department so young men will buy even more cards. The designs are stored in a CD ROM so for seasonal variations, like Easter or Christmas, all the Hallmark representative

has to do is change the CD ROM for each occasion. I mean, there's 500 designs stored in the CD ROM.

Here's an example of some of the cards, and I have seen these — they're high quality. There are some competitive products which are done with plotters and the quality is really poor. One final note: I'd like to mention that my brother's company, Advanced Video Integration, is the system integrator for this so please go out and buy all the cards. It'll help his company and he really needs it (Lots of laughter).

There is a new urinal at Dataquest. This is not our new logo. Dataquest has just installed two of these and again, this started out to be a rather humorous thing because when we installed it just a few weeks ago, everybody said, "Joe, I've got a real hot idea for your unusual application." When I got into this though, it is not humorous at all. This is big business and I think there's a real message here. This is a handleless, hands-off device. It's made by Sloane and called the Optima Flushometer. The black device continuously emits an IR beam so when a person walks up, the IR beam is reflected off the person's chest and the reflected signal starts a hold circuit in that electronic module. Then when you walk away, the hold circuit is activated and it flushes. It's operated by four AA batteries, which are good for up to three years at the rate of 4000 flushes per month. You laugh, but wait a minute. When I talked to the Product Manager about this, it was like talking to an electronic design engineer in Silicon Valley. He kept talking about value added plumbing and he said in the electronic module, there are already enhancements built. I didn't ask him what he meant by enhancements, but he said the plumbing industry has had the capability of doing this for years and years, but the industry is so conservative — they are very slow to accept any kind of innovation, particularly when it has to do with electronics. So they've been doing this, but they haven't been able to market it. We want them, but the industry that installs them is very slow. When I asked him what was in the module, he was very circumspect because this is big business. These valves are $100.00 to $200.00 apiece and when you figure that there's going to be millions and millions of these valves installed, it's big money. I think the message here is that there are unusual applications out there waiting, if we can only be creative and find them. He asked me where the Dataquest conference was being held. When I told him, he said, "fine, I'm going to have my representative install a couple of these valves in the restrooms outside of the conference room. Yesterday during our break, they installed one so quickly they forgot to take off the handle. So the handle's still there, but there's one in the men's room and I believe in the women's room as well. You see these frequently at airports. They have faucets and the IR beam comes out of the side, and there's the electronic module. By the way, I called my broker to ask him if I could invest in Sloane, but I was told it's a private company so unfortunately, I can't make any money there.

There are a couple other interesting applications courtesy of Dave Angel of Information Storage Devices. He didn't send me the text with these slides so I can only guess at what they are, but ISD makes talking chips so I assume this is some type of talking sign that says hard hat area or wear your hat.

Motorola makes a beeper that actually talks to you. I don't know what it says — maybe it tells you the number instead of having to look.

There is an implantable pacemaker. Now I just can't imagine a talking pacemaker. What does it say to you? I mean, there's enough voices going in our heads now without another one telling us something is wrong with our heart. I have no idea what this is, but it must be a talking pacemaker.

In any case, that's the end of the interesting applications and there's a little humor here, but I think there's some seriousness too. Some of these applications that seem rather unusual, like the kiosk and the plumbing fixtures, will

not be unusual tomorrow. We're going to see them all over.

Global Trends Seen From a European Perspective

Pasquale Pistorio
President and CEO
SGS-Thomson Microelectronics

Mr. Grenier: Okay, let's get back on line with the more serious aspect of the day. I'd like to introduce our first speaker, Pasquale Pistorio. Mr. Pistorio has been President and CEO of SGS-Thompson Microelectronics since May 1987. He began his career in semiconductors by selling Motorola products for an Italian distributor. He then moved to Motorola where he held various positions including Regional Manager for Italy and Marketing Manager for Europe. In 1977, he was appointed Director of Worldwide Marketing and Motorola Vice President based in Phoenix, Arizona. In 1978, he became General Manager of Motorola's International Semiconductor Division. In 1980, he returned to Italy to become President and CEO of the SGS Group. Pasquale Pistorio received his B.S. Degree in Electrical Engineering from the Polytechnic of Turin. Mr. Pistorio is a well known spokesman for the semiconductor industry, in fact he has spoken at Dataquest conferences numerous times over the years, both in the U.S. and Europe. Today he will give us his view of the semiconductor industry from a European perspective. Please join me and welcome Pasquale Pistorio.

Mr. Pistorio: Thank you. While I was listening to the marvel over the technology yesterday and today, one thought came to me. As much as I love technology, depend on technology and enjoy these innovations, I hope that the world will not change to the point where I can't enjoy a good plate of spaghetti anymore because there will be a transistor some place. Let's keep some things the way they are, okay?

Good morning, ladies and gentlemen. I would like to start by thanking Dataquest for inviting me to speak today. It is always a pleasure to attend these meetings, especially when the subject is so close to my heart. In particular, as a European who worked for a number of years in the United States, it is in may ways like coming back home.

The title of my address today - Global Trends Seen From A European Perspective - gives me a lot of scope. So, what I would like to do is to divide my presentation into two parts. The first part will address the immediate future - which is this year and next year. The second part will attempt to look into the crystal ball to see what will happen at the end of this decade or next decade, always from a geographical point of view.

By doing it this way, at least no one will be able to contest my predictions because on the short term, after all, we are talking with facts so I'm not taking any risk. And as far as the long term is concerned, I am sure that with time, the borders will blur so that it will be difficult to distinguish what you think I said and what I think I meant.

The first part will certainly concentrate on Europe, with some facts and figures to put the old continent's performance into perspective, and the second part will look into the crystal ball.

Let's start by defining the most important parameter for us which is the electronic equipment production. This year, Europe's

electronic equipment production will reach 190 billion dollars. That is 26% of the world market, which is exactly the same percentage as Japan. I believe this is quite an impressive number, a big percentage that many people don't think about when speaking of Europe.

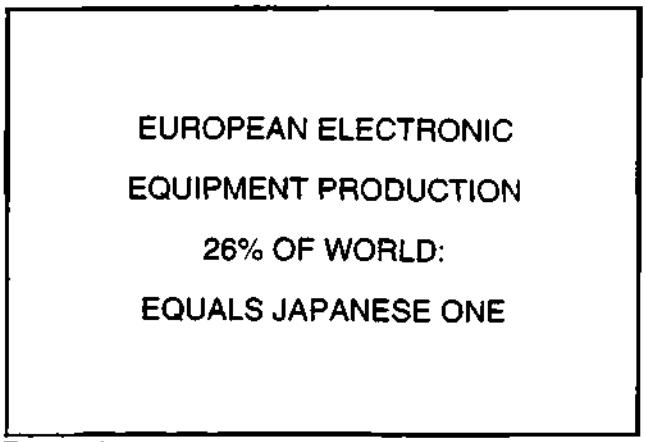


Figure 1

However, what is no surprise is the way the European electronics industry, similarly to the electronic industry in any other region, has consistently outperformed the rest of the European industry in general. From 1983 to today, the electronic equipment market has shown 9% compounded annual growth. This compares with the growth of the gross national product of only 2.5% over the last ten years and just 1.0% over the last three years.

When you break down the equipment market sector by sector, some more unexpected results pop up. For example, Europe is the world's biggest producer of telecommunications equipment. Europe has 35% of the world's production and also is the number one world producer of telecommunications equipment, Alcatel. We are also number one in the industrial sector with 36% of the world market for electronic industrial equipment.

There is the automotive, where with 33% of the world market, Europe is the world's number two producer. Here too, in BOSCH, we have the world's biggest manufacturer of automotive equipment. We are also very strong in the defense markets where we have a respectable 30% and the number two position after the U.S.

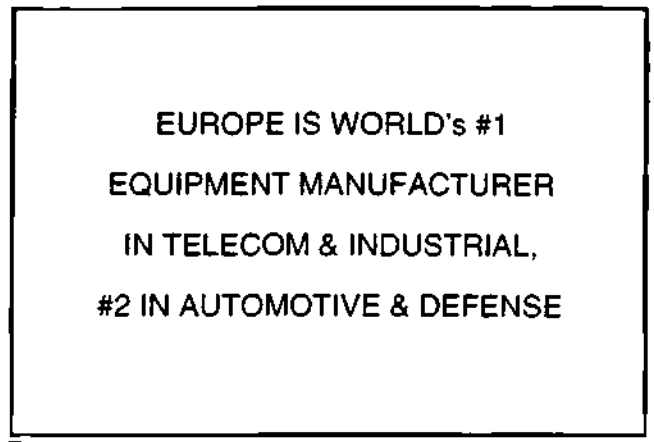


Figure 2

Obviously, we have our weaknesses and the most important of those is the computers. Here, the shortcomings of local producers are only compensated for by the significant presence in Europe of American manufacturers. But in any case, in Europe this year, 7 million personal computers will be manufactured which corresponds to more than $2.5 billion dollars of semiconductor TAM.

In terms of semiconductor consumption, Europe represents 19% of the total world market, a percentage that has remained the same over the last 10 years.

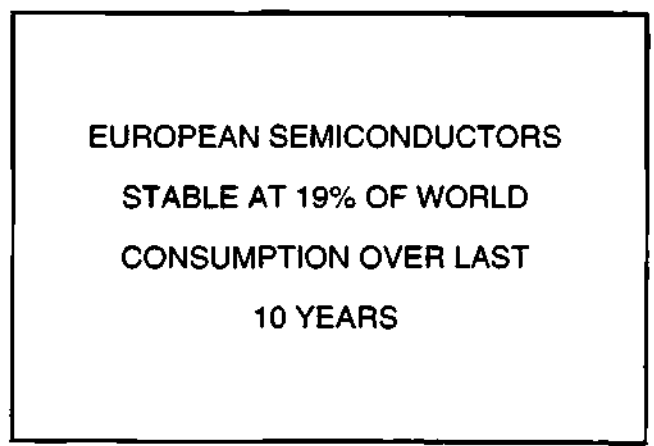


Figure 3

As a small side note, I believe that the low level of Europe's semiconductor consumption results

in part from the high percentage of telecommunications, industrial and defense electronics as a percentage of the total. All three of those sectors have a lower impact on semiconductors compared with the computer and the consumer sectors.

It is interesting to note that while the level of semiconductor consumption is not in line with our 26% of the world's equipment market, it is still very stable. Over the last decade, on the other end, the American share of consumption has dropped from 44% of the world to 32% of the world and the Japanese share from 31% to 29%.

Of course, as everyone knows, the share lost by America and Japan all went to the Asia/Pacific area, which saw its share more than triple from 6 to 20% of the world total.

Let me add here that as far as ownership is concerned, the European semiconductor industry has remained stable at around 11 or 10% over the world market for the last ten years or so, with some rebounding in the last couple of years, having reached the historical minimum with 9.7% some four years ago.

Coming back to consumption in 1993. According to our estimations, we expect to see approximately 20% growth in the European semiconductor market even in the presence of a strong recession in the general European economy.

There are five main issues driving the growth this year:

1. The renewed growth in the production of the personal computers as a result of the switch from 386 to 486-based machines.

2. The export of telecommunications equipment to emerging nations like China and eastern Europe.

3. The increased use of semiconductors in cars in order to meet the increasingly stringent anti-pollution regulations and the focus on increased safety.

4. Renewed growth in the consumer market after 18 months of stock reduction.

5. The take-off in the use of cellular telephones.

That is the picture for this year - which is a good picture for the semiconductor industry, again, especially considering the recession in Europe.

For 1994, we expect the growth of the European semiconductor market to slow down to somehow slightly above 10%. Again, Dataquest has shown 12%, which is in line with our expectations. I must say that we assume always that the Dataquest number is the base part of our planning, therefore we are obviously on line. The main reason for this will be a deceleration in the PC market.

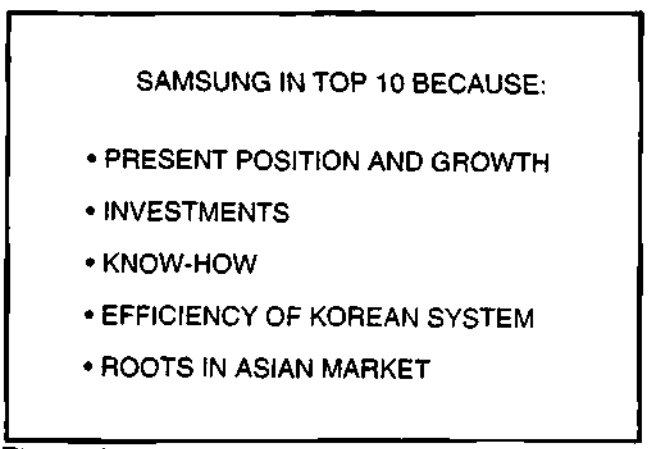


Figure 4

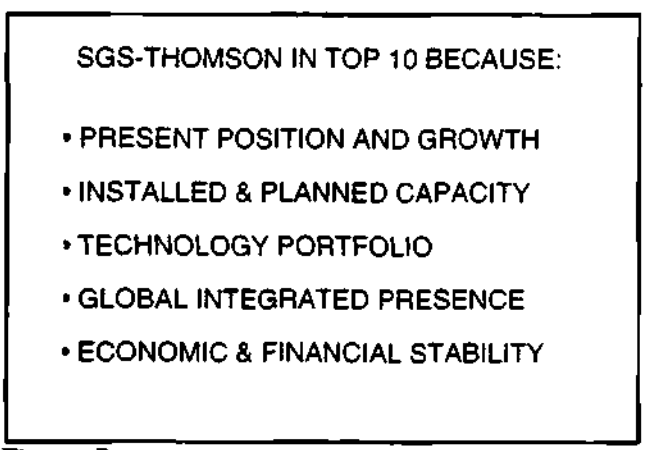


Figure 5

However, the continuing strengths of the telecommunications and automotive electronics markets will continue to fuel the growth.

Well the picture that I have painted so far presents a good side of Europe's performance with the strengths that you may not have expected to see in the overall electronics industry for Europe. However, I should point out that in general, these strengths are in sectors that have benefitted from various forms of protection.

In reality, Europe's ability to compete on the open markets has been and is seriously challenged by policies, practices and social behaviors that have their roots in the birth of the welfare state.

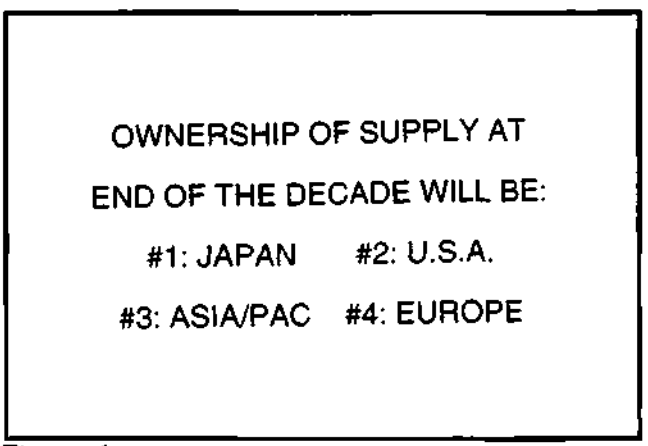


Figure 6

This is what has conditioned Europe's performance in the past two decades and will do so for most of this decade, which brings me to the second part of my presentation - the longer term.

Well European nations, collectively and individually, decided to privilege social peace instead of industrial development. So, instead of moving quickly from an industrial to a post industrial economy, we saw a slower, more gentle change.

While the initial social impact was more acceptable, the net result was that industrial development was slowed down and our ability to compete on the open world market was seriously compromised.

The decline in Europe's competitivity was particularly evident in those sectors that did not benefit from various forms of protection. As we've already seen, sectors like telecommunications and defense, which were inherently protected, have remained strong. But when you look at sectors like the computer, consumer and component markets - where Europe has to compete on the open market - then it is a completely different story.

Why? The answer is very simple. The welfare states mean intrinsically higher costs of manufacturers.

Figure 7

The cost of money is higher because resources absorbed by the welfare state have to be paid. To this we then have to add other factors resulting from our decision to favor industrial peace.

The number of hours worked in Europe compares badly with those common in competing systems - nearly 40% more hours per person per year in the four tigers of Asia and nearly 20% more hours per person per year in the U.S. compared with Europe, just to give you two examples. So, with all other conditions being equal, we need more people to get the same output. What's more, we have much less flexibility in Europe in the way we are allowed to manage our manpower resources and

therefore, also utilization of our assets. So it is difficult for us to react quickly to market conditions and to exploit fully the installed base.

I believe the issue of flexibility is, in the end, the most important for the European system and we have to work on this to regain our full competitivity. These are just some of the brakes on the European industrial machine that are slowing down our growth and reducing our competitivity on the world market.

Europe has taken a long time to wake up to the risk it is facing. In fact, it wasn't until the start of the 1990s that we began to face up to the fact that we were not competitive on the open market.

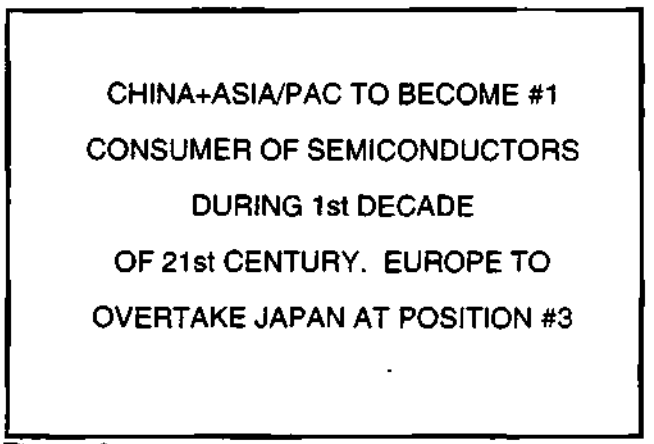


Figure 8

This brought home, most forcefully, the start of the economic crisis which was already bubbling under the surface and was intensified and accelerated by the effects of the Gulf War.

To become more competitive we have to make some substantial changes and we have already started.

A strong program of privatization of government controlled corporations has spread around Europe, with the UK setting the trend and being practically over with the process.

A growing deregulation trend is also occuring in Europe — favored, guided and forced by the European Community. Airlines and telecommunications are the first timid examples, insurance companies and banks will follow.

On top of that, the devaluation of the weaker currencies have put several European countries on a more realistic footing with the rest of the world and of course, are making their products immediately more competitive. Devaluation is a different way of paying the price for wanting too much. You read your standard of living by the monetary automatic effect rather than by policies.

We have also seen a reduction in the cost of money while keeping inflation within acceptable levels. This has been possible because we have also accepted a general reduction in the level of welfare offered and unfortunately, because of the high level of unemployment, and the deep recession.

In addition, we have also seen a general willingness at all levels to make the system more flexible and competitive, allowing us to get much greater use out of our investments in equipment and to respond faster to market changes.

However, that doesn't mean that Europe has turned the corner. Far from it. The European system will certainly suffer from a lack of competitivity for several more years.

Figure 9

The process is going to be long because we are going to have to adapt to some very different conditions and some hard choices will have to be made.

We are going to have to overcome the rigidity of the unions with regard to the flexibility of manpower. People at all levels are going to have to face new realities concerning the levels of welfare provided and everyone is going to have to get used to the idea that there is increased expectations and competitivity for every single job on offer.

Still, I believe that Europe in its search for competitiveness will strive to maintain and I'm sure that Europe will secure a high degree of social solidarity and high respect for the environment. In reconciling these needs, industrial competitiveness on one side and social concern on the other, Europe will lead the world and will provide a model to follow. We must make sure that the search for competitiveness doesn't ignore that human beings and humanity is a descender and hand over the process, not just a mean and I believe in this sense, Europe is going to reconcile pretty well those two aspects.

During these years of change, Europe as a system may continue to lose ground and may be forced to use defensive weapons to protect its position. If it doesn't, several industrial sectors will risk succumbing to external forces and being overrun by the competition with a disastrous impact on a stubborn unemployment level that is already above 10%, with nearly 20% in the age group below 25.

However, what is true for the macroeconomic system in general is not necessarily true for some world class companies with a strong European base. Those corporations will be able to withstand the negative European environment and tendencies thanks to their high level of globalization which allows them to get the best out of every area in which they operate. Of course, we consider ourself a global player.

The negative tendencies of the European industrial environment will be reversed as we move toward the end of this decade. Europe will become much more competitive and as a consequence, the levels of defense will be reduced.

Figure 10

I believe that Europe can reverse the trend because we have the most incredible basic resources.

We have a very strong industrial base of large corporations in all sectors. We have a fantastic infrastructure of small and medium enterprises that are lean, flexible, agile and ready to cope with the opportunity of an environment that is rapidly changing.

We have the scientific and technological know-how.

We have a depth of culture that is unmatched anywhere in the world with an educational system that has its roots in the very beginning of modern civilization.

We have a breadth of culture which has fully retained all of its many national characteristics, resulting in a most fertile environment where creativity blossoms and innovation has become almost second nature.

We've got excellent universities and research institutes - I believe some of the finest in the world.

We have got strong communications and telecommunication networks to link together all the component parts of the European macroeconomic system.

We have some important physical and commercial resources like oil, coal, nuclear power for energy, agriculture, and tourism to give us a solid base to build on.

And finally, we have the potential of eastern Europe.

All these factors and our willingness to implement the changes mean that Europe will rise again to become a formidable player on the world scene.

I mentioned eastern Europe. This is a difficult phenomenon to predict, and I am not a political or social scientist, but I'm certain of a couple of things regarding the process that is bringing free market forces and western democracy to the eastern block.

a. the process is irreversible
b. it will be very, very slow

So, while it is true that there is enormous potential for growth, and particularly in electronics where there is already a lot of know-how and very low costs, this potential will not be realized in my opinion in this decade.

Today's merchant semiconductor market is almost negligible. The biggest market, obviously the Russian market is only 180 million dollar and in total all the ex-eastern block countries represent a market of 270 million dollars which is only 2% of the western European semiconductor market.

Figure 11

But in the next decade, watch out. The potential is there and is based on several evident facts:

1.There is a massive and well-educated population
2. There are immense natural resources
3. There are many virtually untapped markets
4. Formidable scientific and technological know-how
5. Low costs, both in manpower and of brain engineering

So Europe, towards the end of the decade, already in good shape and able to compete, will get a boost from the emergence of the eastern countries and naturally those countries will turn first to western Europe because of its geographical and cultural proximity.

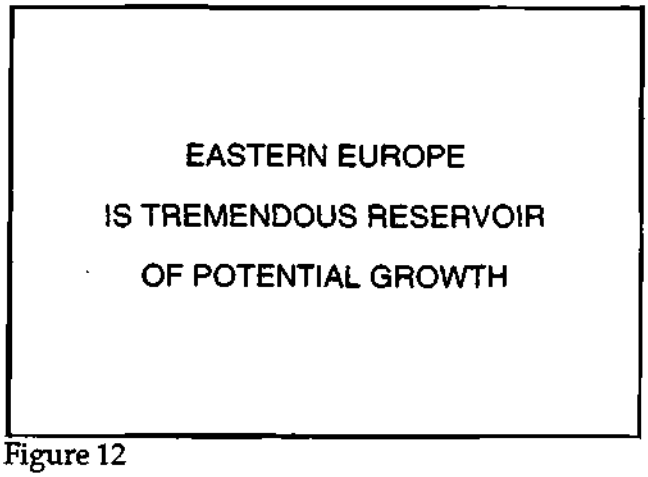


Figure 12

In parallel to the growth in the eastern block, we will witness the explosion of the Chinese market. This will give a tremendous boost to the already tumultuous Asia/Pacific region.

Figure 13

Already we are seeing signs of the way China is going with special areas of industrial development and the success in these areas. Of course in 1997, with Hong Kong joining China, there will be a new boost of industrial western philosophy and methodology that will accelerate the process.

As a result, during the first decade of the new century, we will see a new scenario for the microelectronics industry, with Asia/Pacific, including China, and Europe being the two most dynamic areas.

Figure 14

Naturally, those companies that choose accordingly will have significant advantages over those companies that will ignore this new scenario.

And what will this be?

Well, to synthesize the way I see the consumption of semiconductors and the distribution of the microelectronics market in the future, we will have:

1. China and Asia/Pacific becoming the world's number one user of semiconductors sometime during the first decade of the next century.

2. America will be the second biggest user, somewhere not far from the Asia/Pacific region.

3. Somewhat surprisingly, Europe will be in third place, a long way behind the first two, but ahead of Japan.

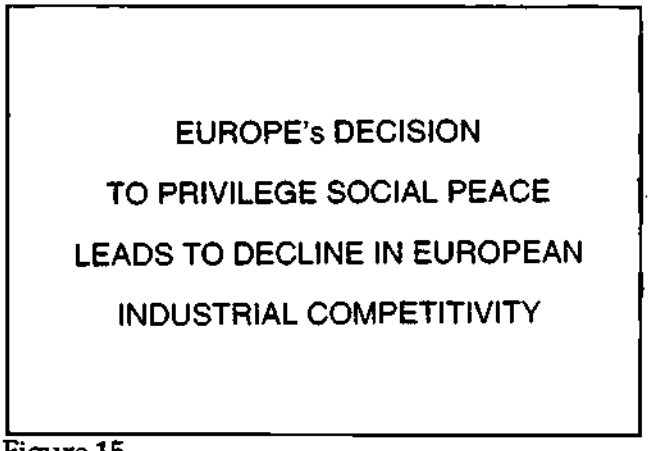


Figure 15

This is consumption and doesn't mean too much in terms of ownership of supply. There the story is completely different.

Through this decade and the next one, I see Japan keeping the world leadership in terms of ownership of semiconductor, the leadership that they gained in 1986. They will still be followed closely by the United States. However, the cumulative weight of Japan and the United States will be progressively reduced.

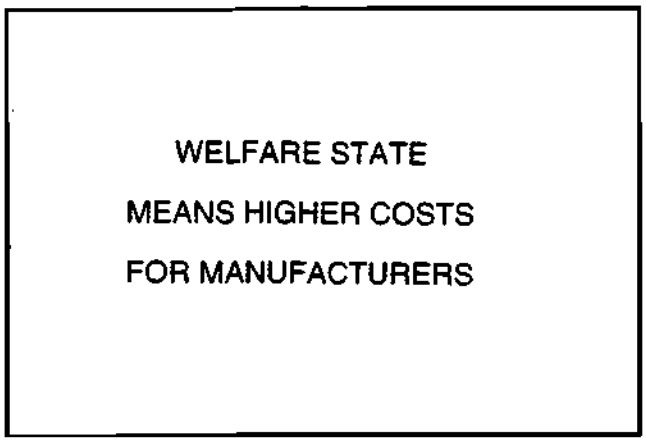


Figure 16

The major change will be in the relative position of Asia/Pacific and Europe. By the start of the next decade, Asia/Pacific will have overtaken Europe to become the third largest macroeconomic system in terms of ownership of semiconductor production. Europe, although in fourth place, will have a slightly bigger share of the market than it has today and will somehow reduce the present gap between consumption and production.

By the end of the decade, the consolidation of the world's microelectronic industry will be completed. The suppliers will be divided in two major categories:

a. on one side, a small group - probably a dozen of the major broad range global suppliers, each having at least 5% of the world market share;

b. on the other side, a large and numerous variety of different kinds of specialists, each with less than 0.5% of world market share.

And in the middle, basically nobody.

Companies today that are in between those two levels of market share, in what I call the instability zone, with either grow up alone or by mergers, or refocus their effort to specialize or simply will be absorbed and disappear.

Where will the major players come from?

As far as the top 10 distribution, I believe that from a geographical point of view, it would be much the same as it is now in terms of macroeconomic system of belonging. There will still be a significant number of Japanese companies and a slightly smaller number of American ones, just as it is today.

However, I see two important changes from today's list in the top ten.

One, I believe that even by the end of this year, Samsung of Korea will move into the top 10.

Two, by 1996, SGS-THOMSON will have joined them in the top 10 ranking.

I base my forecast for Samsung on:

1. Its present position, the dynamics of its past growth and more than anything else, the strong investment and policy of growth that they've followed.

2. The know-how they've applied so well up to now. I see no reason why this should not continue.

3. The efficiency of the Korean system.

4. And, their entrenched position in the dynamic Asia/Pacific region.

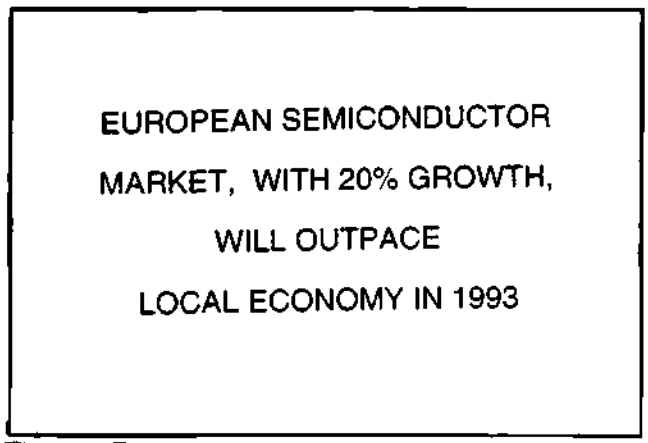


Figure 17

Given these conditions, I don't see how Samsung will miss the target.

My prediction that SGS-THOMPSON will also be in the top 10 by 1996 is based on solid facts:

1. This year our growth will be 30% and we will have more than 2 billion dollars in sales.

2. Our growth this year has been limited only by capacity but with our new 8" capacity coming on-line at our brand new Crolles facility near Grenoble, we will keep our growth significantly above the market, at least for the next two years and future growth will also be facilitated by other 8" facilities in Europe and outside Europe in the advanced planning stage at this moment.

3. We have 0.5 micron technology released and ramping up in Crolles. At the same time, we are increasing our traditional leadership in mixed technologies by pushing even further ahead in power and introducing in parallel new signal mixed technologies.

4. We have made the right choice from a geographical point of view, going for a global integrated presence because they insist on the concept of integrated presence. Very, very few companies have chosen this form. Everybody wants to sell globally, but very few companies have understood that they must be an integrated supplier in each major macroeconomic system, and by integrated I mean with marketing, manufacturing, design, and research. In Asia, for example, we were the first western manufacturer with diffusion, design and assembly facilities. In America, in addition to design and diffusion, we also have advanced the research. We have also recently completed important expansions in our 6" facilities in Dallas and as I've mentioned, we have an 8" facility in the advanced planning stage.

5. We have a very strong network of strategic alliances with leading systems manufacturers, Alcatel or Seagate just to mention two names, and we have a very strong network relationship with other manufacturers for technology and product development, like the alliances we have with Phillips, Mitsubishi, Sanyo or with institutions like Cnet or Leti.

6. Finally, our company is profitable with a profit performance which matches that of the top 10 manufacturers, while maintaining a high degree of R&D expenditure — this year 16% of sales, last year 18% of the sales and a high level of capital investment with this year will be above 20% of sales. Financially too, we are very sound with a debt to equity ratio of just 0.3.

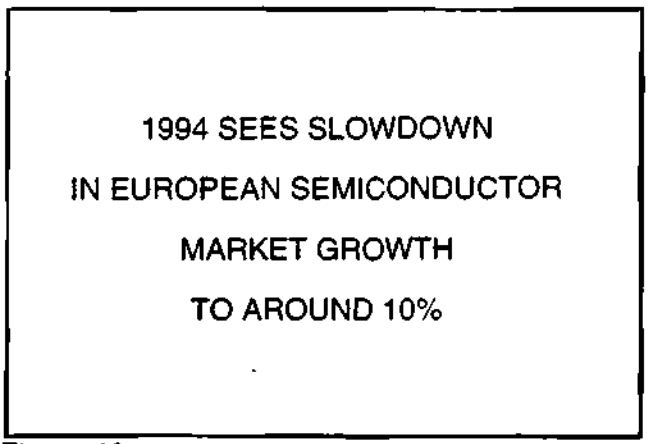


Figure 18

Like Samsung, given those conditions, I don't see how we can miss the target.

In conclusion, I believe that the European electronics industry is intrinsically strong, notwithstanding some areas of difficulty.

As the world markets get even more competitive, Europe will suffer in the short term and continue to suffer in the medium term because it lacks competitivity.

However, the forces aiming to solve our problems are already in place and working.

After a period of relatively slower growth, Europe will reverse the negative trend and make a strong comeback. So much so, that I see Europe passing Japan in terms of semiconductor consumption by the end of this century.

In terms of semiconductor production, Europe will get a slightly bigger share of the total market, but will inevitably end up in fourth place.

So much for Europe.

And with regard to SGS-THOMSON, on top of what I said for the medium term, the top two levels in our organization had a world meeting recently in Paris with the subject of Vision 2000. We are very excited with the outcome of our perspective about our own future, but I will not comment, I will not tell you now because I hope that this will form the basis for another presentation when Europe, like SGS-THOMSON is today, will be again a very strong and competitive player on the world scene.

Ladies and gentlemen, thank you.

Questions and Answers:

Question: Pasquale, when will you have a fab in Phoenix?

Mr. Pistorio: Well, we have, as everybody knows, a world class facility in Phoenix that has remained empty because it was completely adjusted before the merger with SGS and Thomson Semiconductor. Thomson had the strong large capability so we didn't need it. The point is now that all our capacities are saturated and we are seriously considering a new 8" facility in the states, of course Phoenix is part of this consideration. We should come to some conclusion pretty soon.

Question: Do you believe that European companies will gain market share in the European computer market? How about to the worldwide computer market?

Mr. Pistorio: To gain market share in the computer market, you must be worldwide. There isn't, first of all, a European computer market. The players are the same on the world scene and are mostly American, so I think the Europeans have to gain market share in the computer market. We are doing very well in the peripherals applications. We believe that we are the leading supplier to the hard disk drive makers. And we are developing a lot of chips and graphics and other parts of the PC that are opening up. It happens that nobody in Europe today is in the mainstream X86, but there is a lot of activity in all other components of a PC and we were increasing that aspect. So yes, I think that this will change.

Question: What is your projection for European semiconductor import tariffs?

Mr. Pistorio: Well, as you know the import tariffs are coming down and there is no question that by the end of the decade, they will have to fade out. The objective is not to protect, but to maintain a period of progressive adjustment in order to leave the European industry to become more competitive. It was the same treatment Japan enjoyed for many years until it became very strong. So, no question that the tariffs will expire — the question is the pace of expiration and the pace of phasing out. By the end of the decade, in my opinion, they will not exist anymore.

Thank you.

Federal Technology Policy: A New Era

Lionel "Skip" Johns

Associate Director, Office of Science and Technology Policy, Executive Office of the President

Office of Technology Assessment (OTA)

Mr. Grenier: Our next speaker is Skip Johns. Mr. Johns is Associate Director for Technology in Space, Office of Science and Technology Policy, Office of the President. He previously served as Assistant Director of the Office of Technology Assessment or OTA, which he joined in 1975, and was responsible for forming and managing the Energy Program. In 1978, he was named Assistant Director of the Energy Materials and International Security Division. Under his direction, more than 100 Technology Assessments were submitted to Congress on such issues as MX missile basing and the effects of nuclear war. Previous to joining the OTA, Mr. Johns was a Corporate Finance Representative with Alex Brown and Sons. Mr. Johns is a member of the Council on Foreign Affairs and a Fellow of the American Association for the Advancement of Science. He received his B.S. Degree in Corporate Finance from the University of Virginia and was an aviator in the U.S. Navy. Today, Mr. Johns will share the key aspects of the Clinton Administration's Technology Policy as it relates to electronics. Please join me in welcoming Skip Johns.

Mr. Johns: It's a terrible thing when you get old, you drop away some of the things that you did earlier in your life. I was also with Hazeltine, who licensed RCA for color television. I was with Magnavox when Frank Robbin was there and I was with General Instrument when they were working on cordwood construction for semiconductors. So, I feel like I'm an old friend of your industry.

I wish every industry in the country was as healthy as semiconductors in the United States, not only because of where you stand in the world markets, but because of the foresight that you had in doing such things as preparing road maps and thinking about the health of your industry. The way it's turned around since 1985 or so is really very impressive indeed, and I hope will be a model.

I'd like to talk to you first of all about what's going on in Washington and what's changed, because it drives the equation of where the government is going to be over the next four or five years. I won't predict after that.

The budget is the thing that's driving the country. We're 4 trillion dollars in debt and climbing. This administration is committed to reducing the amount of borrowing and paying it off so our children and grandchildren won't have this burden. This issue really shapes what the federal budget will look like in the years ahead. I'll give you an example, because it drives R&D policy and what we have to do to reinvent government, much in the ways that your companies had to over the past few years.

The GDP in the U.S., as everyone here probably knows, is approaching 6 trillion dollars. The federal part of that from taxes and other sources is about 1.5 trillion. Of that, about 500 billion is what you would call discretionary. The rest goes for Medicaid, Medicare, Social Security, interest on the debt — all of the things over which you have no control, unless you're a little

better on your discretionary spending. Of that 500 billion, over the next five years it will rise from roughly 511 billion to roughly 540 billion. That obviously does not absorb cost of living, so it will be declining in real terms. What's in that 500 billion?

262 billion of it is defense, so that basically leaves 240 billion dollars. That goes toward education, labor, agriculture, health and human services, NASA, the National Science Foundation — everything. You can understand why the President has focused on health care costs. At 600 billion and rising 15% a year, it wouldn't take long for the health care part of our budget to eat the rest. It's a serious problem.

With regard to that 500 billion, the part that my office is concerned about is roughly 76 billion dollars, which is the Federal R&D Enterprise. Approximately 60% of that has been defense; 40% of it has been for other civilian purposes. Included in that money is roughly 3 billion dollars of the National Science Foundation, principly for basic research, 10 billion dollars for the National Institute of Health, principly for health care and drug research and about 40 billion dollars for defense spending, including 15 billion dollars for NASA. If you add up those numbers, the rest, transportation, agriculture, the other agencies, are a very small percentage. So you can see our distribution coming down from 40 billion for defense to 15 for NASA, 10 for NIH, 3 for NSF and that gives you a very small number tapering across the rest of the agencies. As part of the change that has been driven, it's not only the budget imperatives, but that the Cold War is over. The end of the Cold War and finding out our potential Cold War adversary doesn't even existing anymore has had very important impacts with regard to the way this country has been investing its R&D resources and its tax money. One of the things that is clearly the case is that we have a large R&D establishment that has been supported by defense as well as a large production capacity that's been supported by defense. That's both good news and bad news. We produce 75% of the satellites in the world today — we're a formidable force with regard to launch services in the world, aircraft are our largest export industry. We have a very strong Health and Drug Industry, some would even argue too healthy. Many of these have derived from our Federal Investments in R&D. One would not want to dismantle this R&D capacity foolishly. As a consequence, that changes what it is that we have to do. Historically, an administration coming in would just take what that administration felt was important and set money aside in the R&D budget to be spent to support those activities. Basically, that meant turning up the printing presses and borrowing more money for that purpose. This administration is committed not to do that.

As a consequence, we've got to put some order in how that 76 billion dollars gets spent and we also need to follow through on a commitment of the administration to shift that defense R&D from roughly 60:40 defense to more like 50:50. In the course of this, we must also move our defense dependency more to the commercial industries versus having a separate industry set up to function and support our defense establishment. Peace, as we all know, has not broken out in the world. I think the White House has had a strong reminder of that this past week. Nevertheless, the types of strategic investments that we've been making are not smart. We have cut back in the prior two administrations. In fact, the defense expenditures were cut back starting back in 1985 and then continually to the present time. Those cut backs are going to continue. How to use these defense resources, particularly the R&D resources, so that we don't create straight losses to our GDP, so that we don't have regional impacts that become great social costs not only to the individuals who are affected by it, but to all of us who will pay for those costs, require great care and consideration.

The administration put out a technology policy that was released at Silicon Graphics on February 22. I suspect some of you saw it. We

would like to be measured four years from now against following through on just what we outlined in that technical policy. Let me site the goals, if I may:

- Long-term economic growth that creates jobs and protects the environment.
- A government that is more productive and more responsive to the needs of its citizens.
- World leadership in basic science, mathematics and engineering.

A simple set of goals.

I'm going to start with R&D priorities, then talk a bit about defense conversion, the information infrastructure, clean car, NASA and a legislative agenda. However, I'd like to save some time for Q&A at the end because it's true that we get locked inside the beltway — we need to be beaten up a bit by folks like you who have a fresher perspective, being outside of the Washington scene.

First let me just say, the Office of Science and Technology policy, which most of you perhaps have not heard of, is run by John Gibbons, who is Assistant to the President for Science and Technology. It's principle role is to coordinate Science and Technology in the Federal Government. This is 22 agencies that have one or another type of roles in the Executive Branch. So this coordination activity has been more in statement than in fact. Coordination has occurred in the high performance computing area and in global change and in very few others, something less than 10% of the overall budget.

In terms of R&D priorities, that's just not possible anymore. If we are going to spend R&D money on what's important, we've got to stop spending it on what's not important, and the only way we can do that is to set priorities. We have a commitment to bring industry in to advise on R&D priority-setting and we intend to do that. We've asked each federal agency to categorize their R&D in 11 different categories. The purpose of this is so that when you're setting R&D priorities, you're not saying is this AIDS research contract more or less important than this fuel cell development contract and if we can get it in the proper buckets, then we have a group of categories in which industry can be asked in to advise us on R&D priority setting. We intend to have an interagency group made up of each agency who spends money in each of these categories, sitting together to work out R&D priorities across the whole federal government. It hasn't been done before and it's time we started.

Much of the R&D endeavor in the U.S. has built up over the last 40 years of Cold War and that means that we are preserving Mr. Nixon's, Mr. Carter's, Mr. Regan's, and Mr. Bush's R&D agency in many cases. If you're unable to start what's important or current, you're preserving the past and foregoing the future. We just can't do that. The industry role in giving us advice is the difference between picking winners and losers. That's not a sport that this administration intends to play.

We have instructed each of the 22 agencies that I mentioned to increase their amount of activity with the private sector from 10% to 20%. What this means is an agency like NASA, which has been very responsive to the Aerospace Industry through Aeronautics to the Aircraft Industry, has a wide range of interesting R&D activity, but they have had little outreach to the private sector, other than Aerospace and they are going to increase that activity. In fact, I sent out a call on the Clean Car Initiative to see what they were doing since last spring's instruction to them, and 25 cases involved or related to Clean Car activities were sent back from the various centers in 24 hours. It's actually working - it's encouraging.

In defense conversion, as the military budgets decline, the administration must have a coordinated strategy for investing defense assets, people, facilities and technologies into the commercial economy to create jobs and stimulate economic growth. Two dimensions of that strategy are key - the transition assistance

to targeted workers, communities and firms that are hurt by defense cuts and military base closings, and two, investment in job training facility reutilization and dual use technology that will create new economic opportunities. This strategy must also reflect the urgent need of the Defense Department to change the way it does business as defense technology becomes both more expensive and less sophisticated than it's civilian counterpart. DOD must rely increasingly on the commercial technology base.

Now I'd like to move to the National Information Infrastructure. This administration is strongly oriented toward science and technology as the key to prosperity, economic growth and high quality jobs in this country. The National Information Infrastructure, started by Vice President Gore when he was in the Senate, is one of the key initiatives that will drive technology into applications in the home, in the office, in the libraries, in the schools, and in the places where those productivity gain opportunities can be best utilized. It also should be a continuing source of growth opportunity for this industry.

The NII will be a seamless web of communications networks, computers, databases and consumer electronics that will put vast amounts of information at the user's fingertips. Satellites are an essential element of this growing information infrastructure.

The NII also includes the trained people who will build, maintain and operate these systems, the applications that exploit the new technologies and the consumers that will benefit from these new tools. But the NII is not just telecommunications, hardware and applications. It's also a new attitude about the future, and about the relationship between government and the private sector.

Through NII, the Clinton Administration is committed to working domestically with business, labor, academia, public interest groups and local governments to ensure that all Americans will have access to information and will be able to communicate with each other using voice data, image or video anytime, anywhere. Nor are the benefits of the NII intended to end at the shores of the U.S. Internationally, the Clinton Administration is committed to working with the global community to understand how these new information technologies and services can be made available on a global basis.

The National Information Infrastructure will be most effective when it becomes integrated into an essential global information infrastructure. Development of the NII can also help unleash an information revolution that will change forever the way people live, work and interact with each other. The NII will ultimately connect the nation's businesses, residences, schools, health care facilities, and other public information and social service providers through a broadband, interactive telecommunications and information network. The NII will be capable of transporting large quantities of data at high speed and making two way video as common place as phone conversations are today. The NII will also spur the creation of a new generation of information appliances that will allow people to access and manipulate data in ways that we cannot even imagine today. These applications might include interactive learning devices that employ next generation virtual reality tools or tiny wireless computers capable of complex design and engineering tasks, or pocket sized devices that allow doctors access to medical resources from remote locations.

In the next generation, the creation of these devices will be driven by human imagination and by the nearly insatiable appetite that people have for more information and faster communication. Today in the United States, the private sector is already developing and deploying key elements of the future infrastructure. Even current federally supported networks operating on a national scale, such as Internet, rely on facilities leased from private sector providers. U.S. firms now

invest about 50 billion annually in the U.S. telcommunications infrastructure. These privately owned resources will continue to be the foundation upon which the NII is built and maintained.

To clarify, this is not a government built information infrastructure. The government will provide some aspect of delivering this to those, perhaps through libraries or elsewhere, where it may not be afforded as a service without government assistance, but we're talking about a private national information infrastructure, not a government one.

The Administration's program stresses a government private sector partnership in which the Federal Government promotes necessary development, but does not seek to become a national network operator. The principle role of government is to enhance and complement the efforts of the private sector and to assure that the benefits of the information infrastructure are available to all Americans at a reasonable cost. In developing it's policy initiatives under the NII, the Clinton Administration will strive to promote private sector investment through appropriate tax and regulatory policies. The President has already signed into law legislation that provides incentives for private sector investment in R&D and new business information.

One of the most effective ways to promote investment in the NII is to introduce or further expand competition. The Administration will work with Congress to pass legislation that will seek to ensure greater competition and universal access in key communications markets. To ensure that information resources are available to all at an affordable price, the Communications Act of 1934 established a nationwide goal of universal service. That is the widespread availability of affordable telephone service. A major objective in developing the NII will be to extend the universal service concept to meet the information needs of the American people in the 21st Century. The Clinton Administration intends to work diligently to ensure that the American people are not divided into telecommunication and information "haves" and "have nots." We intend to promote technological innovation. The Administration is committed to accelerating the development of those technologies which are critical for long term growth, but not receiving adequate support from private person, either because the returns are too distant or the investments too great. In particular, the Administration is maintaining a strong support for the high performance computing and communications initiative and is proposing new investments in development of applications in education, manufacturing, health and digital libraries. We intend to promote seamless and interactive access to the NII. To ensure interoperability and openness of the many components of an efficient, high capacity initiative, NII standards for voice, video, data and multimedia services must be developed. These standards must be compatible with a large installed base of communications technologies flexible and adaptable enough to meet user needs at affordable costs.

We need to improve the management of the radio frequency spectrum. The Administration is committed to streamlining it's procedures for the allocation and use of spectrum. Changes are already underway and will provide greater flexibility and spectrum allocation, including increased share of spectrum between private sector and government users, increased flexibility in technical and service standards and increased choice for licensees in employing their assigned spectrum.

Effectively coordinating NII initiatives with other nations is critical. The NII will develop in the context of evolving global networks to ensure that the benefits of new products and services can be enjoyed on a global basis. The United States will continue to work diligently in international policy and spectrum allocation seeking to reduce trade barriers to the flow of new information, products and services and

eliminate the barriers caused by incompatible standards.

Now I'd like to move just for a minute to the Clean Car initiative. You folks may have heard something about it out here. Last Wednesday, the three CEOs from Ford, General Motors, and Chrysler were on the lawn of the White House announcing an agreement with the President and the Vice President for creating a new Clean Car over the next decade. This car will be three times as clean as any car today, but it will meet all of the standards that one has come to expect and desire in an automobile. It will be comfortable, fast, safe, affordable and you'll want it, if we're successful. The automobile represents one in seven jobs in the United States. The increasing dependence on imported oil is now running 50 billion dollars a year at current oil prices, and as we all know, those numbers can double very quickly. Our oil consumption since 1985 is up nearly 50%, and it's going to continue to rise, so that burden of importing oil, which other nations share as well, is a continuing economic drag on the nation aside from the National Security implications of increasing dependence on fewer and fewer sources of oil in the world. As we've seen in places like China and elsewhere in the Third World, which is the largest growing market for energy these days, the demand or the necessity to raise the price of oil in order to moderate demand from those countries that are supplying the oil is going to become an imperative. That's just one of the beneficial reasons of having a car that essentially doesn't pollute. The external cost associated with the problems in L.A. for air and 22 other cities in this country is an issue. Italy in the summertime has to go at an odd and even license plate and the effect on their GDP for having to do this in the interest of public health is costly indeed. So we have an objective of designing a car or charging these companies with designing a car and the Federal Government is providing resources to help support that development, which have important long range social goals as well as cost containment for the wide number of costs that the kind of air we have in L.A. creates on society. So, this common goal makes it clear why taxpayer dollars are being invested .

Let me tell you why we're so excited about the project. The goal is unprecedented and is possible only because of technological progress made in areas like advanced materials, motors, fuel cells and other technology during the past few years. Both the government and industry partners recognize this goal. While this represents an enormous technical challenge, we should acknowledge the courage it took for the leaders of the U.S. Industry to accept it. Really, we negotiated with them for the better part of six months to see if in an era where trust has not been a strong commodity between government and industry, they could actually come to believe that we were serious about achieving these goals. It's critical for the environment since it aims directly at technology. Also, it's critical for ensuring control over both urban air pollution that can ensure control of greenhouse gases for the long term future. It's a true joint venture between a well-coordinated team of Federal agencies and the big three auto manufacturers. We've agreed to ambitious joint goals and promised to work together. It's a model of the kind of private/public partnerships we hope to build in other areas. The agreement breaks decades of deadlock between industry and government about the best way to ensure low automobile emissions and high safety standards. Successful development of the technology for such a vehicle could greatly reduce the need for regulations. The agreement is, however, a research agreement and does not address regulatory issues.

It's a key opportunity for using the unique resources of the U.S. Investment in Defense. It makes the expertise of the Department of Energy's Weapons Labs as well as research facilities throughout the Department of Defense available to U.S. Industry. It can restore the technical leadership of the U.S. Industry and provide the basis for exporting technology and products worldwide.

This is a model of the kind of agreement where there is a social aim and a market aim, which work together. A national launch policy for NASA is another example. We have been working to reinvent NASA in a sense, to redirect those resources within NASA so that they are more responsive to market needs in general. We have redesigned the Space Station which is to produce a station that meets mission goals instead of goals that were set up in this 40 year Cold War era. It involves 14 nations and may shortly involve a 15th nation, and is our principle man in space activity.

Now I want to touch on just one last area of some of the initiatives that we intend to pursue to create a world-class business environment for innovation in the private sector investment. We intend to make permanent the research and experimental tax credit and the need for additional U.S. Investment in R&D is clear. Currently, the United States invests 1.9% of GDP in non-defense R&D as compared to 3% in Japan and 2.7% in West Germany. We will increase private R&D expenditures to make research and experimentation tax credits permanent. In the past, the effectiveness of this credit has been undermined by a series of six and nine months temporary extensions. The credit cannot induce additional R&D expenditures unless it's future availability is known when businesses are planning R&D projects and projects costs. R&D activities by nature are long-term and businesses should be able to plan their research activity knowing the credit will be available when the research is actually undertaken. Thus, if the R&D credit is to have an intended incentive effect, it should be permanent. The President has just signed a three year extension. We would have liked for it to be permanent. Our partners on the Hill, hopefully, will think one more time about this in the next three years. We intend to create incentives for long-term investment in small business. The administration will send legislation to Congress designed to provide incentives for those who make high risk long-term venture capital investments in start-ups and other small enterprises. These companies are the major source of job creation, economic growth and technological dynamism in our economy. We also intend to create incentives for investment in equipment. Currently, America's chief economic competitors are investing twice as much in plants and equipment as a percentage of GDP as the United States. Furthermore, studies show a high correlation between investment in new equipment and productivity. Since new technologies are often embodied in capital equipment to stimulate additional investment in equipment, the Administration will propose a temporary incremental investment tax credit for large businesses and a permanent tax credit for small businesses. We intend to reform antitrust laws to permit joint production ventures. The Administration will forward legislation to Congress which would extend the National Cooperative Research Act of 1984 to cover joint production ventures. The escalating costs of state of the art manufacturing facilities will require firms to share costs and pool risks. We intend to ensure that U.S. trade policy strengthens high technology industries. To remain competitive, America's high tech industries need full access to overseas markets, an effective protection of intellectual property rights. The Administration is committed to multilateral and bilateral negotiations and enforcement of existing agreements that will accomplish these objectives. The trade policy must also be consistent with a vigorous public research and development program.

Well, I've touched on a few things. One of my favorites is a new initiative in Technologies for Education and Training. I'll save that for another time, but I would very much appreciate any questions that you may have about what we're up to and I hope you'll invite me back so that I can report on how we're doing in the years ahead. Thank you.

Questions and Answers:

Question: Recent reports have indicated a substantial increase in government employees. How can the budget be cut with this direction?

Mr. Johns: Actually, the numbers you must be talking about are an increase in state and local employees because the Federal employment is not only down, it's down substantially and it's been on a relatively flat trend or slightly downward for the past fifteen years. Now, in fact, the White House says, as you folks have heard, and I can testify it's true, cut its staff 25%, this being a very inactive blaise faire government, that meant that we can all go home early, at least maybe one day. At the moment, it means most people are working six and seven days a week. But the President has issued an order to all of the agencies to reduce their employment over the next five years by 252,000 people. I know NASA has just informed 200,000 people that they're being laid off, so I think you're confusing State and Local Government with Federal.

Question: Mr. Pistorio just related to us the problems in Europe brought about by extreme taxations, strong unions and welfare, causing them not to be globally competitive. Why is the present U.S. Administration pursuing the very path that has destroyed European competitiveness?

Mr. Johns: Well, if you folks would study the tax laws in Europe, you would be delighted to trade for the tax laws in the United States. The taxes are substantially higher. I might also add that while union takes a hit, we're talking about a few million workers that are in unions and out of 117 million work for us and the unions are way less than 10% of that pie. Furthermore, their memberships have been declining over the years. I think we speak of a spector there that is just not as much an issue as one tends to see it today. For example, the unions have been working towards increasing the quality of jobs while decreasing the work force and in the auto initiative, Mr. Beaver, the President of UAW, was on the stand. One might have expected that in the stereotypical union reaction they would be opposed to such a clean car initiative.

Thank you very much.

China: A Newcomer in Asia

Dan Heyler

Manager, Semiconductor Research

Dataquest Asia/Pacific

Mr. Grenier: Our next speaker is Dan Heyler. Dan is the Manager of Dataquest Asia/Pacific Semiconductor Research. He is responsibile for Market and Industry Coverage in Taiwan, Hong Kong, Singapore, China, Malaysia, Thailand and the rest of Asia region. Before joining Dataquest five years ago, Mr. Heyler worked for the U.S. Department of State in Bejing in Taiwan, where he did research on Asia/Pacific High Technology and Trade Issues. Mr. Heyler graduated from Bowdoin College with honors in Asian studies and has done field work at Bejing University and Tunghai University in Taiwan. Dan is based in Taipei and is fluent in spoken and written Mandarin Chinese. Dan will get a perspective in the semiconductor and electronic equipment production in China and I think his talk dovetails very nicely with the talk that Mr. Pistorio gave this morning. Please welcome Dan Heyler.

Mr. Heyler: Good morning.

