20th Annual

SEMICONDUCTOR

Conference

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EXECUTIVE SUMMARY REPORT

117

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Semiconductor Conference Keynote Address

Gary L. Tooker
Vice Chairman and Chief Executive Officer
Motorola Incorporated

Agenda: Communications: High-Tech Oases; Predicting the Future; The Global Wireless Revolution; Semiconductor Technology—The Enabler; Applications; The Market

Communications: High-Tech Oases

Dataquest's conference theme of "The Semiconductor Horizon: Silicon Desert of High-Tech Oases," is a positive one. I see a world of high-tech oases connected by a multiplicity of wired and wireless communications. There is a trillion dollar opportunity in telecommunications equipment, a trillion dollars in wireless equipment and services.

Predicting the Future

At Motorola when we were looking at opportunities in telecommunications twenty years ago, we knew that semiconductors were the key.

In the 1950s, Motorola came out with a transistorized two-way mobile radio which helped make us the leader in that business.

In the 70s we were doing research into something called cellular telephone which held great promise but was being held up by regulatory problems. A new industry called paging also looked interesting.

Today the semiconductor content of the typical digital cellular phone is greater than that of the average car. We expect cellular to continue to boom The digital revolution is transforming two-way land-mobile radio and paging and technologies like personal communications and wireless data are just getting started.

The Global Wireless Revolution

We are in the middle of a communications explosion brought about by an influx of significant population numbers into the global marketplace.

Today countries with 85 percent of the world's population have only 29 percent of the world's telephone lines! These emerging nations have found that they need a new kind of infrastructure for the Information Age—a telecommunications infrastructure carrying voice, data, and image by radio and through wires.

In China where there are no where near enough telephones, the Chinese have devised an innovative scheme whereby pagers are used as "half-a-phone". Equipped with a code book and a pager, people are using pagers to send messages in code! With a population of 900 million, India is another enormous potential market for paging.

Two-way land-mobile radio technologies are also becoming popular in emerging markets. Two-way land-mobile had 36 million subscribers last year making it bigger than cellular. The Motorola Integrated Radio System (MIRS) can include dispatch, telephone interconnect, short messaging and data capabilities in the same system.

Microcellular systems, second-generation cordless telephone systems, and wireless data networks are helping to fill the gaps and meet the exploding demand. A good example of this is the Iridium global communications system which is expected to be commercially availability by the end of 1998. It will enable a person to make or receive calls over hand-held pocket-sized telephones worldwide. Services will include voice, data, facsimile, and paging.

Today there are almost half a million people willing to pay a significant premium to use nationwide paging. We think that the worldwide telecommunications industry could grow to about $6.4 trillion by 2010. We expect about $1 trillion of that to be in equipment, with wireless at least $200 billion of that.

Semiconductor Technology—The Enabler

To a great extent, the coming global communications revolution will be based on digital technology, and advances in semiconductor technology will be the driving force.

- The increasing speed of processing has been a major driver of advanced wireless service.
- The cost of computing continues to decline dramatically
- Powerful devices keep getting smaller and smaller, consuming less and less power.

The workplace will become increasingly wireless. There is tremendous potential demand for data communications for those millions of mobile workers. Wireless data will make possible real-time two-way transaction processes that will pay the way for carriers.

Right now there are no real two-way wireless communicators on the market, but Motorola will be introducing a family of communicators, starting with a communications device and later adding products featuring speech recognition, still images and graphics, and ultimately full-motion video. Pagers have evolved into wireless answering machines.

PDAs and wireless communications are only in their infancy. History shows that it takes about a decade for a new technology to gain broad consumer acceptance so disappointment in market acceptance of PDAs today is premature.

What we are talking about are wireless information skyways. The real potential of the National—or Global—Information Infrastructure is that it will enable individuals to have access to image-based information and entertainment services. This will be made possible by three converging forces:

- The availability of bandwidth brought on by developments in fiber, signaling, allocation of spectrum, and satellites.
- The availability of computing power brought about by advances in the semiconductor industry.
- The emergence of competition and choice brought on by new telecommunications policies worldwide.

Applications

These forces will enable people to communicate face-to-face. People can be more productive whether at home, at the office or on the road. We may see a fundamental change in the workplace when there is no need to go to a certain place, like the office, to work.

There are many new applications for wireless technology, including:

- Law enforcement could be aided with two-way transmission of fingerprints
- Wireless LAN will resolve the issue of wiring classrooms
- Wireless networks in the home could control everything from security to stereos
- Remote monitoring of patients and emergency response
- Wireless systems to track inventory and vehicles
- Energy conservation, traffic management, collecting tolls electronically

We predict that by the end of this decade:

- There will be over 100 million cellular and PCS subscribers
- Paging could go from 50 million to 150 million subscribers
- Wireless data should come from nowhere to 20 million users

Additional spectrum will be needed. Digital cellular and private systems have been possible because of the ability of re-mining existing spectrum. We will need additional spectrum for industrial and public safety services, Intelligent Vehicle Highway Systems and satellites services, and for data, paging or voice systems. More spectrum means more flexibility.

The Market

We think that the market for semiconductors in the wireless arena will grow at a compound annual rate of 18 to 22 percent over the next decade. New wireless systems require combinatorial technologies providing information compression, spectrally efficient modulation, and advanced system architectures.

Low-cost powerful microprocessors, highly integrated ASICs and low-cost memory device make it possible. The low power and high energy characteristics that are vital to portable and wireless products are found in the PowerPC603 family. The PowerPC microprocessor provides a single architecture designed to scale the entire spectrum of communications, computing and embedded products.

Conclusion

As we look to the future it is with a great deal more optimism than was the case 20 years ago. The industry is much stronger today. There is a great deal more cooperation among industry players and through consortia like Sematech. The future is truly an exciting one. We have barely tapped the possibilities of the semiconductor revolution and we look forward to a world of high-tech oases connected by wired and wireless communications.

The Semiconductor Outlook: Where Are the Surprises?

Gene Norrett
Corporate Vice President and Director
Semiconductor Group
Dataquest Incorporated

Agenda: The Reconciliation; 1995 Outlook; 1994 Growth by Region and by Product; Major Semiconductor Applications; Forecast Assumptions; Electronics Forecast; Semiconductor Capital Spending a Key Factor; Forecast by Region, Product, and Country

The Reconciliation

We made two major assumptions last year:

- Constant currency from about August or September of the current year through the following year
- DRAM price-per-megabyte was going to drop by 10 to 12 percent

We forecast the industry to grow by 15.2 percent. Neither of these assumptions was valid. Therefore, there was only a growth of 13 percent.

1995 Outlook

All the regions of the world today are basically synchronized and driven by the pervasiveness of personal computers and personal communications. Their growth curves are above the 20 percent growth rate mark.

The fastest growing part of the world is the Asia/Pacific region. Growth curves, except for Japan, should remain above the 15 percent level.

We will see some shortages in 1995, but because of all the capacity that is being put in place, improvements in efficiency, and yields, demand more in keeping with supply than what it was in 1994.

1994 Growth by Region and by Product

By Region

Asia/Pacific is the fastest growing part of the world, due to personal computer demand, followed by the United States. Japan is growing the slowest. China is becoming an ever-increasing factor in electronics manufacturing. Asia/Pacific is seeing increasing consumption of semiconductors in the Japanese factories that have taken up residence due to the effect of the appreciated yen.

North America and Europe are experiencing continued growth due to the growth of personal computers, as well as the increasing demand for higher electronic content in all of the toys that are being bought.

By Product

Memories and microcomponents tower over the rest of the industry, representing 53 percent of the total semiconductor industry.

The 4Mb DRAM and the x86 microprocessors were the highest growth products in 1994. 4Mb DRAMs will grow approximately 29 percent, 486s 13 percent, and Pentium revenues are going to grow fivefold.

MOS Logic: the highest growth devices were cell-based ICs and PLDs, each growing 21 percent. Gate arrays are up 19 percent.

Analog: mixed-signal devices are growing at 33 percent, driven by personal communications and multimedia.

Other Semiconductors: are growing approximately 17 percent, with the largest subcategory, discretes growing at 19 percent.

During 1994, demand has exceeded supply for most leading edge components as a result of from the past underinvestments in manufacturing capacity, particularly the significant underinvestment in Japan. Today this situation is lessening somewhat because of the considerable amount of additional capacity being put in place by the Koreans, the Japanese, and the Chinese manufacturers, who have traditionally been the largest suppliers of foundry services.

The Windows 3.1 explosion has also had a hand in the memory shortages as users have demanded more memory to handle all the advanced features of this powerful operating system.