I think there's been a good deal of discussion on Asia/Pacific, not only by Dataquest but by other companies in the industry. This is the 19th Annual Semiconductor Conference and I think Gene has spoken about China for at least the past five of these conferences. Asia/Pacific is really going to be the key to the next growth in Asia as we'll see in this upcoming presentation. Companies are going to have to restructure their organizations to prepare for a variety of different scenarios within the region.

I'd like to first begin with a look at where the economic situation stands in China, how you'll have to deal with those varying economic changes within the region and how your organization should change and adapt to deal with infrastructure changes, inflation, social change and political change. I'm going to focus on the key points of those issues. There are hundreds of issues we can bring out in a forum such as this. We'll handle as many questions as we can at the end. There are some slides included at the end of this presentation that have been incorporated. If you'd like copies of those, be sure to give me your business cards at the end and we'll discuss these later. I am based in Taipei, so if you need to contact us, send us a fax.

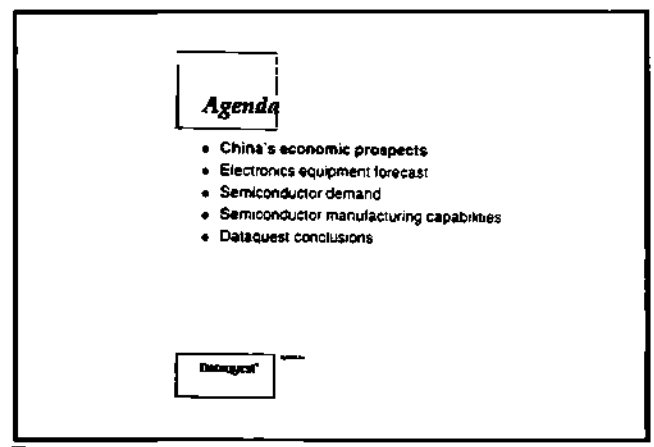


Figure 1

After moving from the economic process, I'm going to get into the electronics and equipment production trends not only in China, but within an Asia/Pacific scenario. Where is China within the realm of Asia/Pacific? China is going to be key to the growth in Asia/Pacific as a whole and the regional dynamics are changing significantly. In addition, your organizations and Dataquest's organization will be changing. As we add head count, our

services will change to mirror those growth trends.

What does that mean for semiconductor demand? We'll get into the various regions within China where the growth segments will be and where some of the potential customers for you will be now and in the long term. We're looking at the semiconductor manufacturing as not only a trend within China, but also as an opportunity to benefit and penetrate those emerging semiconductor markets. Then, I'll conclude and make some recommendations to you.

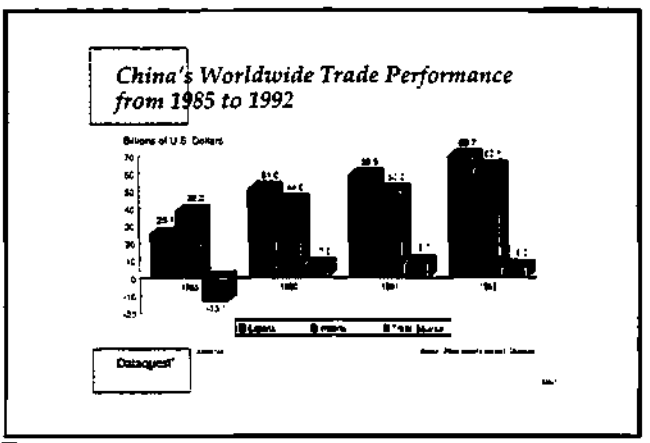


Figure 2

Well, we've seen Asia/Pacific, really starting with Japan, as the emerging Asia/Pacific power leading us to the 21st Century. We see the NIEs emerging following Japan by about ten years. Those economies are all export driven economies, bolstered by both markets in Europe and North America. We see that Taiwan, Hong Kong and Singapore have developed due to PCs and peripherals, particularly disk drives, with extremely strong exports both in North America and Europe. Korea is also fvery strong, as we all know, in consumer electronics. This growth has been followed by tremendous growth now in the Asian Region Association of Southeast Asian Nations.

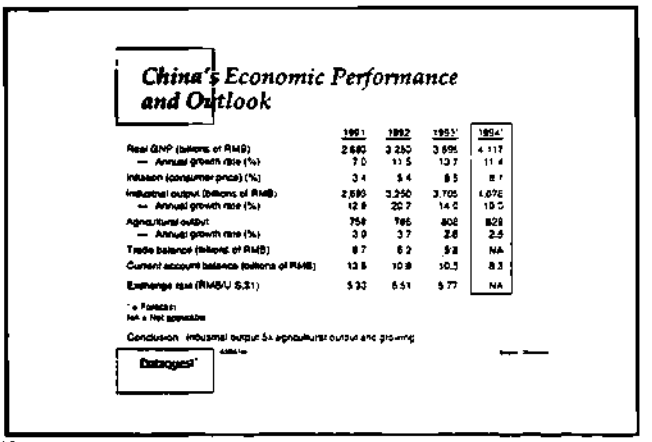


Figure 3

So, in addition to the NIEs or the NICs, which stand for Newly Industrialized Countries and Newly Industrialized Economies, we're seeing a continuation of that growth moving off shore to Thailand, Malasia and Singapore. That investment is being driven by not only Japanese investment — North American companies and European companies such as SGS-THOMSON have been in the Asian region for many years now, so this combination of export growth in the first wave, moving to a third wave of integration within Asia/Pacific and now the second half of this third wave will be the China growth. So the investment is going from Asia and now into China due to labor shortages in the Asean region and infrastructure bottlenecks. China now is absorbing much of this next wave of growth which we think will accelerate between 93 and 97.

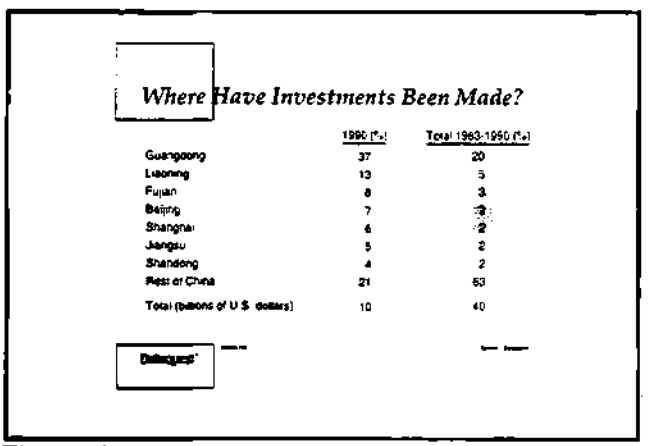


Figure 4

From an economic standpoint, you're looking at the first half of the growth here from 1989 to 1993 — the tail end of it. Malaysia, Thailand and Indonesia as well as Philippines and the other countries in Southeast Asia are really leading this wave of growth. We see Hong Kong, Singapore, Taiwan and South Korea still with very large economies, but slowing slightly. China at that point was really at the peak of one of it's boom/bust cycles and was experiencing relatively slow growth, and that's what lead to the slow down in the Hong Kong economy.

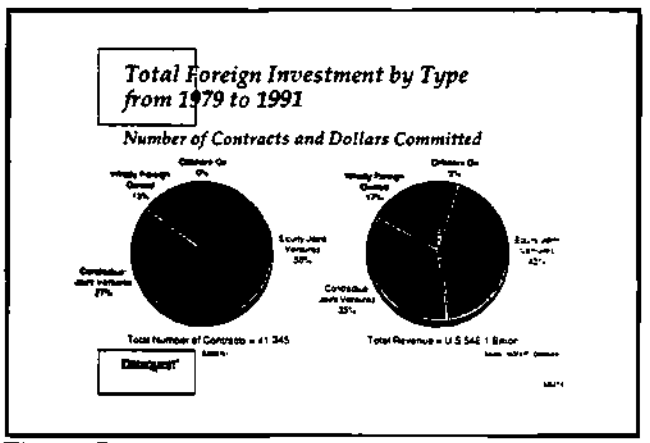


Figure 5

Now our forecast for '93 and '94 — Asia remains strong, the Asian nations remain strong in Southeast Asia, however, China is clearly leading the growth in our minds from '94 onward. By the way, many of these statistics are compiled by our parent company, Dunn and Bradstreet. Now, as you look to China growing, Hong Kong also pulls up as a result of the growth in China, which is expected. However, China's growth in 1993 is much, much faster than the Chinese Government would like. In fact, Lee Pung was seen on the beaches of Northern China as he lost his position, unable to control inflation. Consequently, somebody else from the reformist side of the Government has been promoted. His name is Zhu Rong Ji, and his task is to slow the growth in China. He has a 16-point plan which is showing some initial success and we expect these points to have much more of an effect in '94 than they do in '93, so clearly it's going to slow, but that's a good sign. There is just so much investment flooding into China — you'll see that it takes a while for it to trickle through the economy.

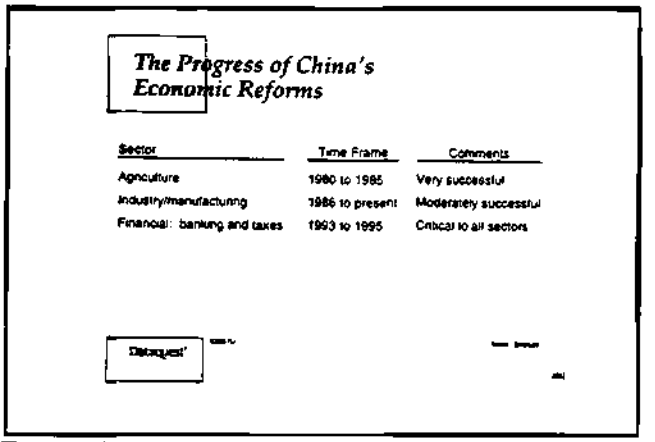
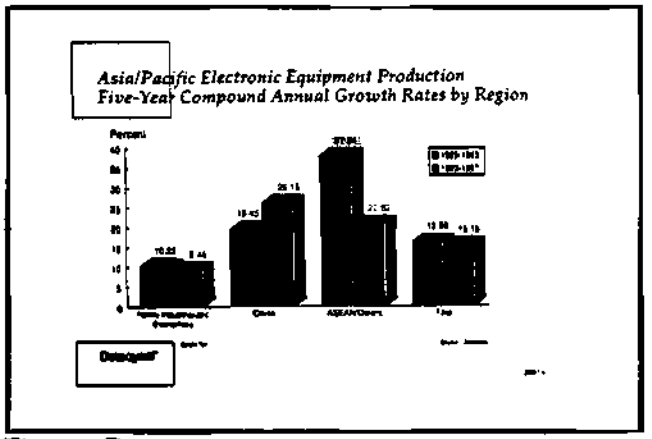


Figure 6

What's most important to note about the Chinese economy, is that China has become a trade powerhouse in ten years since it began it's open door and economic reform policy. On the left of the chart, in 1985, China's total worldwide trade was 63 billion dollars. It operated at a deficit of about 13 billion. In five years, it grew modestly, yet significantly to 95 billion, but it gained a surplus in those five years of 7 billion dollars, so its total trade will be 95 billion by 1990. However, in just two years, it increases to 40 billion to 133 billion total trade for China in 1992. It sustained it's trade surplus during this post 1990 period. In 1993, trade will continue to boom, however imports will slightly exceed exports and there'll be a slight to flat deficit, but this is due to large capital expenditures taking place in the South and the Coastal Regions in China — I think that's a good sign that they are capital related and China is also trying to control it's consumer, what they call rampid consumerism, which we consider a good thing in the States. They're trying to hold down consumer spending to lower inflation and reduce imports and dependence on VCRs, televisions and cars.



Figur e 7

Here's a bunch of economic statistics — I'm going to hit about five points here. But first of all, please turn to the industrial output line and I'd like to make a couple of changes. There is an error in the slide. Industrial output in billions of dollars should read from 1991 in billions of dollars, 1773; 1992, 2000; 1993, 2190; 1994, 2343.

First of all, when you're looking at the GNP in growth rates, again we mention that China will slow in 1994 and we expect it to remain at about that level in 1995 and will average about 7% to 8% through the remainder of this decade. That's the target of the Government and that's fairly realistic provided the reforms, that I'll discuss later, will be successful.

The second key point here is that inflation is relatively high and has been since 1992. This rate is very conservative and could be even higher than 8% in the urban areas. Urban areas range from 15% to 20%, which is the cause of concern at this point. Agricultural output is relatively slow, and it's a small percentage of the total industrial output, which is actually three times the agricultural output of China. It is an industrial nation, although 70% of the population is in the rural areas. The actual size of the economy is largely industrial.

As we mentioned, the trade balance will likely be flat to deficit in 1993. You need to look at the current exchange rate as the official rate. This is conservative. When you go to China and you do business in China, the swap rate is actually about 10, and the official rate is what the bank will give you, but on the gray market you can get 10.

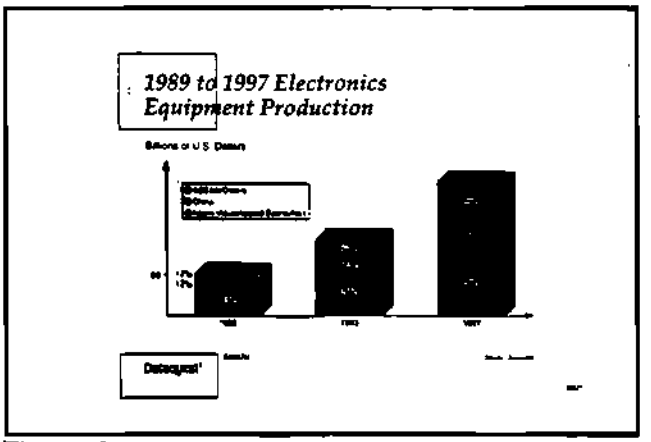


Figure 8

Now the key drivers behind this export boom and the economic growth in China are largely due to the foreign investment that's flooding into China. However, again we're seeing a dramatic growth after 1990. In 1990, it's about 10 billion dollars in foreign investment. From 1983 to 1990, its 40 billion, but in 1991, 1992 and 1993, in those years, it grows from 15 billion in '91, 40 billion in 1992 and 60 billion in 1993 alone. Where are those investments going? You're looking at Guangdong Province absorbing a large part of the Hong Kong investment. Liaoning is in the North and that's absorbing Korean and Japanese investment. A lot of electronics manufacturing going in to the Northern part of China, Manchuria, with a long history of Japanese involvement. The Fujian Province, which is a southern coastal province about 50 miles from Taiwan, is absorbing massive amounts of Taiwan investment and they do speak the same dialect. Beijing, Shanghai and Jiangsu are really a conglomerate of multinational Japanese, European, and North American investment and Shandong is also a mix, with a considerable amount of Japanese and Korean investment off the coast of Korea.

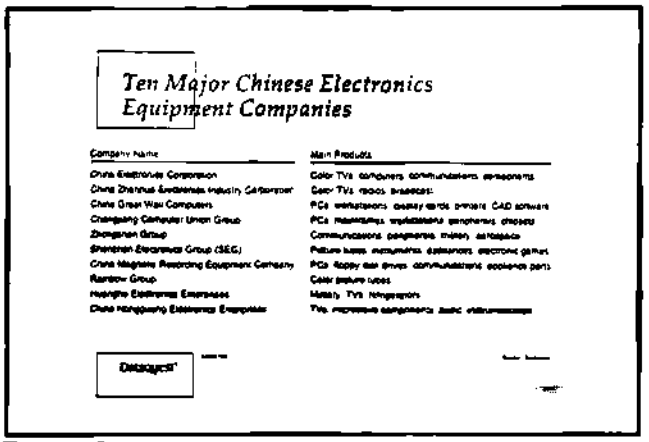


Figure 9

Now what kinds of investments are going into China? A variety of ventures are moving in, however, joint ventures remain the most popular form of penetrating the Chinese market. You have equity joint ventures and contractual joint ventures — together they equal about 87% of the 4100 contracts that were in China from 1979 to 1991. When you're looking at the 1990s, its about 50 billion in total investment. 78% of the dollar value is in joint ventures. Joint ventures are a good way to penetrate China to get into the market and avoid taxes, however, if you're in there for a joint venture, you need to think about keeping it small. If you're in with a large joint venture, you'll have to go through the central authorities and that's usually in excess of about 30 million dollars to exceed the limit between a provincial investment and a central or national investment. So it's good to keep it small, good to keep it within the provinces or the cities — that's what's happening here. The number is increasing and the value is increasing as well.

Now China's economic reform really began with Deng Xiao Ping's open door policy. However, he really consolidated his power due to his success in the agricultural reforms. That gained momentum and moved into the industrial and manufacturing center, which lasted from about 1986 to 1991. That was moderately successful because he dealt with a variety of bureaucratic entrenched industries that are in the urban areas. Those are modeled off the Soviet economy and he's got to move into those areas to further breakdown the Communist party entrenchment as well. That has been moderately successful. He's introduced a responsibility system in which Managers or Bureaucrats now have to be responsible for both the profits and losses of the companies in that sector. However, the key to the next five years really is in the financial and banking sector and this is the challenge of the new Minister, Zhu Rong Ji, who's got to go in there and essentially create a financial system that is non-existent.

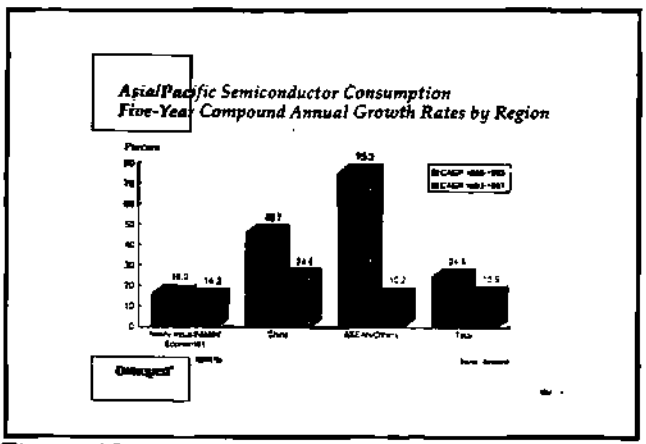


Figure 10

You've got the central bank, People's Bank of China, that is large and bureaucratic. He wants to decentralize that and move it to a much more provincial-oriented banking system such that he can control the interest rates more effectively, control the economy and tune the economy more effectively than he can now. A large part of the problem now is exchange rates, interest rate fluctuation and money supply — that really handicaps him from controlling the economy. So he'll have about two years to affect that and we'll watch and see how he does. Hopefully Deng Xiao Ping will stay alive and there won't be any political unrest in Beijing. He will maintain that position and start to break down those bureaucratic barriers in the urban and financial areas.

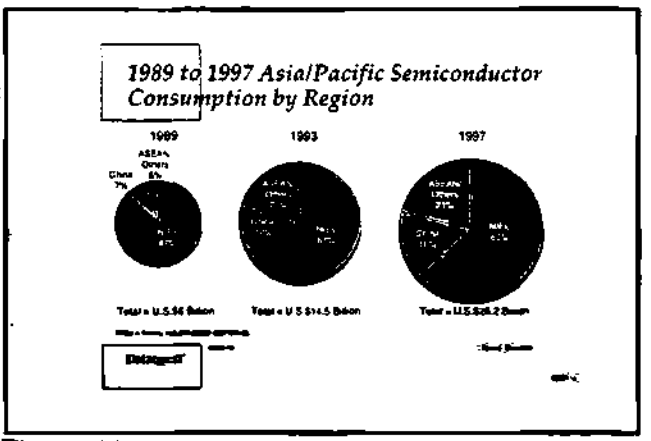


Figure 11

Now, the key economic hurdles we see now, both from an economic point of view and from a business operations point of view, are as follows — if you're in China, you'll be dealing with a certain amount of inflation, which also impacts the exchange rates and interest rates, but you're also going to experience infrastructural issues as well. Infrastructure leading to product delays and bottlenecks in distribution. These are tactical issues that can be dealt with but they're certainly a reality in operating within China.

The third item is the reforms. You have a variety of reforms that are happening very, very quickly, not only at the central and national level, but also at the provincial level. If you're tuned into those changes, you'll be able to benefit quickly and be the first to take advantage of the rapid changes in China. I think the most significant recent reform is really in the trade law - China's International Trade Law. Most of the intellectual property and copyright laws are moving in the right direction. The key for you will be to watch reformsit and see how you are able to enforce many of those central government level reforms.

In the long term, Deng Xiao Ping's successor is very pivotal, but it's not as serious or dramatic as we might think because he spent about the past six years of his time in central government. He's exerted his influence to promote what we call young technocrats within the regime, and those technocrats, what we call young, are over 60, but they haven't really been a problem and lived through cultural revolution. Deng Xiao Ping is really the revolutionary old guard and as the old guard dies, many of these technocrats now have a consolidated base and are making decisions much more on practical rather than political terms. That is really key. However, China is a large country with many provinces and cultures. It needs a strong leader and we expect a strong leader to emerge in the 1995-1996 time frame.

Corruption is a reality and it's going to get worse before it gets better. China is a massive socialist nation, the largest in the world, and it is decentralizing and mobilizing. So as you have state run enterprises, those enterprise obviously will have access to resources, distribution, and goods, and you've got bureaucrats who are going to abuse their power in that transition. However, it's important to distinguish between what is cultural, what is accepted and what is against the law. Often times in our minds, it's a fine line, but I guess the advice to you would be look at the norm, do what is accepted and stay away from corruption — it's not a Dataquest recommendation.

I think looking at the most favored nation, that's a very key issue. The U.S. is 20% of China's total trade, so the most favored nation is very critical to China's continued growth. Trade issues also relating to the entry into GATT was a hot issue last year. China will enter GATT, it's just a question of time. The reforms that have to take place are significant and the financial reforms are also very much a determining factor of that entry into the GAT system. I think China was very optimistic about getting into GATT last year, but due to the exchange rate issues, it didn't get in at that time and there are numerous other issues the U.S. is pressuring as well.

I think the final key issue here is the increasing power of the provinces. This has been good and in some sense, has been driving the

growth, but in other senses, the central government will need to keep control in terms of collecting taxes, keeping the economy on course and guiding China into the 20th Century to keep those provinces together. It's going to happen under the next stage of financial reforms which will impact the taxation structure in China as well.

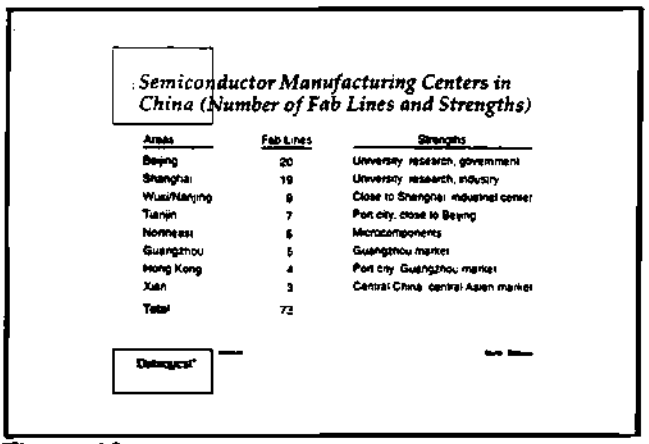


Figure 12

Now although we see very optimistic and very strong economic developments within China, we will continue to read about the contentious issues between the United States and China and will continue to get credible reports of human rights violations. I think in terms of prison labor within China, if you're close to your organization, you know the people there and you're most likely not going to be employing prison labor. We will continue to read about China's missile and nuclear technology sales, however, the U.S. is going to have improve it's intelligence. It was an embarrassment for the States when they searched the cargo ship and didn't find what they had expected. But, these are just things that are going to continue to heighten the public tension between the two countries. The United States again has 20% of China's total trade so it has a lot of leverage in China provided they do it tactfully and privately as opposed to doing it publicly, which causes China essentially to lose face. It encourages them to do the opposite of what the U.S. wishes and the recent loss of the 2000 Olympics was really a very sore spot with China and the United States.

Hong Kong's future will also be a public issue for the United States' Foreign Policy. Intellectual Property Rights will be public, but again we've seen significant reforms in China towards developing intellectual property loss.

What do all these economic trends mean for electronics? In looking at electronics equipment growth within China, I'd like to look at not only China, but where it stands within the booming Asia/Pacific region. This chart compares 1989 to 1993 growth with 1993 to 1997 growth, by region, within China. So if you look at the past five years, the newly industrialized economies are growing at about 10% compound annual growth rate. This accounted for most of the Asia/Pacific production which is why it was relatively slow. The second part is that the Asian region is really booming again due to the factors of Japanese investment, Asian investment and Taiwanese investment falling into the Asian region.

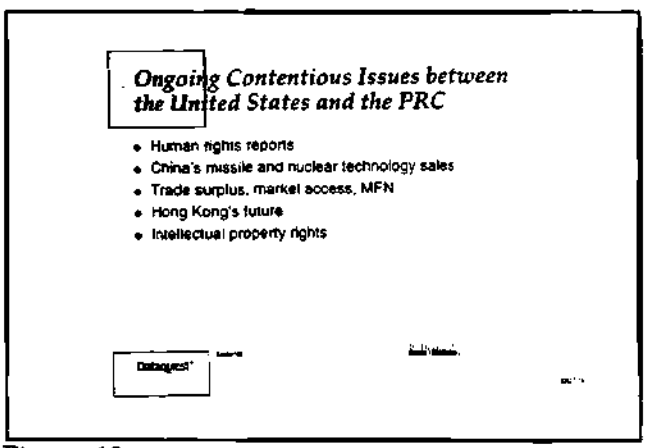


Figure 13

That growth is dramatic. We expect a slow down in electronics equipment production due to labor shortages and infrastructural issues that have caused companies not to want to go into Thailand and Malaysia. Also, the China strength is diverting a lot of the attention to the China market. We expect China to lead growth in the region at about 26% over the next five years in terms of compound annual growth rate for electronics. In dollar terms, in 1989, Asia produced about 50 billion in electronics

equipment. The Asian region accounted for about 12% of that, but that jumped dramatically due to off shore investment to about 25% of the total electronics equipment production in Asia/Pacific.

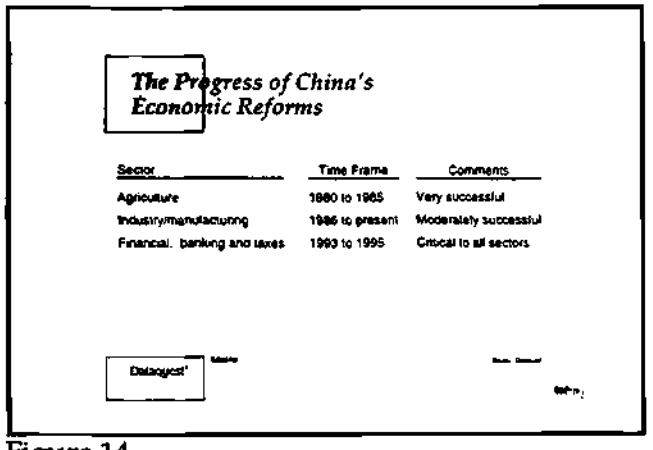


Figure 14

We expect moderate growth, in dollar terms, to represent about 30% of the total growth by 1997 and the total region will boom to about 130 billion U.S. dollars. China is the fastest growing region from 1993 to 1997. It represented about 14% this year and that will grow to 20%, so it's interesting to see that the newly industrialized economies, such as Korea, Taiwan, Hong Kong and Singapore, will account for 50% of the regional growth and we're seeing the other 50% is a result of this third wave that I alluded to earlier.

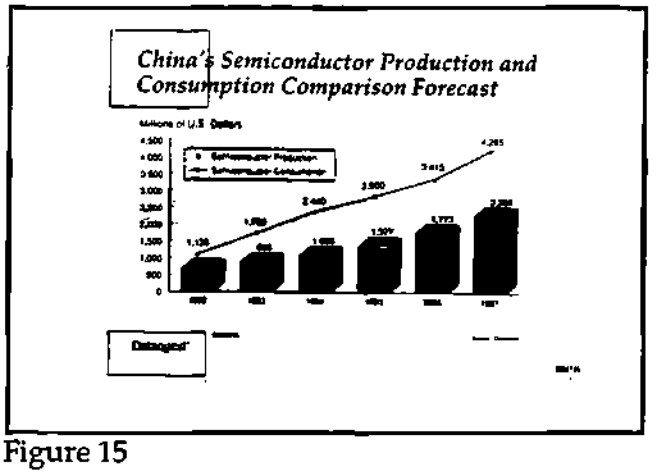


Figure 15

Now for semiconductor manufacturers and semiconductor vendors within China, these are some of the partners and companies you'll be dealing with. They are fairly large electronics equipment manufacturers. A lot of these were a spin off of the Ministry of Electronics. These were state run, state supported industries that have again been a product of the reforms and have decentralized. These companies are changing in form. Again, they are large companies. They will be moving into various sub-sectors and dividing or combining, but you really want to look at these companies as both partners and as potential clients.

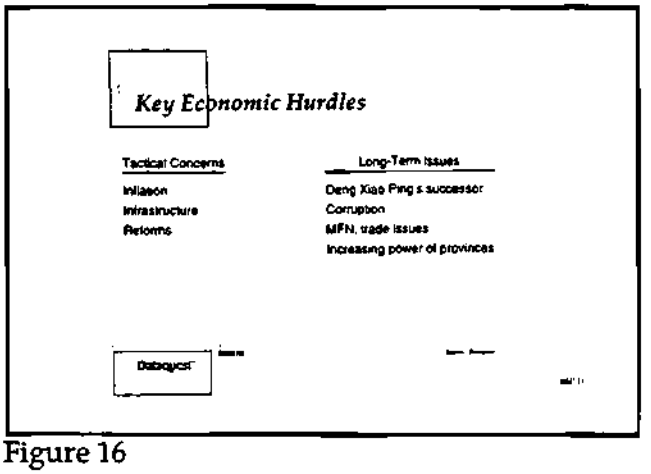


Figure 16

Looking at the products here, you are looking at primarily consumer electronics for the past five years, in particular televisions, appliances, VCRs, audio and video. There's a very large market within China, so it makes sense to manufacture there. In looking over the next five years at PCs and peripherals starting to grow, you see a large multinational moving, Compaq is there and you have Motorola setting up large pager and telephone manufacturing facilities in the region to take advantage of the booming telecommunications market in China. Right now we're seeing mostly finished, completed systems being sold to China, but it's going to make sense to start to manufacture consumer-related telecommunications products within China to benefit from the huge consumer market there in telephones and cellular. We have more information on

companies — this is just a small piece of what we have.

Now all this electronics equipment growth will lead obviously to more demand for semiconductors. How much demand? Asia/Pacific in 1992 reached the size of the European semiconductor market. It will surpass Europe in 1993 and become the third largest region. We are also very bullish on Asia/Pacific as is SGS-THOMSON. It will become one of the leading markets, if not the leading market in the 21st Century. This growth is driven by continued economics and electronics strength in the NIEs, but also the emerging new markets of China, Southeast Asia and even India are up and coming. This is half of the world's population that is reforming, developing and moving into electronics.

This is a similar comparison between 1989 and 1993 compounding the annual growth rate by region. The Asian region grew significantly due to the off shore investment in equipment production, so it's consuming growth. From a very small base, it jumped very dramatically and you're seeing that growth sort of level off for the next five years due to a lot of the off shore equipment investment taking place in China which will absorb and be the major absorbing market growing at about 25% compound annual growth rate. In dollar terms, you're looking at dramatic dollar growth from 1989 to 1993 for the Asia/Pacific region from 6 billion to almost 15 billion this year. That's more than double and by 1997, I'm seeing it very close to doubling again. So, 1993 again is a market about the size of Europe now and you're talking double Europe by 1997. I've heard major companies here that are Dataquest clients that have said our estimates are conservative.

So for China, SGS had alluded to Eastern Europe being about 480 million in 1992. That was about the size of the China semiconductor market in 1989 and now we're looking at a Chinese semiconductor market which is 12% of 15 billion. By 1997, you're talking about a 4.2 billion market for the China economy, which is getting up there.

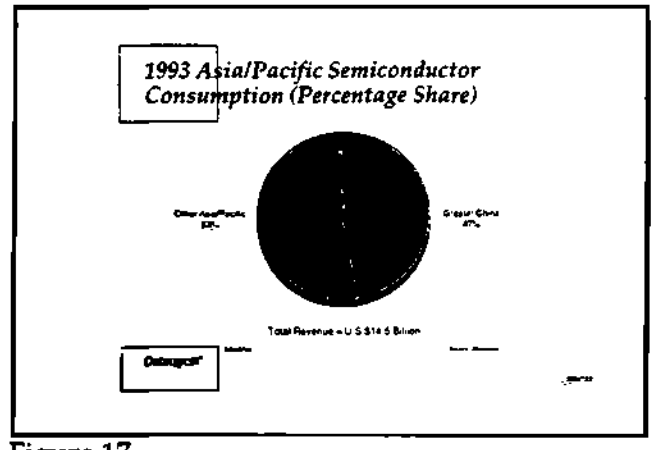


Figure 17

Now when you look at China, and I continue to advocate looking at Asia/Pacific now as a single market, not necessarily a bunch of different countries that we tend not to understand. I am seeing an increasing emergence of a greater China region which combines Taiwan, Hong Kong and China. The cultural connection essentially is historically China, but now you're seeing the economics and similarities emerging — there's a lot of synergy between those three countries. Hong Kong is a marketing center, a trade center, and Taiwan is the technical semiconductor manufacturing base and really a future beachhead into the China market, so that synergy of those three countries is emerging not only through assisting and growing together, but also by becoming a single economic unit. We view that region as really driving and being a core center of the Asia/Pacific growth in the next 10 years.

Now where is this greater China region within the worldwide scenario? It's about half of the Asia/Pacific market and the Asia/Pacific market is right up there with Japan by 1997, so greater China is going to be about half of that. Make sure you think about that when you're managing your Asia/Pacific planning for the future. You have to think about having an operation in which you're leveraging the resources between Taiwan's strong design and

strong manufacturing, leveraging your expertise in trading people in southern China and really preparing to train and set up a manufacturing facility within China. You want those people obviously to be at least the key manager either from Hong Kong or from Singapore or actually Taiwan, depending on the expertise and depending on the product. However, it's going to have to be one organization — one that focuses on product segments and technology segments as opposed to the past scenario of people looking at individual small offices, country by country.

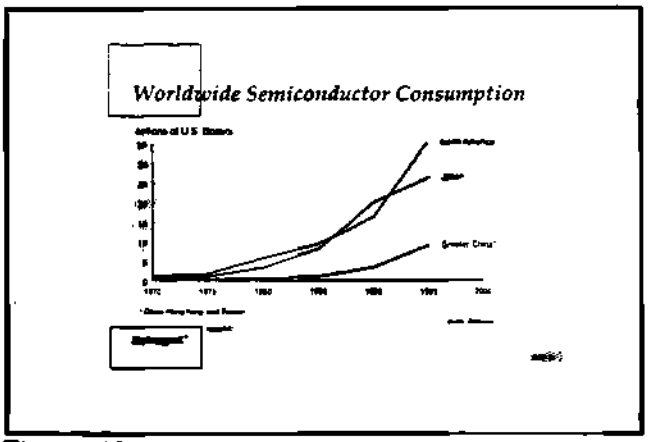


Figure 18

I'd like to move into manufacturing, which is really not only from an interest point of view important in China, but also part of a strategy in penetrating the emerging applications and emerging demand in China. If you choose to set up either assembly or manufacturing within China, your access to the market actually doubles as we look out to 1997. We expect a large amount of manufacturing within China. Not only has the government targeted semiconductors and already spent millions of dollars in purchasing semiconductor manufacturing equipment, it plans to spend two billion dollars by the 1995-1996 time frame in semiconductor manufacturing equipment. Even if they purchase half of that, it still plays into this forecast of large manufacturing. You have a good deal of manufacturers that are there already, both multinationals and domestic companies, for example, Motorola, NEC, and Toshiba.

In Bejing, NEC has just set up a facility and you're seeing a lot of R&D and manufacturing test in the north, so although you see large and fast economic growth and electronics equipment production growth taking place in the south, a lot of investment has been flowing into the south from Hong Kong. The technical expertise, the research and the government — these are the areas in which the expertise is superior in the north. So I think in looking at semiconductors, although you're seeing growth and consumption in the south and on the coast, you have to take advantage of the expertise, universities and research centers, and government and industry centers of Shanghai and Bejing.

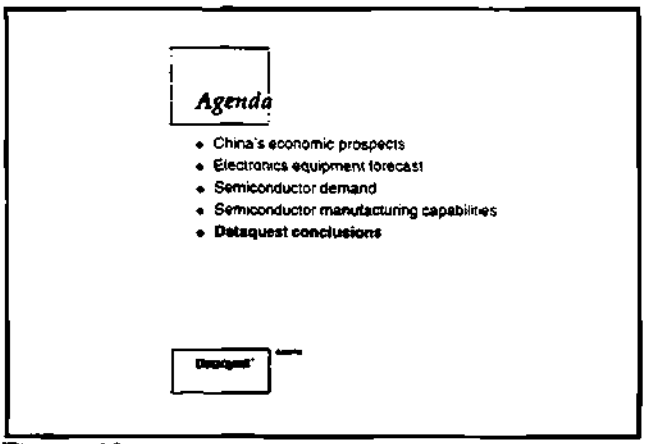


Figure 19

You can also expect a major foreign manufacturer to set up some kind of wafer fabrication capabilities in the south, possibly playing off their Hong Kong or Taiwan areas, but I think those facilities will have to leverage the talent and human resources of the north.

So moving into the conclusions and recommendations, I think overall the economy is fundamentally strong. China is not a debter nation — it has an account surplus as we have showed in the previous foils on economic data. It is facing some inflation hurdles, but the fundamentals are there and the growth will continue. You have large export and trade continued investment along with a large bureaucracy which will stabilize a lot of the

changes taking place. The electronic equipment market is continuing to grow and the market is not only from an export point of view, but also from a domestic consumption point of view. Semiconductor demand consequently is growing dramatically at a CAGR of 24%. In terms of reforms, government and investment, continuing to see them target manufacturing is a key to developing not only it's own internal expertise, but also it's ability to import less semiconductors and satisfy the growing demand for consumer electronics to be sold within China. So again, we continue to think that you need to look at the continuing scenarios. China is kind of something that gets on the headlines, but also look at the region. We've been tracking it for five years and we continue to see that China is a key component of the growing Asia/Pacific market and will be key to the third growth wave as well.

I'd like to read some recommendations to you.

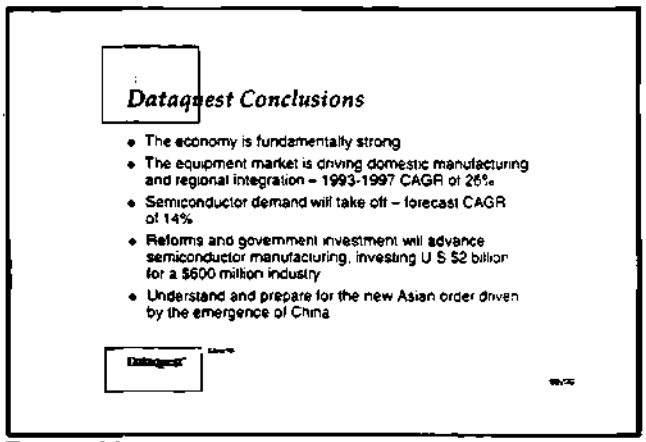


Figure 20

I think the economic investment here warrants investment now at this point to prepare for the future. I think if you take advantage of China's two billion dollars in expected semiconductor imports by 1997, you can double the two billion to four billion by manufacturing within China. In the 21st Century, manufacturing within greater China will suffice as Taiwan's direct trade will be developed within two to three years. I think you're looking at joint ventures within China as really providing the best results and if you look at various case scenarios, joint ventures have been most successful and are likely to continue to be most successful within China. We believe to really act now and to think ahead will lead to your success in the region. Thank you very much.

Questions and Answers:

Question: For U.S. companies with offices in Hong Kong, what recommendation would you have for them in 1997 or after? Should they stay in Hong Kong or focus in Beijing ? Why stay in Hong Kong?

Mr. Heyler: You know, I think 1997 has a lot of drama. Again, you need to look at really the concrete issues that are going to take place in Hong Kong. It really would depend on the products. There will be changes in Hong Kong — whether or not those benefit you or inhibit you will determine your decision. Some companies have chosen Malaysia due to fear and changes in the legal system in Hong Kong. I think the key point is that the Hong Kong legal system has leveled the playing field and the British system is strong and has protected companies. How that change will be most critical and whether or not it's going to make the playing field level or not in companies with bureaucratic connections remains to be seen. How much the mainland bureaucratic culture will impact your operation in Hong Kong will be significant, but it also holds a potential opportunity.

Question: What is the situation of China about CoCom.

Mr. Heyler: CoCom has been important in the past, but we're seeing a couple of factors relating to CoCom. First, the reforms have progressed very rapidly. Second, what does China need? Currently China doesn't need a lot of 486 computers. It has a large demand for 286 and 386, then semiconductors so the demand for ICs is not leading edge. The bulk of the market is very low end, mostly consumer related ICs, so currently CoCom is really not an issue when you're looking at the bulk volume.

Computer Market Trends in Japan

Junichi Saeki

Director, Computer and Peripheral Research

Dataquest Japan

Mr. Grenier: Our next speaker is Mr. Saeki from our Japanese office. He's the Director of the Information Systems Group at Dataquest Japan. He is responsible for supervising all research and analysis performed by the Japan Informations Group and also for specialty areas of technical computers and superperformance computing. Before joining Dataquest, Mr. Saeki was Manager of the Computer Systems Section at Schlumberger in Japan where he was responsible for developing scientific computer systems in international computer networks. Prior to joining Schlumberger, Mr. Saeki was an Assistant Professor at Numazu College of Technology for 10 years, where he studied numerical computational methods for mathematical problems, applied mathematics and computer science. Mr. Saeki received a B.S. Degree from the Nagoya Institute of Technology and an M.S. Degree from the Engineering Division of Nagoya University. Please join me in welcoming Mr. Saeki.

Note: Mr. Saeki's verbal presentation was not available.

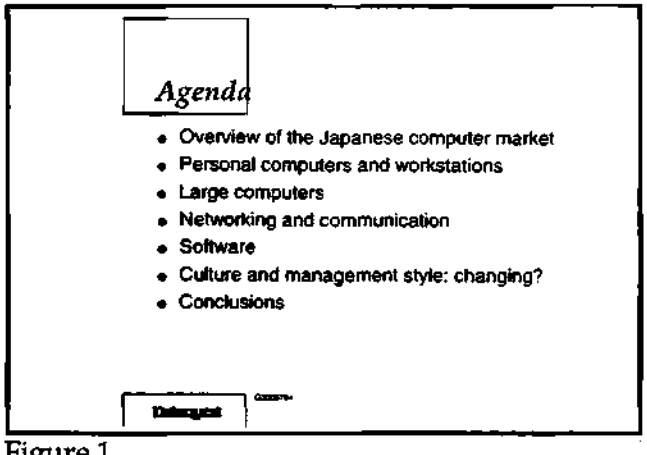


Figure 1

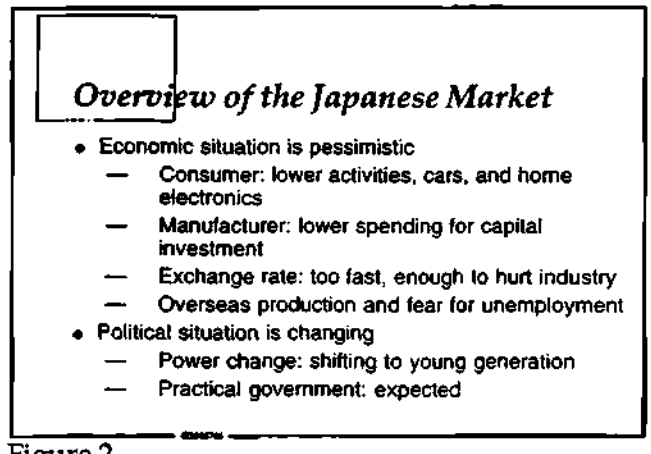


Figure 2

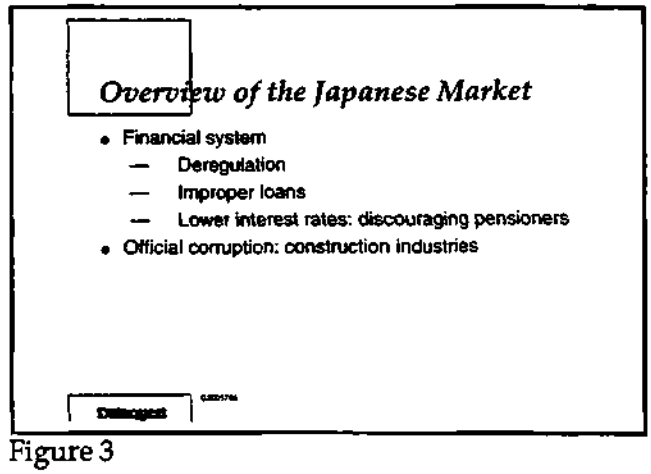


Figure 3

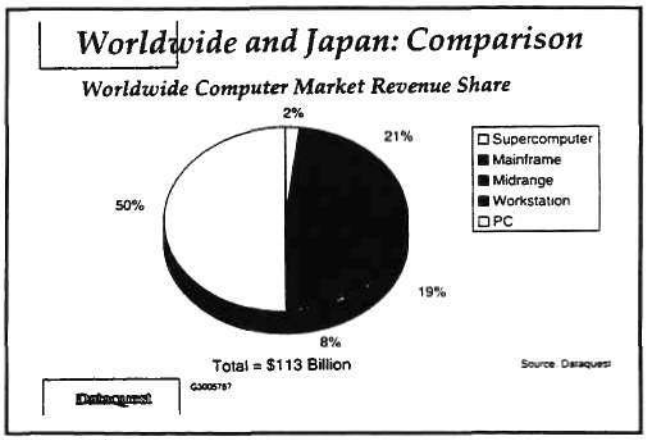
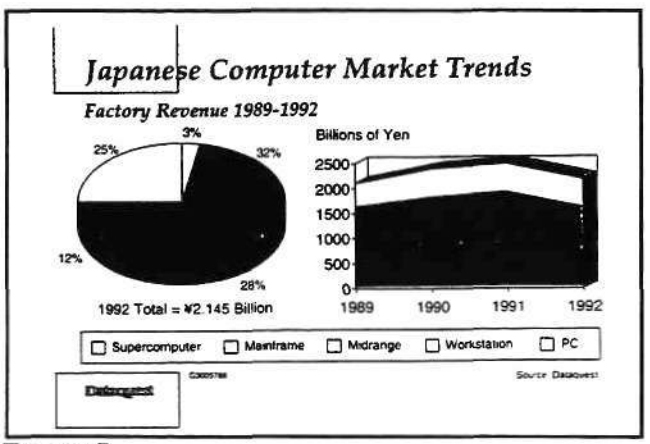


Figure 4



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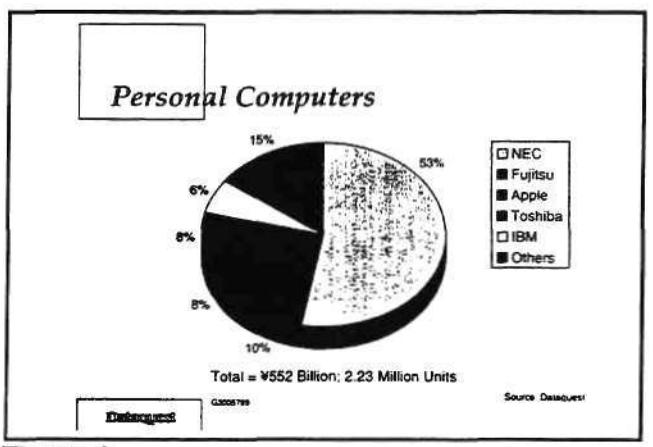

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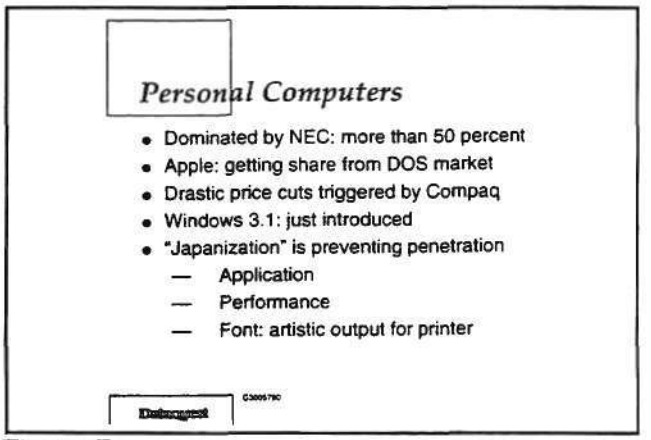

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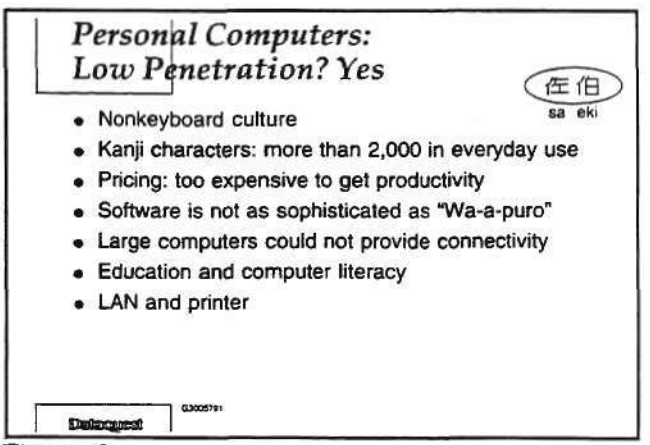

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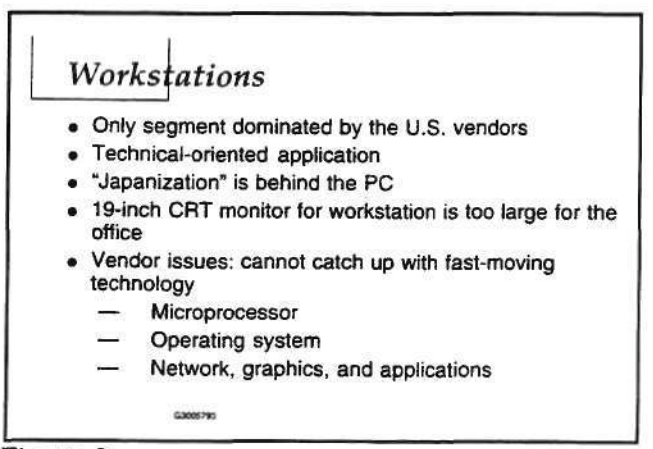

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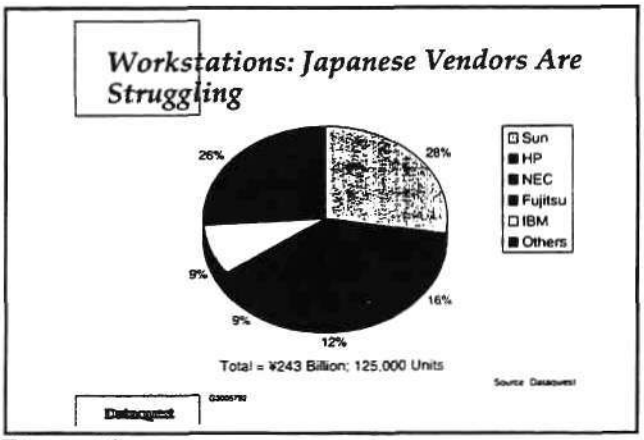

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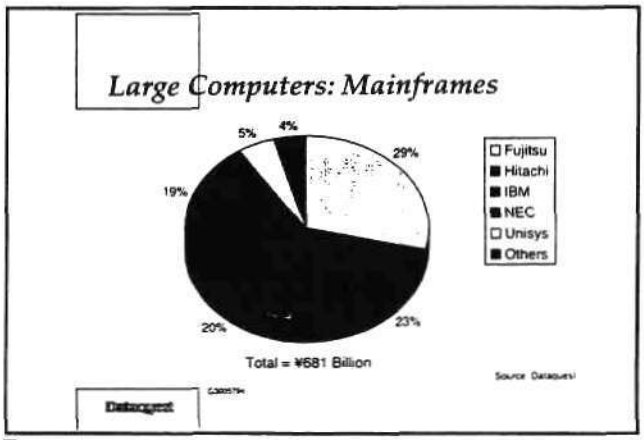
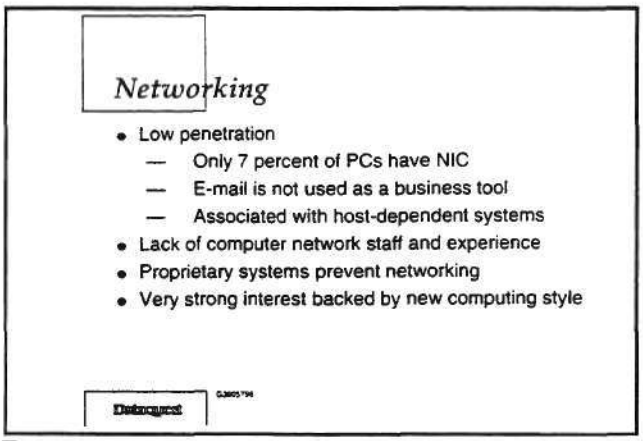


Figure 11



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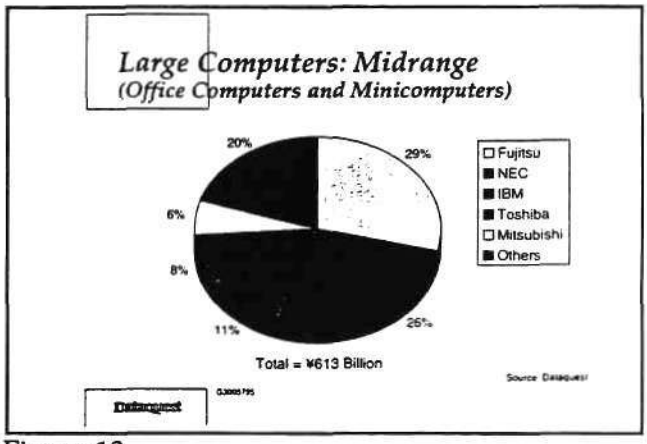
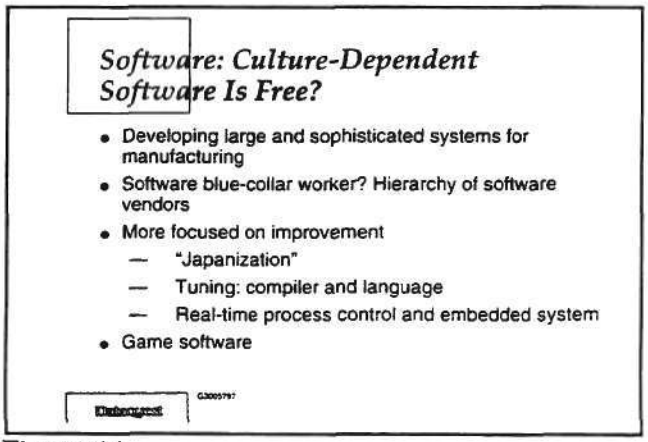


Figure 13



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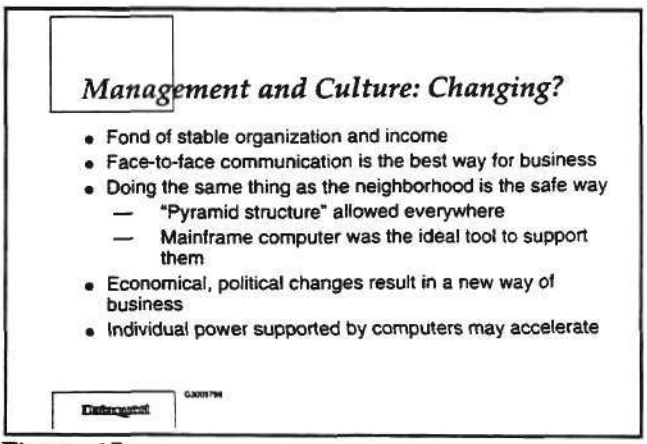

Figure 15

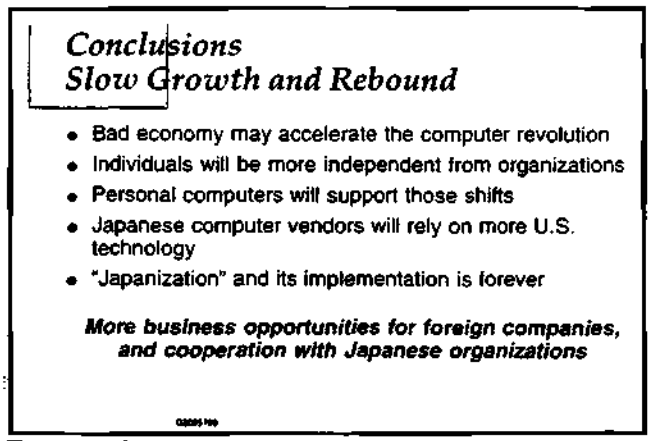
Conclusions
Slow Growth and Rebound
• Bad economy may accelerate the computer revolution
• Individuals will be more independent from organizations
• Personal computers will support those shifts
• Japanese computer vendors will rely on more U.S. technology
• "Japanization" and its implementation is forever
More business opportunities for foreign companies, and cooperation with Japanese organizations

Figure 16

Cooperation and Competition in Converging Markets

William P. Weber
Executive Vice President
Texas Instruments, Inc.