Major Semiconductor Applications

Data processing. Represents 47 percent of the total available market for semiconductors, 34% of which comprises PCs, mid-range computers and servers.

In 1994, 45 million PCs will be shipped worldwide, with leading edge systems having approximately $1,700 worth of semiconductors (this figure of 45 million PCs excludes multiprocessor PCs as well as after-market boards and chips).

Premise communications systems. Is the next biggest category with 7.1 percent. Includes networking, modem, and line card chips.

Forecast Assumptions

Dun and Bradstreet's (D&B) macro economic forecast:

U.S. decrease in GDP from 3.6 percent in 1994 down to 3.3 percent, lower growth of capital spending (new construction), and very good growth for facilitating factories and offices under construction, as well as those that are already completed.

Japan is dragging itself slowly upwards as a result of huge government spending. Japan also anticipating increasing their capital investments from approximately 1 percent this year to 3 percent growth next year. GDP should increase by about 2.3 percent in 1995.

Unemployment in the combined Germanies continues to increase, resulting in falling consumer prices. GDP is increasing as factories and offices have become much more productive and efficient through the use of electronics. Germany has also experienced something of a boomlet in automotive sales.

In China, foreign direct investment is going through the roof. Manufacturing output has been rising by over 20 percent for the last four years. Alliances are being formed. Beijing still has to solve the high levels of inflation, inefficiency, and considerable labor unrest. The central government is trying to rein in this massive economy. Investment, consumer prices, and GDP growth will be slower next year. China should continue its rapid expansion into electronics manufacturing and consumption in 1995.

Electronics Forecast

A 16 percent growth rate this year in the United States and a 15 percent growth rate next year. By the year 2,000, there will be 100 million PCs shipped. The principal reason for PC growth this year and next year is the growth of the SOHO market and portable markets.

Total worldwide electronics to grow about 5.2 percent. Desktop and portable PCs, high-end servers, and open architecture workstations to continue to drive data processing industry. Emerging product categories will have high growth in subnotebooks, X Windows terminals, power laser printers, copiers, and PCMCIA cards.

Communications to grow by 5 percent. Highest growth markets include Ethernet, Token ring cards, modems, voice processing equipment, cordless, and digital cellular phones, pagers, FDDI and ATM cards, and fax machines.

Semiconductor Capital Spending a Key Factor

- Significant underinvestment in 1992 and 1993, causing capacity shortage that we have today
- Long-term manufacturers will continue to invest about 17 percent of their revenues in expanding their plants.
- In 1994, worldwide manufacturers' capital investments will increase to just over $19 billion, a growth rate of 36 percent.
- In 1995, there should be a $2.6 to $3 billion increase in capital spending, or a 14 percent growth rate $22 billion.

Forecast by Region, Product and Country

By Region Overall 26 percent growth for 1994 and about 14 percent for 1995.

- **Japan.** The only region not achieving a double-digit growth rate next year will be Japan. The electronics industry in Japan is principally in large and mid-range computers, high-end consumer, industrial and communications equipments, which will not grow at the rate of PC manufacturing. Since much of Japan's low- to medium-level consumer electronics manufacturing is now in the Asia/Pacific region, there will be relatively low growth in semiconductor consumption in Japan.
- **Other regions.** A continuation of 1994, with PCs, personal communications and other communications products, as well as peripherals, driving the industry.

By Product

- MOS Memory, the largest segment, will enjoy fifth year of revenue growth.
- DRAM revenue boom will continue strong through the first half of 1995. As a result of strong capital spending in 1994 by the Japanese and Korean DRAM manufacturers, revenue growth will slow in the third and fourth quarters. 4Mb DRAM demand will peak in the first half of 1995 after which demand will gradually decline as market shifts to the16Mb. 4Mb pricing will decline quickly in the latter part of next year. Since yields are still low on the 16Mb, prices for these devices will decline slowly throughout 1995.

- Memories with 13 percent growth rate in 1995.

- Microcomponent with about a 25 percent increase. The principal driver is the x86 family, and, specifically, Pentium-class devices. Windows 95, games, efficiency improvements, and multimedia, all driving users to upgrade existing platforms.

- Strong growth projected for Microperipherals in 1995, including one of the hottest areas—PC core logic chipsets.