Mr. Grenier: Our next speaker is Pat Weber. Mr. Weber is Executive Vice President at Texas Instruments and President of TI's Components Sector. Mr. Weber is responsible for managing TI's semiconductor, materials and controls, and consumer products business in addition to semiconductor research and development and TI's international operations. He has been a member of TI's Board of Directors since 1984. Since joining TI in 1962, he has held a number of positions in TI's Defense Electronics, Digital Systems and Semiconductor Business as well as corporate assignments. Mr. Weber serves on the Board of Directors of the SIA and the University of Texas at Dallas. He is also a member of the U.S. Philippine Business Council. Mr. Weber holds a B.S. Degree in Engineering from Lamar University and an M.S. Degree in Engineering from Southern Methodist University. Please welcome Pat Weber.

Weber: Thank you, Joe. Well I appreciate the opportunity to be with you today to talk to you about the convergence of the end equipment markets and what that really means in terms of the semiconductor and the electronic companies. When I was thinking about writing this talk, I realized everybody is talking about convergence of the three C's. In addition, I was going to talk about cooperation and competition so it turned out to be six C's and it got a little complicated so we decided to shorten it.

This new competitive environment does shift the power from the historically vertically integrated company to the virtually integrated company and TI's been talking about this for some time. In short, the vertically integrated company, in my view, is a dinosaur. Now successful partnering relationships allow a company to quickly adapt strategies to compete in the increasingly dynamic market place. The time consuming and also expensive process of inventing technology, developing distribution channels and expanding customer bases will force companies to focus on their core competitors while increasing their cooperation with others.

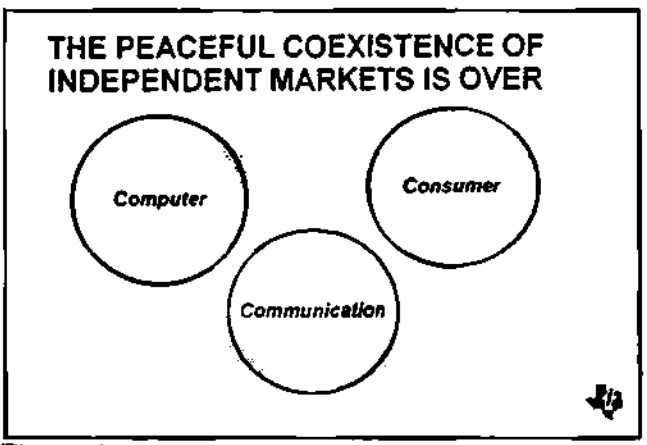

Figure 1

The peaceful co-existence of separate computer, consumer and communications markets is history. In the past, companies competed in isolated industries with different problems and different opportunities. For example, the telecommunications industry provided excellent voice interconnection products, while their ability to handle data was somewhat limited. The systems were large and centrally located, requiring purchasing decisions at the capital expenditure level. Typically, this was

made also by the manager of Information Systems. The computer industry was concerned with the MIPS and Megabytes necessary for processing digital data and Voice, audio and video were from an analog world. Interconnectivity was of moderate importance to the buyer, while lack of user friendliness was not very important because the systems were intended to be used solely by the technically literate. The consumer product industry had a completely different set of concerns and problems — focusing on reducing cost and size was very important. The significance of the Christmas shopping season for consumer products was not a factor in the computer or the communications industries. So what are the forces now eliminating the separation of these industries?

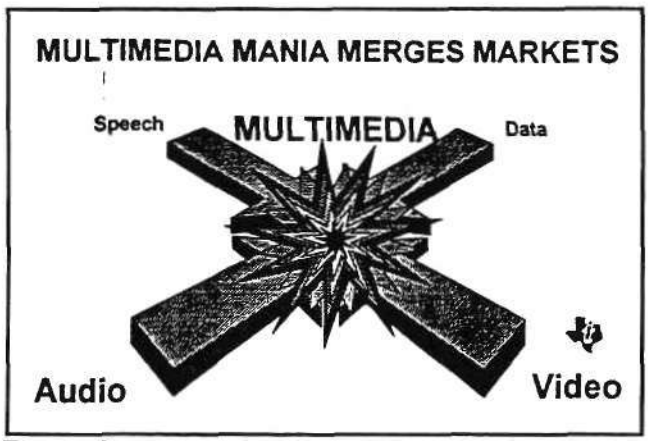

Figure 2

The forces driving these industries into competition are the same forces that allow audio, video and speech to be created, processed, transmitted and displayed on equipment with a high degree of interconnectivity and interoperability.

The cross over from analog to digital transmission of audio, video and speech has created an explosion of opportunities and a myriad of hypothetical products that can bring these media together into a single product. People usually think of multimedia as the ability to combine video, audio and computer features in one hand held box that does everything.

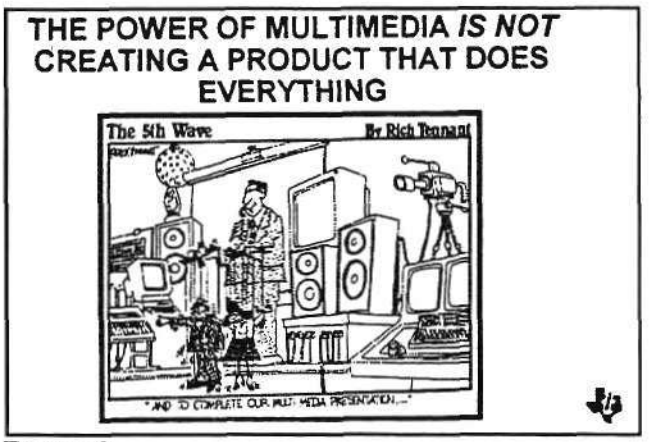

Figure 3

The real value of multimedia, at least initially, will not be the creation of a product with complete video, audio, data and speech functionality.

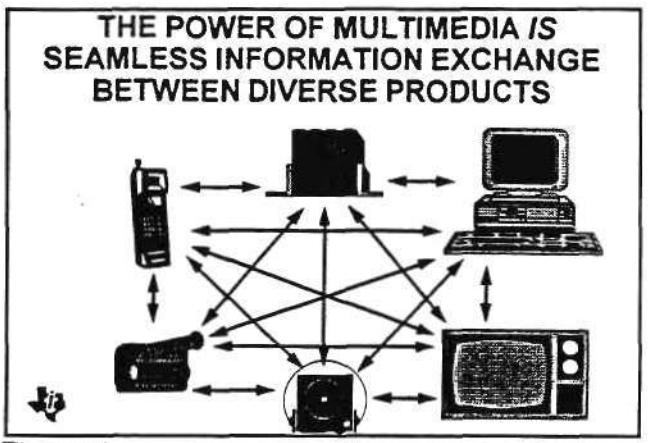

Figure 4

The initial concern for the multimedia market is creating products that can easily exchange information between widely diverse products. Texas Instrument's emphasis is to develop the technologies needed to facilitate the seamless and efficient exchange capability.

An interesting analogy to this multimedia viewpoint is the console television. U.S. TV manufacturers were convinced that what the world wanted was a beautiful piece of furniture that enclosed a record player, tape player, television and speakers. The idea of modular components was dismissed as too confusing for a couch potato. Now history proves that

introduction of mix and match parts with standardized interconnection was a winning market innovation.

With the world moving to wristwatch pager phones, home shopping on a personal computer and business presentations including CD quality sound, digital video and 3-D animation, a new set of market and technology factors that change the rules of industry competition have emerged. As the current squabble over Paramount illustrates, the ownership of information is one of these factors. Simplifying the use of technology with graphical user interfaces is another.

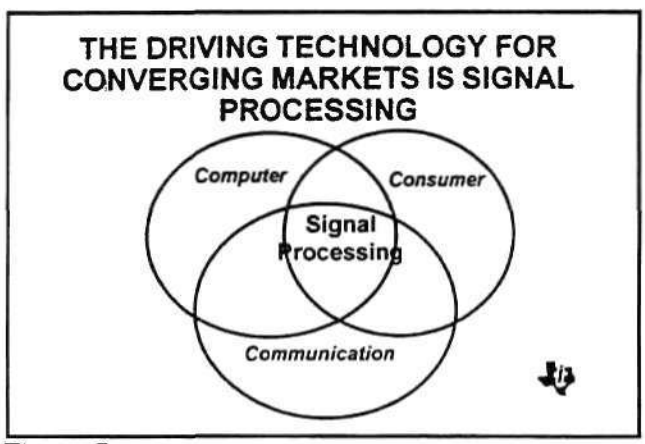

Figure 5

A third factor is the semiconductor technology that drives multimedia throughput. The technology enabler for multimedia is signal processing. Algorithms for compressing voice, video and audio require advanced signal processors. Communication networks capable of rapid data switching and transmission depend on signal processing as well. The processing and display of digital information also depends on signal processing. While microprocessors drove computer market growth in the 1980s, we believe that the market in the 1990s will be driven by signal processing technology. You heard Bob Kavner of AT&T yesterday amplify this point very vividly with his vision of the future.

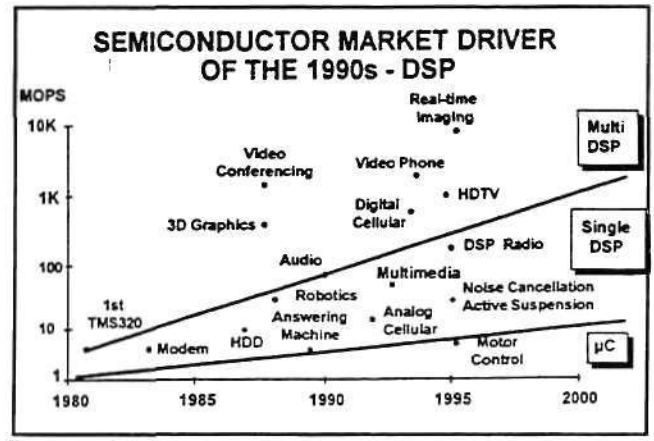

Figure 6

Now at the heart of signal processing is digital signal processing and TI just happens to be the world leader in digital signal processing. As you can see from these charts, DSPs have evolved significantly over the past ten years. We've got over 10,000 customers worldwide. Today, DSP technology forms the foundation for emerging multimedia markets. DSPs have contributed to the ability to shrink hard disk drives while increasing their average capacity. DSPs are needed in communication products, such as digital cellular and modems. In the display arena, DSPs enable video conferencing and are the core of future high definition television systems. So, in short, digital signal processors are key to achieving the functionality desired of future products.

Figure 7

Therefore, the semiconductor industry will play a significant role in the growth of multimedia

by providing the enabling technologies just as it has done for so many years. With limited band width and storage space, compression products become increasingly important. Multimedia transport requires the upgrading of communication networks to handle the increased volume of data. The miniaturization of systems to meet the consumer's portability constraints requires solutions that can integrate analog, power, memory and logic into a single chip at an affordable price. We can do this today with our mixed-signal technology capability and also the design tools that exist. Signal processing techniques will increasingly be used to provide the real time intelligence that user friendly systems will require.

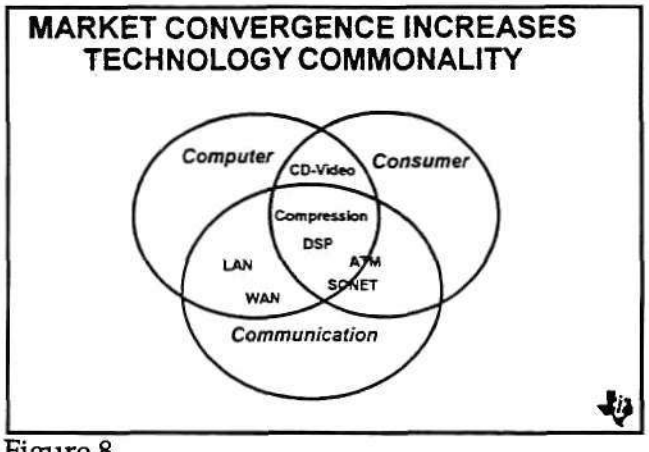

Figure 8

The convergence of markets means technologies can now span the needs of larger markets than the individual computer, consumer or communications markets.

Now this is especially true in the consumer market which has been dominated by the Japanese with analog technology in the 1980s. But I think the move to digital re-opens the consumer electronics market to U.S. companies by capitalizing on technologies developed by the computer and communications markets. This opportunity to serve new markets is driving a new wave of alliance relationships in the industry. Up to now, alliances have generally joined similar kinds of companies for technology development or manufacturing alliances such as Intel and IBM several years ago, TI and Erickson Telecom, Motorola and Toshisha and several others. However, the alliances that are forming today cut across technology and market boundaries so that you have high tech companies teaming with Disney studios and MTV. Now imagine the reaction a few years ago if Bill Gates had announced and alliance with Disney and Mickey Mouse. This is what's occurring now. When you look closely at today's alliances, you often find that partners on one project turn out to be competitors on another. It is my belief that most of these cooperative arrangements are essential to success in today's global competitive marketplace. Unless we cooperate as companies, governments and individuals, we will not be successful competitors.

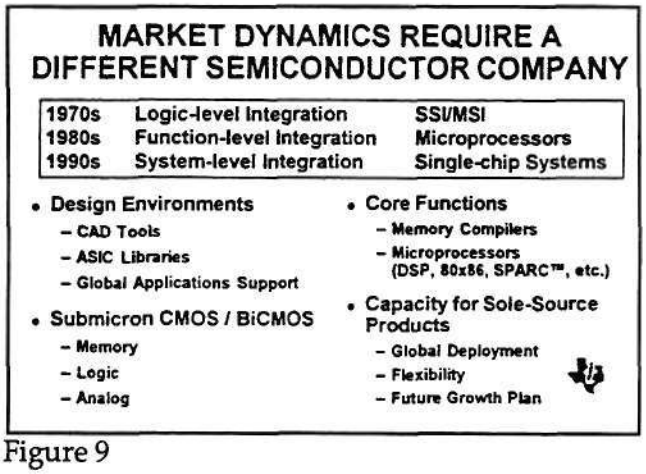

Figure 9

Now we realized this market change in the mid-1980's and we knew that we needed to make a significant and fundamental change in our business model in order to stay competitive in the 90's and the twenty-first century. The strategies of the past just weren't effective. Semiconductor manufacturers led the way in the 70's by offering standard logic-level integration circuits. In the 1980s, semiconductor companies drove function-level, integration of devices, such as microprocessors and applications processors, such as graphics and DSPs. Yet today's environment of system level integration requires much more than delivering a standard chip.

Today's system level chips demand that semiconductor companies provide the proper design environment with open tools, ASIC libraries and worldwide support. You must be able to integrate memory, logic, analog, digital and power all on a single chip. We're talking about in the very near future, tens of millions of transistors at .5 and .35 micron technology with this ability to be able to mix technologies. System level chips help differentiate end products by integrating special features around core functions such as microprocessors. The microprocessor is only one of the cores and the resulting semi-custom circuit is usually needed immediately and in volume quantities, necessitating sufficient worldwide production capacity with built-in complexity. Customers need be able to design in one region of the world, prototype in another region of the world and deliver high volume production to their customers in all regions of the world.

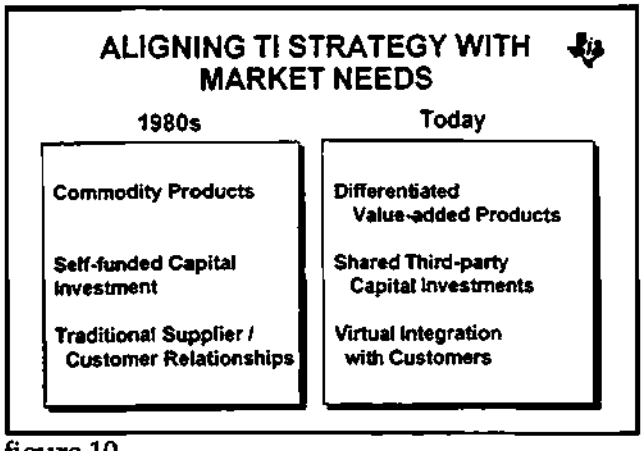

figure 10

TI's solution is to align with market needs. We were previously known for commodity products and I think that's what the entire industry is known for because about seventy percent of the world's seventy plus billion dollar semiconductor market is a commodity, or bought on price. The value lies in the differentiated products and in the relationships with the customers. The market today is only about thirty and TI now has positioned over forty percent of its product base in differentiated products.

We departed from a self-funded capital investment strategy and I think we wrote the book on joint venture relationships with both customers and governments. We've been doing it over the last five years while everybody else has been talking about it. Also, we replaced a traditional supplier-customer relationship, with one of virtual integration with our customers. In other words, we're focusing on core competencies and trying to get a win-win relationship that provides a competitive advantage.

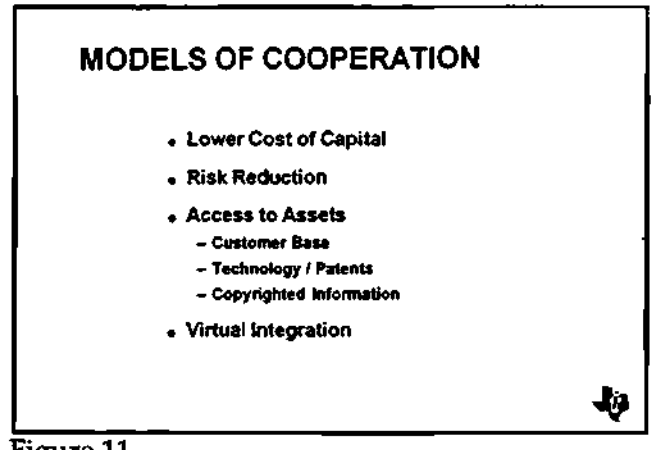

Figure 11

My fundamental message today is this: in the emerging multimedia markets of the future, the most successful and competitive companies will be those who cooperate the best. I would like to share some insights into TI's approach because I think they can be applied to converging markets of the 1990s. I think we now have proven that our approach is working and is a winning way for the future. Now, behind every alliance is mutual respect and mutual dependence. That's really the key. All of these are like friendships — they are built on integrity, long standing relationships and eventually, you have such a close-knit relationship that you are mutually dependent upon one another. There's nothing better than that. First, you have to define your goals and needs and second, you have got to have a realistic view of your strengths and weaknesses. Third, you've got to select strong complimentary partners and you better know which market you're going to participate in and

where your competencies match the best. Finally, you need to structure and manage the relationship so that both sides win not only for the short-term, but also for the long-term. Now in our earlier analysis, TI had four basic reasons for developing strategic relationships with suppliers, customers, competitors and even governments. We wanted to lower our cost of capital. We wanted to reduce risk. We wanted to share investment. We wanted to have access to assets that we did not currently have and we also wanted to become closely aligned with our customers.

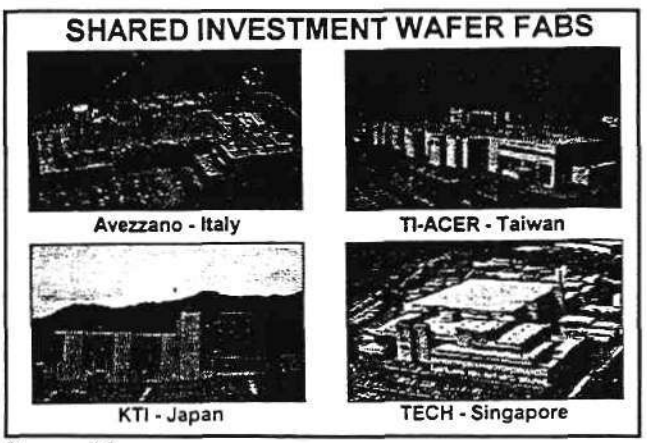

figure 12

Let's talk about the high cost of capital in the United States in the 1980s. Mr. Pistorio talked about this earlier, about how particularly the Japanese got a free ride from their low cost of capital throughout the decade of the 80's. But that world has changed. The U.S. has been reducing its cost of capital and Europe is also paying attention to theirs. However, this was a key issue in the 1980s that had an interesting play on the dynamics of investment and market share. So we had an obvious concern about this and about investing in this industry because now we're talking about billion dollar wafer fabs.

Through relationships with customers, governments and others, we and our partners have now built four new submicron CMOS wafer fabs in all parts of the world. We have one in Europe and three in Asia that are all in various stages of completion and production. This represents over 1.2 billion dollars of investment by government and customers, basically investing in TI strategy. I think that's quite a vote of confidence with that level of investment. Very importantly, as this slide shows, three of our new wafer fabs are in Asia and as others have talked about Asia's role as the largest microelectronics market in the world. It is the fastest growing market in the world and I think we are now well-positioned to participate in it.

In the case of Avezzano, Italy, the cooperation came with the Italian government. They were looking to build a strong technology infrastructure in the center of the Italy. TI already had a chip assembly and test facility located in nearby Reati, Italy. The resulting incentive package between TI and the government extended beyond the submicron CMOS factory to also include university research and development relationships as well as incentives for TI's other businesses located in Italy.

In Taiwan, Acer computer was looking for basically a source of dynamic RAMs that was indigenous to Taiwan for their personal computer business. This joint venture factory is now in volume production of 4 megabit DRAMS with Acer having a guaranteed supply at competitive prices.

Kobe steel in Japan, was looking for a way to participate in the semiconductor business and the resulting KTI factory is now running 4 and 16 megabit dynamic RAMs on 8" wafers.

Our most recent joint venture, a fab we opened last week, is really an interesting one. This involves TI, the Singapore Economic Development Board, Canon and Hewlett Packard — now we have a global alliance of companies as well as governments participating. This factory was dedicated last month and is in pilot production of both 4 megabit and 16 megabit dynamic RAMs.

You've got to understand, we start up all of our submicron wafer fabs with dynamic RAMs because in my view, that is still the best driver, for manufacturing technology to get the defect density down and get all the equipment shaken out. Then you have a very efficient submicron fab that can do many, many things. As a result of these joint ventures, TI has now shifted its capacity mix to the point where more than 70% of our capacity is CMOS, submicron CMOS and BiCMOS. Plus, we have some of the world's most advanced facilities coming on-line to support our customer's submicron requirements worldwide and are probably better positioned worldwide with leading edge capacity coming on stream than any other competitor in the world. We did all of this while achieving our initial goal of reducing our cost of capital, but I think it also significantly positions us now to continue to grow market share. Now, I want to emphasize to everyone that joint ventures are no panacea. I can assure you they are very tough to manage.

I had one of our board members describe to me one day how he was with another company that participated in joint ventures. He described joint ventures like two people sleeping in the same bed, but with different dreams. I can assure you, he's pretty close.

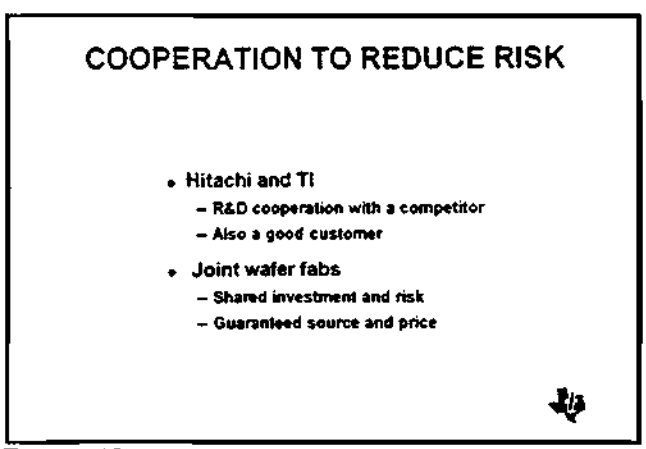

Figure 13

With the increasing cost of technology development, we are teamed with Hitachi for memory development. This lets both companies share the investment risk and also evaluate more technology alternatives. This relationship began at the 16 megabit dynamic RAM level. It was successful and has been extended to the 64 megabit dynamic RAM. The key reason for the success was the high level of senior management involvement and interaction, and that's another key about any relationship. It not only has to start at the very top of each company, but the way it works best is when the individual engineers finally have a working relationship such that the relationship becomes seamless. It really requires a top to bottom understanding. With Hitachi, we have a senior management committee that meets regularly to review progress and results and we have an operating committee that oversees the daily activities. We also created an intellectual property committee so that any resulting joint technology develop could be properly registered and protected. It's interesting to note that TI and Hitachi remain competitors in the open market in this particular product area, even though we have shared in the up front development and research.

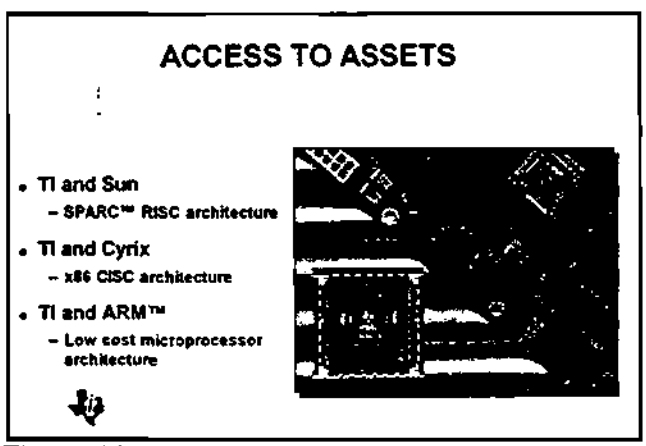

Figure 14

Now system level integration often means adding peripheral functions around a central core function. Creating competitive solutions to customer needs require that TI has access to a portfolio of processor architectures. The cost to develop these processor architectures independently would have been prohibitive and no one company really has all the cores that you need. So through alliances with SUN Microsystems, with Cyrix and also with

Advanced Risk Machines (ARM), we are now able to offer our customers the best of both RISC and CISC microprocessors.

Again, building around the core with ASIC as a backdrop. Cooperation in sharing these assets provides more growth opportunities for all companies than anyone of us could exploit on our own. Now the case of SUN and our BiCMOS technology, this is 8/10 BiCMOS combined with our system knowledge to produce the 3.1 million transistor SuperSpark which in 1992, was the world's number one selling RISC microprocessor.

Our relationship with Cyrex gave TI access to an important microprocessor while giving them an important second source.

In other areas, we needed a RISC architecture that would work best in control and access environments. The ARM architecture is an excellent solution, particularly in the automotive and telecom markets. Plus, our alliance with Advanced Risk Machines gives them a new channel in which to market their processor.

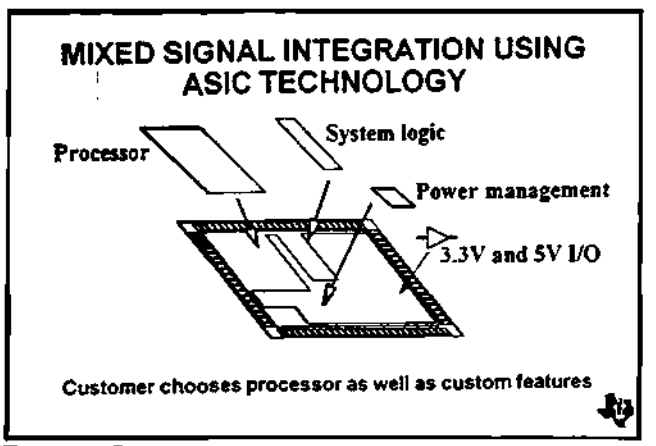

Figure 15

In the age of system level integration, combining more functions on one chip requires an ASIC methodology and a mixed signal process capability. I think a lot of people have been confused about ASIC. ASIC is not a product in my view. ASIC is a methodology. The ASIC methodology and the knowledge assets behind it are key differentiating points in the solution of a semiconductor supplier.

The resulting customized solution with a choice of processor, system logic, power management and linear functions can let the customer differentiate their products and get to market faster.

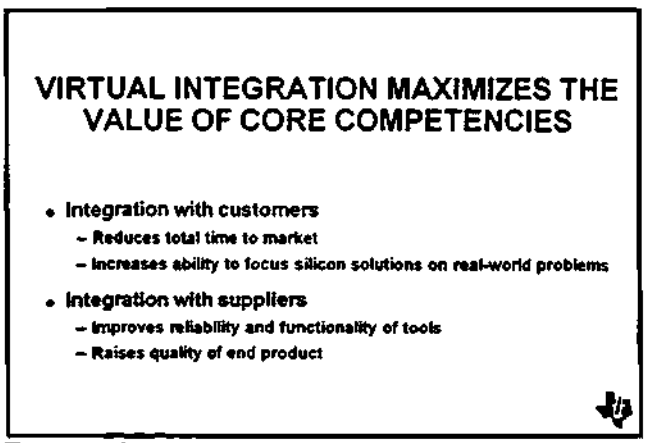

Figure 16

Again, the key is being able to integrate the design tools at the system level and the end at the microelectronic level to get the optimum trade-offs, but none of this is possible without cooperation again. This cooperation is vital not only with our customers, but with our suppliers as well to create a virtual enterprise that maximizes the value of each company's core competencies. Companies can no longer afford to be the best at everything. We think that each company should focus on its core competence, which in our case, we believe to be signal processing, integration and miniaturization.

For instance, there are fewer and fewer electronic companies with captive wafer fabrication facilities. The reason is that the cost of staying at the leading edge of process technology and affording the billion dollar fabs for capacity is prohibitive. That's a key reason why Erickson Telecommunications is an alliance partner with TI and today, a large majority of all of Erickson's designs are jointly designed and produced by TI. I think this is just a model of what we've been able to do in every region of the world and every segment of

market with relationships with Sony, Canon, Hewlett Packard and many others.

Our engagement with Erickson is a good example. I raise Erickson because this was one of the first alliances we formed back in 1987, so we kind of use that as a model in terms of doing this with others. Today that really covers semiconductor solutions on their Sonet line cards. It also covers their digital cellular telephones that were designed around a customizable DSP as well as a lot of BiCMOS ASIC and it also involves co-management and development of their small internal research and development wafer fab.

We have to earn our stripes everyday with Erickson as well as all of our other customers. Yet by working together, sharing process design rules and design tools and having engineers at each other's locations, we can reduce the total time to market while delivering focused silicon solutions to our customer's equipment needs.

As I said earlier, customers and companies cannot afford to be the best at everything, which is why TI is also working with leading edge suppliers. So you can take this model with customers and apply it to suppliers and get a total virtual company

We have done this in terms of industry standard hardware and software platforms in the computer aided design area and we built upon our relationship with Mentor Graphics and with Cadence so that our ASIC tools and libraries are highly compatible with theirs. We have a similar arrangement in other areas such as logic modeling and simulation and I think the benefit to our customers is quite clear. They get access to a network of TI certified suppliers by working with us and the result is improved cycle time, reduced cost, increased reliability and functionality and also enhanced quality.

Although we have some cooperative arrangements in which we compete in the end-marketplace, as I mentioned earlier regarding Hitachi, we are increasingly finding that customers prefer working with a non-competing supplier and I don't think I need to drop names about that. This allows co-development with both end equipment knowledge and also semiconductor knowledge working together without the fear of losing competitive advantage in the end equipment markets.

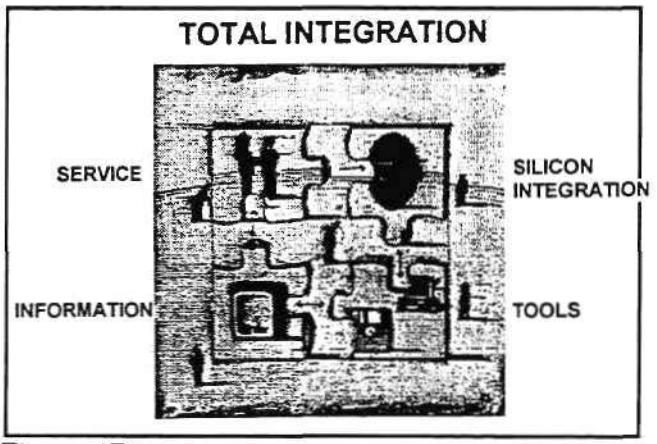

Figure 17

As you've already seen, the formula for success in today's competitive global market is very different than before. Today's and tomorrow's wonders will not just be those who provide leading edge products and technologies, but also those that provide the tools, information and service. At TI we call this Total Integration, in other words, TI stands for total integration. It's kind of interesting, since TI invented the integrated circuit 35 years ago, that it's still the name of the ball game — being able to move more and more of the system functions onto that little chip of silicon is still continuing to move at a very, very aggressive pace and I think TI is right at the beginning of it, but it's much more than just silicon technology.

It's also the tools, the information, the service and just as importantly, being able to deliver all of this worldwide. We are very fortunate in having this 35 years of infrastructure where we've got 50 plants in 19 countries. We've been in Asia over 25 years and Europe over 30 years, so we are very well positioned to deliver this total integration capability to our customers to

help them to get to market faster with better products.

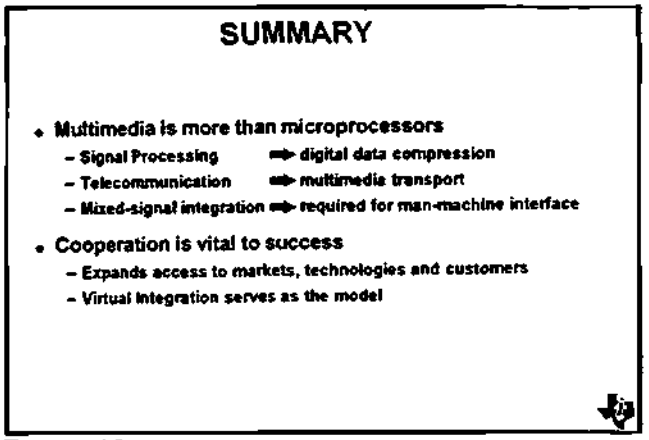

Figure 18

So in summary of the multimedia market, the need to rapidly convert, transmit and process signals is the chief technical challenge. Signal processors will be the engine to solve this technical challenge in the 1990s with silicon solutions ranging from data compression to multimedia transport to man/machine interfaces. The convergence of formerly separate markets is creating the multimedia industry. The nature of it is a bit unclear, but huge potential is creating a host of alliances that are seeking access to markets, technologies and customers. That's why there's this wild scramble that's taking place all over the world — people are trying to shape this new industry. For these alliances to succeed, I think companies need to know their needs and have a realistic understanding of their strengths and weaknesses.

They need to pick strong complimentary partners and they also need to structure their relationships to win, not only short-term, but very importantly, long-term. We're talking about win-win relationships that really do require integrity, respect and mutual dependence and that is not something you take lightly. In the semiconductor area, cooperation and virtual integration is vital to competitive success and I think few, if any companies, have the resources to go it alone anymore. The risk is just too great. Now for the companies that pick the right partners in this converging world of computer communications and consumer, I think the result is really going to be improved stability. I think we're going to get increased time to market with better performance, lower cost and all the other wonderful things we'd like to achieve. Along with that I think we increase the size of the market, the opportunities and just as importantly, the probability that we can be successful in these markets.

Questions and Answers:

Question: In the mid 1980s, TI swore they would never allow themselves to be so exposed again in commodity DRAMs. Today, all four of TI's most modern fabs are all DRAMs and TI doesn't have enough logic to follow up if memory prices drop.

Mr. Weber: Is TI overexposed again? Let me see if I can clarify this for you. TI had too much exposure to DRAMs back in the mid to late 80s. If you recall, back in the '85-'86 time period when we had this terrible dumping problem in DRAMs from Japan, the entire industry lost several billions of dollars, so I think everybody came out of that period saying, "woe is me —maybe we shouldn't invest in DRAMs any longer." Then we had the nice rise of '87- '88, when the market was very nice for producers because we had pricing very high, so everybody made a lot of money. That started a new cycle of investment by the entire world which lead to an over capacity from 1989 through the middle of 1992. During this time period, TI was transitioning its strategy from dependence on commodity products, and particularly too much exposure and dependence on dynamic RAMs, to logic. As I mentioned to you, we have made that transition. All of these new fabs that I talk about are submicron CMOS fabs. They are not memory fabs and that's the beauty of it. We start these fabs up with memory because I still think that's the best vehicle to drive the defect densities down, but then we convert these fabs over to higher value added logic devices.

Obviously, this is why we have such a good relationship with many of our customers because we have all of this capacity that we can use to serve their sole source needs. I think the difference is that dynamic RAMs are only about 15% of the total market, but they still are a very important part of the market and one that you have to participate in, in my view, if you're going to be at the leading edge particularly of manufacturing technology. So don't be confused about TI strategy. We are a very broad based supplier with a lot of technologies. I think it requires that you be involved in every aspect of the technology, but I think you'd be amazed at what a small part of TI's revenue actually comes from DRAMs.

The Multimedia Decade

Trip Hawkins
President and CEO
The 3DO Company

Mr. Grenier: Our next speaker is Trip Hawkins. Mr. Hawkins is the President and CEO of The 3DO Company. 3DO was formed in October, 1991, and has already forged strategic partnerships with Matsushita, AT&T, Time Warner, MCA and Electronic Arts. Mr. Hawkins is also Chairman of Electronic Arts, which he formed in 1982. Prior to starting Electronic Arts, he was with Apple where he provided leadership for Apple's successful entry into the business market. Mr. Hawkins holds a degree in strategy and applied game theory from Harvard and an M.B.A. from Stanford. Trip and his company have recently been featured on the cover of Time Magazine and perhaps more than any other company embodies the merger of Hollywood and Silicon Valley. 3DO and its partners have recently launched it's first multiplayer product just in time for the Christmas season. Please join me and welcome Trip Hawkins.

Mr. Hawkins: Good morning. It's a pleasure to be here today. What I would like to do is talk a little bit about why I think that we're on the brink of the multimedia decade, why multimedia technology is in fact going to be possibly the fastest growing market for electronics this decade, sort of displacing personal computing which was the fastest growing market in the last decade. We'll talk a little bit about why we should even care that it's going to happen and why it's going to happen fast and to reinforce that, I'll talk a little bit about the history of other consumer electronics media and how multimedia compares. Then I'll get into some of the myths that are floating around today about how this market is going to develop.

Of course, you could have very much of a "So-what?" reaction about multimedia because it's been so overhyped. The reason that this is something you should care about at a very fundamental level is that as mammals, we need to play. Brain scientists have proven that the single most important way that you develop your intelligence is through interaction — you learn by doing. You probably know that Chinese Proverb: I hear and I forget, I see and I remember, I do and I understand. It is somewhat of a coincidence that until now, the electronics in the home that are software-based electronics have been passive media like music, video, and television. They have not been interactive. There is an interactive media in the home that everyone uses and it's called the telephone. In fact, you'll spend a lot more money on it then you'll spend on other kinds of media. But we're now on the brink of finally being able to deliver interactive technology into the home that's good enough for mass market use and we think that this market is finally going to happen. You'll see a lot of latent demand for it. I put the term "artificial dumbness" up there because instead of using artificial intelligence, we seem to be overly reliant today on this passive media, like television, that's making us less intelligent as we go along, even though all the evidence from the media experts, like philosophers John Dewey and Marshall McLewen, suggests that we need to have media that's more interactive.

Some trends that are supporting this: one of them is that as media get more realistic over time, the market places for them have gotten bigger. That's true about all forms of media starting with storytelling, which is now, of course, on movie screens and in every home

through the VCR and cable television. It's also true about interactive media. As video game technology has progressed, the marketplace has gotten bigger and bigger. It's become more mainstream with adults and people of a wider age range and that trend is going to continue. There are significant opportunities to improve the realism in interactive technology. It is also becoming a lot more convenient because you can do things at home now that you couldn't before. The movie industry, in fact, has gotten theatrical revenue, which it is spending on theater tickets, to an all time high. It's about $5 billion, but the spending on watching movies at home is about four times larger than that because it is so much more convenient to watch movies on cable or on a VHS format VCR. So we think the same opportunity exists for interactive technology because today there's actually more money spent, about $7 billion, on coin-operated games, then there is on movie tickets, but in the absence of a technology as good as VHS for interactive technology, there isn't much of a home market yet. Another thing is that over the last 40-50 years, there has been a major trend in consumption, such that if you look at disposable income, an increasing percentage is spent on recreation. In the 1950s, it was only 5%. By the 1980s, it was more than 6%, in the 90s, it's around 8%. Each of those 1% differences is $30 billion a year, and over time, the share of that that gets spent at home because of demographic changes is increasing. Society is getting less centralized and people are not even frankly feeling that comfortable in terms of the safety outside of their own home these days and what that means is people are looking to electronics at home as an increasing percentage of how they're going to spend their recreational dollar.

Another thing to look at just over the course of this decade: It's 1993 and we have seven years until the year 2000. As of the year 2000, the kids that grew up in the original Atari era are going to be in their 30s having their own families. The kids that grew up on Nintendo are going to be in their 20s and won't need their parent's permission anymore. And not only that, the number of teenagers in the United States, because of the baby boomlet, is going to grow from 13 million to 19 million in the next seven years. With all of these trends, what you're going to see is a huge market, much bigger than today, of knowledgeable customers that grew up on interactive technology. They'll expect to have it as part of their everyday lives, they'll want better and better forms of it and they'll spend more and more money on it. This is definitely going to be happening.

Now another thing that we can all benefit from in this industry is the digital synergy from taking all of these media data types and making them digital, so you not only can create a new form of interactive media, but you can also bring along better forms of existing media. Of course with the music CD, we already have that one example, and now the industry is working on putting video on a CD as well. This would allow the consumer to get much more value out of the electronics, which means the consumer will spend more money on the electronics to get the best electronics that will do the job and they will have these devices with multiple uses and a lot more versatility because of that digital synergy.

Now here's a blast from the past: There was one year during the heyday of radio when 35% of all of the furniture purchased in the United States was radios. Those were the good 'ole days, but now to talk about some of the factors that have influenced the success in history of these different formats, one of them is having real strong backers. Obviously, there are plenty of cases where that has been true. Another one is if you bring out a product that does represent a big jump in performance, in many cases the consumers will never figure out that it's better. They won't consider it so much better that they should junk what they already have. It tends to create a lot of confusion. A good example of this is S-VHS. It has about twice as many lines of resolution as VHS and it has 2% market share and over time, I expect that to decline rather than to expand. Another example is color television. The color television market grew

much more slowly than black and white television, whereas black and white television is one of the fastest growing new media in history. There were one-half million black and white TVs sold the first year, a million the second year and over 2 million the third year. This is in the 1940s. If you adjust for inflation, the price of that first black and white TV was over $1,600.00 and the programming was terrible — yet it sold like hot cakes because it was so much better than radio and people appreciated that big jump in performance. Having ready customers also makes a big difference. The awareness people had about radio helped black and white television. That's another key factor—people have sometimes spring boarded on in terms of having a ready marketplace. If you can combine that with a performance jump, you've really got something.

Software support must be given adequate attention. This has not always been the case. For example, the VCR and the music CD player actually suffered from not having enough software support. In the music business, there was a lot of resentment that it initially cost more money to press a CD than it did to make an LP. Some music companies, therefore, would not support the CD, but fortunately for Philips, they own Polygram and Sony owned Sony CBS. So you had at least a couple of the major hardware companies with enough vertical integration to get the software support initially.

You might find this one a little bit surprising — it's the exact opposite of the business market. In the business market, you absolutely have to have backward compatibility. In the consumer market, it vary rarely matters because the consumer usually buys the device, they use it for a period of time, they feel like they got their money's worth and they're perfectly content to move on to the next thing. For example, a lot of people will buy their music CD player and they'll hang on to their turntable, right? They'll hang on to their old LPs but they don't say, " I can't buy a music CD unless it plays my LPs." They just don't think that way in the consumer market, it's not necessary for the same product to do both things. So the irony here is that when you have backward compatibility it tends to slow down the development of a new market so that would tend to influence your forecast. In the absence of backward compatibility, when you have a really important paradigm change in the conception of the product, you can get really rapid market growth. A good example of that was Apple going from the Apple II to the MacIntosh or the PC market in general going from the Apple II to the IBM PC. Also, black and white TV growing a lot faster than color TV is another good example. Another good example is Sega. Nobody thought Sega could accomplish anything against Nintendo, at least hardly anybody did. Their product was totally incompatible and they overcame a lot of other obstacles and seized the day.

Having low media costs is also important. This is typically not true in that when the VCR came out, when the music CD came out, and when broadcasting was initiated, it was very expensive to get the software in the hands of the customer. The floppy disk was the one example. IBM was able to leverage off the invention of the floppy disk, which was already several years old by the time they introduced, but typically this has been a deterrent to market growth because of software availability. The same thing for ease of manufacturing. A lot of times these new consumer devices have a lot of mechanical components that are like rocket science and the manufacturers are uncomfortable getting a really high production volume right off the bat. A couple of exceptions to that are products like the PC and the Nintendo Entertainment System because they're pretty much relying on semiconductor technologies and very proven mechanical technologies that were already in high volume.

Offering multiple brands has been essential in the success of every mass market consumer device. That's important to retailers because they want to give their consumers a choice, and they don't want a vendor to have so much power over them that they can put a gun to

their head. So they need multiple brands that are software compatible. If they don't have software compatibility, it completely screws up the dynamics of the market. One example of that is in 1948, when CBS introduced the LPl. RCA three months later announced the 45 RPM record and they were both positioned as long playing music devices and the record industry went into a four-year slump, so record sales actually declined for four years after that situation. The lesson? A little bit of confusion in retail can create a lot of problems. What you want is multiple brands of hardware that are all software compatible and one class of software that plays on all of them. That works for the retailers and that works for the consumers. Consumers want to branch off as well.

Finally, you like to have your price low enough to attract an audience, but frankly this is not usually the case. If you adjust for inflation almost all of the successful mass market formats came out with prices closer to $2,000.00. Video games are the only technology that have come out at much lower prices. They basically are toys with toy capabilities, so they have to be priced like toys, and they're pretty expensive for toys.

Finally, having multiple uses is certainly a benefit. It would help offset risk in the software area which is what happened with the VCR. They had to wait a long time to get a lot of movies on video cassette and the fact that you could record off the air really got the product going.

Now if you look at these 10 key factors in total, you notice that a product like 3DO, and this would be true about a similar multimedia system, is in the favored position because of the nature of the multimedia market today, the predecessor markets that it's leveraging off of, the maturity of the technologies and the advances in semiconductor technology. With all of these things going for it, compared to those other formats, I again think this is going to be a very rapidly growing business.

Now I'd like to talk about some of the myths about the development of these markets. The first one that's kind of interesting to look at is the question about pricing. Sega and Nintendo love to criticize 3DO's pricing, which by the way is about $699 today. We think the price will come down next year nad even moe so the year after next, but they think $699 is too high. My view is that familiarity breeds contempt and all I can say is that with Sega and Nintendo, it's ironic that with all the experience they have had selling interactive products to interactive customers, they have so little confidence in the consumer and in the technology. To disbelieve that an interactive system could be good enough to attract mass market interests the way every other mass market device has is rather pathetic.

Another myth is that it's a glorified video game business. It's fairly common for these new markets to be described in old terms. Remember, Western Union had the patent on the telephone in their grasp and they turned it down. The government initially thought that television was only going to be useful for civil defense broadcasting. Ampex thought the VCR would only be used by TV stations for time shift broadcasting. It's not unusual, when you have an important new market, to have it be completely misunderstood. This is just one example of it. The multimedia business is fundamentally different from video games. In the video game business, you're manufacturing a cartridge that has semiconductor memory on it that's very expensive and has very little memory. You've got maybe one or two megabytes of RAM and the manufacturing cost is $10 to $20 — a killer cost for a piece of software inventory. Now every real software business from books to records to video to computer software has very low manufacturing costs relative to its value, so you can go to the retailer, give him lots of product in an incredibly wide variety of categories and give him exchange privileges so if he ever wants to return any inventory, you can give him a mark down. Any title that comes into the channel will go through a series of price adjustments over

time and there'll be lots of different titles in the marketplace. The consumer expects that, which is why when you go into a book, music, or video store, you get so many choices. Video games don't work that way because the inventory costs so much to make that you cannot offer that to the retailer. The retailer says if I can't exchange it, I'm going to be really, really selective and I'm only going to buy Mortal Kombat. It's a self-fulfilling prophecy, so you basically make it into even more of a toy business than it would have been otherwise.

Another myth is that hardware and software are separate businesses. This is just an artifact of the past that is now changing. We don't find very many hardware companies at all that are just going to be satisfied being a box maker — it's too obvious now that a lot of the money is in controlling the intellectual property that makes the software work and also in the content itself. Therefore, I think a major trend for this decade is partnering and synergy plays, where companies are more vertically integrated and have cross investments or licensing situations where a company that develops a hardware technology isn't going to just put it in the public domain for the software industry to exploit. They're going to charge them for it and there's going to have to be some meaningful form of sharing the spoils across all these different markets by the different constituencies.

Another myth is that Hollywood is going to dominate multimedia because they control the content. My response to that from working with Hollywood is that they are too content doing what they're already doing. They love making movies and frankly they have a lot of problems in their ability to break out of their old mold and get into new areas. I think that you're going to find that there's a whole new industry of software companies that are developing tremendous opportunities for entrepreneurship because little tiny start-up companies can accomplish amazing things. The technology is a leveler of the playing field, so it's actually going to be easier for a lot of these small technology-driven companies to learn what they need to do to make movies interactive than it is going to be for the movie industry to use their content in the interactive domain. I'm not trying to rule them out, I'm just trying to say that they're not going to completely control everything.

Another myth is that information highways will wipe out retail. I think there is going to be a coexistence of the broadband networking with broadband media like CDs. They each have their strengths and people like to shop—you know, we all have that shopping instinct and you get a real touch and feel experience from shopping at a retail store. There's an issue in terms of what you want to own and what things you want to put on display in your house versus what things you want to rent over a network. If you're biased toward renting, you'll probably consume from the software network. If you want to own it, you'll probably want to buy it in a retail store and get a really nice package. I'm sure we all have books and other media at home that we've never even read because it felt good to buy it, and that feeling is not going to go away— CD media is going to get better from here. It's going to get to be higher capacity, continue to go down in cost, and continue to be very competitive with other channels of distribution like networking.

Another myth is that interactive TV is just going to basically be your TV with a PC in it. We don't think the PC TV is the right solution. It's not the right display resolution, you're viewing from the wrong distance, it's the wrong level of hardware performance, it's the wrong software — just everything about it is wrong, and so we think that interactive TV is going to be based on all new technologies.

Now who can set the standard? Now we obviously believe that like VHS created a huge market for home video, there needs to be a standard in multimedia. That standard we think is going to be set by people who have the experience to understand these markets and know how to do the different parts of the job, people who can put together broad

partnerships of companies that don't exclude anyone important. We think it's essential to make a big jump in the performance in the hardware to really enable mass market interest and you've got to be very flexible in how you do business with all these different industries. Plus, you have to get tremendous software industry support. We think that's what 3DO is doing. Of course, we have hardware support right now from Panasonic, we have licenses with AT&T and Sanyo to manufacture 3DO hardware and we'll have other companies who will have licenses as well. By the fall of 1994, we think there will be several brands of 3DO hardware shipping in the marketplace, not just in the U.S., but also in Europe and Japan.

We have probably more software support at launch than any other format in history. Here's what the Panasonic player looks like. Now I'd like to just do a brief demonstration if we could bring up the display. Just to summarize, we think of this technology as being "real life in a box." We think this is an industry that's really on the brink and it's something that a lot of people are going to benefit from in a lot of different industries.

The first thing I'm going to show you is part of our Sampler CD which comes with the machine. What I'm going to show you first is full motion video that's playing off the 3DO system without any special hardware. A lot of you I'm sure are familiar with MPEG decoders and we plan on supporting MPEG. We have a cartridge adaptor you can plug in on the side for an MPEG decoder, but one of the remarkable things about 3DO is that we can play pretty high-quality full motion digital video even without MPEG, using only the standard 3DO processing architecture which has a number of custom chips associated with it. By the way, we're very open minded about what foundries can manufacture them. Right now we have foundry licenses with AT&T, Toshiba and Matsushita. Now, using a software algorithm for compressing the video, we are able to play back full screen, full frame rate, full color video right off of a CD. We can put about 40 minutes of this quality on a single CD. This is actually Batman watching his black and white television in the Bat Cave. It's what I said earlier about slow upgrades to color television. What's neat about this technique is that you can include digital video in interactive titles, educational titles, information titles or you can just put 40 minutes of video on a single CD and have it play back. Of course, since it's a CD, it's less expensive to make than a video tape and it doesn't need to be rewound. It's also much more durable and can be randomly accessed by track. Check out the user interface on Batman's computer here.

Let me show you one more thing on this disk which is an interactive sports title. To give you the feeling of it, you can create a sports game in which you really feel you're part of a broadcast. The characters that you're controlling can be shot on video instead of being just little hand drawn stick figures so you get much more of a feeling of realism in the game play. This is a little snip from PGA Tour Golf from Electronic Arts. Again, everything I'm doing, I'm just playing straight off the CD player here. Another thing you can see is the way they can introduce a product now. It allows even small software companies to communicate just like they're big television broadcasters. Even the fonts are chosen here to look like TV broadcast displays. Here's a golfer I'm controlling. Notice there is a very high frame rate and a lot of colors in the image.

Now for a completely different type of disk. This is a photo CD from Kodak, or it's Kodak format. Now, you can take your family pictures and get them put on a CD. The 3DO player can do a lot to manipulate them, including zoom so you can actually record a soundtrack and it will actually sequence through a whole slide show for you automatically. The 3DO image processing here allows me to manipulate the image very quickly. I can do things like flip it or rotate it — this is really fast image processing that's made possible by the 3DO system.

Another thing that we can do is have some fun with regular music CDs because we can put programming on the TV while you're playing your regular music CD. There's actually a ROM chip inside 3DO that has a megabyte of programming instructions on it for all these traditional forms of disc so it'll do all the normal things that a music CD player would do, but it also can do all these fun graphic things.

Now, let's move on to another form of interactive CD. This is a children's educational title. This one is for pre-reading children and it allows them to create their own interactive story and create an environment they can interact with and make a lot of fun things happen. This one, in particular, is a story about a little car named Putt-Putt who needs to find a pet so he can join the parade. And when I'm ready to leave the scene, I just find the big arrow, press the button and move on to the next scene. So it's a whole form of storytelling that is driven by what the child is doing with the product. To give you an idea about the companies in the industry, this is a seven-person company named Humongous Entertainment.

Okay. Just a couple more demos now. This next one is from an old demo disk, but it gives a good demonstration of how different our hardware performance is due to the difference in our architecture. A typical PC architecture is basically a building where all the processing is taking place with one road where all the traffic is moving. Of course, over the years we've built bigger buildings with more lanes of traffic on the road. What 3DO did was create a multiple-building architecture with multiple roads that are communicating simultaneously with a lot of different custom processes. So here's a simple demo where we have some objects moving around the screen using transparency. We got an IBM hacker and asked him to create this same demo on a 486 PC running at 33 megahertz, which he did, and on 3DO it runs 120 times faster. In addition to running 120 times faster, 3DO can also add more items to display — we can scale them, we can rotate them, we can warp them and we can do all these things simultaneously.

Here's another interesting demo which is a good way to compare us to the other end of the computing spectrum, the graphic workstation marketplace. We use graphic work stations to create some of our content. For example, in this next demo, the yellow ball that's bouncing around, that's a beautifully drawn ball with really nice polygon shading calculations that was originally created by taking a $50,000 graphics workstation and spending a full minute to draw the ball. Once we had it drawn, we captured it as a 3DO animation cell. Now we can whip it around and redraw it several times a second. We can have it be programmed to fall with gravity, to compress when it bounces, to have a shadow automatically tracking across the floor and to be translucent with all the sound effects. Each of these different objects is an independent task running on our multitasking operating system, and it's all running in real time. I can instantaneously change the lighting. You'll notice while I'm doing this the visual integrity is holding up very nicely.

Okay. Just one more demo. This is a title that is still in development. It's called Twisted from Electronic Arts and it's a spoof on a TV game show. The idea here was to make computing in the home a more social experience, to create something that four people in a family could do together with radically different skill levels. In this one, basically you're assuming the role of one of four characters from the TV wasteland including a TV preacher, and a used car salesman that's also an Elvis impersonator. There's an aerobics instructor that's dressed in combat fatigues because she has the war crimes work-out and there's a rock and roll star. So you assume one of these characters and it's nicely handicapped so that there are different things that adults can do and kids can do — it has a lot of educational value for kids. You notice that there's a lot of use of high-speed animation here, but also use of good quality

video shot on film with actors. Do you notice how seamlessly it's able to use digital video along with computer animation? I'll just show you this one last thing where you come to a challenge matrix. Here's where you would interact with another member of your family trying to outguess each other on this matrix. So if she picks B and then he picks B, we'll get the choice in the middle, which means I'm going to get blown up, but if I didn't get that choice, I would have a challenge, a little game I'd have to play or a trivia question to answer. So it just gives you a taste of the flavor that this technology allows.

Thank you very much.

Breakout Session: The Future of Home Multimedia Communications

Greg Sheppard, Moderator
Director/Principal Analyst
Dataquest Incorporated

Panelists:

William G. Luehrs
Vice President and General Manager, Video Systems
Scientific-Atlanta, Inc.

Bruce Ryon
Principal Analyst for Multimedia
Dataquest Incorporated

Ed Thompson
Director, New Business Development, Broadcast Products Group
Compression Labs, Inc.

Simon Dolan
Director of Marketing, DSP Division
LSI Logic

Kevin Seeman
Director of Broadband Services
Pacific Bell Information Systems

Mr. Sheppard: In case you haven't read a newspaper in the last year, there is a war going on out there for video-based interactive services to the home.

The prize is no less than monthly revenue from 95 million homes in just the U.S. alone. If you figure service revenue anywhere from $20 to $100 per month per home, we're talking about 10's of billions of dollars. This opportunity becomes even more enticing if we note the fact that phone and cable company revenues have been flat over the last few years.

The players in this revenue scramble include cable TV companies like TCI and Time Warner, phone companies like Bell Atlantic and Pacific Bell, and a host of new entrants. New players include Hughes with its DirectTV, direct broadcast satellit system and a group of

companies exploring wireless interaction including a company called Interactive Network. The wirless companies are using FM radio, cellular, and even the vertical blanking interval of the TV signal itself.

Some of the different services envisioned include video on demand, which is basically renting a movie from your couch, if you will. A few more are home shopping and banking, including bill paying, video telephony which we saw some examples of yesterday with AT&T's talk and network-based video game delivery as well as games played over a network A few more include T.V.-based directories, such as ordering movie tickets from your couch, and on-line services. Right now you've got to go to the other room and dial up America On-Line. Why not do it from your television set as well? How about receiving E-Mail at home? There will be many new hardware opportunities with a range of new buzz words and acronyms coming at us.

Sonet, which is the optical fiber technology, is already being displayed throughout America as well as other parts of the world. ATM is another technology that works with which stands for Asynchronus Transfer Mode, you can think of as the network's network. ADSL, is yet another enabling technology. It stands for Asymmetric Digital Subscriber Loop, is a way of improving the twisted pair phone line. This will all show up in transmission as well as switching equipment.

We'll also see new types of subscriber equipment, primarily in the form of some sort of set top box. This equipment, will include RISC-based CPU technology. It's also got to be able to decompress video and audio. It also has to provide a back channel or a two way communication capability back to the service provider, whether it's ordering the movie on demand or in video conferencing, a real time, high performance link.

Some of the issues I'd like to explore with our panel today include what do customers really want in services and how much are they willing to pay? Who's going to deliver what services out of the various contenders here? What are the set top boxes going to cost and what are the standards issues concerning those, especially compression? So at this point in time, I'd like to introduce our famous group of panelists here. Over here on my right is Ed Thompson, who is Director of Business Development, Broadcast Products Group with Compression Labs; next to him is Kevin Seeman, who is Director of Broadband Services with Pacific Bell Information Systems; next to him is Simon Dolan, Director of Marketing, DSP Division, LSI Logic; on my left we have Bill Luehrs, Vice President and General Manager, Video Systems, Scientific-Atlanta; and on the end is Bruce Ryon of Dataquest, who is in charge of our Multimedia Service. So I'd like to start things off by having every member of the panel give an overview of their current activity in this marketplace in terms of products and services. That will set the stage for getting into further questions. So if I could start with Ed, please.

Mr. Thompson: At Compression Labs, we're a Hardware and Systems Manufacturer. We will be building real time video in coders and set top boxes. We have a number of activities involved around MPEG video, which is our current focus for new product development. Currently, we have Spectrum Saver, which is the world's first entertainment quality compressed digital broadcast system which we introduced a little over two years ago. It was a manufactureredand designed pre-MPEG, using proprietary compression algorithms. Today, we're working on MPEG in a variety of areas. We're members of the Advanced T.V. Research Consortium, which was one of the groups that had a proposal before the F.C.C. for high definition television. Our proposal was for an MPEG system — it looks like the ACTV standard will be based upon MPEG, too. We're also the compression supplier to Hughes for the direct T.V. Broadcast System, which will be launched sometime next Spring. It will actually be the first digital entertainment developer to consumers. We are involved very much in the

video on demand area. We are the compression suppliers for both end coding and set top decoders to Bell-Atlantic for their video on demand trial that they're doing with their employees in Alexandria. We currently have the only video on demand decoder box available on the market. It's a prototype, but designed for these type of tests. We also have a number of strategic relationships which have been previously announced with companies like On-Demand Technology, which is a server vendor, Reliance Comptech, which is a fiber cobax vendor, BBT, which is a fiber in a loop vendor, technologies, Thompson Consumer Electronics in the area of DBS and Phillips in the area of set top boxes for video on demand for the BBT Networks. So we have a variety of activities focusing on real time MPEG-II head end coders for broadcast applications and MPEG-I end coders for storage applications.

Mr. Sheppard: Kevin.

Mr. Seeman: Hello, I'm Kevin Seeman. I work for Pacific Bell Information Services, not Systems, but Services. That is a unit of Pacific Bell. About six months ago, Pacific Bell announced its intention to build a broadband network to essentially every home in California, at least every home it serves, which is about 80% of the homes in California, over the next two decades. By the year 2003, we want to have half the homes served with broadband interactive two-way networks and the next decade after that we'll serve the rest of them. That may sound like a slow time table, but if you consider that's something on the order of 10 million homes, half a million per year will be passed by a new Pacific Bell network. It's very aggressive, especially for Pacific Bell. I regret that I can't say more than those numbers. We've essentially been hamstrung to those years and intentions. Pacific Bell will get a lot more specific in its what, where, when and how, probably within a month, but as of right now, all we can say is that we're going to provide a broad network and I think we're willing to say that it's not going to be the ADSL. It's not going to be over your twisted pair. We recognize that it's not competitive or adequate for providing services so we're talking about a brand new network. On that network, working for Pacific Bell Information Services, it's my job to figure out what set of services to deliver in addition to the basic one — telephony and cable T.V. So, my group is looking at which platfor delivers these services and what services to choose. Is it movies on demand and video games? Yes, we believe at least in the intermediate term. It's also home shopping, and probably in some form, home banking as well. Educational services we believe have great value, especially in the public policy arena, but we're not sure it has great revenue potential. So my job is to deliver those services in the short-term, in the middle of this decade. I like to look out to the year 2000, which is where much of the hype is directed — when everyone will have all these services right there in their living room. However, we need to focus on what it takes to get there and if you consider the enormous amount of capital it's going to take to deploy file servers everywhere, with set top boxes on every T.V. set, we're talking at least $300.00 to $500.00. Some prototypes right now are in the multi-thousands of dollars. We have to reformat existing movies and come up with new ways to develop applications. There is a lot of money that has to be out there just in order to provide the infrastructure for a service providing network. Then on top of that, the thing that's got to justify it is that we really have to get consumers to change their behavior. Now in the cast of video stores, maybe that's easier. It's easier for you to point and click and choose the video you want from your couch. Maybe you're willing to pay a 50 cent premium for it — it's never out of stock and it's brought to you at your convenience. Now when it comes to other services, such as shopping, people are comfortable going to the malls. In order to justify that huge investment, we really have to channel a lot of activity that today isn't over the network and I think a lot of people are assuming that problem will go away, but there's some big behavioral changes that need to take place in the home.

Mr. Sheppard: Thanks, Kevin. Simon.

Mr. Dolan: LSI Logic is a manufacturer of semiconductors, silicon chips. Historically, we're best known for the fact that we've pretty much invented the ASIC (application specific integrated circuit) business about 12 years ago. Currently, as well as being an ASIC vendor, the company has also been a significant player in RISC microprocessors offering both the SPARC and mixed architectures. We have also been a player in the PC world with our chip sets and graphic controllers in that market. The fourth area of the company, the area which I represent, is our signal processing division. Our focus has been on the very high speed signal processing which is the domain of video and clearly, video is what matters in this emerging world that Kevin and Ed are talking about. Specifically, we are targeting chips — the functionality to go into the classic machine which is being referred to and generically as the set top box, regardless of who it belongs to or who makes it. There is, we think, probably about three main areas of technology that are going to be in that box. There is, first of all, the part that people talk about most — the audio and video decompression circuitry or source decoding. That seems most likely to be done to the MPEG standard. The second area, which is often overlooked, is what we call the channel coding or decoding. That's the part of the box where the analog signal that's coming in off the cable or off the satellite dish is demodulated, errors are corrected and the actual bit stream information is extracted from the signal. That's actually quite a significant piece of a system in itself, with almost as many gates in roll logic terms as the video and audio decoding. The third area, which is mail, may not become significant. We'll probably hear a lot more about that this afternoon in terms of the actual controller or the on screen display and what kind of operating system needs to be run on the box. So, it seems that there is likely some scenarios to be a 32 bit CPU of some sort in the box as well and that could be an Intel architecture as one of the proposals out there, it could be mips based or it could be power PC based. There are a number of different architectures being proposed. So there are three main areas of logic in that box and it's associated DRAM. At LSI Logic, our strategy is to attempt to offer or to complete all of the logic that's available in that box. That's everything other than the DRAM and specifically the source and channel decoding that I've mentioned. At that end, we have announced a number of products through the course of this year for doing MPEG audio and video decoding. Also, we're doing error correction which is a significant part of that channel decoding. Looking forward, the way these boxes are built, we believe that with the levels of integration that are now available with silicon technology, it's going to be fundamental that a significant amount of the silicon is going to be common. It's going to be standardized across numerous vendors boxes. However, there's always going to be some part of the silicon which will have to be custom and separate. There will be separate ways of doing conditional access, the correction and separate ways probably of how the actual channel changing and display information is done. So we think from a semiconductor point of view, it's going to be very important to be able to offer the combination of a large amount of the system being essentially pre-designed, but with the ability to customize parts of the chips to make a system which is tailored and differentiated to a given system provider.

Mr. Sheppard: Thank you Simon. Bill.

Mr. Luehrs: Thank you. My name is Bill Luehrs. I'm from Scientific-Atlanta and I'd like to show a few quick overheads. I talk better with overheads than I do with my hands, something in my heritage I guess. Scientific-Atlanta is about a 700 million dollar company and it's mission is to build the transportation systems that link people who provide content like video, audio, text and voice over a network or over a transportation system into subscriber's homes. We are in the cable T.V. industry, which is our single largest segment. We call it the broadband industry. We are #1 or #2 in all

the broadband industry. We are #1 or #2 in all of the market segments that we serve including transportation, distribution and set top boxes. In fact, Scientific-Atlanta has now produced it's 15 millionth set top box and we're looking forward to being a participant in this digital world in the future. We've taken some raw looks at the numbers of what we think the exploding opportunity is and digital is what's creating this opportunity because as digital comes into this market, we see the information, communication and entertainment boundaries fading. Right now the cable T.V. services business is about an 18 billion dollar business, but if you look at all of the other places where that company or that business can now hunt, it's about a ten-fold expansion or 180 or 200 billion dollar business. Some people describe this multimedia market as zero billion dollar a year business on its way to a zero trillion dollar a year business. There is some digital hype, but we see some real numbers that represent opportunities for us. We think further, and I agree with Kevin Seeman, that the cable T.V. network is very well positioned. You have the capability of providing digital video compression. There is a network in place that we are evolving to a hybrid analog digital network including fiber optics. Video compression will allow much more videos to be delivered in a given channel bandwidth so you really will have the 500 channel universe and the two way cable plant with fiber to the serving area and nodes will provide the opportunity for reverse bandwidth. Our vision of how a system will evolve is what we call a "Digital From the Sky" system whereby all types of programming information, compressed programs, analog programs and data are delivered over satellite through some kind of control system. This can be content that's provided by people who are in home shopping to video on demand to near video on demand and all those kinds of interactive opportunities. We call it Subscriber Management Information Processor, down through a broadband cable network, probably 550 to 750 megahertz and into the famous set top box in the home. That set top box is going to be very multi-functional and multi-dimensional and will be a very smart box in the home. Some of the early entrants in this were partnered in the full service network trial with Time Warner and Silicon Graphics so we're putting the risk 4000 chips of silicon graphics into these boxes to create something more powerful than anyone has in their home computer today, and that's going to be on top of your T.V. set. How do we think this whole thing is going to grow? One of the questions that was asked earlier is what will consumers pay for this whole thing. Frankly, we think that you've got to have the compelling content, and the innovative marketing and distribution and we believe that those two things will soon be available. We'll need a cost effective platform for delivery to the home. We're not there yet — we're only building trial boxes and not really rolling these things out in mass deployment, but all those things have to come together in a way that rewards the participants for their contributions at a price the consumer is willing to pay. At the moment, if it costs us $49.95 to be able to deliver when that subscriber wants the movie, he's not likely to pay for it, so we've got to figure out very cost effective ways to build this network. As we see the evolution of this process, we think that it's going to start with analog. We're building set top boxes that already have graphics displays and the power of an XT Computer in those boxes today so we'll be able to do some two way interactivity even though it's in an analog world.

As you see, when you get to a digital world where it's basically a one way 500 channel expansion, you'll be able to do more of these kinds of services and then ultimately the interactive digital will be, we think, the ubiquitous box that will be in the home. The key, however, is that you need to have a very simple navigation tool so the subscribers can find their way through this and that starts with a very good electronic program guide. We'll be going to a base one way interactive 500 channel box, probably in the 1995 time frame and then truly get to mass production of the ultimate box probably in the 1996 time frame. That box will

be session based, two way interactive, and able to do real time connection between subscribers and homes with very high level graphics. We believe that the interactive intelligence is going to reside most likely in a cable communications, home communications terminal or a set top box as we call it. That's where the bandwidth capacity is and that local processing will enable us to select data from this vast firehose of information that's going to be coming into the home in this cable network. It's not likely to be in the T.V. set. There's 180 million of them out there and how many of us trade our T.V. sets in when it's time to buy a new T.V. set. They all end up staying in our home some place or in a second home. It's not going to be a PC although there will be PCs in the home and we're not competing with the PC business. We just don't see the PC as being the platform that's going to create the information entertainment platform for the future. So, Scientific Atlanta's approach is to build today what we call 8600x analog home communication terminals that have these kinds of processing capability and on screen displays. We'll be able to move it into a digital dock if you will, that is to say include the MPEG digital and audio decompression chips, and finally end up with a box that has the power of a Power PC. In other words, we'll have very, very fast processing, very good quality graphics so that we can do our games and interactive shopping to provide the brilliant colors that the systems will be capable of. This is our description of what that food chain looks like. There are going to be people that have to be very good at developing hardware, both in RF and digital hardware, to be able to connect the two way network from the outside, analog and digital services to the subscriber in the home and the T.V. So we'll have a port output on these boxes that connects to the T.V., a remote control that allows me to migrate easily around the system, computer, printer and game unit ports as well as possibly fax ports and whatever other kind of devices you want to connect to it. We believe that it will also be important to have custom software drivers that control those functionalities, and I'll show that a little later in the next chart. We'll also need a very good application program interface that allows the people who are creating the content to create compelling content without having to worry about porting it from machine to machine.

So our final view here of the home communications terminal is that the kinds of people that are building these hardware boxes are going to be people like Scientific Atlanta and other companies that understand how to build a cable infrastructure network and have custom software drivers to control functions that will be required to be able to build this network like a tuner demod, decompression demox, etc. There will be an application program interface that allows content to run on a variety of these platforms in a truly open, interoperable session. We believe that we can build an API, but there are also other very good companies like 3DO, Kaluda, Silicon Graphics and Microsoft that can provide that kind of capability. That's where they fit in the food chain and then ultimately you will have people that provide the killer applications, the movies, the information systems and the messaging like Prodigy, downloading services and so on, and that content will come from a number of different sources. We will provide some of that content, other software developers will provide it and operators themselves, like Time Warner, will also provide a significant amount of it as well. So, that's our sense of how this industry is going to evolve. However, for this really to be a mass production in millions of subscriber's homes, these boxes have got to get down to hundreds of handfuls of dollars, and that's our vision. Thank you.

Mr. Sheppard: Thanks Bill. Bruce.

Mr. Ryon: Hello, I'm Bruce Ryon, Principal Analyst in charge of Multimedia Research at Dataquest. My whole purpose in life at Dataquest is basically to get the supply side of information from the various market segments such as semiconductors, PCs, optical and storage and then build a model of the products that use all of these various technologies. My

first task is really to reconcile all of this data coming in. As an example, I just went through a process of defining what the multimedia PC number was based on with all the supply side information. It was very interesting how you see descriptions of the multimedia PC being very large, but given all this other data coming in, I came up with a figure that was much truer I think to the actual shipment rates and found that it was a much more realistic picture. The second, and probably the biggest thing that I do, is invest all of my research dollars in demand side research. I take all the supply side information from the various markets and then work on defining what people will buy and how much they will pay. Just in the last three months, I've completed three demand surveys. The first one was on video conferencing in large businesses. I also did a survey on what was needed in the content development market and I'm in the process of, hopefully, within the next week, being able to release a study on what the demand is for home interactive multimedia products. Some very interesting results from that survey show that basically people are very interested and there's a very high demand for interactive products in the home. However, what people are basically telling us is that they want control over what comes into the home. They aren't necessarily interested in 500 channels, but what they are interested in is getting control over what they see.

As an example, we found that people had very little confidence in T.V. news and they wanted to be able to find a way of using T.V. news the way that they use newspapers. They want to be able to cut a story off, see more of a story, avoid certain stories — have more control over what it is that they're consuming. A number of the presentations that you see in interactive products in the home is sports-oriented — being able to get different camera views, getting statistics on players and so on. But what we found out was that there was a very high confidence in the consumer base regarding what they're currently getting from the sports programming and that they really didn't feel the need to purchase interactive sports programming products. As an example, there's a company in Mountain View called Interactive Network that's having significant financial problems and TCI basically had to bail them out based on the fact that they, in large part, were selling an interactive sports programming product. So those are just examples of what we're trying to do in establishing where the demand is right now.

Currently, I exist within the software group. I cover all hardware and software demand, but my real focus is in the solutions area. I tend to be much more realistic and practical about what the technology will and won't do. I've been in the multimedia business, in it's various forms, for the last 20 years, since my college days. I have been involved in a number of leading-edge technologies that had a lot of sizzle, hype and interest, but they never went anywhere in terms of sales, so I'm very used to being in markets that are big on promise, but little on delivery. The biggest service that I provide to our clients is giving people a very realistic view about what they can do in terms of good business decisions about where to go with the market. So I'm the curmudgeon or contraire unit in the market because I see the PR hype level being up here, but the actual demand being somewhere probably 20% down the road.

Mr. Sheppard: Well thanks. What I'm going to do now is start some general questions and then we'll open it up to the audience in a little while so you can get your questions in. I'm also inviting the panelists to ask questions of each other. So just everything short of a brawl. I'd like to start out with the $64.00 question. Which services are consumers going to want and what will they pay. What do you think the deployment time table is? I'll just open this up for the first one who would like to just in.

Mr. Thompson: The deployment I think would be what you mean by interactive video. If you consider a near video on demand delivered by DBS, it's going to be next spring with Hughes with the DirectTV service. Certainly, Bell Atlantic has announced that they will have a

mass deployment, just what mass means is I don't know, but I presume more than a couple of hundred of video on demand decoders in their network by the fall of next year. So there will be opportunities to see what value the programs have. I think it's a little difficult to tell right now. I used to work at RCA a long time ago and believe it or not, when we first introduced VHS VCRs, it was a hard sell. We had dealers saying why would anybody want one of these things to record TV that's free. It was a very difficult sell because nobody had the vision to see that there would be movies available for the home that the entire view industry created here. So I think it's sometimes very difficult to anticipate what will catch on and what won't. What seems obvious to us right now will seem to be bad prognostication based five years from now. I think a clear analogy in the market will be video on demand and it's easy to explain to the customer that he can go and substitute Blockbuster Video's service at his home and that's a fairly easy sell. I think that will be the initial driver. I think it will take a while for the other things like E-Mail, video phones and home shopping to catch on because the first driver will be I think getting video on demand or near demand to the home as soon as possible and to replace Blockbuster.

The next step may be to replace Tower Records. I mean if you could deliver digital video to the home, is there a reason why you can't deliver digital audio? You could buy your CDs over the network, whether it's over satellite or cable or the telephony network. The next service after that may be to replace Egghead Software. Is there a reason why you can't buy WordPerfect and have it downloaded through the cable system and load it onto your PC?

These types of analogies I think will make it a little easier for the consumer to understand and see the value of it. It's a little harder to sell the value of being able to sit in front of your TV and interact with it. A lot of people interact with their TV through their toes with a beer in their hand, and sitting in the Barcolounger and that concept is going to be a little harder to sell. It's going to be a little slower to catch on. But if you can draw the analogy of what services you're getting today and how to get them cheaper or more conveniently, I think those will be the services that will catch on first and the other interactive ones will take a while. I think ultimately it will be a good market, but we shouldn't bet our eggs on that portion of it.

Mr. Seeman: I'll take the second half of that question, which is how much will people pay. And I'll also take the first part of your answer Ed, and that's that video on demand is probably the nearest term service that's deliverable and economic. Now let me split that in half. We've got movies on demand and we've got TV on demand, or let's say time shift TV. For movies on demand, we know how much people pay for it already — $3.00 at Blockbuster or $1.95 for three days — there's a very well known price sheet video. Pay for View is fairly mature in terms of the stability of it's prices. We don't expect people are going to pay a great premium for video on demand. Again, we add some convenience and we add the opportunity that perhaps there will be more titles available. The service will be configured so that they never run, so there will be some additional utility, but that's not going to jack up the price from $3.00 to, as Bill said earlier, $49.95. We've got a serious economic problem to push down the cost per movie into the $3.00 to $5.00 range. Now let's move on to TV on demand or time shifted TV. We also have a very well-known price paradigm, and that is it's free. Providers say they potentially could give you Roseanne whenever you want and users are saying they want it. Providers are thinking they'll charge you $1.29, but users are thinking TV is free, so again we've got a gap to close in terms of what people are willing to pay. Our research shows that it's probably not more than 50 cents per episode for a time shifted TV. It's easy to see if it's inconvenient for people to watch, lets say Seinfeld and Cheers, so they time shift that four times a month at 50 cents — they just added $4.00 to their bill. A few of those and you see your bill go up quickly. You get your

bill and your kids have done it too and your bill is $25.00 more. Your going to disconnect.

Mr. Ryon: I think our research as well is supporting your data. Basically, people aren't really willing to spend more than $5.00 maximum for video on demand. I think the other thing too that came out in the research that we've done is that people want fixed costs. One of the reasons why the cable pricing has worked up to this point is people can count on a $20.00 or $10.00 or $15.00 fixed fee every month that they can budget. What gets consumers is these open ended charges and they're not necessarily going to sign up for them because — you've seen the problem with 976 numbers and so on — people want something that they can budget in. This is not the 80's where there is a lot of disposable income in the home. You've got people that have got other priorities in life and interactive television may not be one of them. So that has to be factored in very, very closely because there's a huge price sensitivity. There's very high demand, but there's a very strong price sensitive element to that demand. I should say also that there have been tests on interactive television going on throughout the country and you should also take a look at some of the other video text services that have gone throughout the world, like the Minitel System in France. There are some fairly clear indications about what people will use in interactive areas. I think the biggest thing or one of the major points in our survey was that people don't want too many options. I think that's one of the problems they found in the GTE experiment down in Cerritos, California. If people get too many options, if they feel overwhelmed about what's available to them, they will not use it because they would rather not have the hassle of navigating through the various user interfaces. So there's got to be a real value and it should be very easy to use.

Mr. Luehrs: I'd like to offer a comment also. Maybe I'm atypical here, but I think of interactivity this way. When I come home, I'd like to interact first with my refrigerator. Maybe it's a can of coke or Anchor Steam. Then I'd like to interact with my microwave and get something started for dinner. Then, finally, I'd like to interact with my TV and when I interact with that TV, what I'd really like to have is a simple remote that I can press and find out how my stocks did today or find out how my baseball team did today — not too well I might add, but that's another story. Then I'd like to find out what's interesting to watch on TV, whether it's some kind of network program, video on demand or near video on demand. Maybe it's a shopping experience. You know, we haven't really talked much about shopping here. HSN and QVC had incredible growth in the cable industry to get to the point where they're now a billion dollars a piece in sales. However, they are operating in a 60 billion dollar retail market and the thing that's preventing them, I think, from continuing to grow in double digit growths is because people don't want to sit down and watch through the junk jewelry before they finally get to something that they're really interested in. You don't want this linear programming, so the way to avoid that is to get it to the point where the kinds of things people are interested in are available right away.

So from our model in the kind of research we've done, our thinking is that it's not going to be any one service that's going to put us over the edge. It's got to be a stack up of a number of different kinds of interactive services to finally get a package that the consumer is going to be willing to pay for. We've looked at different kinds of numbers, but maybe that number is as much as $20.00 a month provided it gives them interactive home shopping, movies, games and information services, sort of a limited Prodigy kind of thing. However, we believe it can't start with just one particular service.

Let's talk about Blockbuster and the video entertainment it provides. Today's Blockbuster subscriber pays $2.78 and buys 4.33 movies a month. So that's a total of $11.00 per month per household that's coming into the home. Now if Blockbuster, or if we as an industry have to pay

say half of that $11.00 to the rights holders for the content, the movie, that is, then we're talking about $5.00 or $6.00 of free cash flow that's coming to the provider of this network. Well if that set top box cost $500.00 and I'm getting $5.00 a month, do I have a business here? Frankly, I don't think so. As an industry, we've got to get to the point where there's enough of these compelling services that we can get a collection of services into one particular architecture so that every one of these things stacked up in terms of a number of choices can create the economics for the whole industry.

Mr. Sheppard: I'd like to ask somebody to comment on the time table. When will we see a million users out there in the U.S. market up on interactive digital systems like this? Any guesses?

Mr: Luehrs: A good analogy here are where these from the point they were being introduced to where they were in 10% of American households and that period was over ten years. The same thing is true for color TVs. When color TVs were introduced to American households, it took over ten years to get to the point where they were in 10% of American households and the same thing is true of VCRs. So now we're talking about a digital network that we're going to deploy Many of the elements are in place, but a lot of different kinds of services are going to come together and, frankly, I think it's going to take some time. We will still see an analog delivered video environment in the majority of subscriber's homes for a number of years to come. I don't know if that number is three years or five years, or maybe the turn of the century, but it's going to take a while. What we're seeing at this point with Bell Atlantic, U.S. West and Time Warner is that all of these things at this point are trials to figure out how this business works. These are not mass commitments of billions of dollars going forward with any kind of certainty. They're going to spend some millions of dollars this year, but they always have the right to stop and go off in some complete different direction. So what we don't have today is mass deployment. What we do have is people trying to find that magic formula. Once we get this convergence, then I see it taking off, but this is not going to be something that's going to wash over the face of this earth in 1994-1995.

Mr. Thompson: I think your analogy of the color TV and VCRs is very good. If you go back and look at the history of both of those technologies and chart a graph of sales, program availability and the number of hours of color television available being broadcast to the sales of color TVs, you'll see that there was a big spurt of color TV sales around 1963-65, in that period. That was exactly when most of the networks starting having prime time color television broadcast available and if you look at the availability of the sales of VCRs and chart it with the sales to dealers of rental videos, you'll see the same type of growth chart. Once there was programming available to put in that VCR, the sales of VCRs took off, the cost went down as the volume went up and the market exploded. So the availability of very interesting and compelling programming to fill these 500 channels on a cable network or fill all the servers in a video telephony network will, I think, be the driver to make those million boxes happen. It won't be the availability of the technology. I mean the technology will be available for the most part by next year. It will be the availability of content.

Mr. Ryon: And the availability of the right price.

Mr. Dolan: If I may comment on an issue that possibly is being overlooked a bit here. Everyone just spoke an awful lot on the U.S. market and putting in perspective the compelling value over and above the 30 or 50 channels you get today in the U.S. through cable. There is another area where a lot of this technology, I think, will take off which is the approximately two billion people who don't live in the U.S. and for whom we hope to get a 30 channel TV system. It'll be quite a significant

change from where they are now. If you look at the economics of what digital does, it allows you to use a couple of spare transponders on the telecommunication satellite to set up a 30 channel satellite TV system, which has previously been impossible. So I think there is a place where this market could grow a lot quicker outside the U.S. by allowing a service which we kind of know people in the U.S. will pay for to be offered outside the U.S. to a potentially large market. I think by looking too much to our neighbors about when will people pay for services, which are more than they're currently get on their U.S. cable system, is perhaps being a bit narrow minded about technology.

Mr. Sheppard: The next question I have is who's going to deliver these services? I'm going to have a cable coming into my house, a phone line and a satellite dish on top. How do I rationalize all of this?

Mr. Seeman: It's not a phone line — it's a new network from the phone company.

Mr. Sheppard: Is that going to be fiber by the way, or can you comment on that?

Mr. Seeman: I can't say.

Mr. Thompson: I think you'll see all four. You'll see it on phone lines as well. I'm not sure ADSL is going to be an end all technology, but maybe an interim technology that allows an auerbach to deliver services to neighborhoods where it is right. It's not economical to dig up streets and put in fiber, but if you get enough homes in a particular neighborhood subscribing to ADSL networks at 6 megabits, and by the way you can deliver an awful darn good video at 6 megabits, you can generate an income stream from that neighborhood. That income stream can be used to deploy fiber and upgrade the neighborhood from ADSL. They pull out the receivers off the side of the box, move them to a new neighborhood and do the same thing all over again. I have worked for auerbach. I don't know the economics of that, but that is certainly a plan that many of RBOC have discussed with me. It's one way to get into the business early before they can deploy fiber into every home and generate a revenue stream that begins to be used for the mass fiber deployment they ultimately would like to do.

Mr. Seeman: I do work for an RBOC and per our analysis, it just doesn't add up, but I understand that Bell Atlantic and others believe in it strongly. In direct answer to your question, Greg, I think the answer is yes. Who's it going to be? Cable, RBOC and DBS. I think we're going to see increasing amount of competition in the space on your set top for who's going to provide these services. And even beyond that, at least as far as Pacific Bell is concerned, there will be competition for who provides the services over the wire that Pacific Bell puts into your home. There may be a set of services brought to you by Pacific Bell Information Services. There may be a set of services brought to you by GTE, Mainstreet or Bell Atlantic. There is going to be competition introduced on many levels. The FCC is trying very hard to make that happen and we believe it's going to happen.

Mr. Ryon: I think that the competition is going to be great for consumers. What you'll see is different services that will wind up being fairly distinct between telephone and cable and so on. I think people will make choices based on what kind of services they want, the delivery system or the advantages, so if people find the pricings better through the cable system, they'll buy cable. If they find some information services that they find cheaper and basically the same product through the telephone services, they'll do that. So I do see it as a mixed, basically a Chinese menu of services, but I think it's going to wind up being very distinct in terms of what services wind up being the favorite services in the home based on who is delivering them. I don't see multiple services or the same service being delivered over the multiple mediums.

Mr. Luehrs: I agree with that. Now I think the government is becoming more enlightened

about giving the regional Bell Operating Companies the opportunity to deliver video services in their networks as well as other networks, however, what you're not going to see is people overbuilding each other and having multiple pipes into a home. There's going to be one pipe that offers this kind of service. It's most likely going to be a broadband pipe, one that starts out being fiber and probably ends up with the last node, if you will, out to the subscriber's home being some kind of coax. Yet it's going to be something that provides the ability to have multiple TVs, multiple services, and multiple viewing capabilities in terms of quality delivered all at the same time. People are going to want HDTV signals of the Superbowl delivered to their very high end TV and at the same time, they're going to want other kinds of services. They'll want multiplex coming into their home and delivering game services to the child's bedroom while you're watching the Superbowl. So the subscriber's demand for quality is only going up. They're not going to be willing to live with something less than they can get and what it's going to take is for the industry to sort itself out as to who is going to be the provider of that pipe. I'm sure there will be many more mergers of the type that have frankly gone in the UK, where both telephony and cable companies are together developing both telephone and cable networks and that kind of pattern will continue in the United States. You won't see several pipes into the home.

Mr. Sheppard: Okay. What's out there in terms of technological road blocks that we could stumble over? It seems like we've talked a little bit about ADSL being an interim technology. It may be fiber, but the coax, still continues to be well thought of, or new technologies like ATM, which can bring high bandwidth right to the home. What are your thoughts on some of the road blocks still remaining? Simon?

Mr. Dolan: I'm not sure there are really any technology roadblocks anymore. They're all economic. You can have a conversation as long as you want to about which one will make the most economic sense and who's going to win. However, if the technology says you can deliver the broadband digital system server pretty much over what existing cable companies have installed to get 500 channels then some of the older systems will probably need upgrading. The technology exists to deliver it over satellite. ADSL technology does exist. It's kind of expensive, but it has the big disadvantage that you only have essentially one stream coming into the home. ATM is essentially an economic problem which lies in whether there is a requirement to overbuild a lot of existing networks. There is probably a big barrier to that, but it's not a technology barrier.

Mr. Seeman: I think I agree with something that was said earlier about the development of applications. I agree, Simon, that we've got a lot of the technological problems in terms of distribution, but authoring systems and software development for the home market, not just the hardware and software, but the expertise in what it takes to develop these compelling applications, are still aces in the industry.

Mr. Ryon: I think the response rate as well is going to be very critical. One of the real successes in what many people call the multimedia area is that video games and video games require very high, very quick response rates, and I'm not so sure that some of these applications can really offer the quick response rates, especially in large switch networks where you need high interactivity, for example, in network games. One of the things that I've pointed out on a continuous basis is that it seems like the CD ROM technology is still very slow. I'm being told currently that the network technology over these networks is still going to give you about the same response rate as CD ROM technology and if you really look at the CD ROM content market, it has written off two-thirds of the game market and if you really look at the game market, you have to subsegment it into three categories — action, arcade or what's commonly called the twitch game, which is

very quick response kinds of games. The twitch game arena is the biggest portion, practically 60%, of the market in video games. The second area is strategy games, which is chess, a very good example of strategy games. The number one game in the cartridge market right now is the Adventures of Zelda and that's a good example of a strategy game. The third area is simulation games, which are the flight simulators and games of that nature. If you really look at the content area and CD ROM, only strategy games do well in the market and the reason is that they don't have the response rates to handle the twitch games, which is one of the reasons why I believe that basically 3-DO has written off two-thirds of the game market. What's happening is that these switching networks aren't going to be able to give the gaming or network gaming experience high enough to have twitch games work over network systems and I believe that the twitch network games are going to be a big portion of the content arena. So, I do think that there are some technological hurdles. I'm not sure the switching technology is really going to be there.

The other thing you have to look at is interactive programming. Interactive programming has a timing element to it that's very, very slow. One of the reasons why you have to sit through the jewelry on QVC and the Home Shopping Network is to give people time to look at the product, think about whether they want to buy it or not and really absorb the experience. As an example, in Interactive Network, you can't put an interactive product over a network in a passive environment because my original background is in the drama and film arena and one of the things you learn very early on is that pacing and timing is very, very critical to satisfaction. You need to be able to give that person the experience in which they are willing to give up what they call suspension of disbelief. Many of these interactive products are going to work in passive environments because again the slow response rate is going to have be built into these programming elements in order to make them successful. So I think that's going to be a very critical element that hasn't been thought about right now.

Mr. Seeman: Can I make a comment on what Bruce said about games? I think a lot of the way the network is being configured is for highly asymmetric applications. Assuming that Bill's going to give us a set top box with lots of memory, that will leave us with a choice. Either it's a twitch game, which gets loaded down onto the set top box and it's fully interactive, or it's a network interactive game, which has to be slow — every time I make a command, it's got to go up to the network and get distributed to my opponent. Doing both implies a symmetric network and that's not on the horizon, which means high speed upstream is not on the horizon.

Mr. Ryon: So you're saying there is a technological problem then?

Mr. Seeman: There's a technological problem with doing both the network and the twitch games. You have to choose one or the other.

Mr. Luehrs: I think many of these boxes are going to be loaded with enough DRAM of memory to be able to accommodate at least today's configuration of games and you'll be able to download them. I think what it really comes down to is a matter of economics. In other words, if it costs $300.00 to deliver these kinds of set top boxes with a certain level of capability, but to add the capability of the twitch game and have it be interactive with other players in other cities ends up costing these boxes an extra hundred dollars. How many of us are going to pay for them? Or are we just catering to the 12 year olds in our families, which is a big market, but you've got to ask yourself this question.

Mr. Sheppard: There's a lot of twitchy 20 year olds out there, too.

Mr. Ryon: I think one of the things you have to understand is that one of the reasons why people stayed out of the video game market in

the mid 80s was because of the huge crash that Atari experienced. You know it went from a 3 billion dollar company back down to a couple hundred million dollar company and their latest results are 5 million dollars for the quarter under Jack Trameel, and right now we're starting to see the upper limits of the technology. One of the things you've got to remember is that with special effects and gaming experiences, people, kids especially, get saturated. They want ever increasing games and one of the things that you've seen in the gaming markets is that they've all gone to 64 bit games, which are going to require massive amounts of storage. One of the questions that keeps getting asked of SGI and Nintendo about this recent 64 bit announcement is, "what's your storage mechanism?" It's going to go way beyond the 16 megabit RAMS that are in place right now. In a couple of years, 16 bit games are going to be passe and there isn't going to be any market for them. People are going to be moving on to 32 bit and 64 bit games that are going to require very, very large amounts of storage in order to be able to play them properly. So maybe what we're saying is that the gaming content won't be available on these networks, — maybe that's going to the reality of it.

Mr. Sheppard: What I'd like to do now is open it up to the floor the audience can get some questions in. Any questions out there? Could you stand up and say your question loudly?

Question: How does HDTV fit into all your plans or is it so far out you can't even afford to think about it right now?

Mr. Sheppard: HDTV. Any thoughts?

Mr. Luehrs: I'd like to comment. As we think about these digital networks and digital deployments, HDTV, as we see it, is one more kind of service that needs to be delivered into a subscriber's home. So when you boil it all down, it's ones and zeros that are coming into this home and the network is going to be able to deliver in a 6 megahertz channel something like 27 or 30 megabits per second of information. I can choose to break that up into 10 megabits that I allocate to being able to deliver this HDTV program and another 4 megabits that I choose to allocate into some other piece of service in my home and sort of break that allocation up. What we see is HDTV will very definitely be a technology that will exist in the marketplace. Personally, I don't see it being a very widely dispersed technology. I think it's going to be that high end, early adopter niche kind of TV experience, but it's one that we have to account for as we build these networks and infrastructures. The system has got to be able to accommodate that kind of TV screen format as well as it's bandwidth requirements.

Mr. Dolan: Another comment on that is that with full HDTV, if you look at the benefits you'll get in terms of the video quality and you compare that to what you can get just by going digital and transmitting what is currently considered a studio quality digital signal, it may be transmitting in 16 x 9 format. The difference between that intermediate step, which will be handled by the kinds of boxes that we're talking about deploying, we'll see the difference between going up to full HDTV. It's probably going to be minor in consumer's eyes, but the actual cost to implement full HDTV over that intermediate step will be very significant in terms of the processing power and memory that have to go into the box.

Mr. Thompson: I think I would agree that it's just a matter of bits whether you're a digital network, if you deliver megabits, you can deliver roughly VHS resolution movies and if you deliver at 20 megabits, you can deliver HDTV. It's just how big the pipeline is. I think it's likely that one of the places where you'll see HDTV first is in satellite delivery because it's fairly simply, for instance, when it's used for direct TV to allocate some of their bandwidth for an HDTV signal. It's very simple to add in an HDTV encoder by linkup in Colorado and broadcast HDTV, provided there are televisions down there to receive it. So, you're likely to see

the first broadcast of HDTV, I would project, around the summer Olympics. I think that's a goal all the hardware manufacturers would like to achieve. I don't think there are going to be very many televisions in consumers' homes to watch it, but it's likely there'll be some in bars and public gathering places as a technology demonstration. However, Simon brings up a very good point. You know a 16. 9 TV done in 720 pixels by 480 active lines on the screen looks extremely good and let's face it, 60-70% of the TVs sold today don't even have a comb filter in it. A comb filter is necessary to get you up to full NTSC resolution. Without a comb filter, you're operating at VHS resolution. So in the mass market, there's no compelling evidence that a lot of people would pay a premium for high resolution. That's mass market. Now there's always the narrower market of the video buyer who was the guy who bought the first VCR and the first camcorder. There will be a market there, but it's not going to be hundreds of millions of homes, tens of millions of homes, or probably even a million of homes by the year 2000.

Question: What relationship do you see between the business market and the home market? You know the business market is the video conferencing with information delivery and there's standards, hardware and networking, you are talking about all the same issue in the home. Do you see a relationship between those two multimedia efforts?

Mr. Ryon: Yes. Our research shows that 80% of the market in multimedia is in the home and that there's very little going on in business other than applications like video conferencing. There's reasons for that and I have a whole presentation on why that is, but I'm not going to go into it right now. Most of where multimedia is seeing some success in businesses is largely in the advertising, presentation and kiosk areas — a number of these areas where media is already in place and multimedia or digital versions of the media is a way of adding utility and making the cost cheaper. However, businesses have been slow to adopt multimedia because it doesn't necessarily make them anymore efficient or save them any money except for in these areas of presentation, training and education — the standard media areas.

Mr. Thompson: If you look at it in terms of digital video, that's being delivered at businesses today. Many private business networks use a compressed digital video satellite delivery primarily for corporate communications and also for training. Networks like Westcot, for instance, are delivering corporate training to GM car dealers. I think you'll see a certain amount of applications there. Certainly, there's no reason why one of these boxes can't reside in the PC on your desk and if you want to take a seminar on transmissions of digital video, there's no reason why that can't be stored on a server someplace. Just like you get E-Mail off of a network, there's no reason why you can't get educational training programs that are corporate or business-oriented using exactly the same technology. But I do agree it will be a significantly smaller market. It may be an early adopter market where you can sort of break in these technologies because the businesses are always showing a little higher willingness to pay the consumers. That's where the PC business started out and it worked for the consumer.

Mr. Luehrs: One of the factors of technological barriers that may have to be overcome is that business would like to have two way video, in other words, this concept of video conferencing. For that you need either a good network or at least, in their particular case, they probably don't need full motion video, so it could be done over telephone networks. But what you need is probably some kind of compression engine at the point of let's say the business so that I can send information back up stream in a compressed format. Now you have to have compressors and decompressors at both ends of the transmission, in other words, at the sending end as well as the receiving end, and my sense says as we work through developing lower cost

decoding technology that can go into the set top boxes in subscriber's homes, I can see a much larger business application.

Mr. Sheppard: Any other questions back there?

Question: How many boxes will be required in the home or are there plans to have multiple outlets?

Mr. Luehrs: I'll start with that. If we continue in this tradition of having information delivered via broadband into the home and if you want to have multiple services delivered simultaneously that might be in different parts of the broadband spectrum, then you're going to need multiple tuners. If you have multiple tuners, that means you either have multiple boxes because along with the tuner goes the D-mod and the decompression. If not, you've got to be able to consolidate those all into one residential gateway, which might be at the entrance to the home and then you have several spigots that are going out to the various appliances in the home. I don't think we know the extent to which multiple outlets are going to be desirable in the home. I think that's really a function of what we ultimately get to for a price point as well as what customers are willing to pay — that will somewhat drive the technology. At the moment, we're all talking about a single box on top of a single TV and if you have multiple TVs that you want the service at, you're going to need multiple boxes. Ultimately, that's probably not going to be the most cost-effective, but in the near term, that's probably the way it's going to start.

Mr. Ryon: I'm not sure that you're ever going to be able to see a distributed version from one box just for economic reasons for the cable companies. I think they're going to be interested in getting the extra rental fees from people for that. Currently, I've got five decoder boxes in my home and the cable company is making a lot of money from that. However, that just happens to be in my family, in my home — that's just our personal willingness to pay for those extra boxes, but I think those companies are going to want to get the extra rental fee for it.

Mr. Luehrs: One other comment. One way we see this working, which I think is very typical of all of these industries, is that they start out when someone comes up with a compelling service. For instance, we launched a digital audio service about 1 to 2 years ago where we were offering 30 channels of digital audio music delivered into the home, 30 narrow cast formats. That requires a separate box.

3DO launched their game player and, at the moment, that requires a separate box. There are people who are providing electronic program guides for TVs that require some kind of a separate box. What happens is the subscriber is now going to be inundated with all these little boxes and what he's going to want is for us to collect them all and put them in to one compelling platform that handles all of these different interesting applications. So from our perspective, we want to integrate digital audio into this box so I can have my DMX coming out of that same box. I want to have game capability via the Sega channel and I want to have electronic program guides — all in one place. Well, all of these businesses start up with separate boxes, but over time they've got to get them placed onto this single platform to make the whole business successful.

Question: We keep coming back to the barrier of cost getting out to the users. I am curious about how advertising can offset this barrier of cost. Not that I would want to sort through the last 500 hours of soap commercials, but can the system, like video on demand, eliminate all commercials and use the time shift? Can you still keep them in or how do you typically try to leverage the advertising we have on TV today into this new world of digital TV and still have the value?

Mr. Ryon: I follow the advertising industry because I believe that is going to be a key economic indicator of what the pricing is, just as you said, and the advertising industry is

really very, very nervous about this whole interactive TV environment. I believe it's going to be necessary. Advertising dollars are going to have to pay for part of this to make it an affordable service, but the advertising industry is extremely nervous about it because on their end, they have to be able to prove some value to their clients about how the advertising works. In product areas that you want very high segmentation and very, very focused, interactive TV in these various channels is going to prove to be a very worthwhile investment. The issue is that over 60% of the advertising dollar comes from products that are generic in nature, like soap and all of these household products, that really have to be hitting a very large portion of people. If they have to split those advertising dollars off into these various segments, i.e. the channels, they're extremely nervous about how they're going to be able to prove value to their clients. What they're going to do is make some very hard choices and start investing only in those channels and programming elements that are going to provide the value back to their clients. I think it's going to be basically a survival of the fittest. I personally don't believe that the economics are going to be able to fill up 500 channels. I believe that it's going to be very difficult for the advertising industry to play an active role in that many choices. They're going to have to be very narrow in terms of what they're offering.

Mr. Seeman: To add to that, I don't think broadcast advertising is going to go away. Soaps, soup and a lot of the low margin goods that depend on a very large audience have to be broadcast advertised. What interactive TV offers is the opportunity to very much target your advertising and that's a very different set of products. For instance, Jaguars — something with a high margin and a very specific customer segment. You can target it to whoever you want and then have interactive advertising in the sense that now the user can grab the kind of information that he or she wants to act on. Now you have the information about how this person acts and you can get that back to the advertiser. It makes the feedback loop to the advertiser all that much more effective, so there's potential for advertising to play a role — certainly not the large funding of it, but there's a role for advertisers. The risk there is that we potentially lose. The users are very afraid of having their private information sent out onto the network and we need to maintain the trust of the user. So that's going to be a very delicate balance. We're going to have to ask for permission every time we get information on you or else you may want to protect yourself by disconnecting.

Mr. Ryon: That's been a big issue in some of the other research that I've seen. The whole privacy element is extremely high in terms of consumers' weariness about having a box that's intelligent, interactive and can provide people with a lot of information. I think Pac Bell's probably got better experience than anybody with this caller ID sort of controversy that has gone on over the last two or three years in California.

Question: One of the weaknesses of broadcast advertising is there has not been a direct response. You can ask to put an 800 number on the screen or ask somebody to write in, but with interactive you can get a direct response, like a coupon in a newspaper or magazine.

Mr. Ryon: There are very large benefits to segmented user response, all those various elements, but the biggest benefit of advertising is it supports current TV models. You're in there for brand awareness. You're not necessarily looking for response back, but you're there for awareness, to keep putting your brand in front of them, and the benefits that your product provides.

Mr. Sheppard: Actually, I wanted to inject a question at this point for the semiconductor marketeers in the audience. What do we think the typical semiconductor content will be in the set top boxes next year and maybe five years out? Maybe Simon has an idea he can share with us.

Mr. Dolan: I think it's easier to address a couple of years out. I think the figure that's being thrown around a lot for the box, I think between $250.00 and $350.00, is an acceptable price for a box top cable operator, so we use $300.00 as a figure. I think if you look at that $300.00, and that's the price that the cable operator will sell when he buys the box directly from an SA or direct competitors, probably almost $100.00 is going to be semiconductor content including RAM logic, microcontroller, DMX signal stuff, give and take some modularity. I think that's what we see.

Mr. Luehrs: That's generous. There were some people who wanted $299.00 of the $300.00.

Mr. Sheppard: Out of curiosity, how much DRAM will be needed in one of these boxes, volatile memory, a megabyte?

Mr. Dolan: That's one of the big digicipher debates going on right now, particularly in the cable industry and this is a Digicipher versus MPEG and a low delay MPEG versus full MPEG debate which affects whether you need one or two megabytes of DRAM in the box. That's for the video reconstruction, a smaller amount of memory required for transport. But essentially it's either one or two megabytes.

Question: Bill made a comment several times that there would only be one pipe going into the home. Two questions, one — are you expecting some type of regulatory issues there with restriction coverage in a region and, if not, how many different providers do you see participating in a given area in order for you to still make some money? You've got all this PCN stuff coming out, the frequency is going to be allocated and a lot of people are looking to use that as another access into the home. There's a lot of stuff going on there and there's a potential for a lot of providers to be out there with satellite or twisted pair or cable or 1.9 gigahertz stuff. How many hogs can you have in the trough here and still survive?

Mr. Luehrs: At least you didn't say group grope like we heard yesterday. I think you will definitely have a twisted pair. There is always going to be POTS, plain old telephone service. You are going to have a broadband pipe in the home and then I believe you're right, there are going to be wireless entrants into this that are going to have opportunities to provide some subset of these services, so it's probably premature at this point. We don't know how it's all going to roll out. My sort of single pipe into the home was really aimed at the fact that I don't believe you're going to have a telephone company trying to build a broadband fiber architecture all the way to the home as well as cable. Cable right now passes over 90 million of these 93 million homes so that network is already in place. What people are going to do is take advantage of the fact that that network is out there. Whether telephone companies over time just buy out cable or cable companies and telephone companies merge or yet some other players become involved isn't all determined. Wireless companies may become more involved and deliver some of their services via wireless and some of their services perhaps return paths via this two way cable plant. I think that's the way this thing is going to shake out.

As far as the regulatory, I think that the regulatory climate needs to exist so that all of these kinds of services have the opportunity to play on a level playing field and we hope that our government will have the kind of foresight to let that happen. Up until now there have been some pretty regulated monopolies, but I think that they've kind of seen an opportunity here to open up the playing field and let this electronic super highway be built, not by government taxpayer dollars, but by entrepreneurs who want to be out there first with the best.

Mr. Seeman: Let me speak from a Pacific Bell point of view. We will have a broadband network in the home. We understand the economics in the cable TV world where they've already got the coax to the home. We'd like to

benefit from that by cooperating with cable TV. Our experience is that we want that in a greater degree than cable TV does. Cable has a lot to lose from cooperating with us. What that leads you to, if you follow that chain, is two broadband networks to the home. Either it leads you to two broadband networks to the home or somebody abandons theirs. We're not going to abandon ours and we don't expect cable to abandon theirs. So I think we will see two broadband networks to the home in many areas.

Question: How does all this interact with my PC at home if we replace Blockbuster and U.S. Robotics and Hayes?

Mr. Thompson: Well, certainly the reason why the set top function couldn't be a card that goes inside your PC is this — you'd have a little bit of a problem in that video for computers is non-interlaced and video for TVs is interlaced. Other than that, I don't see any reason at all why your computer couldn't have a video decoder card in it and your kid couldn't sit up in his room and do his homework over the network. Let's say she has an assignment to learn about elephants. She calls up the networks to the National Geographic video on elephants and discovers elephants live in Kenya. She decides she wants to learn more about Kenya, asks for a file on Kenya and gets a little video delivered to her PC that way. I mean the MPEG decoding is there and, of course, you already have a processor there inside the PC that you don't have to duplicate. I think that will be a market. It will be a smaller market than the set top box initially, but there's no reason at all why it couldn't be configured to work inside a PC or as a card inside of a MacIntosh.

Mr. Dolan: It's not really my province, but I think the whole idea of the PC being replaced by the set top box is like [inaudible]**** PC used to do text based things like spreadsheets to pull up information, send faxes and E-Mail. You just have to think when you sit on your couch, your TV is ten feet away, it's got this horrible interlaced low resolution display and you can maybe see ten rows of characters on a screen at a time, but not very well.

Mr. Seeman: You have no keyboard and you don't want a keyboard.

Mr. Dolan: Right. I think they're actual separate markets and applications.

Mr. Seeman: It may be the same wire coming though. CompuServe?

Mr. Dolan: Well maybe, but I think as Bill said, in England that's already happening. The cable companies compete with the telephone companies for services. Once you have the pipe there, that can happen.

Mr. Sheppard: Any other questions?