- Analog will show a 12 percent growth rate.

- The Other Semiconductors category will grow approximately 10 percent.

By Country

By the year 2000, China, including Hong Kong, will be the third largest semiconductor consuming country, rising from sixth this year. 1995 consumption will continue to increase, but at a slower rate given the impact of the additional capacity and commensurate relief on prices. Demand will be more in balance with supply throughout 1995.

By 1997, Asia/Pacific will be the second largest consuming region for semiconductors, up from its current place of third.

Selected Important Applications for Semiconductors

1994 Revenue (Billions of Dollars)

Data Processing	46.8	
Personal Computers		29.7
Midrange and Server		4.7
Communication	16.2	
Premise		7.1
Public		3.3
Consumer	20.1	
TV		3.5
VCR		2.3
Automotive	5.1	
Engine Management		1.7
Stereo		1.0

Dataquest

G4005308

Source: Dataquest

Figure 1

1994 Worldwide Electronic Equipment Production Forecast

Billions of Dollars

	1994	1995	% Growth
Data Processing	213.7	226.3	5.9
Communications	117.3	123.1	5.0
Industrial	105.7	112.6	6.5
Consumer	145.8	153.0	5.0
Military/Civil Aero	59.4	59.7	0.6
Transportation	29.4	31.1	6.1
Total	671.2	705.9	5.2

Note: Columns may not add to totals shown because of rounding.

Source: *Dataquest*

Dataquest

G4005317

Figure 2

Worldwide Semiconductor Market

	1994		1995	
	Billions of Dollars	Percent	Billions of Dollars	Percent
North America	36,028	28.9	42,438	17.6
Japan	29,322	18.7	30,672	4.8
Asia/Pacific	22,957	31.1	27,051	17.8
Europe	19,296	24.6	22,686	17.6
Total	107,603	25.6	122,847	14.2

Source: Dataquest

Dataquest G4005320

Figure 3

Worldwide Semiconductor Market

	1994		1995	
	Billions of Dollars	Percent	Billions of Dollars	Percent
Memory	31,539	33.9	35,427	12.3
Micro	25,468	27.5	31,801	24.9
Logic	19,099	18.2	20,954	9.7
Analog	15,475	25.2	17,275	11.6
Others	16,022	17.9	17,390	8.5
Total	107,603	25.6	122,847	14.2

Source: Dataquest

Dataquest G4005321

Figure 4

Food Chain Forecasts: The Dataquest Vision

Microcomponents

Jerry Banks
Director and Principal Analyst
Semiconductor Microcomponents Service
Dataquest Incorporated

Agenda: Summary of 1994, Forecast Assumptions; Microprocessor Forecast; Microcontroller Forecast

Summary of 1994

- Microprocessor revenues will top $11 billion. That represents only 31 percent growth for microprocessors this year versus the 60+ percent of last year.
- The 486 peaks this year, due to the conversion to the next generation of microprocessors—both Pentium and PowerPC are in their initial production ramps.
- There will be in excess of 4 million Pentium units and 2 million PowerPCs in 1994.
- Workstations make up nearly 90 percent of total microprocessor revenue, with 90 percent from the x86 (Intel has the dominant position).
- Intel will be successful in driving a rapid transition from today's 486 to tomorrow's Pentium processor.

Life cycles. Going back to the introduction of the 286, 386, 486, and our projections for Pentium, each successive generation has higher volumes than the previous generation. From point of introduction of the product to the point of high volume production, it has gotten shorter and shorter every year.

Pentium is already at a very high volume production ramp this year. Intel is in a strong position to drive the x86. Considering today's operating systems and applications, which are very x86-specific, it's going to be very difficult for non-x86 architectures in the short-term to try to gain a foothold in the desktop PC market.

Forecast Assumptions

- PC market to reach 77 million units by 1998
- But the opportunity for PCs into the PC marketplace is going to be 100 million units, due to addition of CPU and motherboard upgrades, multiprocessing systems, and inventory that the PC OEMs have to purchase.
- Multimedia will drive performance requirements, particularly in the home market.
- Multimedia will help spawn the multiprocessing market, which should account for about 12 percent of computers shipped in 1998.
- Intel will introduce their P6 in the middle part of 1995, with a resulting Pentium volume peak point in 1996.
- Leading-edge fab capacity becomes more strategic, playing a very important role in the future of microprocessors.