Question: It seems like this whole discussion has been on the video rental and games. You know when I go back and look at the numbers Bill put up on the screen here, that would be 11 and 14 billion dollar market. It's kind of like the trojan horse where they really may want the 80 billion dollar phone access market. Maybe the question is, when do you see this capability actually starting to be able to provide phone access services? Maybe they get in the door with the cable TV stuff and then try to get the 80 billion dollars on the home side.

Mr. Luehrs: That's actually part of the trial that Time Warner and the full service network is deploying. There is actually ATM delivered all the way to the set top box so they're going to try that. This network is going to be basically deployed this year with some early proof of concept, if you will, boxes that will be out there in December. Then they'll really start rolling it out next spring. It's really a big open question as to whether or not the economics of using that kind of an approach can work. However, I believe over time that you're going to get in the direction where telephony type services are going to be delivered, or are capable of being delivered through this kind of a network and

there will be a two way cable network that has the capability of passing telephony and alternate access information over that network. By the same token, you have a trial we're also participating in with U.S. West in their video dial tone service trial in Omaha, Nebraska. They're basically going to offer video services, but without telephony coming down that cable, that telephony is going to be reserved for the twisted pair, so I think its really too early to tell. One of the nice things that I think from a Scientific Atlantic perspective is that we sort of see ourselves as the arms dealer. We'll sell boxes to both.

Mr. Sheppard: The mercenary. Another question back there?

Question: As a user, I resist more boxes. I love my computers. Is it likely that we'll have add on boards for our PC that can do the things we're talking about here? I don't want a set top box. I want to dump it in my computer and consolidate rather than proliferate.

Mr. Luehrs: Two comments I would offer. One is that we already have a decoder board that goes inside of your PC and we do that for something we call digital storage and retrieval. We've developed a system working with people who are in the advertising community that want to be able to deliver 30 second spots very quickly and they're doing that via a cable network instead of bicycling them around, using Fed Ex and so forth. So we can store these spots, if you will, on hard drives and then spool them out into video coming off of a hard drive that comes out of a PC today. We're basically using PC chassis. That's the sort of a product we could talk to you about off line.

The second thing I would say though is that the PC is really a workstation. That's where people come home to do work. Then there's also a game place, or an entertainment place, and people want to come home and be entertained. I don't think those two machines become one machine. Those are two different places in your home that have two entirely different purposes. When you come home and you sit down in front of your wide screen 40" TV, you want to go click, click, click with a couple of simple buttons. You don't want to have to sit down and fire up the modem and work with the keyboard to get to the point where I'm now seeing what kind of interactive programming is on tonight. That's not our sense of the Joe six-pack typical consumer, or I heard a new one — Biff Perrier. He wants to come home and press a couple of buttons and sit down in front of his TV and be entertained. He doesn't want to be entertained by the PC.

Mr. Ryon: Actually, when I was at Apple in the Consumer division, we developed a product that was merging a television and a PC and we did a lot of focus groups on it. We found that people had a very tough time identifying what it was. They wanted to put it in one of two boxes. They wanted to either put it in a PC box or a TV box and they didn't like the idea of something that was merged. So we wound up creating a computer that had the ability to play and basically had a TV tuner on it. That's the way we had to position it because otherwise, it was a disaster in terms of identity. People have that very fixed identity so it's a very tough market to crack in terms of merging the two. The two reasons why people buy computers for the home is first of all, to work at home, and second, to provide education at home. Everything else is a distant third and fourth — way down the list. So, people really view their computers at home as a work place and not necessarily as an entertainment center. However, I've never been able to reconcile this one thing that PC software — there's been between 70% and 90% growth rates over the last several years in PC software and I've never quite reconciled how that happens. I don't know if it's being played at work or at home in between very boring sorts of work duties, but that's one I've got to figure out. Where is that software going?

Question: Game software?

Mr. Ryon: Game software, right. PC-based game software has grown 70% to 90% over the last few years.

Mr. Sheppard: Any other questions? Well, thanks a lot for coming to the conference. I hope you enjoyed it.

The Future of Flash Memory

Nicolas Samaras, Moderator
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Dataquest Incorporated

Panelists:

Bruno Beverina
Vice President, Memory Group;
General Manager, Flash Division
SGS-Thomson Microelectronics

Walid Maghribi
Vice President, Non-Volatile Memory Division
Advanced Micro Devices, Inc.

Dr. Toshiaki Masuhara
General Manager, Technology Operations,
Semiconductor and IC Division
Hitachi Ltd.

Tony Barre
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Intel Corporation

Osamu Ozawa Ph.D.
Technology Executive
Toshiba Corporation

Mr. Samaras: Well, good afternoon and welcome to the Flash Memory panel. What we'd like to do this afternoon is just find out what flash memory is about and what the future holds. We have a distinguished panel of members from Europe, the U.S. and Japan and what I'll do is introduce each panel member and then we'll follow that up with some of their views on the future of flash. I'd like to start with Dr. Osamu Ozawa, who is the Technology Executive V. P. for the Toshiba Corporation. Dr. Ozawa, of course, has been the Executive Member for Toshiba since April of 1993 and he's responsible for all the memory development NAND and NOR EEPROM and the reliability of memories. Dr. Ozawa graduated from Nagoya University and started work at the R&D Center of Toshiba in 1971. There he developed the Static Induction Transistor. In 1979, Dr. Ozawa moved to Toshiba's new Semiconductor Device Engineering Lab. He has been heavily involved in DRAM, as you can see from his resume, and we'll find out why he chose that emphasis later perhaps.

Let's move on to Bruno Beverina from SGS-Thompson in Europe. Mr. Beverina is currently the VP of the Memory Group and General Manager for the Flash Division at SGS-Thompson. Previous to that, he was General Manager for the EPROM group. Mr. Beverina has very strong beliefs about EPROM so we'd like to ask him about that a little later.

I'd like to continue with Dr. Toshiaki Masuhara, who is the General Manager of Technology Operations for the Semiconductor and IC Division of Hitachi. He has joined us from Japan. Dr. Masuhara was appointed General Manager of the Technology Development Operations of Semiconductors and IC Division this year and he is responsible for the development of process packaging CAD for LSI devices. From '91 to '93, he was in the Telecommunications Division at Hitachi so he brings a wealth of experience to flash memory devices.

Walid Maghribi is a Vice President for the Non-Volatile Memory Division at AMD. Mr. Maghribi was appointed Vice President of the NV Memory Division in 1991. He joined AMD in 1986 as a Product Line Manager and, in '89 he was promoted to Product Line Director.

Mr. Tony Barre is the Director of Strategic Planning for Intel's Memory Division. Over the past 16 years, Mr. Barre has served in several Management Domestic and International Marketing positions and he is very well-versed on what exactly is happening in Flash Memories.

Having said that, what I'd like to do is just say a few words about our view of Flash Memory and why we're here in the first place. Then I would like to have each panel member give us their view of where Flash Memories are going from their company's perspective. I think the reason we're here is because Flash Memory is potentially an explosive market. From a memory standpoint, it is really small, relatively, to DRAM and SRAM right now, but it has the highest growth rate and the highest potential. To give you an idea, the compounded annual growth rate between '92 and '97 is 63% and that is very unique to Flash Memories. Of course, this is a new market and we expect that of more mature technologies in markets, but this year it is going to be a $400 million market and we think that in 1994, it is going to approach 1.4 billion dollars. Wait, I've made a mistake. 1993 was $650 million, or at least that's what we expect it to be.

There have been a lot of discussions in the recent past about Flash replacing DRAM and, of course, EPROMs and EEPROMS so these are the issues we want to explore today. The way I'd like to proceed with this is to ask questions of the panel members, but I'd like to have audience participation as well. Please speak up if you have a question and I'll repeat it for the panel members. Having said that, I'd like to start with Tony Barre and I'd like to ask him for his view of Flash Memory both from a technology and a market development standpoint. Tony.

Mr. Barre: Thank you very much, Nick. It's really a source of pride to be associated with a market that's growing as fast as Flash is. It's real exciting to be in the middle of it and I want to have my first request for Nick. The next time we convene, I'd like to ask you to compare the growth rate of Flash in its first five or six years to the growth rate of any other memory technology and begin tracking and reporting the results to us at each one of these sessions. I think we'll discover that Flash is setting a new record for unprecedented growth. I'd like to talk about three things. The first is the market for Flash and why it is that Flash is growing so fast. Second, I'd like to talk a bit about the technology. Finally, I want to touch on how the technology can fuel that growth. I'd also like to discuss some barriers and obstructions that really stand in the way of Flash growth and the challenges that lie before the manufacturers to overcome those barriers.

The market evolution from the beginning has been one of simply code storage. In the earliest

acceptance of Flash, it was for people who wanted to have updatable code storage, but their version of updating it typically involved people, a computer at a remote site that required people to get involved in bringing it in, a programmable radiotelemetry device and an airplane that required the pilot to bring it in for re-programming. Being able to re-program your code remotely saved the cost of people so the initial value of Flash was compared to the cost of people doing service calls. In general, this kind of market has grown slowly. It's growing for sure and it's very, very broad-based, but the fundamental growth rate, if you look at embedded markets, is on the order of 10-15% per year — not anywhere near the compounded annual growth rate that Nick mentioned. In addition, the design cycle in these markets is very long. Our experience is that the design cycle can be on the order of three years. If you compare that to the computer market where the design cycle is on the order of three months or maybe nine, you can see that the computer market is more responsive to the innovations that the Flash technology might provide. So the second generation of penetration, the updatable code storage concept, is pretty well recognized for Flash and Flash is in all the key applications and growing rapidly.

Data storage is really the next area. That's really where we're in the threshold right now. The portable computers are fundamental to this area, I think, and the growth in Flash depends not only on the growth rate of portable computers, but on the penetration of Flash into those computers. In general, this is a slower process because of the inertia in the marketplace. Flash is accepted in a number of those applications and there is a number of leading edge products out in the marketplace like HP's OmniBook and Apple's Newton that are using Flash in portable computing applications. We're just at the verge of some new markets. Gordon Moore is fond of saying that most of the new growth in new technologies comes from applications you haven't been able to see yet. Some of the ones at the edge of this idea are credit cards with Flash embedded in them and patient monitoring cards where the data for a patient's medical record is kept in a card. Those are applications that are just beginning to emerge, but you can well imagine the potential of most of the people in the world carrying around their medical records in a Flash card. That's an awful lot of bits that have yet to be penetrated.

Finally, I should address the potential markets for Flash, including some that are just beginning to emerge. It is very analogous to emulating the human senses — the bits that are required to store sound and visual images are just enormous and Flash is at the edge of penetrating these markets. Some of the leading edge consumer manufacturers have introduced hand-held dictating machines with Flash in them and some of the leading edge high-end photographic equipment manufacturers have introduced Flash in the place of film. So that's where the market might be going. I want to speak about some of the technology only in terms of scaling. I think that the technology is beginning to be fairly well understood. Manufacturability is certainly a challenge in getting the quality of the oxide that you need to keep the parts reliable, but fundamentally, Flash is very, very scalable and we're pretty confident that it's more scalable than DRAMs.

So this leads us to the potential for Flash to be less expensive than DRAMs and that leads one to question if Flash will replace DRAMs. However, I don't think that's really the way to look at it. Flash is never going to be able to have a write time as fast as DRAMs. It's fundamental to the technology — it's not going to be write. So there's gonna be separate applications for each of them, but as new markets emerge, Flash is gonna fit where DRAM won't. Flash is non-volatile and DRAM is not. So I don't think of it as replacing DRAMs, but I see it as growing into new markets that DRAM hasn't been able to penetrate before, such as portable computers. So that brings us to some of the barriers that exist. In getting into code storage, there weren't

as many barriers. When getting into portable computing, for example, some of the biggest barriers that are standing in the way today are fundamental software hierarchies, software memory and software intrastructure that supports the memory. So the memory hierarchy in computers has DRAMs and a little bit of SRAM for cache and disks. In order to put Flash in there, you really need a different way of manipulating the Flash, a different memory hierarchy. HP has a good start in taking some of the codes that used to reside in DRAM and puting them into Flash to make it ROM-able. So there's some changes in the fundamental software and in the intrastructure that need to take place in order for Flash to penetrate the new markets. I think the challenges that lie before the manufacturers of Flash are really threefold.

The first is to deliver continuing increments in functionality. Flash is a new market, as Nick said. It hasn't even been exploited yet for all the new functionalities it may provide.

The second is to build a capacity. Flash — well, any semiconductor factory these days — costs a billion dollars to build and that's not a challenge that's easily taken on, especially in a market as dynamic as Flash where it's hard to predict exactly how big the volumes are going to be. The result is what you've seen for the last two years. People have been conservative about adding capacity and the result is that the market's been short. I wouldn't be surprised if there'll be a shortage of .4 micron capacity and, subsequently, the next generation that comes after that as well.

The final challenge is for the semiconductor manufacturers to go beyond the syndicate of new technology to get rid of the roadblocks. This has to do with much closer cooperation in working with customers than we're used to because changing the infrastructure and the software in certain established markets is something that is critical to the acceptance of Flash and yet, it's not something that is easily taken on by our customers.

Mr. Samaras: Thanks, Tony. I'd like to ask Dr. Ozawa from Toshiba to tell us about his view of how Flash Memory is evolving and, of course, I'd like to take this minute to say for all of us in this room that Toshiba is, of course, credited with inventing Flash Memory Technology. So Dr. Ozawa.

Mr. Ozawa: Yes. I think that Toshiba is one of the oldest companies that developed EEPROM and right now, we are developing all types of EEPROM. I mean NAND and NOR. I think once we are marketing the [inaudible]**** and the [inaudible]**** of that file will be 40 megabytes using 32 and may not meet the demand. This will be developed around 1997. We think the NOR device will replace EPROM so in Toshiba, we have a number one priority for NAND devices — that will have a bigger market. The NAND device has several advantages compared to the NOR and I think those will be higher density, higher programming time compared to NOR and higher erasing time. These are advantages over NOR devices and, of course, NAND has a disadvantage over NOR, which is access time. The access time of NAND is slower, about twice as slow compared to NOR. The reason why we have a slower access time is that we cannot random access NOR because we have NAND already in this area.

Finally, I wish to say that concerning technology trends, the future will be determined by how many cycles we can [inaudible]**** using these NAND or NOR devices. I think essentially NAND devices will have more cycle time compared to NOR because the memory and electrons go through the [inaudible]**** wider area compared to the NOR devices. So we will have a higher reliability compared to NOR devices. NAND will have a higher reliability compared to NOR. I think another issue is shrinkage. I feel that if you use a very small dimension of 0.5 or 0.4 micrometer rings in the operation of NOR, you have to add some injection to [inaudible]**** will be more disk cards compared to NAND.

NAND is a very simple operation from substrates to floating gates through the [inaudible]**** using [inaudible]**** NOR [inaudible]**** mechanism. So I think the shrinkage will be easier for NAND to sell compared to NOR because we can have a very small permanent oxide. In the future, I believe NAND will be more highly produced compared to NOR.

Mr. Samaras: I think what we'll do is approach the technology side of it towards the end. I want to keep us focused on the marketing side in the beginning and I'd like to ask Mr. Beverina from SGS-Thompson to tell us how he sees Flash Memory evolving from a technology and, of course, market standpoint, especially in Europe. What exactly is happening?

Mr. Beverina: A lot of that has already been said so I will keep this short. All of us know that Flash has a growth potential. We are today, as you said, at $600 million dollars and by next year should be reaching approximately $1.5 million dollar so it's very, very big. Maybe Ozawa is right, that in the actual [inaudible]**** would be even. Europe. The first memory was primarily developed in the United States and has to do, of course, with the [inaudible]**** application. In the very beginning, they started with the computer and we know that the computer industry is much stronger in the United States than anywhere else. However, Europe is still a market of about $150 to $100 million dollars in 1993. One perspective is that it's better to grow faster because one of the next markets where Europe will be playing a major role in Flash development is in the telephone, but in particular, the cellular telephone. Well, deflation can present big opportunity and it is mainly all sold for the big memories of twin megabyte list. Of course, in Europe we have all the American computer manufacturers. I think what has happened in America as far as the computer industry is concerned is going to happen in Europe and at the end of the evolution, the big market that will result will probably happen at the same time in all the countries. The only country that probably will start a little bit late is the Asia Pacific market. Now, let's look at some of the applications for the different memories. 90% of the Flash are used in some [inaudible]**** type of market. So the mass storage disk type of market is still very, very small. Looking forward, even in '97, the mass storage market or the disk type market will not be bigger than 30% of the total Flash market so in '97, [inaudible]**** type of market will still be bigger. Of course, the situation is going to be reversed eventually in the beginning of the [inaudible]****. Given that, the choice of the technology that will be dominant is a right consequence so the technology and the architecture are first to follow the application and the application is driving the type of technology. On top of this, Flash is a memory. It's a commodity and as a commodity, what will be driving it is what they call time to volume, time to end and time to cost. The technology that will be more easy to be [inaudible]**** is a high yield, high quality — that will be the one winner from a business standpoint. This, of course, is according to our vision [inaudible]**** the one fact that if we look at the Flash from an application point of view, so far or at least in the last five years, even [inaudible]**** types of applications, the NOR type of architecture is still a winner. The NOR type of architecture shouldn't be used as mass storage. Then [inaudible]**** anyway that the name that could have the space. The name fits perfectly, as Mr. Ozawa said, in the disk so he is just copying the disk, but still, the greatest part of the market is the one that will enforce the standard. For the ROM, I believe that from a scalability and manufacturability point of view, the NOR is simple. The NOR has an advantage over 20 other competitors in the industry making the EPROM so it's much easier to get to the cost structure. If we look at it both from a market interest and from a technology point of view, at least in the [inaudible]****, I believe that the NOR solution will be the winning one. It has to be said [inaudible]**** everybody was just thinking that Flash is going to give rise to what somebody called the Second Golden Age of the Memories. This is likely to happen in the year 2000 or around then and this

is strictly linked to the emerging mobile computing. We've been hearing these days a lot about mobile computing. I personally believe that Flash will be the product that will allow the mobile computing to take off and again, in mobile computing, what is likely to emerge is the necessity of having the so-called execute in place characteristic. Then, of course, we'll have to develop the problem software, but the execution in place will really be the winner. Again, this grows from an application point of view for the NOR. My bet is that the NOR solution will come out ahead in the long run due to it's EPROM-like type of characteristic — it is the only one that fits with the necessity of desecration in Flash. That can't be made because of the limitation in the performances by demand.

Mr. Samaras: Thanks, Bruno. I think we have an equal representation of NOR and NAND on the panel, but we'll get back to that in a minute. I'd like to give some time to Dr. Masuhara to give us his view of Flash Memory at Hitachi.

Mr. Masuhara: Our company is heavily involved with the DRAM industry right now, but I have a table here which describes the millions of units by part number for each year. If you look at the average growth rate and you compare 1997 and 1990, DRAM will be -2.8%, SRAM will be 1.4% and EPROM will be -3.1%. Flash is 74%, ROM is -8.2% and EEPROM is 17.9%. So obviously Flash is a rapid growing market. So we are looking at Flash Memory to be very viable device in the future. I think in terms of applications, there are three major fields. The first is EPROM replacement application. For instance, in the cellular phone you need EPROM or Flash Memory to store your bios or some application software. In the laser printer, you also need some very advanced software. For this purpose, you need fast random access. Maybe in the future, we shall see the 3.3 volt and single supply. The second major application is memory cards like PCMCIA, especially since we are going to have PDAs in the market within a couple of years. This market will grow up very soon. For this memory card, we require the byte density of higher than 2 megabytes and we require very low cost. We also need very fast access time as well and software features. The third major market which will emerge maybe at last portion of this decade is [inaudible]**** higher than 10 megabytes and this could be HDD replacement, voice recording or a digital camera. There may be a huge market involved in this area. For this purpose, low cost and fast re-write times are required. The voltage should be less than 3 volts as well. So to meet all those market requirements, I think there will be many types of technologies. We have NOR technology, NAND technology and Mitsubishi has developed Di-Nor Technology. We have been working on NOR technology to develop one to make Flash memories and we have announced development of so-called AND technology, at least at the conference level, and I think this is going to be very viable to us. This uses the thundering diction for both writing and erasing, which makes it easy to have very high reliability and also write [inaudible]**** endurance is much higher compared to NOR type. So I think the AND type device would meet most of these requirements. I can describe a little bit more about these in more detail later.

Mr. Samaras: Thank you. Finally, I'd like to ask Walid with AMD to give us his view, and before I do that, I just want to make sure that everybody knows that last year, out of those $400 million dollars or so, AMD was the Number 2 player in the world after Intel and maintained about 69% of the market. This is a mass storage market and things will change in the future, but let's hear what Walid has to say about it.

Mr. Maghribi: The year is not over yet. I don't want to repeat what the other panel members have covered so let me cover some new areas in an effort to make this a little bit more interesting. First of all, Flash is probably the most exciting product of this decade. It is referred to as enabling technology. It is allowing system manufacturers to create some new applications. It's not just using the stored

information to allow you to do things in your system that you are not able to do with ROM or EPROM. In manufacturing, for example, it simplifies system manufacturing and the testing of systems so people don't have to decide where they are shipping a system. They can decide all the way at the end line and program in a certain code, whether it's going to Europe, Japan or the U.S. That gives the system manufacturer tremendous flexibility in quickly changing market conditions. That has a lot of advantages and, of course, it's the time to market that's key. You could basically develop your hardware and software at the same time — you could change your software as many times as you want while you are still building your hardware. With the Flash, you could decide how your system configuration is going to be at the last moment right before shipment and even in the field. This what makes Flash so exciting. Now, we all agree that Flash is a very exploding market so there's no reason to discuss it. We must now ask what the applications are. Some of them are growing a lot faster than others. From our point of view that we see this year, some markets in Europe are probably the first and the largest markets today. Europe is eating up Flash products at a faster rate than anything else. A very high density in the gigabit type of density is another market that is exploding. Without Flash, that market would not be what it is today for networking, bridges and routers. For example, it's allowing the networking company to do things they were not able to do with EPROM. Today in networking, Flash has become a must. Without it, the growth of some of these networking companies would probably not have been realized. Of course, PCs, especially high end PCs and workstations, high end laser printers and some modern applications are the products that drove the demand, but common trait for all this is the ease of re-programmability or the ability to get the user to change real time what he wants to change. Now, let's look at some of the trends from the technology point of view. The first generation of Flash, introduced by Intel, was what's called a 12 volt product. Now, the new trend in the industry is a 5 volt or a single voltage product. The 12 volt product does not make sense long term because, as we all know, the computing is becoming more and more mobile and is moving to lower and lower voltage. There is no reason to have two power supply when you could have one, especially when you could add the power supply feature for no additional cost. The second most important trend is sectoring. The first generation of Flash was called bulk erase, where you were forced to erase the whole memory all at once. The new generation of a product is now sectored so you have the ability to erase a portion of a Flash one time. This allows you more flexibility — you can store information in one area of the memory unchanged or maybe use it in the form of boot lock for PC applications. High speed is another trend that's occuring in Flash. A couple of years ago, a product was introduced in the 120 to 150 nanosecond range. Today the flash products are introduced in the 70 nanosecond and 90 nanosecond range and these are driven mainly by two applications. One is the very fast rate of the microprocessor. The second is the application that is really striving for Flash, which they execute in place — that could be a replacement for DRAM. The fourth trend is the high endurance. High endurance is a must if Flash is to have any dent in the disk drive replacement market. Ten thousand cycles do not do it. We think 100,000 cycles is the absolute minimum for such applications and we see that in the next two years, one million cycles of endurance will become prominent because endurance equates with reliability. The failure rate in Flash can happen at cycle zero, cycle 10,000 or cycle 100,000 so you have to average all your failures. Of course, a part that is guaranteed to operate as 100,000 cycles will give an overall system return that is less than a product guaranteed at 10,000 cycles. Lastly is high density. High density is a must. Now, of course for memory core type applications, the higher the density, the higher the capacity. As we could see the trend in GSM application, whereas one megabyte used to be okay, now you need at least four megabytes and possibly eight megabyte. In order to do all that, and in

order for the Flash to really grow as forecasted, you have to give the market the incentive, which is low cost and in order to have low cost, we have to do it the old fashion way. We have to scale the technology and one micron technology is okay today, but in order to be competitive, you really need about a half of a micron to go into production now. It will be .35 micron in the end of the 1995-96 time frame and a quarter micron in the 1996-97 time frame.

Mr. Samaras: Thanks. I'd like to pick up on that power or voltage issue. What we have here is, of course, AMD has a 5 volt Flash and Intel has 12 volt Flash. Toshiba has a lower voltage device. So I'd like to get your view on how this thing is evolving. What is driving the power? Is it the demand from the consumer, the technology or the cost? Dr. Ozawa, would you like to say a few things about the power levels? I know you have a 5 volt.

Mr. Ozawa: Yes. Right now we have a 5 volt only 16 megabyte NAND and the [inaudible]**** in the present count will be about 20 milli Ampers using 5 volt. The NAND operation mechanism is a thundering mechanism so it doesn't require much power for this operation. So I think it could be reduced using 3.3 volt.

Mr. Samaras: When do you think that's going to happen — in two years, five years or more?

Mr. Ozawa: At Toshiba, the 3.3 volt will be used before 32 megabyte NANDS and it will appear around '96 or '97.

Mr. Samaras: 1996 or 1997.

Mr. Ozawa: To the commercial.

Mr. Samaras: Okay. Tony, can you comment on that? I thought that automotive, for example, was a very good application for the 12 volt Flash and what I've heard is that they actually like 5 volts. Is that true?

Mr. Barre: I'll answer the automotive question first. Although you have a 12 volt battery in your car, once the regulator kicks in, you don't really have a regulated 12 volt supply so indeed the automotive people would have to add an extra regulator to generate 12 volts. I think, in general, OEM customers would rather not install an extra power supply to program 12 volts, but let's begin with the technology first. We should all understand that the technology fundamentally needs more than 5 volts to tunnel the electrons through the oxide. That will never change. The voltages will change, but it will always take extra voltage so there won't be anything magic that somehow allows the chip to be programmed in 5 volts or 3 volts. It takes an extra power source and the most common way of doing that today is with [inaudible]**** so I absolutely agree that all our customers would like to have products that program with just one supply, but they also don't want to pay for it. So in order to put a charge pump on a chip right now, it takes up some space. So the result is that customers can choose between having a slightly more expensive chip because it's got the charge pump on it or they can choose to put a power supply or a small charge pump in their system and those can be bought for somewhere between $2 and $4. If you have a system with a lot of chips in it, it's probably cheaper to have a single external power supply instead of having a lot of chips that have this extra charge pump on them. Probably the single chip systems are the first systems that would prefer 5 volts and the question is whether the manufacturer, be it Intel, AMD or Toshiba, can deliver a chip with 5 volt with no incremental cost. Obviously, the next step is 3 volts. The portable computer manufacturers would like to do that because overall power goes down so they can use smaller batteries to lengthen battery life. It doesn't weigh as much and it's a little less expensive. Certainly, to pump from 3 volts to an appropriate programming power is gonna take a larger charge pump so that will be a larger challenge as well.

Mr. Samaras: I know, Walid, perhaps has a different view of this and I'd like to ask if you have a 5 volt Flash.

Mr. Maghribi: I think 12 volt was a greater product as a bridge when it was first introduced, but as we all know, Flash was based on EPROM and EPROM was 12 volts. AMD chose to second source the Intel parts in order to standardize on the architecture, but our strategy was always to move to 5 volt. With portable computing, you'd rather have one single power supply if you can. Of course, with the conventional approach, 12 volt pump may become too large and too costly. AMD's approach was to change the technology by going to the negative gate programming, which required a charge pump that is very low current and thus, has very small area. As a matter of fact, the total charge pumps on our one megabyte product is less than 2% and by the way, that 2% is not a critical area. Resulting from all that, AMD is offering a 5 volt totally for free. There is no premium for the 5 volt so a system user could save, as Tony said, somewhere between $2 to $4 a product. And not only is the 5 volt important, it also offers program erase and read at 3 volts.

Mr. Samaras: At what density do you think that is?

Mr. Maghribi: Sixteen megabytes.

Mr. Samaras: All right. So something doesn't work here. You're saying that in essence, then, customers can get that 5 volt operation for free now. Is that correct?

Mr. Maghribi: That's correct.

Mr. Samaras: Okay.

Mr. Maghribi: Our one megabyte, 5 volt product is the same price as the Intel wood block product.

Mr. Samaras: Tony, would you like to add something to that perhaps?

Mr. Barre: When we learn how to do 5 volts for free, we'll deliver it.

Mr. Masuhara: I think right now we are using 12 volt for RAM, but I think in the future, maybe at about 32 megabytes, we are gonna use 3.3 volts because by using AND types of devices, it would be possible. Let me mention two things from the technology side. First thing is that for the writing mechanism, hot electron injection is a very innovative process. We are basically flowing the current to the floating gate for the [inaudible] **** volt, so you have to have tunnel injection instead of hot electron injection. The second thing is that in order to operate that device on 3.3 or 3 volt, you have to have very tight control of the threshold voltage. It would be necessary to verify the threshold voltage bit by bit. So those are two technologies [inaudible] **** that can be developed above maybe 32 or 64.

Mr. Samaras: So 32 or 64 is the level that you expect it to drop to. I'd like to ask Bruno to join in and tell us what he thinks about the voltages. Are the people out there demanding 3 volts or 5 volts?

Mr. Beverina: The far future is surely 3 volt. The problem is when and how. To me, the driving force is cost because memory is a commodity. There is a commodity need to be first in time to end, time to cost and time to volume. That's a clear message that we, my friends, will have to pass. Then, how to get to the 3 volt with a 12 volt. [Inaudible]****. If you look at the application today or in the next two to four years, the greatest part of the market is stealing the dual voltage so the 12, 5 or 3 volt are the ones they're desiring. We project that the single voltage is probably something around 30% of the market in '97. By single voltage, I mean, either 3 volt only, 5 volt only or 5-3 as well. Of course, maybe by the end of the decade, the single voltage will take the majority of the market, but still, why is this so? Mostly because you don't really need the necessity of spending something more on the EROM and

you can actually have the possibility of simplifying the life using the dual voltage devices. Eventually [inaudible]**** a voltage converter in the system, but what about the result of application? You need a cleaner solution, where absolutely the same that you might have a [inaudible]**** supplied is very important. In that type of application, the sooner you get the single voltage, the better it is. The NOR solution from my point of view is the most important one. If we look at the NOR solution, the only possibility to have the 3 volt is to play with the [inaudible]**** as has been said before. But this is not a technology that is around the corner. It'll take some years before this dream becomes a reality. This is not the solution today, but still people need the 5 volt. How do we get there? Frankly, I believe that the possibility exists of a single voltage device [inaudible]**** plus the [inaudible]**** sooner, maybe starting from a 5 volt solution before and eventually after going to the 3 volt. So, in conclusion, long term, the 3 volt is the challenge. Medium term, the 12 volt is still the majority of the applications. Any time you have more than one device in the application, you probably do not need the 12. In a lot of applications, you might have the need for a single voltage which will be coming eventually as a market. And cost will be the driving force.

Mr. Samaras: Anybody want to add something to that? Everybody agrees? Okay. I want to move on to some of the applications. One of the more recent areas is that of solid state storage. We're hearing a lot about personal computers using PCMCIA cards based on Flash Memory for mass storage and I want to explore that a bit. Is that gonna be a big market for Flash Memory and what do people want right now? HP that has the Omnibook, I believe with ROM-able windows, and they do offer a solid state device based on a NAND technology as an alternative to a hard disk drive. Then we have Newton that just endorsed, if you will, the 12 volts by opting for PCMCIA memory cards so I would like to ask your opinions in that area. Are solid state disk drives replacing hard disk drives in PCs and who is asking for that capability anyway? Tony, would you like to tell us your view onthat?

Mr. Barre: I think the way to look at Flash as a mass storage vehicle and portable computing is to look at the most portable applications — the situation isn't that Flash is replacing hard disk drives. The situation is that hard disks don't satisfy the requirements. For most portable computers, there is a requirement for very low power, ruggedness and much higher speeds. These are areas that hard disks weren't meant to address. They're not able to deliver, but you still have non-volatile storage in those applications so you begin by saying that Flash is going to be the optimal mass storage vehicle for the most portable applications. From there, you begin expanding the penetration of Flash into less portable applications as the price becomes more attractive. I think the early choices being made by the HPs and Apples are because the market just requires the kind of ruggedness and power that Flash can deliver and that disks really can't. So again, I don't call that replacing disks. I call it new markets requiring new functionality that disks don't provide and Flash does.

Mr. Samaras: Do you have a feeling of how many Flash Memory cards will be sold in 1993 or '94 in those applications?

Mr. Barre: I don't have a venturing guess. I would suggest that you ask the manufacturers.

Mr. Samaras: Okay.

Mr. Barre: I think there is one other comment to make. Early on in the development of Flash, we advocated Flash being used for a BIOS for all computers and it took some catastrophes to make that happen. A couple of major manufacturers had recalls of computers costing tens of millions of dollars in order to re-program their bios. Since that event passed, I think you'll find that most all computers are okay now, whether they're portable or desktops or have Flash in their bios. Take a look at HP and Apple, who have chosen to deliver their

initial execute in place applications via ROM. If you were to ask their marketing and manufacturing people today who are struggling with code updates and with maintaining their bug fixes what they think of delivering their applications in ROM and Flash, I think we're heading for a similar catastrophe as that market evolves. I think you'll find a very rapid transition from ROM to Flash for delivering the basic applications in the PDAs and mobile companions.

Mr. Samaras: Okay. I'd like to maybe ask the same question of Dr. Ozawa. I know that you have a cooperative effort with IBM. Would you tell us your view of how this is evolving in mass storage? There has been some impressions that the growth is not as quick as you expected. What do you think?

Mr. Ozawa: As you know, we are now directing memory cards. We call it the Solid State File, with IBM. The point is to make standardized software, I mean, bios. And we are now using PCMCIA ATA as standard. I think the OS2 can handle this SS Card right now and the version of this card is nicely compared to the solid state, excuse me, magnetic disk. The operation speed, of course, is very high. I think next year we hope to ship our Solid State File using 16 mega NAND and we are now planning to produce a Solid State Memory Card using NAND. This is what we're planning so if we can make a NAND chip, I think we can do it.

Mr. Samaras: Since you have the NAND structure devices, does that mean you're targeting the mass storage market primarily? You're going after mass storage solid state disk applications?

Mr. Ozawa: You mean that mass storage means a bigger density than 10 megabytes?

Mr. Samaras: Yeah, but I mean for replacement of hard disks.

Mr. Ozawa: Hard disks. As I said first, we think we can make a 14 megabyte card using 32 megabyte NAND.

Mr. Samaras: Thanks. What is your view, Dr. Masuhara? Are you approaching this market? Do you think that this is something that will be very profitable for Hitachi in the near future?

Mr. Masuhara: Yes. I think for that kind of thing, as I told you, we are approaching AND type cells, which are using the same thunder mechanism and can achieve byte erase characteristics.

Mr. Samaras: Is it necessary to have byte erase?

Mr. Masuhara: I think so. There are some applications. There's one thing I'd like to comment on. For the portable equipment, if their weight is higher than kilograms, people never throw the equipment. But if the equipment is less than 500 grams or so, people sometimes throw the equipment and hard disks are hardly suitable for that kind of purpose.

Mr. Samaras: Walid, I know that you have quite an effort in PCMCIA memory cards. Is it a bright market right now?

Mr. Maghribi: I don't think the memory card will ever replace disk drive per se. There are definitely some applications that require ruggedness, portability and relatively low densities. For those types of applications, people would pay whatever is required in order to have it embedded in their system. Now, in order for memory cards to take over, you've got to have, first of all, suppliers who can make ICs and the fact is, there are only two suppliers in the world who supply millions of units on a quarterly basis — AMD and Intel. So until several suppliers come into the market, I think the fate of the memory card is a little bit questionable. There are some people who have embraced the memory card in the past year who felt very injured after Intel put this whole program on hold. So it's going to be a little while before people get readjusted to the idea

of using memory cards. They have to see that the supply of the Flash ICs is abundant and all the applications that were created by this enabling technology have to be satisfied before memory cards, which is my opinion is a relatively new application, really take off. I think 1994 is not the year for memory cards. It's gonna be mid-1995 before you really see memory card taking off and you have to add the other issue of the software that still needs to be worked out.

Question: Could you please address some of the issues of Flash versus disk drives?

Mr. Samaras: All right. I think that's a very good question. Tony?

Mr. Barre: I think the fundamental thing to look at is the skill or portability. As Walid said, the potential for Flash to replace disk drives on the desktop is virtually nil, but the more portable an application is, the more the Flash features are going to be preferred. So specifically, ruggedness, power and lightweight are features that are inherent in Flash that are not inherent in disks. More disk manufacturers are designing small form factored disks that are more rugged. For a while, they could barely stand one G and now there are some that expect 10 to 50 Gs, so there are some serious efforts being made on the disk market side to improve the ruggedness of disks. However, other shortcomings, such as spin up time, data transfer rate and power consumption make for a tougher choice for a system manufacturer. So if you were to interview the designer of the HP Omnibook, for example, you might look at some of the criteria that he might use in deciding to go with Flash instead of the disk drive. They might have a lot to do with the power consumption that he could tolerate in the Omnibook and the weight and ruggedness that he wanted the Omnibook to have. I think another factor in the longer term is that Flash is on a very aggressive learning curve so I absolutely think that Flash is fundamentally much higher priced than disks. However, I think the learning curve is fast enough that it becomes more and more attractive in a less and less portable application because the price learning curve is slightly more aggressive than small form factor disks.

Mr. Samaras: Thank you. My comment is that the disk drive makers are very aggressive in technology and pricing. We've seen that disk drive prices are now below a dollar a megabyte. The problem is then that you start with 300 megabytes and some of the smaller applications like a PDA don't need 300 megabytes because you don't run windows. So perhaps we have a divergence of applications whereas in the small dedicated systems, [inaudible]**** operating systems or new, small operating systems perhaps Flash memory is appropriate. Of course, in a desktop environment, I would have to agree that a hard disk drive is a very inexpensive and optimum solution. Furthermore, with respect to the ruggedness, we've seen that the disk drives are very rugged now and as the size is reduced, you have less mass to move around, less power and less current. They're very aggressive. If you've seen the 1.3-inch drive from HP, the Kittyhawk, this is quite an accomplishment. I would argue that you could go back and replace semiconductor devices because one of those drives takes less space than two EPROMs in a laser printer environment, for example. So the reverse might be true. The semiconductor vendors might have to start worrying about these micro drives and, who knows, micro mechanics is around the corner and we might have very tiny drives out there. Any comments on that?

Mr. Beverina: I don't understand really the question. Are you asking if Flash is able to replace disk drives? I believe that the market is in some ways fragmented. In disk drives, we have always had some advantage over the Flash, mainly when the gigabit are requested and when low cost is crucial. Flash, as disk drives, will not reach the one dollar per megabyte level, which in a silly consolation is still very, very valuable. Now, if I look the studies of our company, we are one of the key players in the disk drive environment. Now the

problem is how can a semiconductor company help a user to a system maker to hail its own competitive advantage? Now, we help the disk driving manufacturer in getting a lot of performances through other devices, but still there is a lot of application. For example, on the [inaudible]**** , the 300 Gs that somebody mentioned is just around the corner. To me, flash is not an adequate replacement to disk drives in any one of the desktop or laptop applications if the cost and the density is an issue. On the contrary, the flash can be complimentary to the disk drive. Sometime you might need a memory file in a Flash array. Earlier we were discussing the emergence of the mobile computing and the hand held computer. Clearly, Flash could be in a lot of applications there. Now, the Flash Memory card could be a media to move from the mobile computer to the desktop computer. That's where the Flash Memory market will evolve.

Mr. Samaras: So you see then, the Flash card or memory card as a medium for exchanging and moving data from the palmtop to the desktop.

Mr. Beverina: Yes, when the time comes. Meanwhile, there will be a volatile type of application. If you read the magazines, there's a lot of discussion about how the Flash will kill a lot of disk drives. It's impossible. At the moment, let's joint the Flash and the disk drive application while the disk drive is superior to the Flash application. Of course, when we go to what they said before, the execute in place, it will be a characteristic of the mobile computing. In that case, the Flash card is an advantage, of course, but this means that the two will co-exist and that both will develop and grow.

Mr. Samaras: Speaking of killing markets, I'd like to explore this EPROM market. It's not growing at all. The numbers don't support that. It's about a million, billion two and it's not going very many places so what I'd like to find out is how Flash Memory is affecting EPROM applications, devices and the availability of devices? Walid, would you like to try that?

Mr. Maghribi: Well, you made a comment that the EPROM market is not going anyplace. Actually that's very good. I remember when Intel exited the EPROM market about a year and a half ago and they said EPROM has no future. According to Dataquest forecasts all the way up to 1998, the EPROM market is over a billion dollars. AMD has chosen to offer both EPROM and Flash. At a given density, EPROM will always be cheaper than Flash if you implement the same technology. Now, if you stop working on EPROM like Intel did, the Flash will be cheaper at certain times. Of course, a half a micron 16 megabyte with the Flash is going to be cheaper than the 16 megabyte EPROM on one micron technology. Now, as we strengthen the technology more and more and you stop developing technologies for EPROM, there will come a time where number one EPROM at the density that you want it does not exist anymore. Then people would be forced into Flash. Let's take a density, for example, a 2 megabyte EPROM. Well, I don't think that anybody will be taking a 2 megabyte flash all the way to .5 or .25 microns so a 2 megabyte EPROM at a .85 micron will always be cheaper than a 2 megabyte Flash. The fact is Flash is more complex to make than EPROM. Flash has only column redundancy — it does not have row redundancy where EPROM has both. The fact is Flash is a lot more complex to test and has endurance issues still to be resolved. Now AMD has chosen to stay and offer both the EPROM and the Flash and let the user decide. There will always be an application that does not require Flash. In these cases, the OTP or the EPROM will be the cheapest. Now, by the same token, AMD is not making any investment in EPROM past the 8 megabyte so at the 16 megabyte level, there will always be the Flash and by that token you could say, well Flash at that density is cheaper than EPROM.

Mr. Samaras: All right. I'm going to go back to Bruno in a minute on that, but I'd like to ask you, Dr. Masuhara, about your view of EPROM and how that market is developing for Hitachi?

Mr. Masuhara: I have pretty much the same view as Mr. Maghribi. In the memory technology, if you catch the major technology, that's gonna be the ultimate winner so I think right now DRAM on the one side and Flash on the other side are going to be the two winning technologies. I think in the future, Flash may exchange the EPROM and EEPROM markets, especially for the large density ones.

Mr. Samaras: Okay. Bruno, would you give us your comment on EPROMs for SGS-Thompson please?

Mr. Beverina: A year ago, everybody was saying that the new emergence in EEPROM would have been killed EPROM. Today, as everybody said, it's still a 1.4 billion dollar market. During the last two or three years, it's been absolutely flat. Earlier today, we were talking about whether or not Flash is going to kill EPROM. Now, we are thinking in technology terms, but we are not thinking in customer terms. The real issue is the customer. Now, I do agree with Walid when he said that EPROM at the same technology will always be cheaper than Flash. Flash has a bigger circuit to drive so if we want Flash to have the potential for being erased, not only written electronically, it's going to require silicon. Yesterday, Dr. Moore was saying that sometime in memory we are selling the [inaudible]**** of silicon and this is one of the possible strategies. Now, the issue is, the bigger you get, the higher the cost. Moreover, the Flash can't be made in the same process. You always have more process steps. The third is that the Flash is a mixture of EEPROM and EPROM technology, so that today hot electron [inaudible]**** means again that the process is more complex and thus, the cost is higher. If the customer doesn't need the higher flexibility of the Flash, why should he pay more for Flash? EPROM from a user point of view is a long life market. We are still selling huge quantity of a 16k Eprom that was developed in the late 70's to the same company. Why? Because the customer needs a 16k EPROM. They do not need the one megabyte that probably is cheaper on the market because for them, what is really important on top of the price is the ownership cost. The ownership cost includes the effect of changing the program, the effect of changing the design, the effect of changing all the mountainous paper — there is a lot of cost associated with these changes. So if you take into consideration that the customer satisfaction is our all goal in the end, there is no reason to kill the EPROM just because flash has arrived. Clearly, the Flash will be bigger in the market than the EPROM. Flash is adding new opportunities and applications that weren't possible with the EPROM or by the ROM. Now, the number one strategy that we are going to provide is service. I'm wondering, specifically, which type of service. If from one day to the other, I do not give the parts to the customer that needs them, I haven't done my job. The profit is an essential element for all of us as we know. But this is our goals as manufacturers — to create a solution to the [inaudible]**** and still keep the profitability.

Mr. Samaras: Tony, would you have any comments on the EPROM market, and Flash?

Mr. Barre: I think we agree that EPROM technology is fundamentally less expensive than Flash. The focus of Intel's Flash development has really been on developing new markets, not cannibalizing the EPROM market behind us, so we've not really focused on stealing EPROM business. I don't really have much of a report on that. I think that a number of applications that had used EPROM in the past found that it was less expensive for them to re-program via Flash than re-program manually by taking EPROMs out of the system, erasing and re-programming them. So I think some EPROM applications have gravitated towards Flash, but we really haven't tracked those as much as looking for new markets that Flash was opening up. The biggest growth in the Flash market really comes from new markets, not from stealing old EPROM markets.

Mr. Maghribi: I'm really glad that Tony has finally shown the camps of the people who

make EPROM and Flash. I wonder if this is a change in position because I remember Mr. Pashley very loudly saying that Flash would be the same cost as EPROM, just less than two years ago, and promised to sell their Flash to the customer at EPROM prices.

Mr. Samaras: Tony, do you have any comment on that?

Mr. Barre: I cannot guarantee that when we introduce a 64 meg Flash chip it will be cheaper than any 64 meg EPROM chip.

Mr. Samaras: That's a very interesting point because some people claim there won't be a 64 megabyte EPROM. Actually, I had a question for Tony in [inaudible]**** principle. Some people have compared Flash to DRAM. Is this gonna be the DRAM of the future? How are DRAM and Flash going to play out? Let's start with you, Tony.

Mr. Barre: Again, I always go back to the technology. There is no way that Flash will ever come close to DRAM write speed so if you need to be able to write an application in real time or at microprocessor speeds, Flash will never be useful there.

Mr. Samaras: Is there a way around it? Can you actually use software tricks to circumvent that problem?

Mr. Barre: Well, a number of applications take advantage of caches to improve write speed, but that's talking about an order of magnitude or two whereas there's a difference of several orders of magnitude that really can't be bridged. I think the better way to look at the comparison is that today, some manufacturers use DRAM for storage because it's the least expensive solution. So, if indeed Flash can scale faster than DRAMs and become less than DRAMs, then for an application that is cost driven and is not being written real time, the OEM is more likely to choose EPROM. A good example is my notebook computer today. I have 8 megs of DRAM in it and I suspect that about 5 megs of that DRAM is filled up with word processors and spread sheets. It's just really code. It's not being changed and it's not being re-written. So if the architecture of these portable computers evolves, if Flash is less expensive and if you want to take advantage of some of Flash's features such as non-volatility, you may choose to use Flash instead of using DRAM. That's really what we ought to think about rather than Flash replacing DRAM. They're fundamentally different technologies. It's the right technology for the application and I think we'll see that the portable computer will choose to use Flash for fundamental code store and executing directly out of the Flash for executing code. However, there's some enabling that needs to take place in terms of the software evolution and, at this point, it really requires the Flash manufacturers to work with the software vendors and the OEM to make that happen. Simply sitting back as manufacturers and doing what we've done in the past — manufacturing chips and letting the market take care of itself — won't enable the market to grow as fast as it's potential.

Mr. Samaras: Okay. I just want to add one point here. Our numbers show that by 1997, Flash may cost less on a per bit basis than DRAM and that's why I think we're trying to explore that question. Now, having said that, I'd like to ask Mr. Ozawa for his position because he'll have an interesting point. Toshiba invented Flash and then Intel is capitalizing on that. Intel invented DRAM and Toshiba, I think, did very well in that market so I'd like to hear your view.

Mr. Ozawa: Thank you. Yes. I can think of only one barrier to replace DRAM using Flash. The only barrier will be the number of write erase cycles. Right now, we can do write and read cycles to DRAM using DRAMs pens. This is very easy because we don't flow electrons through the silicon dioxide. For DRAM case the electrons flow inside a circuit so it's very safe to write and erase cycle to the tenth times. But for NOR, it's very, very difficult to get the

write erase cycles. I think this is the biggest barrier to replace DRAMs.

Mr. Samaras: Do you think that possibly in the year 2010 or 2020, the DRAM market is going to be smaller than the Flash market actually?

Mr. Ozawa: I think so. First it will be smaller and then the Flash market will be smaller than DRAM.

Mr. Samaras: So you think that Flash is gonna be smaller than DRAM. Is that correct?

Mr. Ozawa: Yes.

Mr. Samaras: Dr. Masuhara, what do you think?

Mr. Masuhara: DRAM is a random access memory and Flash is a quite different type of memory so I think Flash never can invade into the random access area, but there is some application in DRAM in which they use DRAM as a storage. For instance, for the large mainframe, they are using battery back up DRAM storage. So that kind of application can be realized by Flash, but DRAM and Flash are kind of co-existing technologies in the future.

Mr. Samaras: Okay. Anybody else sees this as an opportunity to get back into the DRAM business. Mr. Beverina?

Mr. Beverina: On this issue, I think that more or less all of us agree at least on one thing — flash, of course, is different than DRAM. The speed is an issue, and write and erase cycles are probably an issue. Flash has the advantage of more shrinkability. Plus, the cost will go down much faster than the DRAM. Today the industry is developing the 64 meg DRAM and [inaudible]**** is not yet developing the 64 meg Flash. In memory business, time to volume is important because the yield is the cost which makes the problem in the end. There is no way that the Flash can ever substitute the DRAM, but still there will be some application where the Flash will take the place of the DRAM. In the newer generation computer, while you need [inaudible]****, you might not need the disk drive that goes to the DRAM, but you simply go to Flash and that's an opportunity. There's a lot of cases where in some application, the Flash might substitute the DRAM profitably for everybody.

Mr. Samaras: Okay. I think we have covered the bulk of the questions that I would like the panel to address. What I'd like to do is open this to questions from our audience. I will have a couple of things to address after we get done with that, such as the fundamental challenges that face each one of the companies that are represented in this panel of discussion. Let's open it up to questions from the audience now.

Question: When is AMD going to have a density higher than 2 meg?

Mr. Maghribi: It is our policy not to pre-announce product until we really can make them.

Question: As you mentioned earlier, you expect Flash to be a commodity like DRAM, but right now everybody has a different architecture that requires different protocols. Do you expect in the future everybody's going to merge to the same protocol like DRAM or do you expect everybody to take their own differences in software?

Mr. Samaras: That's a very good question. It has to do with protocol and I'd like to hear your views. We'll start with Mr. Masuhara. Do you have a response to this question?

Mr. Masuhara: I think the future of Flash Memory is going be very application specific. For instance, you have a huge variety of applications like PDA, voice recording, digital cameras and hand held computer, so I think it also depends on the customer. There is going to be very wide variety, but in a sense, memory should have a very common standard in order for the device to become cheap.

Mr. Ozawa: I have quite the same opinion as Dr. Masuhara. A standard doesn't mean it's unique, so there will be several standards.

Mr. Barre: The basic situation is that the Flash market is still a lot less mature than DRAMs. There's still an awful lot of maturing to go on in the marketplace. I think if you look at the DRAM market in its infancy, there were huge breadths of what you might call standards at that time, too. So there's a lot of shaking out to be done and a lot of the manufacturers right now are trying things out and it'll be up to the market to decide whether they want to compensate for differences in software or whether they're going to prefer a standard. Right now, each manufacturer introduces a new functionality intending to address a market need and at this point, with so many new markets showing up for Flash, new needs show up all the time. I think we were inclined to address those with new tricks. If we find in the long term that a standard provides the functionality that a large a hunk of the market wants or that all of us can get to some great low cost point by using the exact same interface, that might happen. However, I think that while the market is immature, you'll continue to see new features pop up each time a manufacturer tries to address a new market.

Maghribi: In a way, I think we do have a standard. I mean the two suppliers, us and Intel, represent 80% of the market, at least on 12 volt, and we are 100% compatible. The 5 volt product is at [inaudible]**** standards and all you have to do is look even at the higher density product and the sector size. It's being driven by the customer, but there's a lot of conversions. Plus, there are some other manufacturers that are still trying to test and try different technology, but the people who had the experience are really focused on one standard and that's us and Intel.

Mr. Beverina: Strangely enough, I do agree more or less with everybody in a sense. The discussion is not what the market is today, that is clear. However, in the market there is a certain standard. The question for this panel is what is the future of the Flash? You said at the beginning that Flash is a device with a lot of potential and functionality. If I had to configure the Flash market of tomorrow, I would anticipate two major areas. One that we might call sometime the [inaudible]**** types of applications and the [inaudible]**** types of applications. But within EPROM [inaudible]**** types of applications, we might be seeing emerging [inaudible]**** application specific memories. Today it cannot exist. We were talking about the Flash earlier and someone asked about the relationship between the Flash and EPROM. What about theEEPROM? Now in the EEPROM, what you're seeing is that the Flash will never pass the EEPROM at the low sides because the low sides create another market. However, Flash eventually will have a bigger market than the EEPROM market. If we take what we did in our company, five years ago, it's considered innovative EEPROM technology. We were the first in the market with a less than 3 volt operation at a million cycle. So we took an old technology, we changed it and we did innovate. What we think today is that through the Flash, we may invent an IEEPROM application, but surely one thing that we might merge in are EEPROM at low sides. This presents a variety of a possible applications in the specific memory area. Now let's go back to the question about how to define a commodity. A commodity means the possibility of producing something [inaudible]**** from a market point of view that you can find parts from multiple vendors. Surely there will be a standard. I do agree that within the standard product there may be some different solutions appearing because any manufacturer will have their engineers work with their customers. There will be a shake out and some will emerge. This is the definition of all technology — for example, the DRAM, the EPROM, but this does not mean that we can't be competitive with other applications. That will just enlarge the set of possible solutions. Now commodity may mean another thing — the possibility of manufacturing at low cost. Again, this is

process driven. If we take my view of the Flash and compare it to the DRAM and EPROM, for example, DRAM and EPROM were devices that were technology drivers. The Flash, because its much more flexible, is not just a technology driver, but technology driven. This allows a lot of creativity and new applications to emerge. One of the problem why the Flash takes some time to emerge is because of its complex design for [inaudible]****. To the extent that the manufacturer is able to make the different variety of product in the same process, consider the variety of products for commodities. This will still have all the advantages of the commodity and then the low cost solution that the customer is looking for plus the possibility of serving a big market.

Question: Will split gate technology be used in EPROM replacement applications.

Mr. Beverina: Again, the issue is cost. The easy manufacturing is one of the ways that cost can be reduces. Split gate technology is much more complex and costly than the EPROMs. Then at the end, surely in a [inaudible]**** market like the one today, split gate can serve some type of application. However, in the long run, it's not likely that will be emerging as a real ring of technology because of cost constraints and because of the easy manufacturing [inaudible]****. There are 20 years of experience in EPROM, which gives the manufacturer a list for the known Flash problems, which are big enough, and the possibility of easy vendoring to manufacturability. This is a must.

Question: Is it true that NOR, because of its priority on software demand, does not have the advantages in mass storage, therefore, NAND will weed out this application due to [inaudible]**** cycle advantages?

Mr. Samaras: I'll answer part of that with respect to the numbers, but I want to let Tony address that first and then the rest of the panel.

Mr. Barre: Software write cycles and growth are the words I wanted to key off here. So far, to implement Flash in a mass storage system, there are several existence proofs out there of at least two, if not three, different software hierarchies that make Flash totally practical in a mass storage application. There is a Flash filing system that's somewhat similar to a DOS filing system that's on the market and continually being improved. There is Flash that's been embedded in disk drives that work directly off of DOS commands in 13 kinds of commands so that whatever hierarchy there might be in the Flash structure, it's hidden from the user and it works without it. Then, there've been announcements of other file systems that will support NOR type Flash as well. So I don't see software development, the structure of software or the Flash data structures as an inhibitor to the usage of NOR type Flash in mass storage.

Mr. Samaras: We've been accused quite often recently that our numbers are very conservative so I'll have no comment to that, but I'd like to ask Dr. Ozawa, will NAND structure dominate the mass storage market?

Mr. Ozawa: I think the operation speed of the NAND card is higher than the NOR card, but I don't think it comes from the software. I'm not sure the operation is determined by the software and Toshiba doesn't plan to replace the mass storage market. We want to enter the disk drive market, which is very small compared to the magnet memory, so as I said, we can make a 40 megabyte using 32 megabyte NAND in 1996. Right now, I cannot forecast the market size of cards or NAND cards in the mass storage market, but I hope it will rise.

Mr. Samaras: Let's go back and revisit something. I think that to some extent, our numbers do include mass storage applications. At this point in time, the future does look very nebulous. What we're looking for are platforms that will be successful and perhaps the Newton or future generations of PDAs that people will adore, carry on a daily basis and then buy more memory cards. Until we have a successful

platform, though, my personal view is that the mass storage applications will be limited, perhaps, to vertical markets and areas where solid state storage makes sense. For example, avionics, high Gs and industrial control. These are areas where solid state is perhaps better solution because of the way it operates and the power requirements. Now, I think we've run of time. Unless we have any other questions, I'd like to ask two general questions to the panel and then we'll adjourn. What about the production problems — are we over those? Do we have enough capacity for the future? I'm gonna start with Intel on that. Tony?

Mr. Barre: I could address where we've been today, and that's that Intel's shipments have doubled since the second quarter. Our shipments will quadruple from the second quarter of '93 to the fourth quarter of '94. We've added a lot of factories. I think the best way to characterized the problem that occurred over the last year was that Intel was real aggressive in forecasting the growth of the market and we planned really nicely. Unfortunately, our execution wasn't quite as good in bringing up the additional fab that we needed. Our plan had it perfectly on time — had it been there we would have been in great shape, but we executed poorly. I think we've made up for that. Our current forecast is to catch up with demand in the first quarter of '94. I think in the long term, however, this Flash market is growing very fast and if I look out I think in general, with as many competitors as there are, I've counted 34 people that have announced intent of being in the Flash market. There's still a general under-investment in the capacity that's gonna be needed to make the market happen. So just as we've seen a shortage of capacity at .8 microns, I think there'll be a shortage of one emerging at .6 in another year or so. We're running as fast as we can to keep up, but, in general the industry has under-invested and with factories costing a billion dollars and growing, there will be a very conservative trend to invest in that first .4 and .25 micron factory that we'll need to satisfy the demand in 1998 as well. So my opinion is that we'll see a lot of cycles and things will get better in 1994, but it'll get worse after that.

Mr. Samaras: So if I understand this correctly then, there's no over-capacity that you're forecasting right now. Is that correct?

Mr. Barre: I don't think that'll happen. I think the Flash market is just really growing very fast and the demands are gonna be so strong that it'll take all of us in the industry running as fast as we can to barely keep up.

Mr. Samaras: Walid would you like to add something to that?

Mr. Maghribi: There is no question that today we are producing a lot more units than at the beginning of 1993. From 1992 to 1993, AMD, for example, increased production by fivefold and today, by the end of 1993, we will have close to 40% of the market share. Now, in 1994, we also plan to at least double in terms of number of units. Now, what's bothering me about the current situation is that there are a lot of people talking about shipping, but there are still the same two people, Intel and AMD, who manufacture anything in volume. Now, let's talk about the equation of supply and demand. The supply has definitely increased in 1993, but also the demand has decreased because a lot of designs that were excited by Intel low prices have actually been turned off. People have reverted to EPROM and that's why you see the EPROM market the way it is. Also the second issue that I have with the capacity is that at least in Intel, who is a major supplier, they are still counting on foundry in order to meet the market demand. I know and everybody knows that foundry is not very comfortable to depend on for running a major explosive business like Flash. So my forecast is that the 1994 supply will still be tight, but if all of a sudden the people started converting from EPROM and going back to the Flash because they feel very comfortable, we may have an even further tightening and I think the situation will not be resolved until a third supplier steps into the

market and start shipping millions of units. I do not see it in 1994.

Mr. Samaras: Bruno, do you have any comments?

Mr. Beverina: More or less, everybody will be included in this investment to increase the capacity to get the Flash. We also are starting to ship reasonable quantities, not yet the volume of AMD or Intel, but quantities that are measurable — in the hundreds. Of course, we plan for millions and this is more or less what Walid is suggesting, but still I believe there is one thing. Today the industry is short of capacity in general and to some extent, the different capacities can be exchanged from one problem to the other and, in the end, the capacity will be taken by the device that will be more profitable to the different companies. So if the current situation of goods in that other market continues through next year, it's not likely we'll have an over-capacity of Flash. Moreover, it is true that there are many people planning to enter, but for the most part, all the big investments will not be extreme before probably the second half of '95. Then we might see a relatively small [inaudible]**** of the situation. I might be agreeing afterwards that '97 could be even worse if we do not invest now for '97. Millions of dollars are going to be needed for investment in this area. In conclusion, we might be seeing a release of the constraint because of what Tony and Walid said. 1994 will be tight to me, still. At the beginnng of 1995, it will still be tight. Finally, in the second half of '96, we'll be seeing more capacity available.

Mr. Samaras: Thank you. Dr. Ozawa, what is your view of the capacity at Toshiba? Will you have adequate capacity for product?

Mr. Ozawa: Yes. For the capacity, I think there are a few obstacles for volume production of NAND. One is NAND is specific process, I mean time [inaudible]**** control, quality control. The other is perhaps a coupling factor between floating gate through a substrate and floating gate to control grid. If we can control these parameters to the appropriate barrier, I think we can produce 16 megabyte NAND and, of course, Toshiba has a growing capacity program, but next year, we are trying to make a 16 megabyte NAND — one million pieces.

Mr. Samaras: And Dr. Masuhara?

Mr. Masuhara: As Dr. Ozawa said, at the beginning of production for Flash Memory, we thought the production would be rather easy compared to now. The fact is that the Flash Memory has a lot of problems when compared to DRAM, but I think we have solved almost all the problems so the production is wrapping up. However, we do have a shortage of all the memory products right now. So the problem is that design allocation. We are doing some five contracts in between [inaudible]**** and some other companies, but we don't have five contracts right now for the Flash Memory. So if the line allocation will be better for the next year, then we may have better production.

Procurement Benchmarking

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A. Kenneth Pattin
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P. William Quinn
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Mr. Giudici: Good afternoon and welcome to the procurement benchmarking breakout session. I'm Mark Guidici, and I am the director and principle analyst of the Semiconductor Procurement Service here at Dataquest. This is my associate, Ron Bohn, a senior analyst with Dataquest. What we track at Dataquest are procurement issues that impact the buyers of semiconductors. We also track the issues around the semiconductor industry and how they impact the user community rather than the supplier base. So what we would like to do today is talk about one of the key issues impacting the user area — the benchmarking process in overall scope. Ron will give a brief discussion of what he has found in his focus report on procurement benchmarking, and then we will have our esteemed panel talk about their views on the subject. Once they have finished going through our set of five questions, we will open up the podium to questions from the audience. Now before I hand the podium over to Ron, I would like to introduce our panel. By the way, the full biographies are in your folders. Collectively, the corporations these panelists represent buy close to 4 billion dollars worth of semiconductors annually.

Our first panelist is Larry Durandette, worldwide benchmarking manager for Hewlett Packard. He is responsible for the development and implementation of standardized benchmarking processes at HP, and his role involves training, consulting and starting up actual benchmark processes with various HP process teams.

Our next panelist is Ken Pattin, Vice President of Worldwide Supply and Acquisition Management for the IBM PC company. Ken is responsible for the supply of PCs from IBM's worldwide sources, the management of supplier network support and final product assembly. He is also in charge of the processes to improve the overall responsiveness of the network, plus the worldwide procurement for all technology required by the PC company.

Next on our list is Bill Russell, purchasing manager of Texas Instruments Defense Systems and Electronic Group. This TI division won the 1992 Malcolm Baldridge award. He is responsible for the worldwide semiconductor procurement function at this division. By playing a key role in the implementation of cross functional material teams, Bill has firsthand experience regarding what looks good in theory and versus what actually works in practice, involving inventory management, procurement and engineering functions, and the coordination of the three.

Our fourth panelist is Bill Quinn, the vice president of purchasing for the world's largest electronics contract manufacturer, SCI Systems of Huntsville, Alabama. His group buys approximately 1.5 billion dollars of semiconductors annually and his purchasing group was the first one to receive the ISO 9000 certification. This well-experienced panel of semiconductor procurement veterans will certainly provide much food for thought today and in the future through the questions that we have prepared, as well as those that you may present later on. However, before we dig into the questions, I would like to have Ron Bohn take the podium here, and he will present some of his findings from the procurement benchmarking focus report. Ron.

Mr. Bohn: Thank you very much, Mark. We have several slides here, so if you would like us to mail you a copy, just leave your business card on the table and we'll see that you get one.

Several years ago, some of our clients recommended to Mark and me, that we start providing some information on benchmarking. So we asked "what kind of information and in what area?" and they said, "anything on benchmarking is being demanded by our management." This was back in the late 1980s. So our first step over the past several years was to provide some information on price benchmarks. During the course of this year, our research operations group performed a procurement benchmarking survey. In this survey, they talked to 100 leading U.S. electronics OEMs regarding their use of procurement benchmarking, and a detailed series of metrics associated with the procurement process. By the way, we do view procurement as more of a process than just a discreet set of functions. One of the key findings of the survey was that just under 40% of the leading U.S. electronics OEMs formally benchmarked their procurement process. Informally, maybe the number will come out somewhat higher. We think that because of the cost issues associated with worldwide competitiveness, more and more organizations will use benchmarking, including procurement benchmarking. That is why we set up this panel here today — to raise this kind of issue to the user community. I do realize there are also some suppliers here and supplier evaluation is another key we will discuss today, but instead of me talking about benchmarking, and I will use some of the metrics to lead you in certain discussions, I would like to hear from some our panelists about benchmarking at their organizations. I would like to start with Larry Durandette of HP.

One thing: Larry is a benchmarking manager. He is not particularly focused on procurement

of benchmarking, but benchmarking at the corporate level. Larry, could you kick off the discussion?

Mr. Durandette: Sure. The first question is this. Does your company offer, at the corporate level, a program for benchmarking, and at Hewlett Packard the answer is yes. What we have tried to do is come up with a standardized process for what the benchmark would cost all of our entities, so that when someone says we are going out to benchmark something, and they talk to another entity about it, there would be a common ground for communication. One of the things that just got mentioned earlier is 40% of the companies that you surveyed formally benchmark. One of the things we find, both in HP and in the industry as a whole, is that there is a lot of confusion right now between benchmarking and competitive analysis, and the two terms tend to be used interchangeably. So one of the first things we usually do with an organization is try and differentiate between the two. What we tell people is that competitive analysis is really based on data found in the public domain, and is used to identify a difference in performance. With benchmarking, you drive behind the numbers, and what processors drive those metrics and why there is a difference. With benchmarking, we really try to answer the "why is there a difference" question. So that's the primary differentiator between the two, and it's an important differentiator. Tentative analysis will lead you to areas that you might potentially want to benchmark, but tentative analysis rarely gives you the answers on how to improve. With benchmarking, you're really looking for the key success factors that allow for performance so you can improve your performance. Do we have a procurement benchmarking program? Our procurement people are doing a lot of benchmarking. Some of it is real benchmarking, some of it is, what we call industrial tourism. (Laughter) Industrial tourism is, "gee, I know my process, but I know I am not very good at it. I have heard somebody else is good at it so I'll fly out and visit them, come back and say, well, they're different than our company." That's how a lot of benchmarking is done in the industry and why benchmarking sometimes has a bad name. Benchmarking is formally defined in HP as a nine step process in the literature as a whole. It's really anywhere from a three to 15 step process, depending on whose you pick up. The common factor in a formalized benchmarking process is to start with determining your focus area. That is, what process is most important to your continued or future success? The data you use to try and make that decision are based on competitive analysis and customer satisfaction.

If your competitors are beating you up, and it's important to your customer, you are not going to be in business very much longer if you don't do something about it. Once you know your focus area, the next real step is to try and determine how to measure that process? Most of us don't do a good job of measurements. We spend a lot of time working with teams on how to measure your process more effectively, because if you don't measure the process up front, when you make a change at the back-end, all you are going to be able to say is, "well, it's different. We don't know if it's any better, but it's definitely different." With the metrics in place both before and after, you can start to answer the question. Not only is it different, but it's better and it's this much better.

The next two steps occur somewhat simultaneously. The first is to document your performance. About 50% of the effort in a benchmarking program should be spent in this phase. Most benchmarking efforts fail because people don't spend the time to document their own process. A flow chart or an ISO 9000 level documentation typically is not sufficient. We look for much deeper levels of documentation. The other thing you do at this stage is develop your benchmarking questionnaire. What questions am I going to go out and ask the best in class companies to determine why they are successful? Well, in documenting my process, the other thing that I work on simultaneously,

is my literature research. I know the process, I know how to measure it and I know some of my issues with it. Those are the keys I use to do my literature search. If anyone does a literature search and comes back with no matches, you didn't do a very good literature search. That doesn't mean if you go out and do a literature search and you come back with a huge stack of literature you necessarily did a good job either. It's hard work, but it pays a lot of dividends. One thing most people don't do when they do a literature search is question the data. They read the article and believe everything they read, or they read the article and say, "naw, it can't be right." Call the author of the article. It's a very valuable thing to do. The author will want to talk to you. It may take him or her a while to get back to you, but the benefit to the author of the article in talking to you is that someday they are going to write an article about your company and now they have a contact. The thing you can get from the author is, "so is it really this good? What didn't you include in your article?" That's valuable information you can use as you try and determine who you might want to visit. During the visit, itself, you really want to drive off your questionnaire. You spent a lot of time developing it, it's driven, it's keyed to your issues, and those are the things you want to understand. Why is someone's process better than yours? You don't want to walk away with just their process. You don't want to walk away with only what we call best practices.

Best practices is," we do A, B and C. " What you really want to walk away with is why did they do A, B and C, and what is it about those things that make them successful? If all you walk away with is the process steps, you are going to come back to your organization and you are not going to be able to drive the changes you want to drive. You really need to understand what's underneath that next level down. After that, it's really just comparing. What are their success factors? Where are the differences versus your performance? What are you going to do about it? The next biggest place for benchmarking effort to fail is in not documenting your process. The next biggest area for failure is not doing anything with the data once you collect it. You've spent the time and effort and energy to collect the data, and you don't use it. Why did you spend the time, energy and effort in the first place? That's kind of our benchmarking program at 30 thousand feet.

Mr. Bohn: Thank you, Larry. We will have questions after we rotate through all of the speakers and questions. The report that we wrote has generated some questions exactly along the lines of what Larry indicated. We call ours a procurement benchmarking study, and there are a few tables in there where we identify some best in class performers, and that leads to the question, "what's the source of the information? Is it competitive analysis type of information?" So that's very key point. Ken Patten, could you make a few comments regarding benchmarking from your perspective there at IBM?

Mr. Pattin: I'll agree with my associate here from Hewlett Packard on the notion that the benchmarking and competitive analysis is often confused, and difficult to separate — we have our share of industrial tourism, as well. (Laughter). (Well, I loved the term). At a micro level, we have looked at the general subject of procurement and the materials flow in all elements of the business, and have rediscovered, discovered and rediscovered all of the warts that are associated with my enterprise. Over and over again, we found them in other places. The thing that we are beginning to focus on is trying to take a look at this thing at the a macro level. By that I mean going outside, in my case the personal computer business, to try and find a macro model that has parametrics similar to the parametrics we are interested in, but are being practiced in other industries with the kind of history and baggage that come with an enterprise that has been in business as long as we have. We try and find a fresh approach to looking at a model of a universe which has similar parametrics, but is being attacked from a completely different point of view, with

different systemics, different approaches in general.

So we have taken the micro view of benchmarking in this particular arena and said, "we've learned about all we can learn, some things we have learned better than others." Let's start to focus on the macro view and try to design, or think about models of other businesses and other industries that have similar parametrics, and see if we can join with those enterprises and learn from them. Maybe they can learn from us, too. In that sense, we are doing something slightly different than what was described here.

Mr. Bohn: Ken, I am going to ask you to stay on for the next question. This question and the next one are really quite challenging questions. It is difficult to present this kind of question in a panel session, however, we gave some advance warning to our panel members about this. First of all, we do view procurement benchmarking as being a strategic approach to procurement. Procurement, from Mark's and my experience, is much more oriented on tactics. DRAM pricing, microprocessor, vendor selection — there are strategic issues in there clearly, but the tactical day-to-day pricing, supply and demand issues are really what largely drives the procurement community. We do believe there should be a long-term evolution more towards strategic procurement, if we call it that, and we believe that procurement benchmarking fits into that. We start off with a definition here of logistic systems. We are talking about a system that would link a company's strategic planning (MRP) process, which could include forecasting that is provided to suppliers with procurements physical systems, which may include material, requirement planning systems, electronic data interchange (EDI) systems and other physical systems, if you will. The procurement benchmarking study shows that more than 80% of the surveyed companies have an MRP system of a different type. However, only 25% buy via EDI, and there is more pointed information there. Even those who do buy via EDI it is not an incredibly great amount, and we do believe over the long term that EDI is a kind of system that procurement should migrate to, but the technology and other factors are really not there yet. The question here is what we'll talk about when we start with Ken. How do they approach the linkage of their strategic planning process with these physical systems to appropriately deal with the tactical issue of getting a timely delivery of critical commodities, whether it is TTL logic, a 486 processor a 4 megabyte DRAM? Also, how to minimize the cycle time, if you will, the purchase order cycle time between the time that the commodity is ordered and the time that they get the final product, and even beyond that, to manufacture that final product. So Ken, would you start off with this one?

Mr. Pattin: Thanks. (Laughter). Procurement. I was very interested to come to this particular session and I am interested in the dialogue. Three words are used in my community and in my company that are not English, or at least when we use them, we use them in different ways. The three words are procurement, purchasing and buying, and to me they all mean something different. I think if we went around the room and asked each of you for your definition of procurement, purchasing and buying, as many a number of people in this times three are the number of definitions I would get for those three terms. We use procurement in a macro sense, and it is—I like the way you phrased it—the process that engages the creator of an asset and the user of an asset, and tries to drive them together in some way. It is really a macro term, and logistics. I don't like to use the word systems so I am going to change the definition here a little bit, because logistics in my view is the process by which procurement and buying and purchasing are all tied together in this particular discipline that we are talking about here today. In my view, in this industry the logistics process that we all deal with, either as users or suppliers, is arguably the achilles heel of the industry. The lead times are far too long in this industry to be responsive to what users

require, and it needs be a focus item, I think, for any serious user or supplier of things like semiconductors to focus on the logistics processes and get them tuned. They take too long. There are too many "hand offs" of information. There's too much misinformation. So it is an area that we have been focusing on an awful lot, and we try to focus on it at a planning level with horizons that are frankly longer than product life. So you try and deal with commodities and how you run logistic systems to focus on how to do things at the end of 1994. We haven't invented yet what we want to do at the end of 1994. So there is a whole set of decisions that occur and it's really classic decision-making in an uncertain environment, which is part of the logistics system. As you get closer in time and you know what you want to do, you have to tie those planning variables to a different set of planning variables. There is some uncertainty as to the volume you want to be able to do it in, but then finally you have to get it down to something you can execute. Somebody has got to write a purchase order or issue a command, and somebody actually starts spending some money to which they expect to get paid for their efforts when the parts are delivered. So the logistic systems and how we put logistic systems together is, and I'll say it again, probably one of the fundamental achilles heels of the whole industry and it's ability to put the kind of value in the complex marketplace that we face.

Do we have a logistics system? We've got more logistic systems than I even want to contemplate. There is at least one other guy on this panel that has a little previous association with IBM, and he will tell you about the logistic systems. If I pass the baton over to him, some of those systems are the same systems that my buddy, Bill, over there used. I don't know how many years it's been now, Bill, but a number of years ago he used to operate in the same kind of environment in which I operate. So we have a history of baggage of some old systems that were designed and we continue to use them because they have value. Some of you may be suppliers and may know a little about them. We have done a lot to amplify them and put in some very modern tools to get the time constance reduced. We are also continuing to look for tools, and are continuing to look for our suppliers to simplify their interfaces and get their systems tuned so we can get a quicker response to the marketplace. In short, we have a system, but it's an evolving one and I think it will continue to evolve for as long as run the business.

Mr. Bohn: This year the word allocation shows up in DRAM, 26-week lead times for the lucky users of TTL logic, and other constraints. I am going to ask Bill to follow up. Just one point about the first company we know of—SCI Systems. The purchasing department got ISO 9000 certification, so Bill why don't you tell us how you tackled this problem.

Mr. Quinn: Let me back up though and talk about benchmarking. I really didn't know that I was doing industrial tourism, but I am. I've been with SCI for five years and we've done three benchmarks. The first one was clearly industrial tourism. We do about 10% of our business in the government sector, and we signed up to do benchmarking with a government contractor in upstate New York, and spent an enormous amount of resources gathering data and passing it back and forth, and then did absolutely nothing with it. The second experience I had in benchmarking was to do it on price. I guess it would be more competitive analysis than benchmarking, but we looked at computer peripheral prices in Asia with one of our competitors, and it was a, "you show me yours and I'll show you mine," and that really wasn't a very satisfactory experience either. However, when we did the third one, we were in desperate need of a decent purchasing system, a decent logistic system and didn't have anything. It was really a primitive arrangement that we had so we went around and looked at the best of grade. We looked at some of the many, many systems that were identified and what they were capable of doing.

As a contract manufacturer, we purchase from almost everyone and it's important that we maintain good relations with almost all the suppliers, because we purchase from our customer's Approved Vendor Lists. We don't control the AVLS as much as an OEM manufacturer would, so we write an enormous amount of purchase orders. We have three regional purchasing centers in SCI — one in Alabama for the U.S., one in Singapore and one in Scotland. We wanted to have a completely paperless system that linked all three together so you could generate a requisition out of one place and have it produced in another region and issue the purchase order from that region. After really extensive evaluation of what was available, we wrote our own and we now run MRP twice a week, Sunday nights and Wednesday nights. Requisitions are generated electronically at the remote plant, one of our nineteen plants around the world. The next morning the planner comes in, decides whether they want to buy it or change the quantity. When you press enter, the requisition is electronically displayed at the buying location we want to buy it from, whether we want to buy it from Asia, Europe or the U.S. It's just an extremely fast way of getting the order processed. We run typically five to seven work days from the time a customer enters an order with us until the time the order is EDI'd to the supplier. We are about to establish a process where we will do a corporate contract table look-up, and if we are buying against either our corporate contract or a customers corporate contract, when the requisition generates, it will first look at a corporate contract table and then EDI directly to the supplier. In that case, we are looking at bringing down that order cycle time. Cycle time is probably one of the most important things in my CEO's vocabulary so we'll wind up bringing that cycle time down to hours instead of days. That pretty much describes the logistics system. We've had it up and running now for about nine months. I'd say about 60% of our dollars are EDI'd. That pretty well describes it.

Mr. Bohn: A quick question. How long is it between the first thought of such a system and when you finally got it implemented?

Mr. Quinn: Probably 3 1/2 years. We didn't do the entire system. We were a beta site with IBM in their enhanced caps system, so enhanced caps is what runs MRP. The part we programed ourselves was the back-end — the purchasing, the buying part.

Mr. Bohn: The next question is going to segue right into this one. We are going to keep this idea of the logistic process in mind, and we will ask some of our panel members, starting with Bill to assume that their company's key commodity requirements are safe for the middle of next year and just maybe if you identify with whether it is a 4 meg DRAM or some TTL logic. Identify something that is a constraint right now, and how do you envision your systems going to work to ensure that your suppliers are going to have capacity to meet your mid-year 1994 demands. I think there's one other element in there, particularly standard logic. Capacity is not just fab capacity. It is also assembly and test capacity, which is another lurking issue. So could you look ahead to the middle of next year? What are we going to do?

Mr. Quinn: Well, let me look back first. Last year, particularly in standard logic, we saw the lead time stretching out and didn't have the ability to get the volumes we needed. The allocations were being held steady with that of the previous quarters. So we went to several of the manufacturers and we actually developed partnerships with them. We went in and found out where the problem areas were and financially invested in some strategies with the subcontractor and with the supplier to get an increased allocation. We were able to meet all of our customers needs that way and through this method of partnering in the true sense, we were able to achieve our goals. Where we really fell short was our system doesn't do a very good job of forecasting, that is, the enhanced caps system doesn't. We are moving

forward now to install RISC (caps) 6000s at each of the plants in the distributed processing environment and we are going to get the plants to do individual forecasting at their level. Our plants typically run between 80 and 100 million dollars — that is a normal size plant for us. We will get the plants, which can do a much better job of it, to do forecasting on the their RISC 6000, and we will up-load it to our IBM mainframe in Huntsville and be able to transmit forecasts, hopefully, in the next few months that will be a lot more meaningful than anything we've ever transmitted.

Mr. Bohn: Now Bill Russell. He's involved in the Defense Systems and Electronics Group at TI, the Baldridge award winner. As a person who sources for military systems, "constrained supplies issues," you're facing them all the time. You're facing a product obsolescence, lifetime buys and those kinds of situations. Could you please give us a description of your system and how you can manage some kind of these constraint commodity situations.

Mr. Russell: Sure. Somebody spoke earlier this morning in one of the talks about mutual dependence on our suppliers, and that's a big part of what we do at TI, in that we have close long-term supplier relationships and through working together, we are able to provide long-term forecasts. This allows them to plan ahead and allows us to get our allocation of product. We have worldwide commodity teams that we can also leverage off each other. We have instantaneous visibility into where all product is being purchased around the globe and we can go to the primary purchasing site and achieve allocation from other areas, in addition to the plant site you happen to be at. Our purchasing system is a paperless system. It's an on-line system and we have an automatic up-load of all of our forecasts from using programs at each plant site — what they feel they will be building over a future period of time with a given probability, and from that we can enter into long-term option agreements with suppliers and purchase against them. That gives the supplier additional visibility into what we're using for their planning purposes and it also gives them an idea of what we are looking for. The other thing we do, for inventory management, is we stratify the parts that we buy based on their value and their value usage and we stock material based on the total value. So our "A" items would be, for example, the top 100 items we purchase and we may carry those two months. The many trivial items, "C" items, we may stock a six months supply. So that's another way we can attenuate some of the shortage and allocation problems.

Mr Pattin: So you read the Wall Street Journal too? (Laughter)

Mr. Bohn: We will be asking Bill a bit later about their supplier evaluation process, and we would also like to talk to you a bit later, since you won the Baldridge, about benchmarking in general. But Ken, we saw in the Wall Street Journal a very robust demand outlook the rest of this year into 1994 for the IBM PC Company.

Some people think that is just great, but in terms of procurement management, we are looking into the middle of next year. We keep hearing about allocation, constrained commodities, and lack of capacity. What specific systems, as we described some of your systems are going to operate to meet some of these commodity challenges. ?

Mr. Pattin: This is real logistics at work. We use the logistics process that we talked about before as the fundamentals. We have two things that we are doing at the moment. One is old and the other is a little new.

First, the one that's old. We have a lot of our own capacity in a vertical integrated structure and we are getting that capacity tuned to be able to deal with some of the issues as we see them in 1994, so we are bringing to bear some of our vertically integrated structure into play. **The second is, it is literally true that the product life cycle on many of our products now is shorter than the component lead times that they use.** So what we are putting into the

development process for our engineering companions to use is something called "design for supply." Before we will allow a particular design to be released so that we can build a model, and in fact even before it's prototyped, we will take the engineering community through their bill of materials and test the market, and test the supply lines for existing capacity at whatever the lead time is. Our mobile Think Pad 700 series and 750 series are modestly famous these days, and in fact, the dilemma has been the notion that we designedthe TFT LCD display into it. There is a limited capacity, and its popularity over-stripped that capacity and you've got to go out and build the equivalent semiconductor factories to build the stuff. So now as we begin to release new models, we go out and test capacity at the upper and lower limits of where we think the volumes might be. Then we either allow or don't allow the product to go forward, force the engineers to pick alternate components or design it in an alternate way that we can source. So we have to drive this fundamental issue back into the creation process, into the development process. Those two things we do different in the face of our dilemmas.

Mr. Bohn: We will visit you again in June of next year. (Laughter).

Mr Pattin: You do that (Laughter).

Mr. Bohn: I want to turn the podium back to Mark Giudici. We are going to start off with TI prospects regarding supplier evaluation and management and it's a very detailed process. We believe it is state of the art or best in class.

Mr. Giudici: As Ron was saying about winning the Baldridge award last year, there is a lot of preparation that goes into winning that kind of an award, and the process that one company goes through may be similar to another company's. However, there are different market factors and other issues that will modify a company's approach to its particular problem. I would like to go through Bill's approach — explain your processes, both thought processes and real processes, that you used to get the Baldridge, including Supplier Management.

Mr. Russell: Supplier management. We set up a supplier management strategy back in 1990 when we realized we had 2000 suppliers, which was extremely costly to maintain. We just did not have the resources to manage that many suppliers, so we had a cross functional group of senior managers at TI get together to discuss how we were going to work with our suppliers in the future, mainly what was important to our growth, as well as our profitability in achieving our company objectives. The result of that was a supplier management strategy that was implemented in late 1990. We took our supplier base and put them through a 147-question supplier relationship model, which basically determines whether a supplier would be a strategic, critical, transactional or problem-solving type supplier. It looks at the certainty of the market, the state of the art of the products that you are buying, and wheter the company you are buying from is a world class supplier. From that supplier relationship model, we came up with 57 total strategic and critical suppliers. We had assigned each of those suppliers a senior level manager to be a sponsor, and there is a kind of power to each of our suppliers. What we do is we work with them to help design them into new programs, as well as channel as much business as we can to them and away from our problem solving type suppliers. By the way, the 57 suppliers is roughly 5% of our supplier base that currently makes up over 50% of our purchases. By 1992, the end of last year, we were down to 1200 suppliers. This year so far, we are at roughly 1000, and our goal is to get down to 500 total suppliers by 1995. For our ongoing evaluation process, we have what we call a supplier performance multiplier, which is a quantitative method to allow a buyer to determine who's the lowest total cost of ownership supplier.

It takes the data that's readily accessible, looking at the cost of conformance, inspection

of the suppliers material, which we add to the cost of non-conformance, the defects on the line,visual inspection, the transaction cost and the cost of actually doing business with that supplier. With the quantitative multiplier, you can multiply "times" the suppliers bid, that will give you a lowest total cost of ownership. Another method we use is a supplier evaluation matrix for many products where a supplier performance multiplier may not be a good application. It's a methodical approach you can go through to come up with the same solution for the lowest total cost of ownership in dealing with the supplier.

Mr. Giudici: Very good. I understand you have a software package that facilitates this process. Maybe you can go into a little bit of that.

Mr. Russell: Our supplier evaluation software is a PC-based software. It runs on IBM compatible software. It's a series of questions, 147 questions to be exact, that ask you yes or no questions about the supplier and when you get done, it will tabulate a result and show you to what degree the supplier is operating in an uncertain market, how critical the supplier's product is to your present and future, and things of that nature. From these results, we categorized each supplier.

Mr. Giudici: Excellent. Bill Quinn. On the strategic relationships that go into management of suppliers, maybe you can give us your thoughts on where the SCI has come from and where you are going.

Mr. Quinn: As I mentioned earlier, as a contract manufacturer, we adhere to our customer's AVLs so I really need to maintain a good relationship across the board with all the suppliers. It's hard for me to not do that, but we have developed a supplier measurement system using the enhanced caps. The thing is already built in there, and we have made our first few passes at it and we are reviewing a delivery performance, for example, with zero days late and three days early, and finding that we don't have nearly the supplier conformance that we thought we had.

Several of the top 50 suppliers came out in a less than 10% on time delivery using that criteria. So our strategy in supplier partnership is really one that with the exception of those that we control directly ourselves, such as Mechanical Parts and probably Computer Peripherals, we are pretty much locked into our customer's AVLS. Our strategy is just to maintain a good relationship across the board, across the world.

Mr. Giudici: Ken, on your views of supplier management with the shifting role of the PC market and reduction of supplier bases, maybe you could tell us some of the history of IBM in terms of sourcing.

Mr. Pattin: Sure. Most of the flows of technology in this business come from manufacturing facilities that are not IBM facilities. If you go back to the logistics processes we were talking about before, we are beginning to treat those facilities as other enterprises and put them in the supplier base like we would put suppliers that are non-IBM factors. So we are beginning to look at the supplier base in it's entirety — the way we view it, the way we try and manage it, and the way we would source in it. If you look at any of the particular commodities that we have, we continue to try and convince ourselves that we have too many and we continue to try and convince ourselves that we need to get closer to some of them, which we would deem strategic. We have similar methodologies. I don't think we've got the 147 questions yet, but we've got a methodology that tries to categorize particular suppliers by whether or not they are strategic tactically and whether or not they've got core skills that we need. We continue to try to do that, and I think as we begin to move from the point of when you create something until the time you actually deliver it to somebody who is going to use it, and try and get the cycle times closer and closer. We are going to be forced to reducing our total supplier base and getting our

relationships more finely tuned. I've been in this business 30 years and I've heard this for 30 years in some way, shape or form. I think the reality is upon us, particularly when we are trying to execute, that we are going to have to get our supplier bases down.

So this whole management process of how you evaluate them and using on time delivery and the old methodologies is a whole set of things that we are rethinking. How do you really decide whether or not you want to get this guy has become a fundamental part of your business.

Mr. Giudici: Great. Thanks a lot. Another topic that came up in Ron's report was the value of third party certification plans. This would cover issues like the Malcolm Baldridge award, ISO 9000, 9001, various magazine certificates and the like. What we would like to do is to maybe touch bases with you, Bill, on what your thoughts are on this issue. ISO 9000 certification, that is.

Mr. Quinn: We have just finished having all nineteen plants around the world certified under ISO 9000. We use several different agencies to do it. We certified the purchasing department as a separate entity because the three regional centers serve all 19 plants. We thought by having the officers come in first and audit the purchasing process, then they wouldn't have to ask those same questions when they went to visit the individual plants. That's what motivated us to do it and I believe we were the first purchasing organization in the world to receive that certification. 3M in St. Paul has now achieved the same level, Electronic Business Buyer magazine in January is going to feature SCI systems registration of their ISO 9000. It's meant a lot of things to us. One of the things that's meant a great deal is having the customers come in with their own individual quality forms. If you could point to an ISO 9000 and say you have the plan to certify another ISO 9000 and this is where we operate, the customer seems to take a liking to the fact that they can now sidestep some of those multiple questionnaires. Some of the multinational companies that are our customers would come in from different divisions with different quality plans and somebody wanted me to apply for a Baldridge award and somebody else wanted me to be certified under ISO 9001. So taking the bull by the horns so to speak and just certifying the whole purchasing process was our solution.

Mr. Giudici: Thank you. I want to thank HP, IBM, SCI, and TI for being here today and also to our audience.

The Emerging Role of Equipment and Materials Suppliers in the Semiconductor Industry

Joe Grenier, Moderator
Vice President, Semiconductor Manufacturing and Applications Group

Panelists:

Eugene Bernosky
President, CEO, and Co-founder
Applied Chemical Solutions

Thomas Nelson
Process Manager, Electronics Commercial Development Group
Praxair, Inc.

John Osborne
Vice President
Lam Research Corporation

Bert Allen
Manager, Device Technology Sub Micron Development Center Fab 25 Wafer Facility
Advanced Micro Devices

Mr. Grenier: Please take your seats. This is the way we are going to do this is. I will introduce the panel members and then Clark Fuhs from Dataquest will give an overview for about ten minutes. Then I have a number of questions which we will address to the panel, and after that, if there is time, we will open it up to questions from the audience. Lets get started.

In the past, equipment companies simply delivered their equipment to the semiconductor company and material companies simply delivered their materials to the semiconductor companies. However, now both equipment and material suppliers are increasingly being asked to deliver and do more, as the semiconductor companies want their suppliers to become more involved in the manufacturing process. One of the things we want to define today is what is a product now? It used to be just a piece of equipment or the material. What is a product today and what are all the features that the product embodies? What we'll look at is where

this trend will be and what the future role of the equipment and material suppliers will be as the industry evolves. We should note here that what is happening in the equipment and materials industry is just part of a larger phenomena that is happening throughout the electronic industry food chain. We talk about the electronic industry food chain with electronic equipment suppliers up on top and the semiconductor suppliers and the equipment and material suppliers down on the bottom. To give you some examples, contract manufacturing of electronic systems where a company contracts out, for instance, like IBM, to have their computers built. You know about SCI and Selectron. These are companies that are building their business on doing contract manufacturing.

In the case of the semiconductor manufacturing, the ultimate is fab-less semiconductor manufacturing, where they entirely contract out their activities. In the equipment and materials industry, it is same thing. The semiconductor company is looking downward to his vendors and he is trying to contract out, if I can use that phrase, more and more of his activities to the material and equipment suppliers. I think that in every tier, wherever there is an interface between the supplier and customer, what we are finding is that the companies are trying to concentrate more in the higher value added activities and figuring out ways of eliminating or contracting out the lower value added activities. So today, we want to explore the future role of the equipment and material suppliers, and to do this, we have five gentlemen on our panel representing various aspects of the industry. John Osborne on my right, Senior Vice President of Lam Research, Bert Allen, Sub Micron Development Center, a manager of Device Technology for AMD who is assisting the start up of AMD's FAB-25, Tom Nelson, Process Manager of electronics for a Commercial Development Group of Praxair, Peter Silverman, Manager of Process Equipment Development from Intel and Eugene Bernosky, President, CEO and co-founder of Applied Chemicals Solutions. We have on the panel two semiconductor companies who are the customers, an equipment company, a materials company and then we have Applied Chemical Solutions, which is a combination material and equipment company.

I thought before we would start that each panel member could just briefly state why he is participating in the panel and what he can bring to this. Eugene, why don't you start.

Mr. Bernosky: Thank you Joe. A little explanation about what we do at Applied Chemical Solutions. We are primarily an equipment manufacturer/equipment designer, and we are in mainly the liquid chemicals area, however, with the evolving marketplace, we have gotten more and more involved in materials management. We are often confused with, perhaps, being a chemical supplier. In the past, with reference to the liquid chemicals area, the device fabs would buy various chemical distribution or precision mixing equipment from an equipment supplier like Applied Chemical Solutions. They would take these modules and install them into their facility.

The fab would have their own A&E firm and their own construction or contracting firm to lay in all the high purity piping, but over the last several years, there has been a real transition taking place and that is, companies like Applied Chemical Solutions are now asked to get much more involved in the project. Everyone in this room is probably familiar with the huge new fabs and retro-fit expansions taking place right now. The market is quite favorable for new equipment. If we look at the last six to eight bids and jobs that we have undertaken, not only are we asked to supply the systems themselves, we are asked to quote on an A&E firm and actually take accountability for all of the engineering that goes into the fab. We are asked to install the equipment. We are asked to talk about addressing the value added for other processes,

like chemical reprocessing, chemical generation and on-site mixing — questions that would normally be asked of your chemical vendor. One of the things that is evolving in the liquid chemicals area is that there is a technological evolution taking place that, perhaps, the gases have been going through for fifteen or twenty years. People are finally starting to see that they have alternatives and they're learning how to treat their liquid chemicals. They are asking companies like Applied Chemical Solutions to help them evaluate their alternatives, and are also asking us to take accountability, not only for the systems, but for the integration of those systems into the fab. At the same time, they are expecting us to look at the alternative technologies to add value to the chemistries. They are looking at us as experts in the liquid chemicals area. It's getting real gray as to where our responsibility starts and ends, but there is no question that the marketplace is changing, and we are being asked to take a leadership role in that. The fabs appear to be moving away from taking accountability for some of the support systems like liquid chemicals and cleaning materials, where that is not their core of confidence.

Mr. Grenier: Thank you, Eugene. Tom.

Mr. Nelson: I am with a gas supplier and we supply cylinder quantities of specialty gases like phosphene and twenty or thirty other specialty gases.
We also provide nitrogen, hydrogen and oxygen and with larger customers, on-site nitrogen plants that actually cryogenically take air, distill it and make high purity nitrogen right at a semiconductor production plant's facility. As was just mentioned, ten years ago the philosophy was to just deliver the gases. Then the semiconductor company took over. Well, what we are seeing now is that the gas supplier is being more and more involved with the total systems approach. In some cases, you're actually running the gas systems at the semiconductor facility under contract to the semiconductor manufacture, and that means maintaining gas cabinets, changing cylinders out in the gas cabinets, installing new piping lines in the facility and providing point of use guarantees for piping systems that are still owned by the customer, but are really jointly run by both the customer and the gas supplier. Examples of some of that would be making point of use guarantees of gases to the tool of nitrogen purities, like trace oxygen and moisture of 10 PPB or even less, going out of one PPB — making those kinds of guarantees and being more and more involved. I think a good way to summarize it is that the semiconductor companies are good at manufacturing semiconductors and the gas companies are experts in using and supplying gases. What we are seeing is that the semiconductor companies are saying to the gas suppliers, "we want you guys to be involved and handle the gases for us, so we can concentrate our resources on manufacturing chips." I think that is the trend that started with the larger companies, but we are now seeing that some of the medium tier smaller companies are getting more interested in what I call these complete site services that have the gas supplier responsible for more and more of the operations at the customer's facilities.

Mr. Grenier Thank you, Tom. Bert.

Mr. Allen: Thanks, Joe. Thanks, Tom. Twenty five years ago, in the semiconductor industry, about half of the equipment that we used was manufactured, designed and assembled by the semiconductor manufacturer. If you didn't like what you got, you rebuilt it to serve a different purpose, so the semiconductor companies were truly in the equipment manufacturing business.

As equipment manufacturers spun out from that to form other companies which we see all around us, there developed, at least from my perspective, an adversarial relationship between the semiconductor manufacturers and the equipment manufacturers. In other words, if your equipment didn't work, it was the manufacturer's problem. They were a source of problems and you beat on them to get results. That was about tens years ago. There has been

a rather substantial paradigm shift or transformation since then, and in successful relationships with equipment manufacturers today, there is a partnership. The equipment and material manufacturers aren't seen, at least from my perspective, as adversaries, but as partners and sources of solutions. Now, we have taken great care at AMD to select manufacturers, both of materials and equipment, who can sustain that type of relationship. As I see it, there is an extension of that moving in the direction of where we're going now, and to tie together a little bit of what both of you have said — that the interest from the semiconductor manufacturers is the point of use. It's on the surface of the silicon wafer in process, so that we are interested in somebody delivering a product to the surface of the wafer. That product might be power, a plasma density, or it might be a purity and we want it at good economics. What I am saying is we need a seamless boundary from the source of materials and equipment tools to the wafer, so that, for example, the photoresist thickness on the surface of the wafer is the same all the time and that is not just a photoresist manufacturer. That is a photoresist manufacturer and a spin-track manufacturer. So we want to see a seamless boundary there, but I am not sure how that is going to develop.

Mr. Grenier: Thank you, Bert. John.

Mr. Osborne: I'm John Osborne with Lam Research. I think that just to summarize a couple of the points that were mentioned here earlier. Lam Research has transcended, in the last five years, from a company that had about 300 people to one that today employs about 2000. We went from seven locations to about twenty-two locations worldwide, and the thing that happened during that time frame was certainly the same shift that was mentioned here earlier. We started off providing hardware, then we got into a little bit of support and then we started providing process solutions. With those process solutions, the hardware became a minor part of the product that we were supplying.

What we'll see in the future is a continued trend of this nature, which is very consistent with what Eugene was saying. Today, the hardware probably consists of about 20 to 30% of it. Application notes, ongoing process support and process development is now becoming a very major area, including complete ownership in areas like training people on how to operate the machines, preventive maintenance procedures — essentially a womb to tomb type of a scenario. I think the issues that are facing us are twofold, at least from our perspective.

One, we believe we have to continue to adapt in order to continue to grow in this environment, but that adaptation involves taking more and more ownership. Last year, the boundary was kind of drawn into place around ownership, preventive maintenance and a little bit around process development. However, I think that there is going to be a time when purchase orders are being replaced by development contracts. The process solution provider, which we consider ourselves to be, actually will end up with a development contract to do everything from developing a process to developing the equipment to go along with it to installing the equipment to placing that equipment into an area and sustaining it over time.

The challenges that I see around that scenario are threefold, and I guess this is where we need to continue to learn and adapt as one. We have gotten pretty good at pricing our product, as it is today, but as we get more and more into the ownership, it is not obvious how we can continue to grow and make a profit because the service component of the business is continuing to grow at a very, very rapid rate. Second is the difference in people. Today about 44% of Lam Research is technical. We had around thirty process engineers five years ago and now we have about one hundred and fifty process engineers. However, I am not sure that is enough and I am not sure that we are going to have the right resources, the right type of people, the right training and the right management to continue this ownership. The

third area actually gets into responsibility. As we move further and further into the area of cooperation with the device manufacturers, we are getting very, very close to being responsible for the [inaudible]**** yield in the fabrication facilities and I think that this is good, but it also leads us into an area where before we could put our hands around a box of defined responsibility. In the future, I think that responsibility is going to grow and it is going to get very close to the areas that the IC manufacturers are measured in today.

Mr. Grenier: Thank you, John. Peter.

Mr. Silverman: Thank you. I'm Peter Silverman. I manage Intel's Process Equipment Development Group. Our job is to select the equipment we use in our factories and to work on programs that improve the capability of the equipment, primarily working on output capability. That is certainly the major weakness of equipment today. I certainly agree with the observations of the other panelists. We try to give that to you with an Intel perspective. Intel is big. We are definitely not fab-less. We are building factories at a rate that surprises even us today. We have three major 200mm half micron facilities going full steam, and we are starting to put up a structure for future factories for the next generation. We do see an evolution of the relationship between the equipment suppliers, the material suppliers and the manufacturers. We are going from a situation where we used to buy things and then take ownership ourselves to a point where we are looking for much more of a total cradle to grave type of solution from the suppliers. For example, we are looking to suppliers to sell us equipment which meets safety specifications so that we do not have to bring it in, and as we are doing now, undergo massive retro-fit programs. Close-up equipment that is sold by the supplier base today is not ergonomically acceptable and we are ending up with carpal tunnel syndrome in our operators. We are looking to suppliers to foresee this kind of problem and deliver solutions to us so that we don't have to engage in retro-fits. Our expertise is in doing the detailed process development and in particular, in what we in the industry call process integration. It basically means stitching everything together so that you get a chip out of it instead of a bunch of disconnected pieces. The suppliers need to sell us equipment that meets the safety, environmental and output requirements for running a factory. We see output as a major problem for the industry in the future. If we can't increase the productivity of our equipment, we literally will not be able to build our factories. The current generation of factories is running about a billion dollars for a typical size factory for a large manufacturer and if the trends continue, we will hit two billion dollars at the quarter to micron generation and even Intel can't afford that. So we are looking to mutually solve that problem in higher productivity equipment.

Mr. Grenier: Thank you, Peter. With that background, I would like to introduce Clark Fuhs who will give a brief overview to set the scene for the questions. Clark is a Senior Industry Analyst in the Semiconductor Equipment, Manufacturing, and Materials Service and he has recently joined Dataquest. He came from Genus, an equipment company, where he had over ten years of experience. Clark has a B.S. degree in Chemical Engineering and an MBA from the University of California. Clark.

Mr. Fuhs: Thank you, Joe. I would like to welcome our panelists and everyone to a discussion on the future role of the equipment and material suppliers in IC manufacturing. As you have just heard, the role of the equipment and material supplier is changing dramatically, and I'd like to look at this through the use of the equipment landscape. It used to be that the IC manufacturer had complete ownership for the performance of the entire landscape. Presently, the performance of the major equipment sets, systems and facilities, with the exception of one or two in the effluent control area, are owned by the suppliers. The interactions are still primarily owned by the IC manufacturer. We see a change, however, in the ownership of

these interaction areas in complete subsystems to the supplier community. Why are these changes occurring? These are viewed as the key driving forces for the changes — reduced cycle times and quick processing to reduce Work In Process Cost. Reduced cycle times also are driving a trend toward turnkey design solutions and fast start-ups. Flexible manufacturing and multiple product fabs drive changes in the way equipment is evaluated. Both of these and other actions are being driven by seeking higher return on capital. How can we measure the global success of these changes? Everyone is very familiar with this curve, as shown numerous times with the wafer fabs. In short, the costs are increasing dramatically. While this may be emotionally stressing, is this necessarily bad? Or are things just different? From an econometric standpoint, this graph is not really enough information from which to reach any conclusion.

The slide shows that markets and spending are growing within a couple of percentage points of each other in the long run though the pattern for spending tends to be cyclic. This situation appears fairly dynamic, but it is healthy. According to published reports of a number of U.S. semiconductor companies selected here, capital spending as a percentage of revenue seems to be in check over the long haul. Wafer fab equipment spending as a percentage of revenues has also remained stable. With real revenue per employee up, stable spending percentage and growing markets, all appears econometrically satisfactory. Granted, the changes that have taken place appear to be necessary in order to maintain this performance so it is likely that a further change and probably culture shifts in the future will be needed to continue this pattern. Barriers to future change is one area that we will cover here today and we can characterize these in one of three areas. We call these cultural, technology and system/infrastructure. Cultural barriers refer to those thought process and procedures of the past that are inhibiting productivity improvements going forward. Some of the key culture barriers at issue might be the IC manufacturer's appearance to want to stay involved in determining the path for improvement as well as the results. Should this change to a "results only" philosophy? Is standardization of equipment good? By this, I mean the effort by the equipment community to produce more of the same kind of product to reduce their manufacturing costs. Is this good? Does it provide benefits to the IC manufacturer? Or is the IC manufacturer so specialized in each company, such that the mind set of the equipment community needs to be changed? As Joe mentioned, what is the definition of the product being delivered? Clearly, we are beyond just shipping equipment and materials. Finally, who pays the cost of development? Equipment and material suppliers have borne the brunt of most of the costs associated with developing new technologies. The only exception to this is Sematech, who over the last few years has infused some money into American equipment manufacturers. Over the last ten years, two major wafer size shifts have occurred — 6" and 8" wafers. These costs are accelerating. The way of the past is accelerating prices. Can this continue? Some technical barriers exist and need to be overcome. Perhaps the lack of equipment design models is forcing empirical work, which is slow and expensive. As far as measurement techniques are concerned, there are not enough measurement techniques out there to detect some of the things we are trying to measure. Also, the capital requirements for pursuing new processing technologies are massive and may hinder new players.

Using limited capital R&D wisely means a prioritization of these issues. How will that be done? Systems and industry infrastructure may need changing or in some cases, building. Automation standards, as they relate to equipment and feed control systems, are non-existent and partnerships to handle landscape interactions are few. This panel will look at what is needed for performance measures, characterize barriers for future progress and suggest solutions for the industry going forward.

Mr. Grenier: Thanks, Clark. As we have been saying over and over again, the role of equipment and material suppliers is changing as the relationships evolve, but how do we measure the success of the relationships? How can we quantify whether things are improving or not? So the first round of questions I would like to focus on involves metrics. What are the metrics involved? In particular, I would like to start off with the semiconductor companies. Bert, I will address this question to you and we will modify it as we go to the equipment and materials, but basically tell me about the metrics by which you judge your factory performance and how can equipment or materials suppliers improve your performance by changing that metric?

Mr. Allen: The operations metrics for a semiconductor factory generally involve how much a piece of silicon costs in dollars per square cm. The current target for world class silicon is somewhere between the area of 4 and 6 dollars per square cm. There are a lot of metrics that underlie that bottom line metric, such as cycle time (how quickly you can put silicon wafers through the manufacturing process), line yield (how many wafers come out as compared to how many wafers you started with), wafer sort yield (the percentage of good dye on the wafer) and activities (the number of wafers you can produce for a given factory and a multiplicity of metrology metrics having to do with control of the factory while you are processing wafers). Those are all metrics in the manufacturing process. There are metrics that we also deal with that involve our relationships with our material suppliers and our equipment suppliers. Some of those metrics get soft. They don't look like a numerical analysis. We ask ourselves a few questions. Do we meet with these people once a month or once a year? What does their manufacturing site look like? What kind of statistical process control do they use? Does the company seem sound?

Are they easy to work with? Do they create seamless boundaries? Do they create an environment which empowers their people to work through to solutions? I could go on, but we've veered off into an area that is not so easily measured when we are dealing with relationships with our equipment suppliers and our material suppliers. Our focus with both is what it does to the wafer in the wafer manufacturing process.

Mr. Grenier: Thank you. Peter, could you give Intel's view on that?

Mr. Silverman: Sure. Specifically talking about process equipment, when we go to select a piece of new equipment for a technology, we have a hierarchy of needs that we go through. First, the process capability has to be there. If it doesn't do the job, it doesn't make it. The next thing we look at are the environmental and safety aspects. We will not use a piece equipment that creates environmental problems, regardless. We will abandon the technology and find another way to do it, but this is a hurdle. We bring no equipment into our factories that does not pass the SEMI safety specifications. Those two hurdles being met, the key thing that tends to differentiate one piece of equipment from another is the cost of ownership or more particularly, the output capability. How many good wafers can you make per unit time? That is a function of the speed of the equipment and the number of wafers per hour you can crank out of it. It's a function of the yield, although a relatively weak function, because most equipment has very high yield. It's also a function of the reliability of the equipment and this is clearly the major focus area for us. I harp on it endlessly, because it is the road block we see. The other things that we look at are the capability of a supplier to give us worldwide process support. Intel has factories in the United States, Ireland and Israel. We need a company to give us support at all these areas and to do it consistently in each place. We are moving more and more towards a model where we have a very large degree of support from our equipment suppliers. In the factory in Ireland, for example, all the equipment maintenance is done under contract to our equipment

suppliers. They provide site supervisors and all the technicians. Intel does not have maintenance people, so it is entirely contracted. Those are the major things that we look at in a company. We do want to see process capability within a company as a way of giving us support. That tends to come in very heavily in the initial evaluation phase.

Mr. Grenier: Thank you. John, as an equipment company, what are the metrics by which you are being evaluated by your customers, and what can you do to improve your performance to meet their internal metrics?

Mr. Osborne: The bottom line answer, I guess, is that you are measured by whatever the customer measures you against. I think that if you divide it out in a couple different areas, the very first thing is providing a technology solution consistent with what Peter said. This is if you don't have the process and the capability of providing a process. Then all of the rest of the issues as far as cost, ownership, environmental and safety are second hand. So we see it in the hierarchical sense as if having a technology is one thing you have to prove. You have to show that you are capable of providing a process solution. The next major area after that, on a global basis again, is overall cost of ownership. The cost of ownership involves issues that were brought up by both Bert and Peter, involving throughput, overall support, the reliability of the equipment, the amount of operators required to run the equipment, software support, and so forth. The cost of ownership also gets into the area of the extended ownership that you have to take over in terms of the installation and preventive maintenance. After that, I think the next major area it gets into, and it's universal, is the image and overall relationship that you have with the customer. Primarily, the image involves the concept of how easy you are to work withand your financial stability. Most companies we see, today that are global competitors, and there are only about four in each technology, seem to have a pretty universal financial strength. They have a global operation, which means they are able to support global companies. They seem to have a current investment in R&D that ranges from 15 to 18 percent that continue to evolve for the future. Above all, they really foster that relationship. Customer satisfaction is a very, very important part of it. The fourth level gets into the particular company or particular region type of concerns, and the metrics in Asia. For example, today if you go over there, and you don't have a footprint that was 1/2 of your former footprint, they hand you your lunch and show the way to the nearest subway stop. So there is a lot of pressure coming now, at least in the Asian marketplace, for reduced footprint. Other companies are looking for increases in automation. That is another big thing as far as the rim goes — the ability to interface with fab level MIS type of systems and be able to have a certain level of automation. Then it varies again by company, involving things like safety and environmental, but those are unique I think to the particular company as opposed to common industry drivers. That's pretty much the sum of all the metrics.