Microprocessor Forecast

- Very high growth for RISC products, although x86 revenue in 1994 is expected to be an order of magnitude higher than the combination of all the Open Systems RISC architectures
- By 1988, x86 revenues will be more than eight times the combined revenue of RISC products.
- The PowerPC, although small by x86 standards, is expected to displace the 68000 next year as the number two microprocessor architecture in terms of revenue. It's currently best positioned to challenge the x86 hegemony.
- Embedded 32-bit microprocessors currently completely dominated by Motorola, with its 68000 family and 68300 family. This market will not produce sufficient growth opportunity in the short-term until new PDAs/PICs start to take off.
- By the end of the forecast period, the x86 family still will control three-quarters of the microprocessor revenue in 1998.

Microcontroller Forecast

Microcontrollers not the revenue leader, but in terms of number of units shipped, there is no contest. In 1993, over 2 billion microcontrollers were shipped, and of that, the 8-bit category grew over 30 percent, representing nearly 1.1 billion units shipped in 1993.

What really differentiates a microcontroller from a microprocessor is that the program memory resides on-chip, versus off-chip.

The office market is a growing area, although not the largest; a lot of electronics are going into the automobile.

Microcontroller growth is in 16-bit. In 1994 the 16-bit microcontroller market will be about $850 million compared to $4.6 billion for the 8-bit market. The 8-bit market is showing very strong growth as well, although it would be growing much more were it not capacity-constrained.

Motorola is the largest producer of microcontrollers, completely dominating the category.

Summary

Microcontrollers are going everywhere (in anything electric), and current sources of supply can't keep up with demand.

The 4-bit market is a well-understood, well-defined market that is saturated with suppliers, and whose life cycle is being extended only because of capacity constraints in 8-bit.

The 8-bit market is large, it's where the opportunity lies today, and where it's going to lie in the future.

The 16-bit market is showing very high growth, but over the long-haul the 16-bit life cycle may be somewhat truncated by the invasion of these highly-integrated 32-bit processors and derivatives coming into the marketplace.