Mr. Grenier: Okay. Eugene, from your perspective, what are the metrics by which you are being evaluated, and how can you improve?

Mr. Bernosky: Well, as has been said earlier the one thing I think is universal is the qualitative aspects of having a seamless, very comfortable working relationship with the customer, and I think that is just a constraint of doing business. You don't get the business if you can't work with the customer. So that's a hurdle you have to get over that is not necessarily measured until things become less favorable. I think the cost of ownership certainly wraps a lot of things up like equipment reliability and standard measures of performance for an equipment company. Where things really start to get difficult is you have organizations or suppliers getting more involved in things that are not necessarily their core of confidence. I'll use the example, if you ask Lam Research to go install the gas lines, that would probably be getting a little bit out of

their range and it would be difficult to say what the metrics are for that. The process tool vendors role is to get a certain result on the wafer surface. On the cleaning side, which we get more involved with, the role of the wet bench manufacture or the cleaning tool manufacturer is to get a certain result on the wafer surface, whether that be cleanliness or a completeness of removal of some layer of material or a particle speck. However, the gray zone is in how you measure the things that we are doing when we are getting involved in delivery of the cleaning chemistries and the end-user is asking us to get more involved with the process tool vender to get a certain result on the wafer. Those are the measurements of the benefit of having a higher chemical purity — having a closed loop reprocessing system. This is where the metrics get a little bit shaky because there is not a whole lot of data in that area. There is no accountability, nor is it real clear who is accountable for what under that scenario.

What that will get into is something that is difficult to measure — what is the cost benefit to a higher purity cleaning system? This is really pointing out some of the metrics that become difficult, with what the real cost benefit is to various chemical systems, various levels of chemical purity and various on-site chemical processes. Those are the things that currently are real difficult to measure, but clearly, the supplier and the device manufacturer have got to work that out.

Mr. Grenier: Eugene, as a follow-up question, what percent increase in performance does a semiconductor manufacturer get by having on-site chemical generation versus having the chemicals delivered? What is his increase?

Mr. Bernosky: That's one of the things that there is no absolute answer to. It's the same question with gases, as to if you 10 PPB moisture in a line, how much benefit is it having at 1 PPB? I'll make a few generic comments about the current industry conditions. The semiconductor device manufacturers are real clear to us that they don't want to necessarily pay a higher price for a greater purity product. They expect to see continuous improvement and they would like to keep the price setting and the cost of various processes at parity, but to get improved performance, which in this case, would be higher purity. The absolute dollar benefit to having the higher purity is real difficult to measure. One of the things that is not necessarily shared that often with the semiconductor supplier is a whole other area that gets into quality and that's conformance to the specification. One mistake can cost a device fabrication facility millions of dollars so if you set up a system in the case of an on-site gas to chemical generator that is more reliable than the liquid source, what's the value there of the mistakes that don't occur? That seems somewhat qualitative, but it's difficult to measure the absolute purity benefit that you get.

In the chemical systems arena, there is a whole other area though that needs to be looked at and this gets into on-site generation as well as reprocessing and that's elimination of packaging. Eliminating a lot of the waste that's associated with the chemical processes is one thing that I will say the U.S. semiconductor industry is starting to value highly. They actually do put a dollar value on what the waste stream is going to cost, or in the case of processes where you are replacing an existing use and dispose process, there is a real value to eliminating that waste stream and they can put a dollar and cents number to it.

Mr. Grenier: Thank you. Tom, from a gas supplier, just how far into the fab are you going, or being asked to go now, and how much do you guarantee, and what are the metrics by which your performance is being judged?

Mr. Nelson: Well, it's purity or products you provide, but it used to be like I said in my opening remarks — you just dropped at off at the door, then somebody else took over, but

what we are seeing now is that the gas suppliers are becoming more involved. They're providing supply systems where there is an on-site generating nitrogen plant or bulk tanks or specialty gas cylinders. That is a more traditional role and the way those are evaluated is by asking what purity can you provide and how consistent. We have had cases where we have actually worked with the semiconductor firm's general contractor through their piping contractor to put in piping systems in the customers facility and guarantee purity, not just at the start up, but on an ongoing basis for as long as we are the gas supplier at that facility. We'll provide 10 PPB gases, oxygen, moisture and nitrogen, for example, and that's an ongoing thing so we'll have people at the customer's facility managing those gas systems. If the customer wants to make an addition to a gas system, we get involved in making sure that those installations are done properly — the correct weld procedures, the correct purge procedures, the right tubing, valve and components that are consistent with maintaining a 10 PPB system and doing that all up clear to the point of connection to the tool.

One of the other things that we've done, and we have been doing this for a fair amount of time, is we've got a specialized service where we are actually able to measure purity of gases inside the tool. Initially, we started to work with atmospheric pressure, low pressure and also particle work. We are actually taking gases out of a tool and measuring purity during processing and giving the oxygen content and moisture content or other contaminants that might exist and making suggestions. In some cases, we work with the tool manufacturers. In other cases, we work with semiconductor firm companies like the ones represented here and create programs where we have suggested some better ways to operate tools so we are getting intimately involved in that and operating systems. In some cases, we even operate the customer's gas detection systems for safety inside their facility so we're more and more involved in the whole operation of the facility. When you get involved in those kind of things, reliability and supply are absolutely critical. Something like nitrogen is used in almost every process inside of the semiconductor firm. It is used everywhere so if the nitrogen system were to go down, that would be a real problem. Thus, 100% reliability of supply is absolutely critical. We are working with our customers more and more to have redundant systems, dual regulators, dual filters and dual kinds of supply just from the point of view that a customer can't afford to be without the product. Safety, of course, is a standard thing that's been involved a long time. Those things have to be continued. I think reliability is probably the thing that we've seen in the last couple of years that people are realizing has to be 100% reliable.

Mr. Grenier: Thank you. We keep talking about increasing relationships, but there may be certain barriers to increasing those relationships. First of all, we haven't been able to put anything quantitative on the very soft metrics on increasing of relationships. We have hard metrics on factory performance, but there seems to be a gap here about how we can measure improvement in relationships. So lets look at the barriers to increasing the relationship. We have identified cultural, technical, and system barriers. Lets take cultural barriers first. What are the perceived cultural barriers to increasing the relationship between a semiconductor company and its supplier, and if we can identify some of those barriers, what are the solutions?

Mr. Bernosky: I gave this one a lot of thought and it really boiled down to two cultural issues — trust and value. The first is that you've got to trust the partner on both sides. There has to be a great deal of trust because essentially, the end-user in this case is going to put a lot of faith in his supplier to do what is right for the end-user. Then you get into the issue of value, which is how much that service and trust is worth, and those two issues can be very difficult to get through in the early stages of the relationship. In terms of cultural barriers, there has to be an awful lot of trust built up between

the supplier and end-user, and then you've got to come up with an effective way to value the service that's being provided because now you are no longer just providing a product that is necessarily ... well it's all tangible. If you've got something that includes a processing system along with the materials, that should have a certain value. What does it cost for the supplier of that whole service to actually provide everything for the end-user that the end user-used to have to provide the infrastructure for? So that gets into what is the real value of the service when you are getting away with something like an absolute technology core that might be part of a processing tool.

Mr. Grenier: Eugene, can you give an example of how trust would increase a relationship ... a specific example?

Mr. Bernosky: Well, let's use the example that we're asked to install a gas to a chemical generator for one of the critical cleaning chemicals. Let's say, HF. Let's assume that the end-user has decided to work with Applied Chemical Solutions to do it. We can provide a piece of capital equipment. It turns out the customer also wants us to operate, perhaps even own this piece of equipment, and they'd like to get a result on the wafer — this wafer is going to be this clean after they do their RCA cleaning step, but the reality is they'll probably say the chemical's got to be this clean when it gets into our wet bench.

So now we have got to be concerned with his DI water source because that's going to be one of the two key raw materials here. I've got to have absolute faith that the customer's DI water on-site is absolutely clean. He's got to trust me to go out to the gas source, which my company is not basic in, bring in a gas that's ultra-pure and know that the process that's going to take this gas that we didn't produce is going to take his DI water. He's got to trust me to get the end result that has been specified in order to clean this wafer. So there's got to be a lot of trust going both ways. Then he's got to trust that I'm going to pick the right gas. He's got to trust that we're going to go through the correct procedures to make sure all the raw materials are clean enough and, here's a case where there's going to be three parties involved in getting the same end product. There's got to be system put in place and then the parties need to trust each other.

Mr. Grenier: Would anybody else like to take a stab at the cultural barriers?

Mr. Silverman: Sure. From our perspective, we feel that the suppliers don't really understand the business that we are in as well as they need to. The integrated circuit manufacturing business is one that is extraordinarily competitive. It requires an enormous degree of investment just to remain a participant. It is an environment where year after year, we have to give a higher performance for the same amount of money, whether you are producing a DRAM or a microprocessor, the price you get for your product stays constant, but you have to give more to the customer over time. In contrast, the materials that we buy escalate in price with each generation. We also exist in an environment where our customers insist that we have no interruptions of supply because our customers are in an equally competitive business. So, our decisions are entirely data-driven. We are expected to make commitments and to meet those commitments. In contrast, we find many of our suppliers operate in what I would call a "best effort environment." That's something that we cannot live with. We can't work in that sort of environment. We, as a customer of the suppliers, need people to make a commitment to us and then follow through. By the way, that is independent of whether we are dealing with a billion dollar supplier or in the case of some 10 or 20 million dollar supplier. Reaching that gulf of expectations is the cultural barrier that I see.

Mr. Grenier : John, would you care to comment on that?

Mr. Osborne: I have a personal agreement with a couple of points from both sides. I believe that from a supplier type of side that there is a lack of data — that a lot of times, we tend to focus a little bit too much on the subjective parts of the interaction and the relationship and not quite as much on being data-driven. The trouble with the data-driven is that there are always pressures for time. There are also pressures for economic solutions and data-driven done correctly takes time and is expensive. So there's a tendency to avoid it wherever possible, but I really do believe Peter made one good point —the relationships in the future are going to be more data-driven, not less. There are two other things I see. The IC manufacturers also have a bit of a lack of experience in giving up their core competencies or changing their core competencies. One of the things that we talked about from a cultural standpoint is that it's much easier to go into a Fab-10, for example, in Ireland, which is a completely new facility, and set up a system where there is no precedent. If you go into an existing area and try to impose a change of ownership, there are always a lot of people within that facility that, at least in our experience, are very resistant to making the change. I think as we move up the learning curve, both suppliers and manufacturers will be limited by the fact that they are moving into new areas that they haven't been comfortable in before. That's probably the only differences between the comments that came up.

Mr. Grenier: Bert, you said there were soft metrics in measuring a relationship, but it sounds like what we're hearing is those soft metrics have to be turned into hard metrics.

Mr. Allen: I'd like to make a comment about that and an extension of what Eugene said. In our Submicron Development Center in Sunnyvale, we have gas delivered to the point of use with a guarantee. And the gas is delivered to the machine, but the gas supplier sits in the morning operations meeting in that fab every morning, and he sits through what the performance of the fab is and reports on what the delivery system of the gases are. So that's an integration emerging of a material supplier with an actual fab operation in process. Now, I think this is done, I think, Tom, you mentioned that is what some of the suppliers are insisting on. Now, in the process of doing that, the yields go up and down; hopefully go up on a continuous basis. But when they don't, or when there is a gas problem, he's right there to recognize it. What the metrics could involve into, because then you get the consequences of this, they are still soft metrics in the sense that the supplier becomes aware, in real time, of what is going on with what he is providing.

Mr. Grenier: Okay, let's turn to the technical barriers. We've postulated there are certain technical barriers to improving the relationship. Can we identify some of those technical barriers and some ways of removing those technical barriers? John?

Mr. Osborne: I think this is one that is fairly bigoted. It involves issues around standardization of equipment that have been brought up before. Right now, 95% of everything that we produce has got some level of special modification on it or some component that is unique. However, one of the things that we constantly find in looking at the equipment development is that we don't have software models that really relate the process to the equipment capability. In fact, right now what we do is all empirical. If we want to make a modification for the equipment, either in hardware or software, we go in, test it out and get the results. Then with a couple of exceptions, almost everything that we do is basically a 3 to 6-month type of effort on a major significant type of change. From a technical barrier standpoint, we need to evolve to the same place that the ASIC manufacturers are now, where there is an agreed upon set of models that we can use. This way we can do simulations in a matter of hours versus a matter of weeks and months.

The difficulty has been, though, that this has been a Holy Grail. Every 3 or 4 years it pops up and somebody will go off on a white horse to start looking for the Holy Grail. I don't believe that just because they haven't found it yet that we should stop looking for it because I really believe that we won't meet the cycle time type requirements. We won't be able to contain the development costs unless we've got a good set of models that relate equipment performance to the process and device design.

Mr Grenier: Would anybody else on the panel like to take a stab at technical barriers?

Mr. Nelson: In a gases area, one of the barriers that the gas suppliers seem to have is that the analytical techniques for measuring, especially purity, tend to lag behind the purity of the materials themselves. The purity of the materials coming out of a purifier, as specialty gas or whatever, are often better than the analytical methods used either for QA or in laboratory procedures. An example of that in the last couple of years is an analytical technique that's come out called atmospheric pressurization mass spectrometry, which has allowed measurement of impurities in bulk gases, especially like in nitrogen or argon, to below a part per billion. Actually, that's with some of the purification technology to provide high purity gases. This is the first time we've been able to actually see a non-zero reading on some analyzers. We saw purities down in the range of 500 to 100 parts per trillion, but we were never able to see that before. The analyzers are always zeroed-out. So there are some things like that and that's kind of expensive. A lot of times the R&D cost to develop new analytical methods are more expensive than the R&D cost to develop new production methods. Especially when you get over to the specialty gases where you've got 30 or 40 different specialty gases, and they have their own requirements of toxicity and corrosiveness, it's more expensive even then to develop analytical methods. So from a purity point of view, that's one of the limitations that do exist.

Mr. Grenier: Thank you, Tom. Before we open it up to questions, because time is rapidly moving on, I'd like to ask each of the panelists what they view as the perfect relationship that may eventually happen downstream. Let's start with the semiconductor companies first. Bert?

Mr. Allen: Well, as I said in my introductory remarks, the ideal situation from the semiconductor manufacturer would be one in which seamless boundaries are the key operating philosophy along with trust and integrity. How you balance the cost to accomplish that, I'm not sure. How you identify the barriers and metrics associated with that needs a lot of work. Yet the bottom line is that the semiconductor manufacturer needs to build a wafer of product economically with very low contamination and very low particles. In my view, the continued effort of the semiconductor manufacturer, the equipment supplier and the materials supplier is to create an environment with seamless boundaries.

Mr. Silverman: I would say that, ideally, we are looking for one where we can purchase a total solution from a supplier — one that provides us with a working process, highly productive materials and equipment and worldwide support capability. Further, we'd be looking for a relationship which is data-based, where people make decisions in a highly objective manner based upon the numbers, and in which we mutually trust each other. I'd say the foundation of that is meeting the commitments that both sides make.

Mr. Osborne: We spent some time about a year or so ago defining what a world-class customer was. I think it's real important that in a relationship you have an understanding of what your ideal customer looks like. I think there are three elements, two of which are pretty soft and one of which is pretty hard. The soft part of it gets into a true openness of sharing. One of the things I'd like to use as an example is that in some companies there is the

capability of being there in the fab area working right alongside the people and getting real time data as to the performance of the equipment and the service. As an example of that type of openness, I think that has to happen on an on-going basis if we are going to continue this relationship as far as taking more ownership. So openness involves sharing everything from technology road maps to manufacturing road maps to even small types of things like where you plan to put your next factory. The second element is also a little bit soft, but it involves the ability of the customer to work with a supplier. A lot of times, we find out that there are still major difficulties even when we're looking at a data-driven type of area — differences in fundamental problem-solving approachs and in the design of experiments. I think that there has to be a common language in order to have the communication driven. The third area, though, is something I think is still soft in our industry, and that's standards. Now, one of the things in the overview was that a world-class customer has to come close to presenting one voice to the supplier. Many companies, especially the leading IC manufacturers, globally have attempted to do that. However, there still are fairly significant differences from fab area to fab area, even within the companies. There are also differences in many areas of standardization, and I think if you were going to have a perfect relationship, you would have a customer who was willing to go out to talk to the other IC manufacturers to try to proactively drive standards. That's still an area where we spend an awful lot of time and effort trying to resolve these issues.

Mr. Nelson: Well, I think nowadays any supplier working with a customer, whether it's in a semiconductor industry or any other industry, has to bring value to that customer. Openness, trust and communications are absolutely essential if the supplier and the semiconductor firm are going to work together to bring that value. The supplier can say, "Well, there's a number of things that we could do to possibly help you in the operation." Then the user has to come back and say, "Well, let's explore those ideas. Let's see what they can bring." I think we're going to have to become more knowledgeable about those processes so we can better understand them, and then propose solutions that are going to bring value to the customer and to us as a gas supplier so in the long run, both of us can continue to make some money.

Mr. Bernosky: I've got to get in one plug while I have the opportunity about standardization. In general, our philosophy has been, rightly or wrongly, that we don't build a standard product because as hard as we try to provide a standard product, there is always 5% of the product that every customer wants to change. I'm not so sure that you can have "a standard product" that's identical in each and every case, but there are some things that are specific to customers and that's just part of doing business in this industry. Anyhow, I think the dream relationship or the dream set-up for a relationship is that we as a supplier are given a set of requirements and there is agreement on what those requirements will be. Most importantly, there is a means to measure compliance to those requirements that we all agree upon. Then let us go out and meet or exceed those requirements, which are going to be measured as time goes on. And last but not least, you need a mechanism that allows continuous improvement to benefit both parties. For example, if you can figure out a way to drop the cost or significantly improve a wafer process, and if you've got ownership of the things that led to that improvement, there should be a way that benefits both parties.

Mr. Grenier: Thank you, Eugene. Let's have some questions from the audience.

Question: I'd like to address this on behalf of cluster tool manufacturers. In your opinion, has the integration of several former processes onto a common platform contributed to the economies of scale. Is there really any dent in their reduction of cost being visible yet, or are they still proving themselves?

Mr. Silverman: It's definitely contributed, but negatively. Cluster tools are a disaster. We've gone from batch process tools which were high productivity and continuous processing tools — tools that never stopped working, like a continuous flow-type tool. The industry has become enamored of cluster tools. They do offer an advantage in that they give you the shortest cycle time for linked processes, and if you are an ASIC factory, and that's where the drive has come from, there are some advantages. But for a high volume semiconductor manufacturer, it's just the opposite. Intel has a metric and we call it the value added time and it's simply the percentage of the time that something beneficial happens to a wafer. If you look at cluster tools, that number is down around 25%. The rest of the time, you've got a chamber conditioning, something heating or the wafer moving around from chamber to chamber, but you're still paying for the whole tool.

Question: You looked at how the suppliers can continue to improve their techniques for the semiconductor manufacturers — look on the other side. Are device architectures designed with manufacturering taken into consideration?

Mr. Allen: Design for manufacturing is something that usually occurs after integration is completed. It should be occurring before integration is completed so that the processed technology is more robust as it's introduced. There is an extension of the number of wafers required to develop a robust process, and in 1963 Bob Noyce published a paper and he indicated that it took something on the order of 100,000 4-inch wafers to go up the learning curve on, I believe, a 64 megabyte EPROM or something like that.

I did a study at AMD on the 256 and found out that 3 or 4 years later, it took us somewhere between 30 and 60 thousand wafers. That told me we were doing a little better job than Intel had been doing in 1980. The extension of this is as the wafer size gets larger, you'll need maybe 300 wafers to go down that learning curve by the year 2000. Now, you can't get down the learning curve of 300 wafers easily unless you start out by designing the architecture to be robust from the start. So there's a lot of effort going on to accomplish this.

By the same token, with 12-inch wafers, and this is perhaps in contrast to what Peter said, they are very big. They've got to be automated and if cluster tools have not emerged as a good manufacturing process, a lot of steps will be linked by that time. So those cluster tools that we talked about have got to work seven years from now. They don't work now, I mean, putting together a high volume manufacturing line, you want to minimize the number of cluster tools you put into it. Sometimes you have to because you have linked processes, but on 12-inch wafers, you've got to get down this learning curve on a new technology on something under 1,000 wafers, and we're already seeing well below 10,000 as being the learning curve to get to a mature technology. I think it makes a statement on what you were saying and answers a little bit of what you were asking. We've got to learn how to design robust and simple technologies from the start of the project.

Question: There was a seminar at Semicon West this year that was discussing factory automation. A gentleman from Sematech mentioned that they had done a survey and found that, I think it was [inaudible] and the people on the panel kind of went back and forth about this. The equipment suppliers said the chip makers never want to pay for it, and the chip manufacturers said we want it, but they want charge too much for it. It seemed like there was a kind of a chicken and the egg problem, with standardization of short term costs versus potential long term gain. I wonder if either of the device gentlemen here or the equipment people would like to add to that.

Mr. Silverman: Yeah, your right. There is a confused situation. The suppliers want standardization. On the other hand, the suppliers have somewhat of a vested interest in

not cross standardizing because if John's tool is the same one I can buy from Applied, there is obviously an issue there. So I think everybody is somewhat at fault. However, I think the problem is going to be very quickly resolved because the next wafer size will be 12" or larger in Intel's opinion. A cassette of 8" wafers weighs around 15 pounds, a cassette of 12" wafers weighs 25 pounds and a cassette of 16" wafers would weigh around 40 pounds. You know, the 12" and larger factories will have to be fully automated. So the solutions will come fairly rapidly because in the future, that will be a necessity.

Mr. Grenier: Any other questions? Clark?

Mr. Fuhs: It seems to me that the elusive metric we've talked about here is one called yield, that it has been difficult for that number to come out in either a direct way or some other normalized form. Is there some thought that metric yield will be shared in some way soon?
Mr. Silverman: Let me comment on that. I think it the wrong metric. You cannot afford to operate a state of the art factory unless you are getting extremely high yields. The way one of our engineers put it to me was if every yield improvement that was promised came through, we would be running a 1000% yield. Yield really isn't the metric. The metric is output. If you can get the maximum output out of your equipment, then you get the maximum profit out of the factory. For a given technology generation, the decisions are made five years in advance of when the factory is needed. At the time you have to deliver a product to the customer, if the factory output falls short of meeting its forecast, there is no way to recover because the time to build additional capacity is too large. The key metric is output.

Mr. Allen: Peter, I would assume you mean output in the form of wafer yield multiplied by line yield multiplied by activities which could be construed as yield.

Mr. Silverman: In that sense, yes, but the thing that is frequently quoted is "well we will get the particles down a little bit here and we'll get the line yield up." All those things are important, but in any state of the art factory, you will by running a high line and die yield. You may have very poor equipment productivity and that will nail you. As a wonderful correlation, we find any problem with equipment can be fixed by running it slower. If you have a particle problem, you clean it more often.

Question: I guess I'm trying to establish whether the yield, the measurements of the conclusion that you reach, is the real one based on the data that you have at the moment. Is that data still accurate based on production of the sophistication that is required to track such things as contamination?

Mr. Allen: It has to do with the question of can you measure the level of contamination and particles that's generated either by the equipment, the materials or the processes that you are using in the fab. The answer is, for example, fifteen or twenty years ago, we used something called a CV plot, which measured the degree of contamination in diffusion furnaces. Those are useless measurements today. The only way you can get that is with surface photo-voltage or TXRF, which is an inferential solution. We are looking at measuring thicknesses on deposited films in plus or minus a few angstroms and the surfaces of the wafers vary by that much. You may get refractive indices, variation and the like so we are operating right at the limits of our metrology, and in some cases, we are beyond our metrology. The only way we know whether our gases are any good is to put an APIMS on it, as Tom said, but we can't keep one on there because they a cost a million dollars and take a Ph.D. to run. So there is a lot of metrics that we don't have handles on. We have to do it through inference and statistical control. A good Class 1 clean room can't be measured. You put a particle counter up there underneath the hepifilter and leave it there for a week and it measures no particles. Well, that doesn't mean anything. It just means that for it week it didn't measure a particle. So in the gas

systems, we have an on line measurement that has a sensitivity lower detection limit of 20 PPB on moisture, and its always at 20 PPB. Well, where is it below that? I don't know. We're pressing the limits. In equipment, for example, you can now measure particles in the vacuum and the exhaust stream, but we are not exactly sure where those particles are generated.

Mr. Grenier: Thank you. Well I think we have run out of time. I would like to thank all the panel members for participating, and thank you attending this session.

Signal Processing Application Trends

Jerry Banks, Session Leader
Director and Principal Analyst
Semiconductor Microcomponents Service
Gary Grandbois, Session Leader
Senior Industry Analyst
Semiconductor Group
Dataquest Incorporated

Mr. Grandbois: This is the Signal Processing Application Trends Section. I think the word application may be a bit misleading. We'll really be talking more about Signal Processing Trends in terms of semiconductors and the market, and of course touching on applications, but the main focus really is not the application side of it.

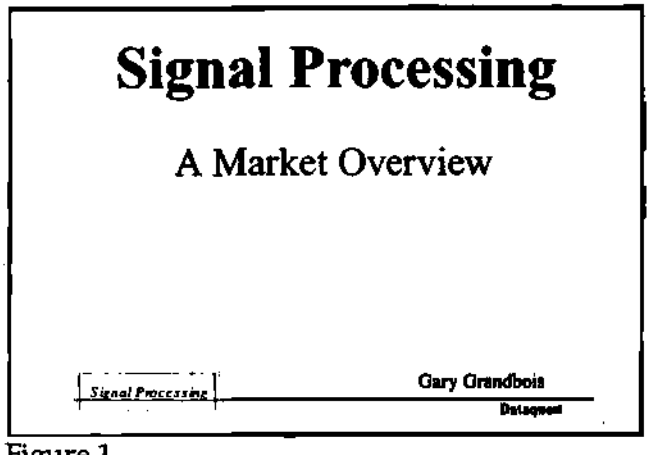

Figure 1

I'm Gary Grandbois, an Industry Analyst. Jerry Banks is also here and we'll be talking in sequence. I will be starting out. My background tends to be more in the analog and mixed signal IC area. Jerry covers the digital side in DSP.

Today we're talking about Signal Processing. You've heard over the last two days all about the changes, the convergence of consumer communications and computers and what that means. Of course, consumer entertainment products and communication products have been dealing with signals for some time. Bringing them into the computer market signifies a real change. Computers typically don't get involved with signal processing so the interest in signal processing has started to emerge very significantly. Signals have been around for a long, long time, far longer than digital computers. It's not a new area. We're going to go through many of the aspects of what signal processing is and how it affects these changes.

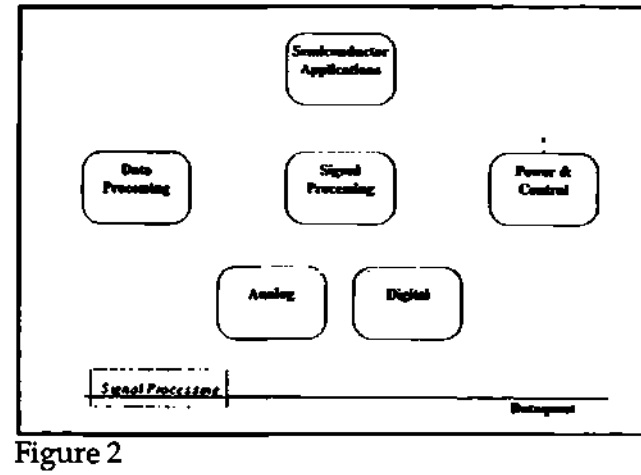

Figure 2

In looking at the semiconductor marketplace, there's any number of ways to divide it up. It

can be by products, by markets, or signal processing versus data processing,versus power. Actually there's an infinite number of ways, but that's what we'll look at today. Data processing — dealing more with data, numbers and information that originated in terms of numbers and payrolls — the kind of things digital computers accomplish. Signals have typically been in the analog domain, but what we're seeing now, of course, is the changeover to digital signal processing and all that entails.

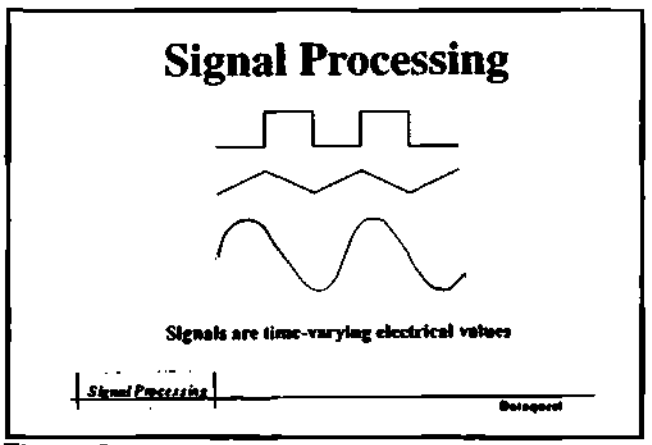

Figure 3

Signals really are time varying electrical quantities and they are values. Time is an important consideration because they exist in real time. They typically are generated in the real world by some kind of physical disturbance, for example, audio, visual or seismographic, but they don't originate in the realm of numbers as a payroll would. So signals can take on lots of different looks, but they do vary in time. Some of the shapes you see here are typical of signals. This one, the square wave, typically is confused as being digital. It could be digital, but there's no way to know by looking at it. For instance, in FM radio reception, the signal is brought in, amplified very strongly, the top is clipped in order to eliminate the amplitude modulation of noise and it looks very much like this. It's still analog in nature, however.

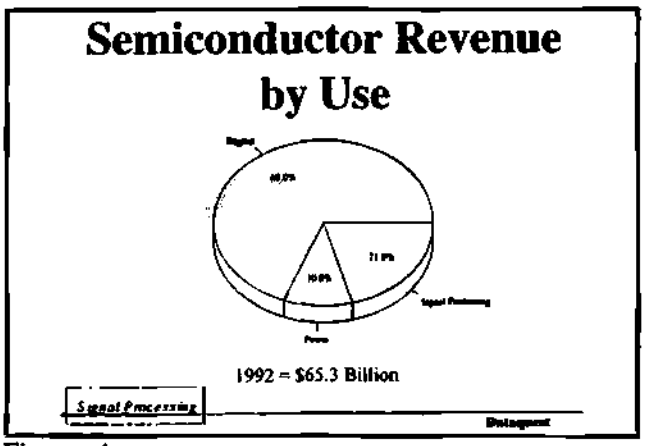

Figure 4

Signals can be electrical quantities. They are electrical information in terms of voltage, currents and impedance, so rather than carrying numeric value, they carry these electrical analogs that change in correspondence to the physical phenomenon that they're measuring. They could take on an infinite range of values, but that can be infinite in terms of frequency. It doesn't have to be voltage. It can be current, it can be impedance or it can be other things, but the key word is real time.

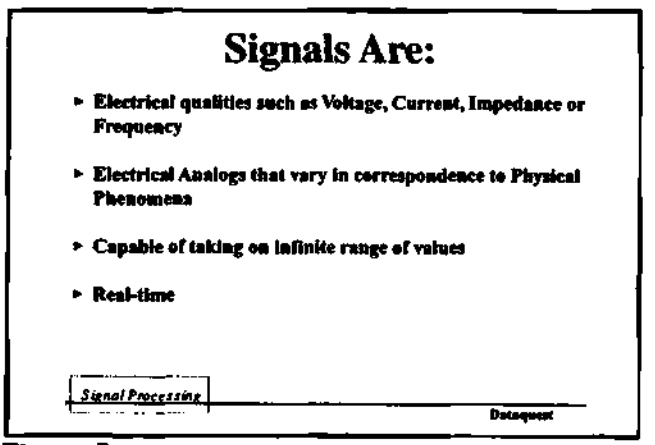

Figure 5

Now by use, signal processing was only 21% of the semiconductor consumption in 1992, so it's fairly small compared to the digital market and the data processing market, but it is larger than power. Now this has changed over time. Signal processing, at one time, dominated electronics. When I was young, Electrical Engineers were

known as Radio Engineers. Of course, that's long passed. Digital computers were introduced in the early 1950s and the IC business really was catapulted by digital techniques and digital products. So signal processing has dropped to 21% of the total market, but what you've heard the last few days is it's going to start growing. There are some things going on, such as communications and multimedia driving that growth.

Question: Are the numbers for ICs only?

No that's total semiconductor, not just ICs. That includes discrete, opto, every kind of semiconductor used in signal processing. Now in order to be signal processing it really has to be in the signal stream, so a signal comes in, is handled in analog fashion or it may be converted to digital, but it's in the signal path. All the controlling functions that may be involved, for instance in a product that's a signal processing product, wouldn't be counted. They could fall into the digital area like remote control television for example.

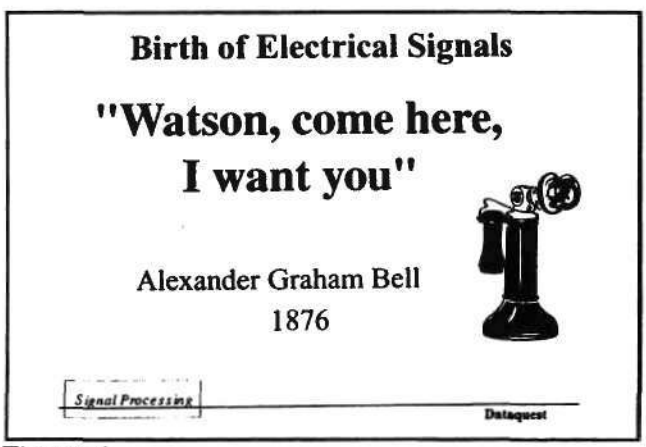

Figure 6

So signal processing actually started with the telephone. In 1876, Alexander Graham Bell was working on some methods to improve telegraphy by using frequency division modulation. He realized that these wiggling currents, which he called undulatory currents, could be transmitted in some way and would be representative of the human voice. The telephone came out of that and that really issued in the era of signal processing. It really took over from what I would call digital processing, because prior to the telephone there was the telegraph and the telegraph really came into its own with the Morse code and coding scheme. It was a digital format of long and short signals being sent and had to be end coded and decoded by people at the receiving and transmission end. So the telephone pretty much overwhelmed that complex system because it had so many advantages.

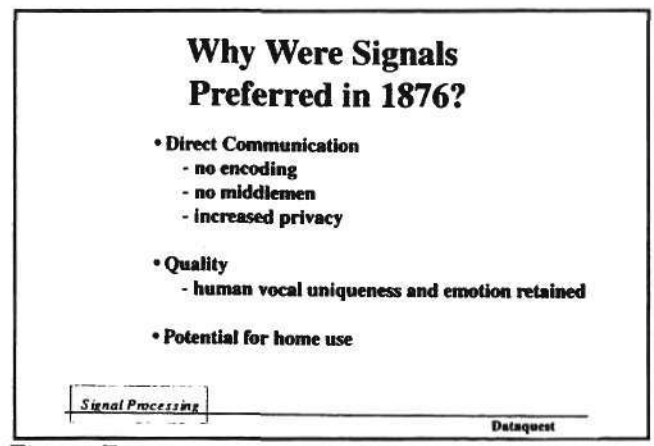

Figure 7

It was analog in nature, it was intuitive and it was direct. You didn't have to have a middleman, the privacy was increased and it could move into your home. There are a lot of advantages in operating in the analog domain.

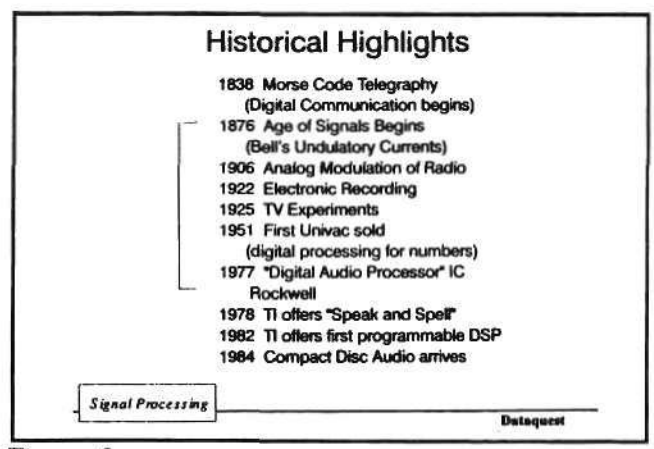

Figure 8

So here's a brief history showing that coming in 1876, analog signal processing really dominated

signal processing for 100 years and now we're at the point where it's changed. In the mid-70s, the digital computer started to move out of the laboratory and products started to appear. DSP started to come into its own, very slowly, but we started to see products such as the Speak and Spell, and programmable DSPs and it really took off with the compact disc. But in 1951, nobody could have guessed that the appearance of a digital computer in the market place was going to have such an impact.

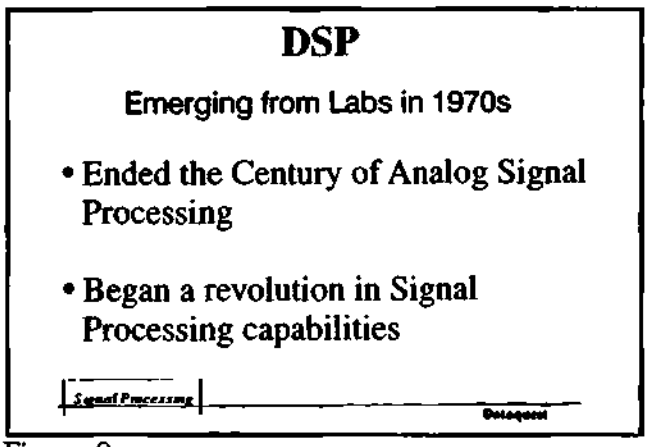

Figure 9

So this is a confirmation of what I've just said. Analog signal processing was the dominant part of electronics, but it has pretty much ended. It's not gone, but it's era of dominance has ended and we're starting to see a lot of changes.

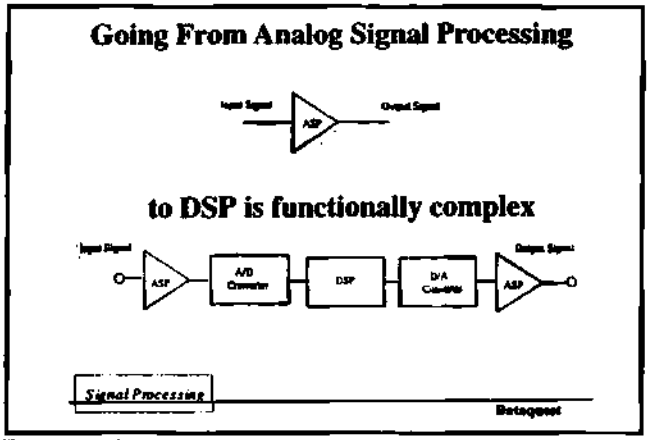

Figure 10

Now functionally there's quite a difference between analog signal processing and digital signal processing. I really simplified analog processing here and made it just a functional block. Obviously it's much more complex than this depending on the function. It can be a single IC or many ICs and many passive components, but still it's functionally somewhat simple from the standpoint of using common ICs. When you move into the DSP area, you do start out with analog signal processing to handle the signal input. You may require some kind of impedance transformation, you'll need amplification, you may have a multiplexer to select signals, a sample and hold to grab the signal and hold it so the A to D convertor can convert it. That sample and hold has to do the job quite well — it cannot move or jitter in time or you're going to have some errors in your signal. Then it goes into the A to D convertor, then it's in a numeric format where the DSP can handle the data and do whatever it does. It comes out into a D to A convertor and again analog signal processing to finish off the signal and make it acceptable to whatever it's driving. So functionally, it gets very complex.

For instance, you could do a filter in DSP, but look at all the components you need to do that. Some very acceptable filters can be done with a handful of analog parts, let's say three ten cent up-amps and some passive components. Forty cents can do a decent filter depending upon what you need. In order to do that same filter in the DSP, you need all of these functional components and that's going to be very costly. DSP might be as low as $2.00, but you've got data convertors on both sides and all the processing — now you're up to a pretty high cost system. You need a justification for that and the justification is all the things that can be done in DSP.

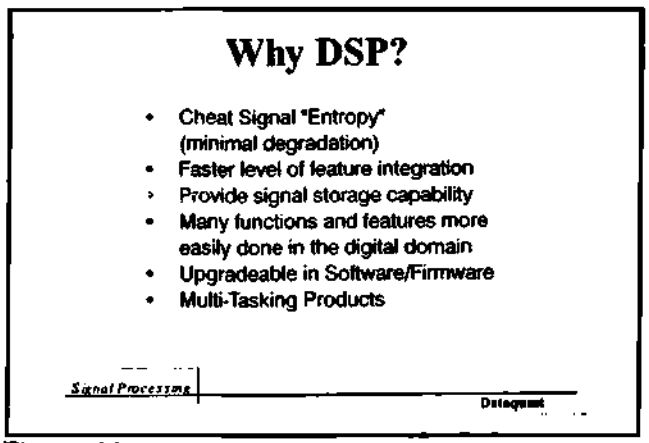

Figure 11

One of the most important is that the signal degradation that you get in analog can be eliminated. Once it's in the digital domain, it's virtually non-corruptible. You can add bits for error correction, you can make noise margins significant enough and you can pretty much eliminate the degradation which, of course, is why you can continue to make copy after copy of digital information. For instance, a CD. If you could copy that from the compact disc to another digital product, your copy is as good as the original. In the analog world, that never happens cause it's in real time and it's going to suffer the degradation of the media it's superimposed upon.

Another reason for DSP is the fact that digital features have been integrated at an astounding rate over the past few years. You attend these conferences to see the kinds of new products and new functions coming out — that kind of integration just hasn't occurred in the analog world. There are a number of reasons for it — part of it is the wide number of applications, the demands of the inputs and outputs, the performance demands for different applications, and the fact that when you go down in feature size it doesn't necessarily affect the size of the analog functions. So if you're to look at digital integration compared to analog integration over the past decade, there'd be no comparison. So you want to get on the band wagon of the faster feature integration, the reduction in cost offered by DSP.

Another feature of DSP is that at any time you can stop, store the signal and, again, getting back to this degradation, the signal won't degrade. There is really no way to stop analog because it's in real time. You can try and store it on a sample and hold, you can store it on some kind of magnetic media, or mechanical media like a record, but there's really no way to comfortably stop analog in the electrical domain. And there are many functions and features in the digital domain that are really impossible in analog. For example, filters that have virtually no ripple and no face shift. The kind of color key that you see on T.V. with the weatherman standing in front of the blue background. Of course, they're putting in the various backgrounds that they want to show at that time for the weather maps. It's difficult to do in analog, yet easy to do in digital. In addition, you can design hardware that can be changed by simply changing the software of the DSP to take on different functions. Once you've hard-wired your analog system, it can't be upgraded without a new design. In addition, because of that capability, the DSP product can be designed to be actually multi-tasking. For instance, you could design a PC peripheral board that handled the modem functions, the sound functions and any other kind of IO or multimedia functions simply by loading in the new program. Typically, it wouldn't be done at the same time, but the capabilities would be there.

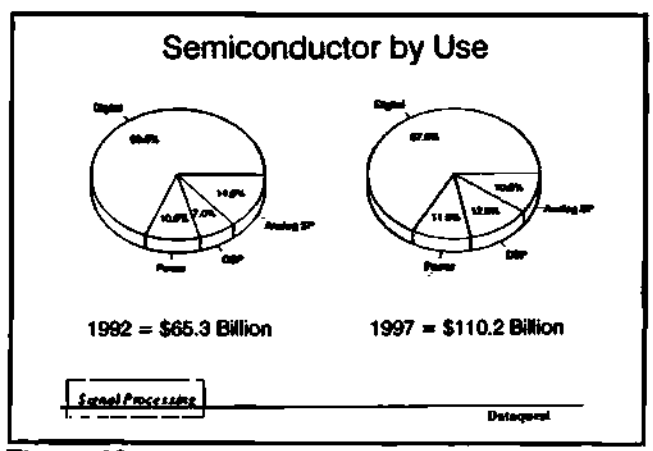

Figure 12

So we've talked about how signal processing is about 21% of the semiconductor market in 1992, and that breaks down to about two-thirds analog signal processing in which there is no DSP in the path. That has been the standard — that's what is usually in your VCRs, your TVs, your Sony Walkmans, all these products. One-third, however, is creeping into digital signal processing. Since the mid-70s, it's taken one-third of the signal processing market and has the potential to take far more than that. So in the mid-70s, analog dominated with three-thirds of the market. In 1992, we're talking about analog having two-thirds of the market. In ten years, analog will probably be about one-third of the market and DSP about two-thirds, plus the expansion of the market place. So here in 1993, we're showing DSP creeping up to 12%, growing much faster than the analog side.

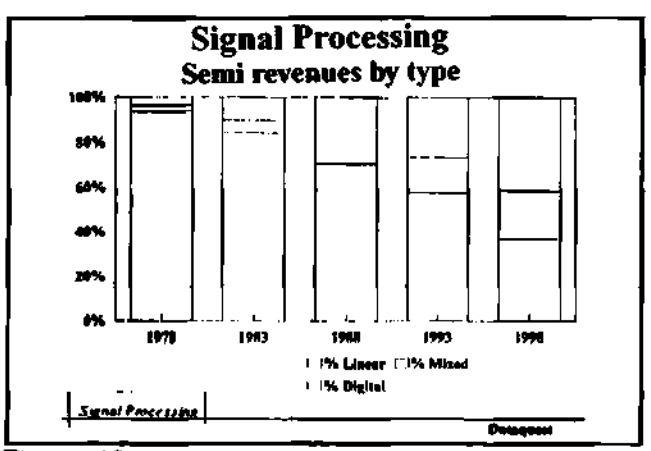

Figure 13

Another way to look at this is in terms of percentage of the total signal processing revenue. In this case, we're looking at specific IC types. Linear ICs, the kind that would typically be found in analog signal processing systems in a T.V. or a communication system, naturally dominated the market in 1978. The mixed signal and the digital products used in DSP started to creep in and have been growing substantially, but linear products still dominate because of the very large consumer marketplace. The consumer marketplace is now just starting to change, and that's where the potential for growth lies.

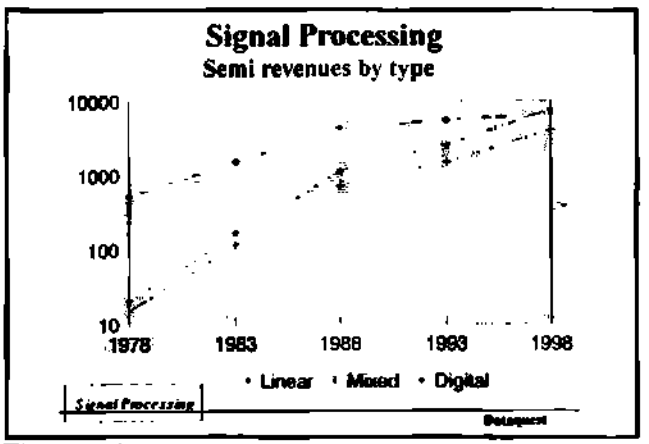

Figure 14

Looking at the same data, this time in terms of absolute revenue, you can see that the linear products aren't going to decline, but their growth is stunted. Since 1988, we haven't seen a lot of growth in linear products. The real growth is in the digital portion of signal processing and right along with digital has to be the mixed signal in order to bring that analog information in and out of the system. There will continue to be some linear in DSP systems for the signal processing front ends and back ends. And, of course, there will continue to be linear used. Systems won't totally go over to DSP. It's doubtful that very inexpensive systems, for instance again the inexpensive radios. Radios continue to be an analog medium and will continue for some time. The cassette Walkman, for instance, is totally linear and will continue to be linear, so we're really looking more at the high end products for the growth of DSP.

Although we talked about the ICs before, I just want to give you the full picture. So in terms of total semiconductor, there's also some discrete and some opto-electronic products. It's probably a surprise to you that discretes are used so heavily in signal processing. For instance, in a T.V., you've got a good portion — 30% of the cost of the electronics in a television is discrete. Discrete power transistors are prevalent in audio equipment and audio amplifiers as well. So discrete is significant in signal processing. It's going to decline as a percentage of the total pie. The growth here, as

you can see, is in the mixed signal and the digital area.

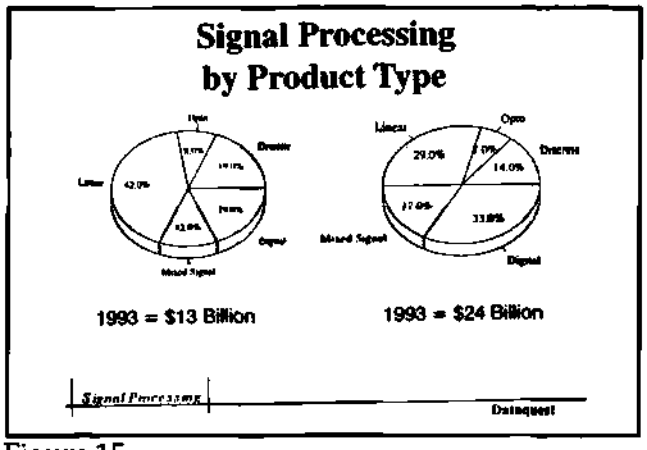

Figure 15

Question: How do you define mixed signal?

Mr. Grandbois: Mixed signal is mixed analog or mixed linear and digital on the same chip.

Question: In any amount?

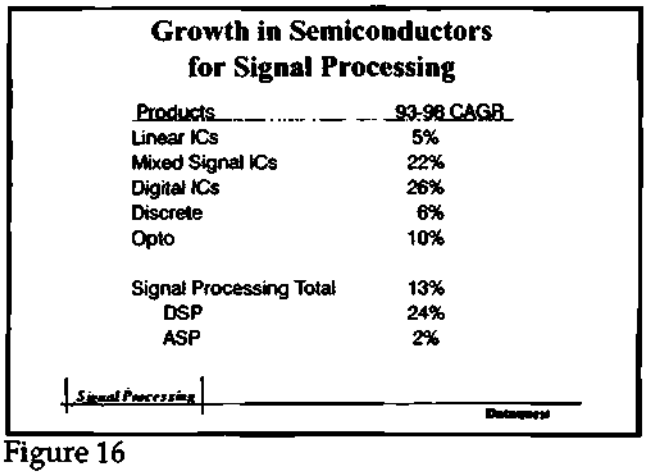

Figure 16

Mr. Grandbois: Yes, any amount. We really look at it on an outside look, so if there's an analog pin, in or out, and a digital pin, in or out, that's really a mixed signal product. It has nothing to do with chip area. So in looking at the growth in semiconductors, you can see that the real growth is in the digital and mixed signal ICs, with digital growing a little faster. They grow somewhat concurrently at first, but the digital part expands as the digital functions continue to increase. So, the revenues will go over the digital area. The linear IC is growing only because of an installed base of linear products. Again, the lower cost audio, video and communication products will continue to be pretty much analog signal processing, besides the linear used in the front end for the DSP products. So that's the difference between the growth in analog signal processing and linear IC growth — the fact that linear IC does have some growth attached to DSP.

Question: Are regulators included in DSP.

Mr. Grandbois: No, actually I don't include regulators because they're a power source. It has to be in the signal path.

Question: [Inaudible]****

Mr. Grandbois: It's amplifiers and special functions, linear special functions, special consumer ICs that are linear for analog signal processing.

Question: Are Interface ICs included in Signal Processing?

Mr. Grandbois: Well again, interface as a power item wouldn't count in mixed signal so it's interface largely doesn't fall into this signal processing category. That's more under the control and power...

Question: [Inaudible]****

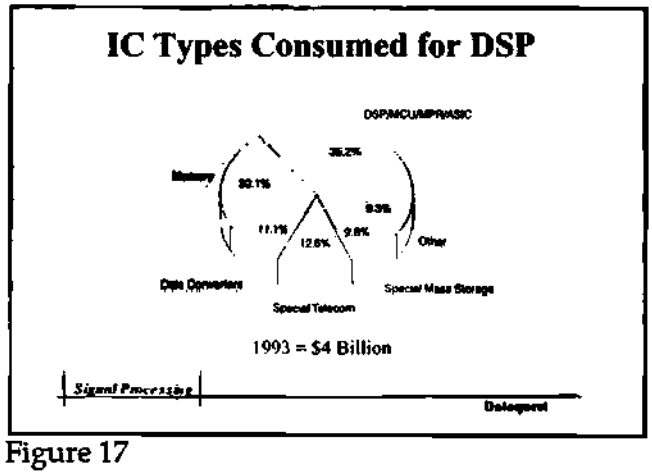

Figure 17

Mr. Grandbois: That's an interface rather than a signal processing product. Now with DSP, we looked at the total signal processing market which was thirteen billion dollars, approximately. We see about four billion being used in DSP and this is a broad selection of products, not specifically those ICs called DSP, which happen to be essentially programmable DSP products. I'm looking at DSP in a very broad sense. With any piece of equipment that does digital signal processing, what are the ICs used in that? So as we looked at the functional diagram earlier, that would involve the analog signal processing, the data convertors, the DSP, however it may be embodied. Of course, it could be a core and an ASIC. Somebody might be using an MCU, it might be a dedicated programmable DSP or it might be a microperipheral that happens to have a DSP core. There's a lot of different ways it could be done and these are some of the products that are involved. Sometimes the data convertors are included on the digital product. That's getting more and more common as the mixed signal microprocessors and DSPs are being seen, but there is still a large market for data convertors used for signal processing. Then there's some special products here, like telecom, mass storage and others, including products being used in the consumer marketplace right now.

Question: What are data converters?

Mr. Grandbois: Data convertors convert the analog signal into numeric values.

Question: [Inaudible]****

Mr. Grandbois: Yes, into the convertors and the data convertors both. Looking at the suppliers of these kinds of products, the analog signal processing market is about nine billion dollars. It's mostly consumer entertainment and telecommunications, but mostly right now consumer entertainment and these are the top five companies. They are consumer entertainment companies.

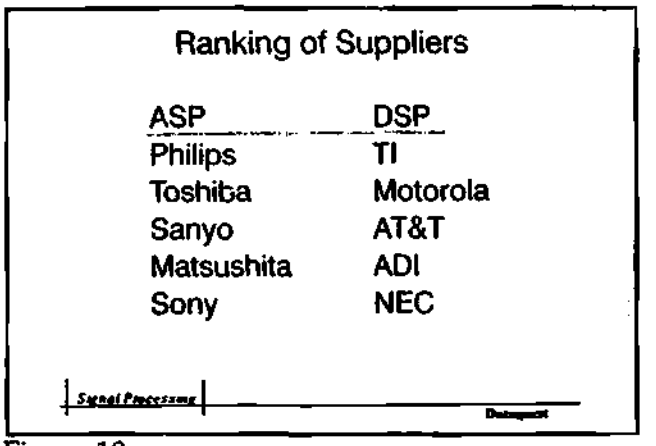

Figure 18

Over in the DSP area we're looking at about a four billion dollar market and these are the companies that supply into that market. Again it's the broad DSP definition, so there's a lot of products including linear, mixed signal and various combinations of digital products and these are the companies involved in that market place. They all actually are pretty broad based suppliers, supplying analog, digital and mixed signal. Now the programmable DSP products, which represent about 15% of what I'm calling DSP here, actually are very close in this kind of market share ranking. So you get pretty much the same companies and I think Jerry will talk about that later.

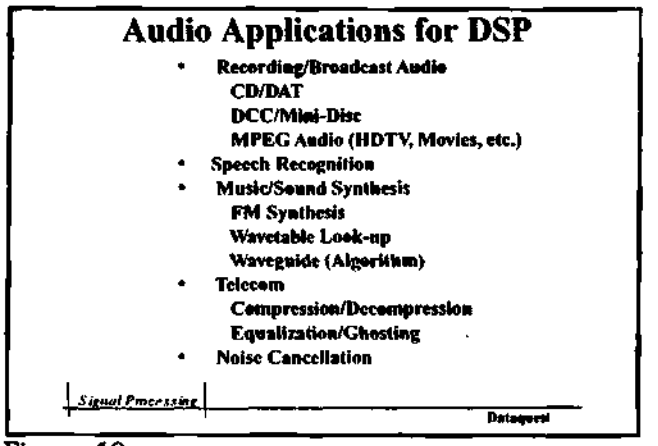

Figure 19

In terms of multimedia, we're really looking at many audio and video applications for DSP and these have been talked about an awful lot lately. Audio applications focus on mainly

compression. The DCC and mini-disc require the compression that DSP can provide in [inaudible]**** audio, another compression scheme. The compact disc and the digital audio tape actually have no compression, but because they are linear in format, they can be handled by DSP. In fact, a lot of the function — the oversampling, decimation and filtering — is actually a DSP function even though there's no compression.

Speech recognition. There's an abundance of sound synthesis on the sound boards now. A big one is wave table look-up, where the DSP handles samples of real music. It's just a very small sample and it has to process it into the kind of sound you really want from it. Wave guide is a new system for sound generation and music generation and it is totally mathematical. Mathematical representations of musical instruments are used and the DSP generates the sounds.

In the telecom area, we are talking about compression/decompression, echo canceling that really should be not ghosting, and, of course, there's noise cancellation.

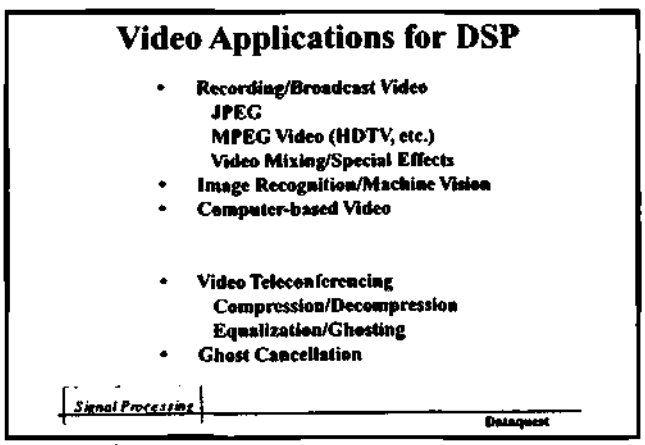

Figure 20

Video applications are really very symmetrical. It's the same kinds of things — compression, the J-peg being the still photograph compression scheme, the M-peg being the moving motion picture compression scheme and, of course, the video mixing and special effects. We talked about the color keying. Image recognition, parallel to speech recognition, is very important for robotics and machine vision. I left a blank here because in this spot an audio was the sound generation, the music synthesis. There really isn't a video analog to that although we saw some today in the 3DO demonstration. There's no real visual arts yet heavily involved in the video area. Video teleconferencing, again, is very symmetrical for the audio telecom system. These are two of the main applications for DSP in coming years and in the multimedia revolution. So, consumer electronics are changing. How they will converge with communications and computers is anybody's guess. However, they are changing of their own volition, so what we're seeing is consumer electronics going from being totally analog in configuration to acquiring DSP functions.

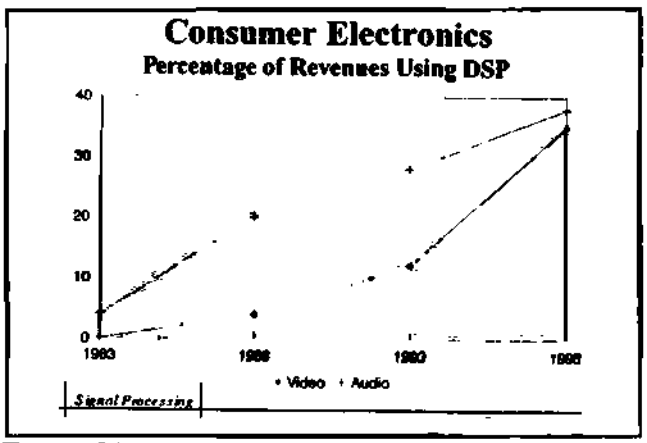

Figure 21

Audio has been an early adopter of DSP and the compact disc. The DCC and the mini disk are perfect examples. On the video side, the T.V. and the VCR have been slower than the camcorders I should say, but they're starting to appear in video, so we're starting to see some inertia and some real growth taking off — a fairly large market that it just poised to take off in DSP.

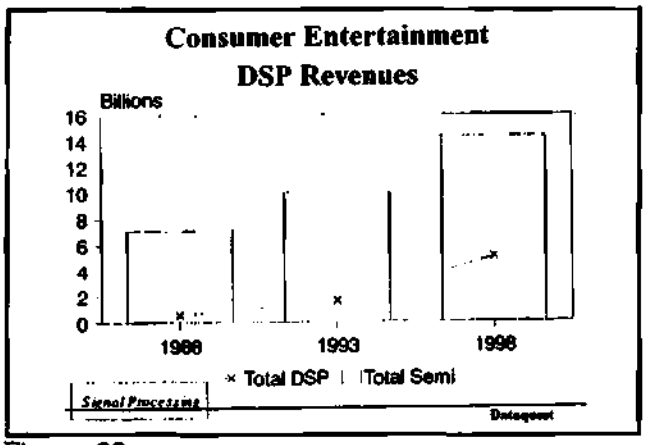

Figure 22

So looking at DSP in terms of total revenues, you can see the total revenues for semiconductors in consumer entertainment products and the red line shows the DSP revenues. We're starting to see significant growth. We expect good growth over the coming years, not as spectacular as probably some people would have you believe, but the fact is there is still going to be a lot of analog T.V.s, radios and inexpensive Walkman kinds of audio systems being made. So DSP is not going to take over the consumer entertainment market in five years.

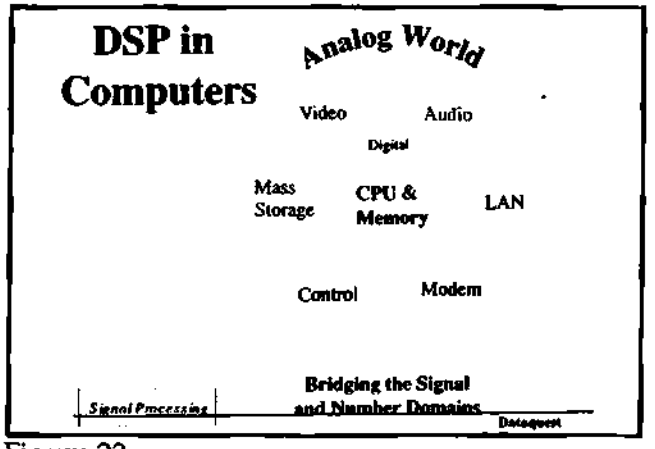

Figure 23

Now DSP in the computer market is something you've really need. The analog world is out there. That's where signals are, that's where all the physical phenomenon are, that's where magnetic disks are, that's where magnetic tape is — all of these things are really analog in nature. Typically, we've had signal processing for disk drives, modems and local area networks. We're just starting to really add the audio and video products, but DSP is appearing really in all of these and has been for some time. DSP in modems essentially is required for the high speeds that we've had for years. I think since we moved out of 2400 baud, DSP has been essential, so that's been around for some time. Mass storage DSP has moved into the motor control and the data path in order to get higher and higher data rates and amounts of data stored. But, again, the new things are the audio and video for the multimedia markets. The signal processing really bridges the number domain, which the computer operates here in its own little world of digital, and the outside world of sound and video and all the other magnetics.

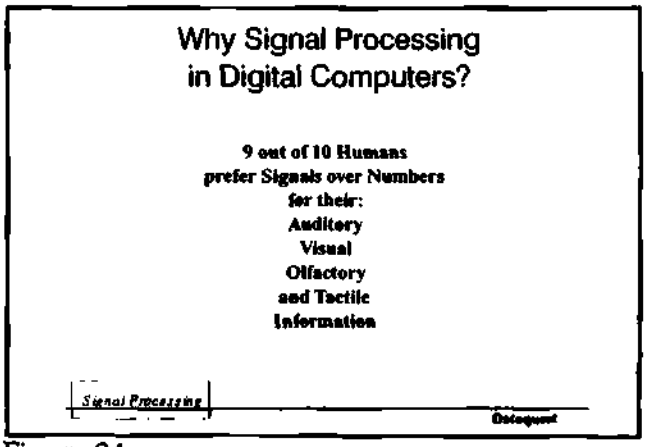

Figure 24

So here's kind of an unofficial survey. Basically, this is why you want digital signal processing. You don't want your information in a table of numeric values. You want to hear it, see it, smell it and feel it. There are other senses we haven't put on here, but the fact of the matter is analog is actually easier for people to interface with. That's the form you want. In fact, I suspect most of you are wearing analog watches and not digital watches. It's easier to adjust and this ease of use really comes down to converting back into the analog world that makes us comfortable. DSP is going to aid in making these computers useful, easy to interface with and easy to understand.

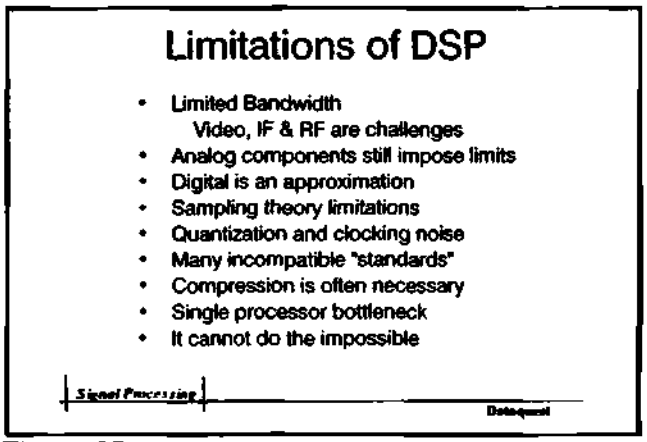

Figure 25

Well, what are the limitations? There are quite a few actually. Besides cost, we are talking about systems that are going be higher in cost, so they're best applied to the highest performance, not necessarily the highest performance, but the high cost items, such as the HDTVs, the compact disc or digital audio. We're talking about the high end of the audio market, the video market, really the high end of virtually every one of these markets. One of the other limitations is, of course, bandwidth. How many bits can you operate on? How much can you do? DSP is fine for audio because that's really up to about one megahertz in terms of bit rate. With video, you're talking 6 megahertz and higher if you go into high resolution video. Some of that can be done, and is being done in DSP. Now you're at 10 megahertz and above and programmable DSPs typically aren't doing that — it's kind of a component level DSP application. RF is way out of the picture unless we're talking about RF for the AM radio, but typically the high frequency RF is out of the picture for DSP processing. So, for the foreseeable future RF will remain analog signals; IF will typically be analog in nature and the DSP will operate down at the baseband of the audio and video. The analog components still impose limits on what you can do in terms of accuracy and drift. It's very important if you're going to be in the digital domain that you're A to D convertor has the monitonicity or the accuracy you're after. The sample and hold has to operate very correctly to get you the right information. Digital is an approximation and always will be. The signal is analog and represents the physical phenomenon fairly accurately at the start. For instance, in audio, you may have a 16 bit audio system. That's great, but that's at the full scale. Let's say it's 96 dB. If the sound goes down to 48 dB, it means you're really digitizing with an 8 bit A to D convertor. If it's 24 dB, your digitizing with a 4 bit A to D convertor. So the wide dynamic range of a symphony orchestra, for instance, it's not all being digitized at 16 bits of accuracy. When you have a soft obo solo, for example, you may have an 8 bit convertor or less digitizing that signal. With sampling theory, you do have to sample two times the highest frequency. There is noise from quantization from clocking. The digital system has a considerable amount of noise. You need to keep that out There's an awful lot of standards around. In audio, the compact disc is at 44.1 kilohertz, DCC is at another frequency, DAT is at a different frequency and the sound in wave files on your computer may be at another frequency. All of these frequencies make it difficult to interact with different products, so that's a problem. That's not totally a DSP or digital problem. Obviously in analog, in T.V. for example, we've got PAL, SEKUM and MTSC, but it just seems to proliferate more in DSP. Compression is an advantage of DSP, but it's also a necessity. You take a 6 megahertz video signal, you sample at least twice the sampling rate, let's say three times. Let's go up to 20 megahertz. If it's 10 bits, you're up to 200 megahertz bit rate for a 6 megahertz video signal that was analog in nature, so now you can apply your 200:1 compression to try and get back to where you were. You can see how compression really is essential and not necessarily a luxury. It doesn't make much sense to take 6 megahertz of analog signal and send out 200 megahertz of bit rate. It's going to be very difficult to do. In the DSP world, generally it's a single processor, a single ALU that handles the information. In an analog system, you can have any number of paths. You can have feed forward signals or feedback signals, so that's the way it's naturally done.

That single processor can be a problem depending on the complexity of the signal.

Question: I believe you are overstating the single processor as a limitation.

Mr. Grandbois: Well, I may have, but it is the difference between analog and digital. You think the single processor is adequate for the job?

Mr. Grandbois: Certainly there are parallel processors and software to connect DSPs together, but it's not always just a single DSP. The other thing is that DSP, like any new technique, sometimes gets credit for things it really can't do. It can't do the impossible. For instance, it's been proposed that it could do a sound wall, replace a sound wall and do noise cancellation for the highway out here so you don't need sound walls anymore. That's physically impossible in analog and it's physically impossible with DSP. So sometimes you get these perpetual motion kind of ideas being brought back with new techniques, but in fact, it just can't be done.

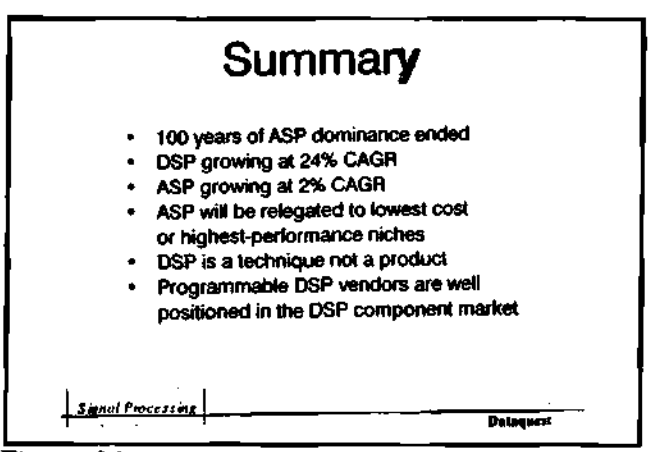

Figure 26

So in summary, analog signal processing which has dominated for 100 years, is on the way out. It won't go away totally, but it's becoming less important and will continue to be in the future. DSP is the growing area. Analog signal processing will be at the lower end of the cost spectrum or the high end where the highest frequencies that can't be handled by DSP are seen. DSP is really a technique of methodology and not a product and that's the way I'm looking at it here. That's why I'm looking at lots of different semiconductors. But the programmable DSP vendors, the TIs, ATTs and Motorola's are the ones that are still well-positioned in the marketplace, and ADI, yes. So that's the end of my presentation, which is more analog-oriented and I'll let Jerry take over for the digital side.

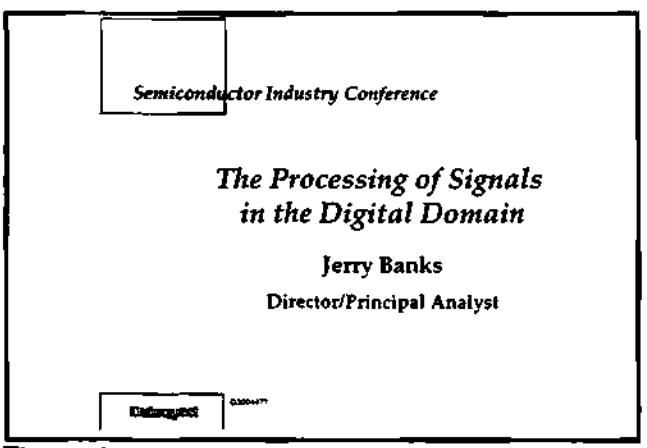

Figure 1

Mr. Banks: Hello, I'm Jerry Banks. Well Gary, thanks for a look at history. I'll be focusing more on the digital side and talking more about function specific and programmable DSPs. I'm going to give a little bit more of a background on DSP as well, coming from a digital perspective.

First, let's agree on a definition of DSP. The way we're addressing it is that it's a processing of signals in the digital domain. It's amazing, you can even have arguments between analog and digital people over what a signal is, but it's just simply processing a signal in the digital domain.

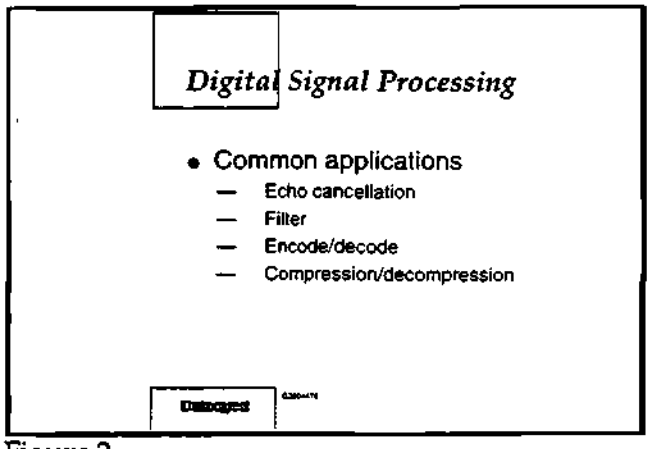

Figure 2

To start with, what has driven digital signal processing, primarily the programmable side, has been modems. Gary mentioned 4800 baud I believe. In the 9200 baud modems, digital signal processing really came into its own, but it's been used for a lot more things than just modems. Hard disk drives today are using digital signal processing techniques to control the spindle motor speed and control the head positioning. You can get to the track faster and you don't have as much overshoot, so there's not as much ringing when you get to the track. Digital cellular telephones, GSM, typically using two programmable DSPs, one for the channel conditioning and one for the voice encoding and decoding. One of the beautiful things about digital signal processing is its simplicity.

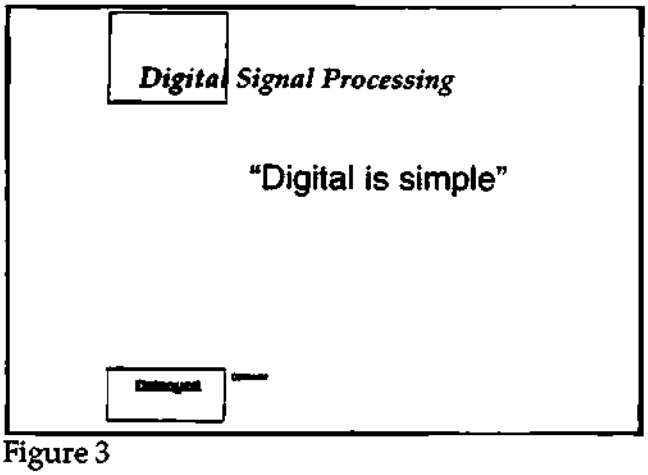

Figure 3

The definition I really loved to close with is this simple phrase: "digital is simple." I guess if you were to take a look at it simplicitically, it looks simple, but I don't think there's anything simple about digital signal processing.

Analog. It seems to be a dirty word these days. Karen Hargrove from Microsoft didn't seem to like it yesterday. Even when TI talked about mixed signal today and showed the mixed signal chart, they showed all this logic and power management in five volts and three volts — they never once showed a power or a linear function on the device.

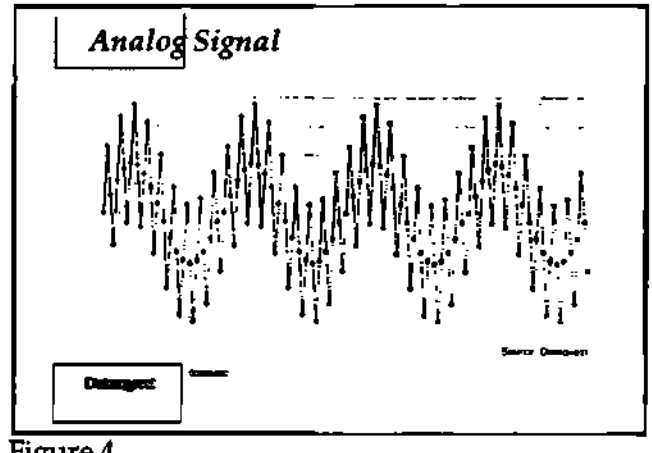

Figure 4

Here's a nice clean signal here. This is an analog signal containing lots of information. I can see why people don't want to try and deal in this domain. It does seem pretty complex and messy when you compare it against nice clean digital.

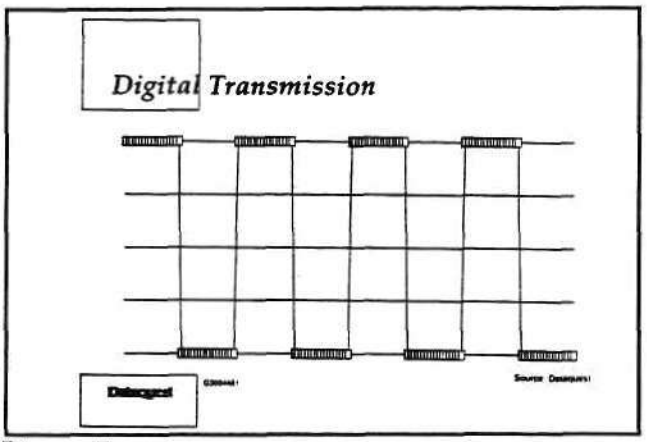

Figure 5

But nice clean digital transmission, what could be better? Now we're going to send this down to transmission line just for a second to show how simple digital is. Now, of course, as soon as you send a signal down a transmission line, it's perfectly shielded and perfectly balanced. There always are some RLC effects in there, Now you are going to end up with a smooth function — you're not going to have this straight square wave running down the transmission line.

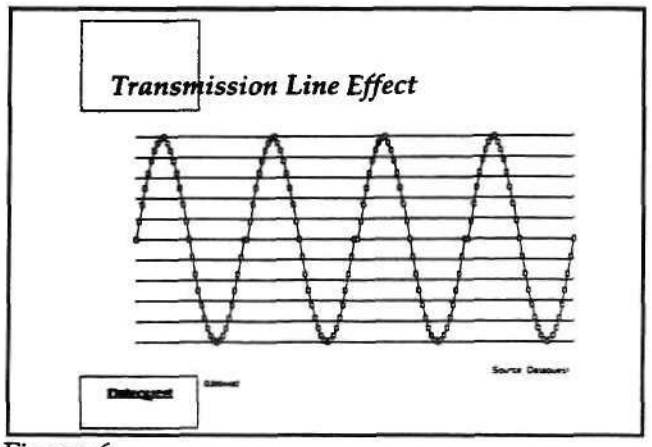

Figure 6

You will end up with a few things smoothed off here, something looking a little bit more like a sign wave, but don't worry, it's not too bad.

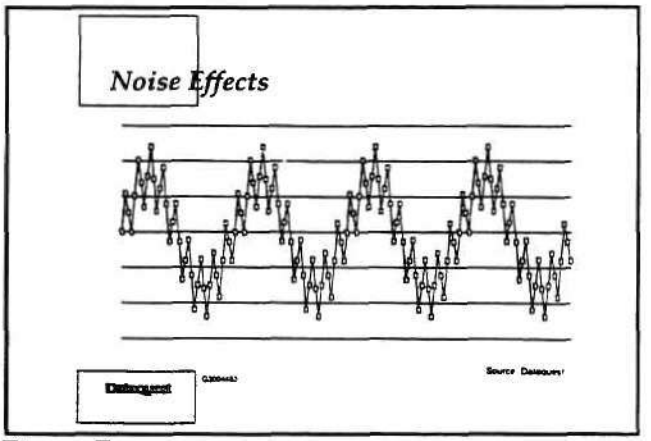

Figure 7

Now most transmission lines aren't extremely clean either so once you've got the rounding effect, you do get a little bit of noise in there, but you can still tell a one and a zero out of here. You can sample fast enough, I think, to capture the noise.

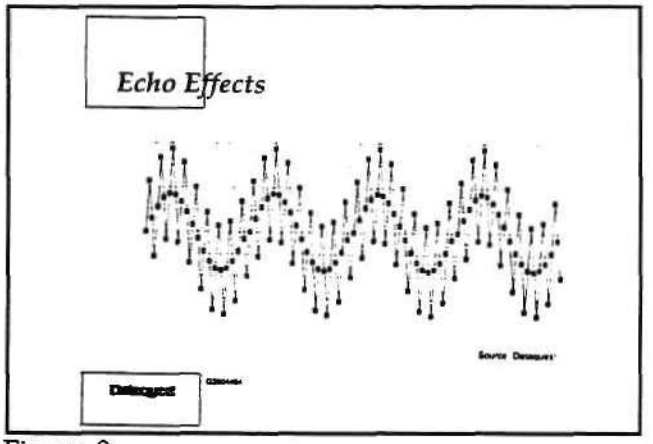

Figure 8

Then, of course, many transmission lines don't get perfectly balanced and I guess instead of echo effect this should be more reflections — when you have reflections coming in and out of phase with the signal.

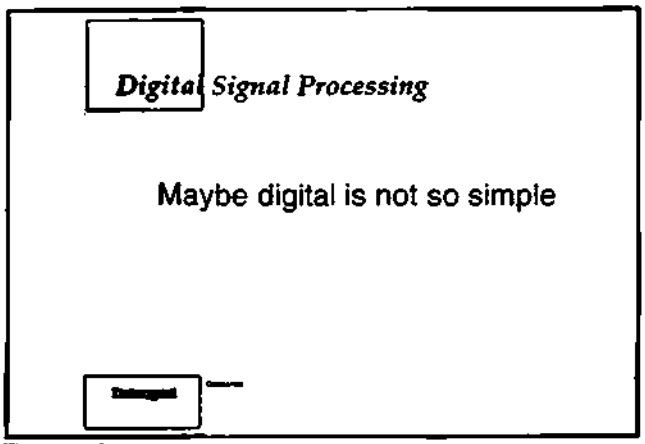

Figure 9

Digital transmission isn't going to be all that easy going down the transmission line path. But thank goodness signal processing can handle all this for us. I like to do this — I'm not an analog bigot. I guess I'm more of a digital bigot, but I hear people talking about digital as if it's the answer to everything and we do have to get to the real world. Digital transmission, square wave transmission, doesn't work very well going down a transmission line. We're already seeing some signal conditioning occuring in some new processors, for example, the Motorola processor that was recently announced. They're having to do signal conditioning, ramping the signals and shaping them so they don't get a lot of ringing on the transmission line, for an automotive application for the multiplex buses.

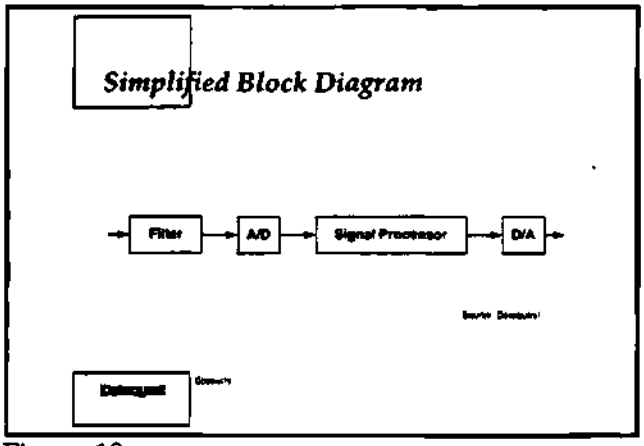

Figure 10

I'm going to repeat a block diagram Gary had up there. Again digital signal processing looks pretty simple. You just bring in the analog signal and do some gross filtering to get some of the major noise converted over to digital and process it in your signal processor. You can go to Analog Devices over here and Tom Cate would be glad to talk to you about that. Put it back in the analog domain and everything's fine. The problem is dealing inside here isn't all that trivial. There's lots of architectures to choose from.

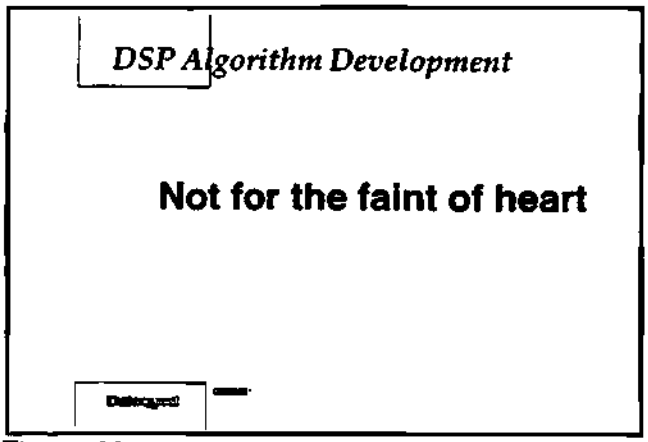

Figure 11

There are programmable devices out there from many suppliers, but trying to convert all of this into a software algorithm that will work in the signal processor is not a trivial task. It takes an extreme amount of talent and insight to be able to convert signal processing equation to free a transform inside a digital signal processor. In fact, Texas Instruments, who is considered the leader in the programmable DSP today, back in the early 80's had their first processor out — the part number was, I believe, 32010. They weren't given a wide acceptance. There was broad application proposed for this product, but people weren't designing it in because it was just to hard to work with. The concept looked great. It wasn't until TI decided to build their own modem — they just picked an application and said well let's build a modem and it was V.22 first and then later, V.32. They went off and did all the algorithms to work on the 32010 and found out that people were taking these canned algorithms and applying

them upgraded to the V.32 spec and ended up using a lot of these canned algorithms to implement a V.32 modem. The 9600 baud modems were almost always using a TI 32010, 32020 or 320C25 signal processor and TI took this and went on to the V.32 and started to fine tune. Motorola, ATT and Analog Devices all picked up on this same methodology and started to develop their own algorithms and work with third party developers to develop these canned algorithms. Literally, you can go buy them off the shelf for the architecture you're working with. I think that is truly what spawned the rapid growth in signal processing, programmable signal processing. In fact, I'm getting slightly ahead of myself on that one.

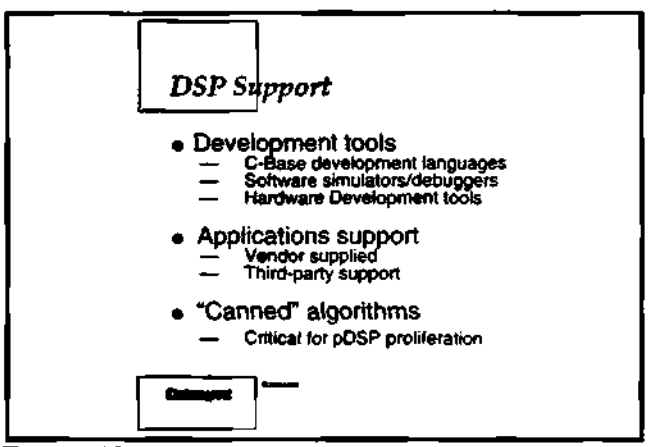

Figure 12

DSP support may be more difficult to support a signal processor than a microprocessor. I think most of us can understand the microprocessor, but implementing the algorithm inside the DSP is a very, very monumental task and a lot of dedicated tools have been put in place. Also required is tremendous applications support to work within customers guidelines to determine how to modify existing algorithms for in a new system or how to develop a new algorithm. A lot of effort is being put into place by the semiconductor companies to go out into the user communities. The systems designers to use their architectures and supply a lot of assistance in developing the algorithms. I think that the standard off the shelf algorithms are absolutely critical for programmable signal processing. I know, we've got Chuck Fox here from Xilinx. Three weeks ago at a DSP conference, there was a paper given about how this group of people were using PGAs and loading software into them. [Inaudible]**** take algorithm to now operate much more quickly then could a programmable solution, but it still is upgradable in the field because now you can essentially write software to upgrade that device. Something like that I don't think is easily done by the average Joe Blow designer coming out of college. I think it takes a lot of help and support from dedicated people to work on things of that nature. But at the same time, there's a lot of room in the marketplace for those kinds of solutions. As we'll see later, the programmable solution has tremendous benefits over a fixed processing solution.

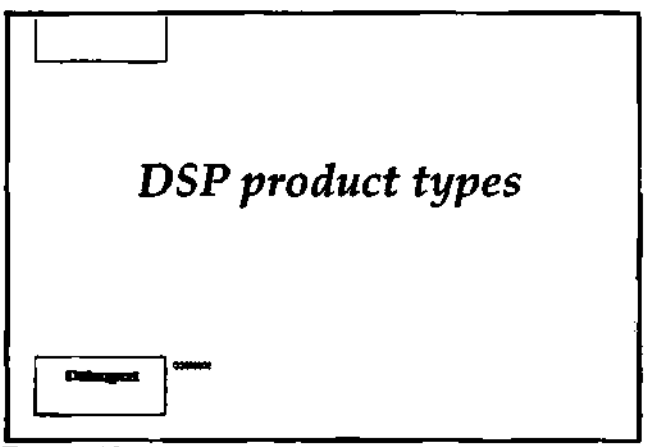

Figure 13

DSP product types — I'll simply break them down into two basic types.

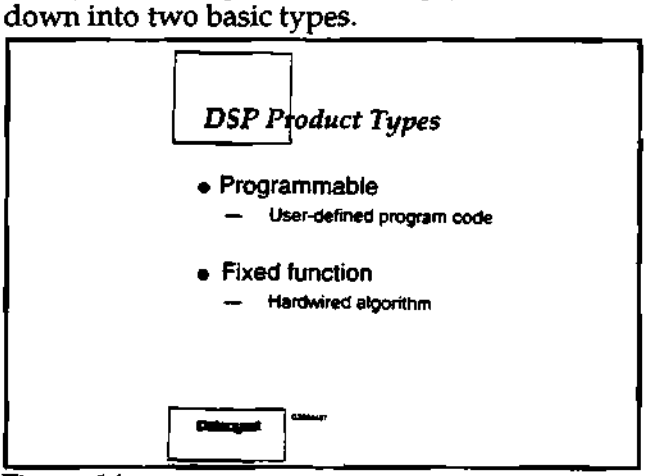

Figure 14

Digital, where it's ones and zeros, and programmable, where the user defines the program code or a fixed function, which has a hardwired algorithm. All I do is MPEG decode, that's all I'm going to do.

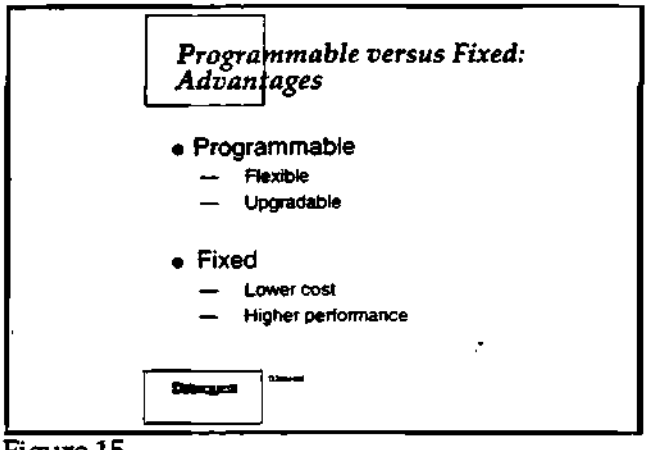

Figure 15

The advantages for programmable are that it's very flexible and upgradable. You've got an algorithm implementing some standard — a couple of things could have happened. You could have misunderstood the standard or it could have been flux and not fixed and sometime down the road the standard becomes better understood or becomes stabilized. You can upgrade in the field with the new algorithm. The fixed function DSPs, which are function specific, are always going to give you lower cost to a function specific algorithm. Lower cost with higher performance, so you trade off the classic flexibility and upgradability versus lower cost and high performance. I'm going to propose later on that in some applications, this can end up being a comparable or lower cost solution than the fixed solution, possibly not higher in performance, but lower in cost.

Question: How do you differentiate programmable from fixed fucntion?

Mr. Banks: Well if you can write code for it, for example, I'm not sure exactly how fixed a Rockwell modem chip set is. It's a fixed function device and you can't write code for it, but I'm sure you can adjust the weights on that though. I wouldn't call that a programmable solution as much as I would say ATT is going after that market also. You can write very specific code for the application out of the function of the other control functions that you'd like to put in as well as the conditioning functions.

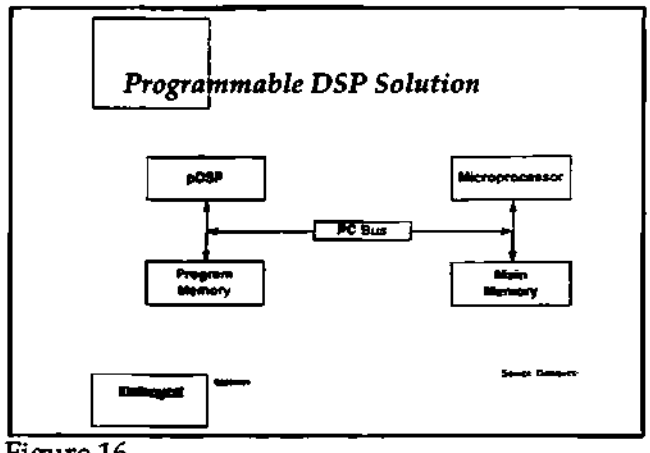

Figure 16

Mr. Banks: Programmable DSP Solution. Now, this is so PC eccentric in here and maybe I should have done a different solution. Let's just consider the general purpose microprocessor, general purpose meaning memory and a bus. I put PC Bus up here because I didn't know whether to put ISA, EISA, PCI, VISA — it's just some kind of a connection to the microprocessor in main memory. Over here is the programmable DSP. Note the cute little "p" over here for programmable. Programmable DSP, you'd have to ask Chuck, could be a Xilinx part too. The program memory is down here. This can be fixed — it can be a RAM or a PROM down here, but more typically these days this is static RAM. The program is loaded into it from either a high density cheap E-PROM where on boot-up to load the program memory contents from the slow E-PROM to into this fast static RAM. You have to run at full speed up here. You can't afford to waste space in this kind of environment. The microprocessor will load/download the proper algorithm that's needed at the time to perform any specific function.

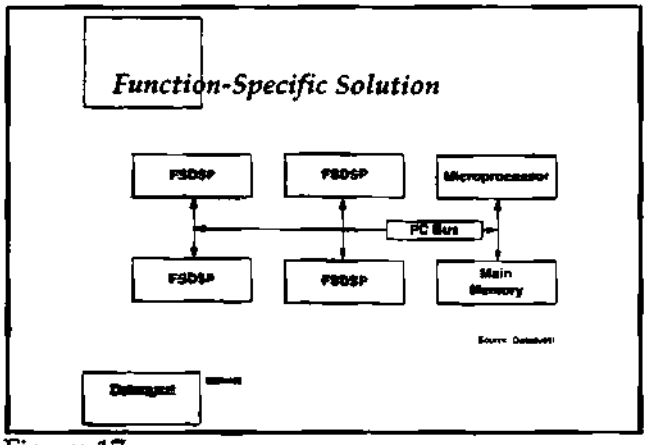

Figure 17

Now this again can work well in an environment where you don't have a lot of form factor issues, where you have more space and performance isn't a key, but programmability is crucial. Now a function specific DSP can work in the same kind of environment. You don't have to tell it what to do and you don't have to load it's program code — it's already fixed inside the device. So here we're showing two function specific DSP. You could do two functions in the space it took to do one programmable solution before. So it saves a lot of space, reduces cost and doesn't require any additional bandwidths in the microprocessor to be downloading algorithms into it. There are various examples of function specific, in fact, there are new variations of programmable solutions being introduced. Zoran, for example, has just introduced a programmable solution for dolby. It's very oriented towards the audio market place, but it's still programmable and set up to implement dolby compression. So they're trying to get to the point where they can optimize enough to get performance and still provide some flexibility in the programmable side.

Today's paradigm — when do you use a programmable DSP? When standards are in flux and when standards are complex. That's a polite way of saying when you can't easily understand the standard and also when differentiation is extremely critical. In the modem example, instead of just buying an off the shelf modem chip set, you may want to do something else differently, such as implement the same standard, but do something else with that same controller. Programmable DSPs allow you the ability to go off to market with a product quickly, even before the standards are fixed or well-understood because you can upgrade them pretty easily. But on the fixed function side, when a standard is well-accepted and in place and when cost is critical, the fixed function or function specific device is going to be the best solution today.

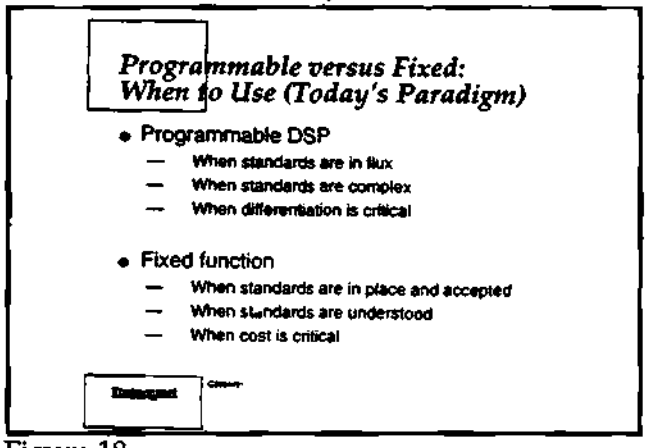

Figure 18

Mr. Banks: Some of the newer programmable devices are becoming more optimized toward specific applications, not fixed function, yet still programmable and very competitive performance wise. Today, people are starting to fine tune their devices versus being so general purpose and becoming more competitive in a specific applications, but the analogy is a good one on the co-processor side.

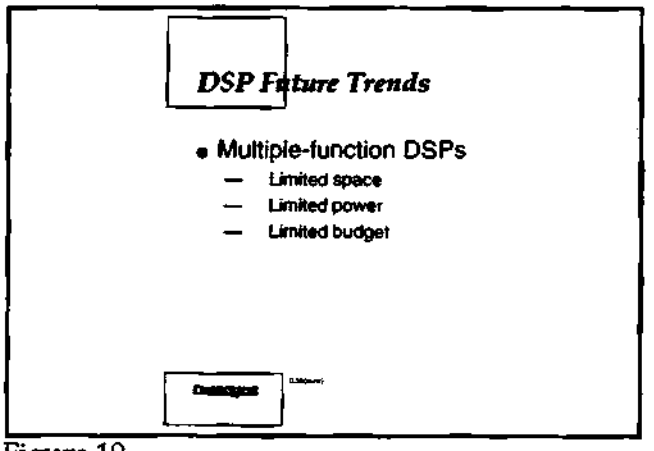

Figure 19

Let's talk about future trends — multiple function DSPs. Say you want to perform several functions.

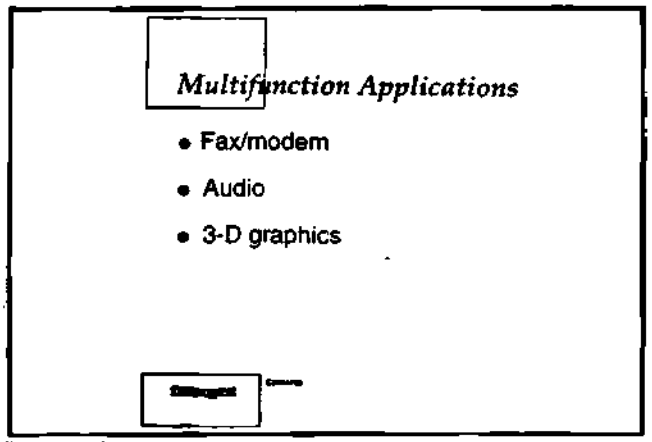

Figure 20

You're doing 3-D graphics, a modem function and some compression. You may not need to do all of these at once and if you're in an application where you need to do multiple functions and you've got limited space, limited power and maybe more importantly a limited budget, it's quite possible with all the three limitations that a programmable solution may be more appropriate than putting several fixed function devices out there.

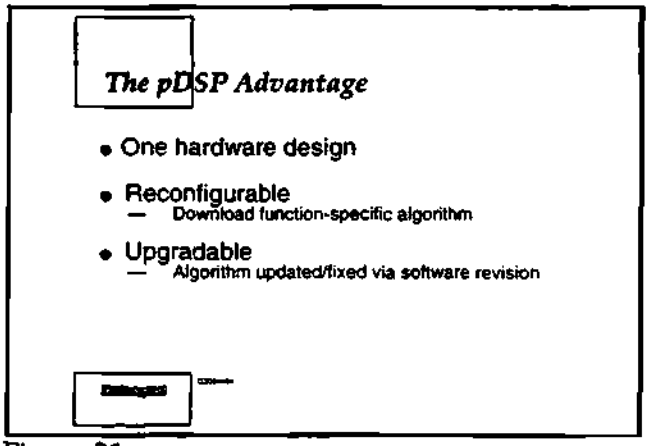

Figure 21

Now for the advantages of the programmable DSP. Basically, you've got one hardware design. You're reconfigurable and you download the function specific algorithm at the time you need it. Now this is something that's not very new. I know at one time Telebit was a leading supplier and they would put in a programmable DSP device, then put in some fast static RAM. Then they take a much larger E-PROM — they had about four different models — and on power-up a section of program code came out of the E-PROM into the S-RAM and it operated. Now these four different models sold for all different prices, but they were absolutely identical. The only thing different was a jumper in between on the printed circuit board. So you'd put a jumper to go to this address or that address. When you boot up, you're just loading that code into your static RAM for program memory. So it's much better for them from a manufacturing point of view, from a support point of view. They were getting the differentiated product and Telebit was able to take advantage of the cost of manufacturing. Again when we're talking about doing any fixes down the road, or any changes in a standard, you try to implement a standard before it's fixed. You can come back later and upgrade that standard if need be in software versus trying to develop a new hardware chip. So basically I think it's quite probable to see a programmable solution not only start to approach the performance of a dedicated solution, but when to use a programmable solution is the same as before when standards are in flux and difficult to understand.

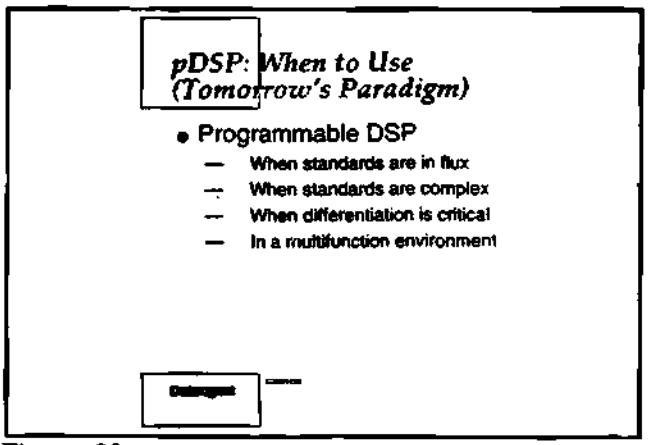

Figure 22

Differentiation is critical, but in a multifunction environment now instead of the old way of

looking at things and saying, "in a multifunction environment, I'm going to use multiple function specific devices." I can look at using a single programmable solution, a single circuit.

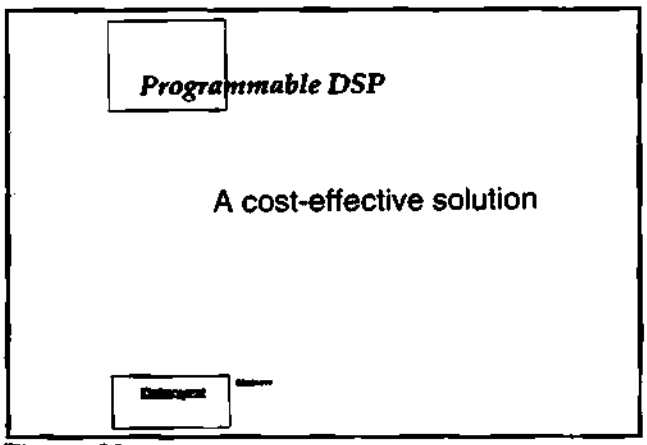

Figure 23

So a programmable solution can be a cost-effective solution. I think the old paradigms are changing a little bit.

Based upon this, we think that the programmable DSP revenue is still going to continue to grow. Now, in microcomponents, we just talk about programmable DSP from the microcomponent perspective, unlike what Gary was talking about.

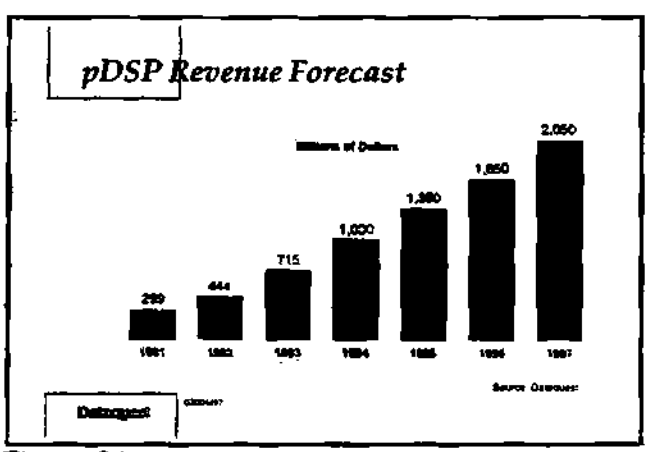

Figure 24

So when we're showing revenue of 299 million dollars here in 1991, this is just the programmable side. In 1992, it will be roughly 450 and this year we're expecting pretty significant growth in programmable DSP. We expect it to exceed two billion dollars by 1997. This is unlike the microprocessor market, where you can assume that X86 is going to control this amount of it and everybody else will fight for the rest. I still think that there's plenty of room within here and enough new applications being developed. There is room for smaller innovative players because the DSP arena is very intellectual property oriented. If you have some key capabilities where you can develop some algorithms and perform some applications, you still can carve out niches in this area. Provide the hardware as well as the software tools to go after it because there isn't the 50 billion dollars worth of software or whatever it was that we heard yesterday afternoon. You know this isn't necessarily supporting the DSP marketplace that you have to be compatible with, although the guys you have to compete against are not sitting still.

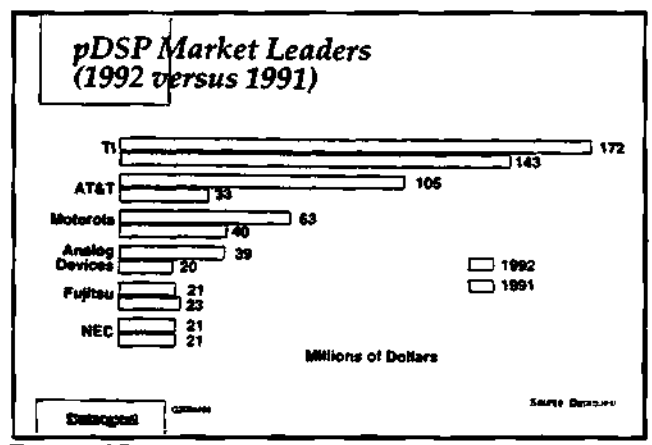

Figure 25

Texas Instruments continues its domination. ATT has shown absolutely stupendous growth, but most of this has been going after the modem marketplace and they're competing head on with Rockwell in this arena. We expect them to continue growing, but not at that rapid pace this year because they're market share in that market has already begun to saturate. Motorola is showing strong growth and the device is nearly doubling from '91 to '92. This isn't an area where the Japanese companies have shown a lot of strength. They seem to be

retrenching at some of these companies. There are some programmable solutions, but still more focus on function specific devices within those companies. There are a few other programmable solutions out there in smaller companies, such as Star Semiconductor, with a reprogrammable S-RAM based solution. It was just introduced and basically, it still seems to be a pretty small and immature market. There is still a lot of room for new players, although you have to be prepared to support it. I know the leaders in this area and they did it with a lot of application support, application notes, tools and actually writing the algorithms for their customers. So if you have the talent and the time to put into it, it can be a very lucrative marketplace.

Question: [Inaudible]****

Mr. Banks: Right, there's a DSP core in the sense of a multiplier accumulator in some cases. LSI Logic has a DSP capability developing custom chips for the DSP market and they've got some design wins in Japan for some of these small palm-top, palm-size camcorders with what do they call it, stabilization?

Audience: Digital image stabilization.

Mr. Banks: Digital image stabilization. Thank you, Dave. They've got some good design wins over there. I guess most ASIC companies are trying to say they have some DSP capability, but it's tough to embed it inside of an array. It's easier when it's more of a standard product that you can access and put traditional debug tools out there to run it at speed and look at the signals.

Audience: You know, as DSP comes down in price, you're starting to see holding channel DSP — a more involved channel in one big high speed processor, sort of like amplifiers when amplifiers were channeling [Inaudible]**** from A to D.

Mr. Banks: Oh, we're starting to see some pretty cheap DSP in Japan. TI is selling some of their product for below $3.00.

Audience: There's a lot of DSP now that's under $10.00, down to the $3.00 to $4.00 area.

Mr. Banks: So it's starting to impact the consumer market as well. The numbers that we're forecasting here I think are conservative if anything. As I said, we're probably the lowest of the people who forecast DSP.

Audience: [Inaudible]****

Mr. Banks: I believe so, but I also think it's still going to require continued software support. I think we'll see people offering software as a product or an algorithm as a product. You'll go buy it, whether you buy it from Analog Devices or from third party suppliers.

Audience: [Inaudible]**** might have thought the programmable kind of flattened off. A lot of third party software guys come in, they write something on it and the first thing you know you've got a bunch of product being sold. So it's not just the IC supplier. It's the IC supplier and the third party software companies — they're kind of creating a market. It's unclear to me that one would rob the other, but it does seem to happen that way. The third party software guys or somebody out there will write the software and make it happen.

Audience: Jerry. I'm going to ask you to consider a category under your programmable DSP — hardware programmable, so that there are two categories. I think the hardware programmable category [inaudible]****

Mr. Banks: The interesting thing about DSP is the programmable side is that it'll surprise you even though you're looking for it. When this market first started _____for DSP, the applications [inaudible]**** just coming out of the wall. They were not invented by the supplying company necessarily, but then you go grab these people and you work with them.

You offer them breaks, you say can you can use this algorithm, you develop it to market and then give to other people. It's a snowball effect and you have to do that. In the DSP market, writing the algorithms is not easy. I still don't think it's well diffused in the marketplace. TI shows this chart — it used to be just Ph.D.s, Master Degrees, B.S. Degrees, Technicians and a few others. I still think new development is up here in the Ph.D. and above level in a brand new ground of algorithm development. I think the only reason the people down here are really using it is because they're taking somebody else's idea and modifying it or just using it verbatim. I still think that this is a great opportunity for intellectual property protection. Get in there, carve out a very protectable and defensible nitch and try to go after the general market. I think you have to be pretty big just to try and go after the general market, but if you can focus on applications where you see a distinct advantage, and sometimes the customers point those out to you, there's a chance. I think this is very much unlike the microprocessor arena where there isn't much room for new players.

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