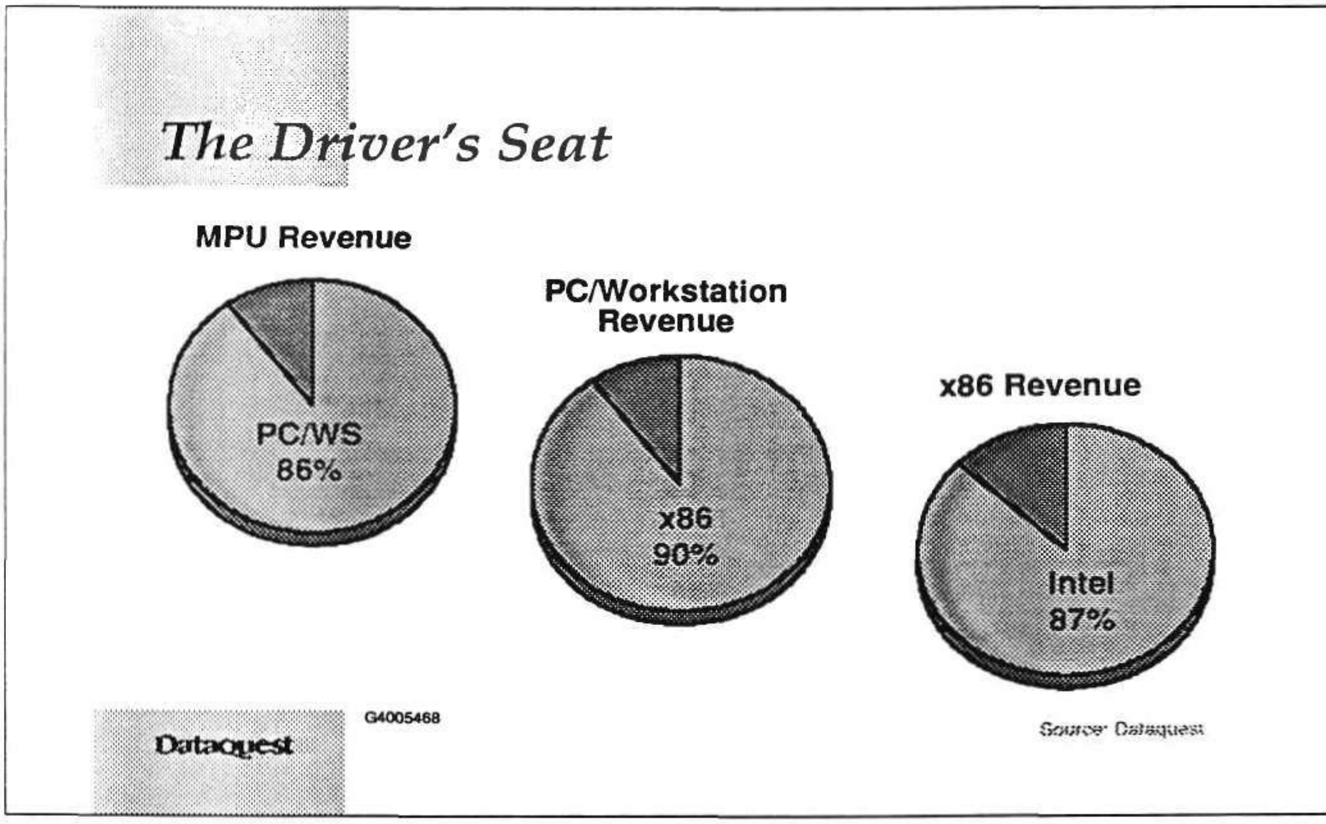


Figure 1

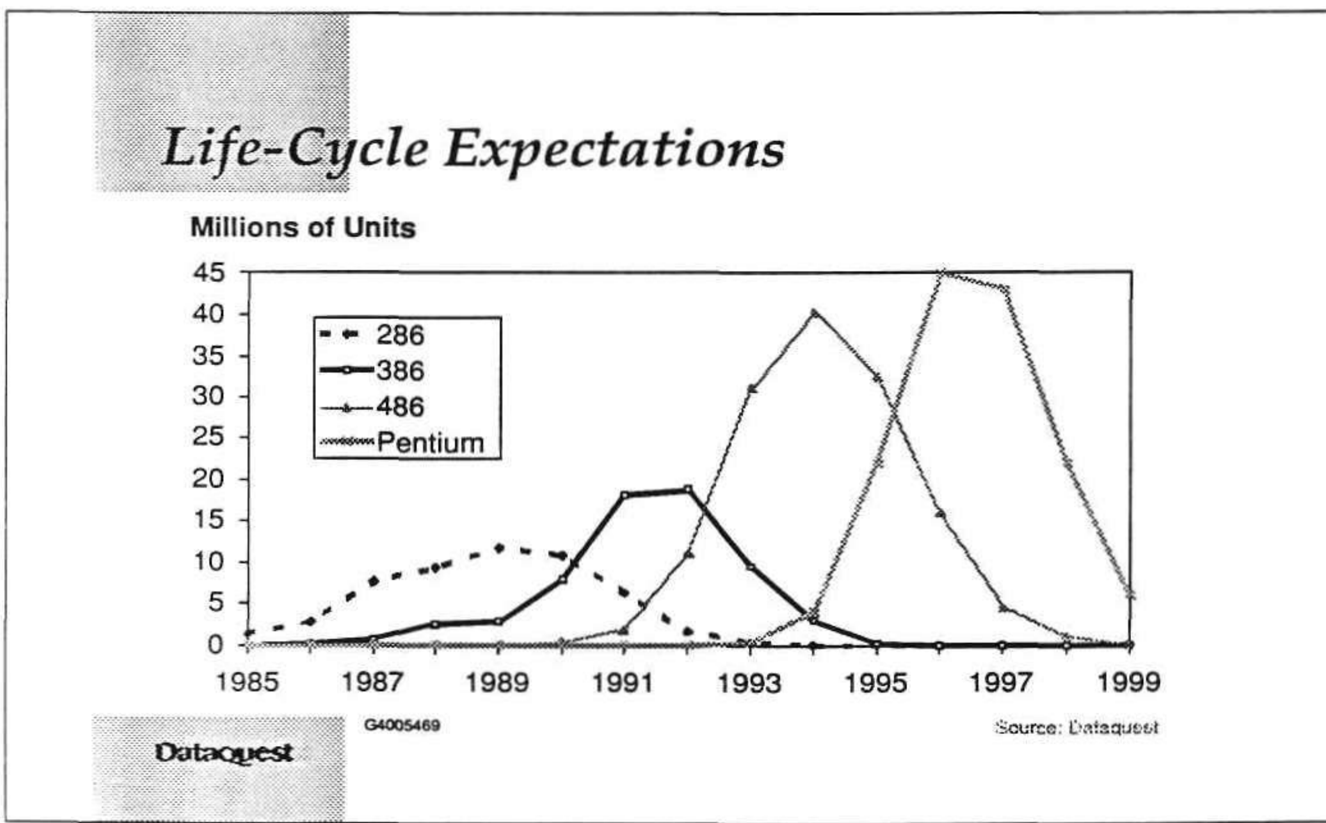


Figure 2

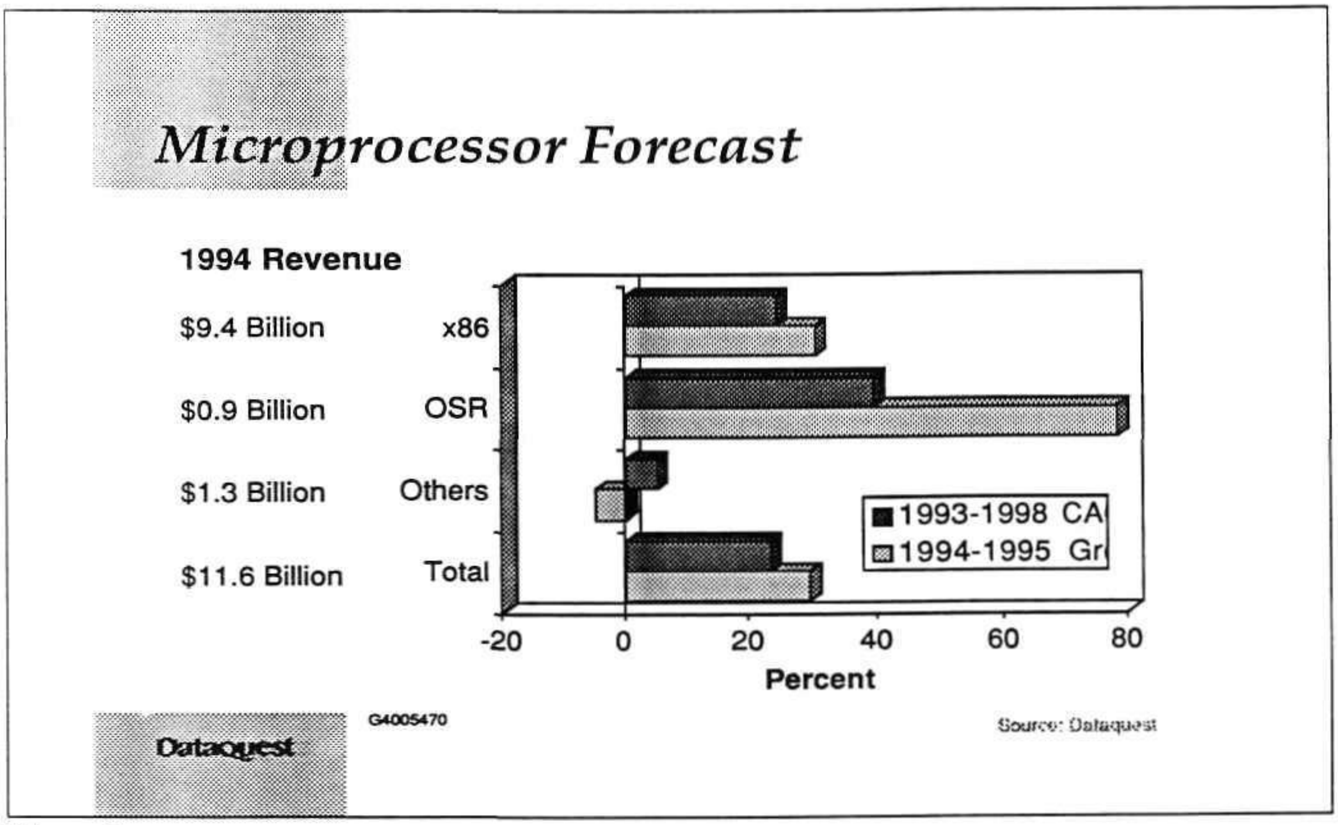


Figure 3

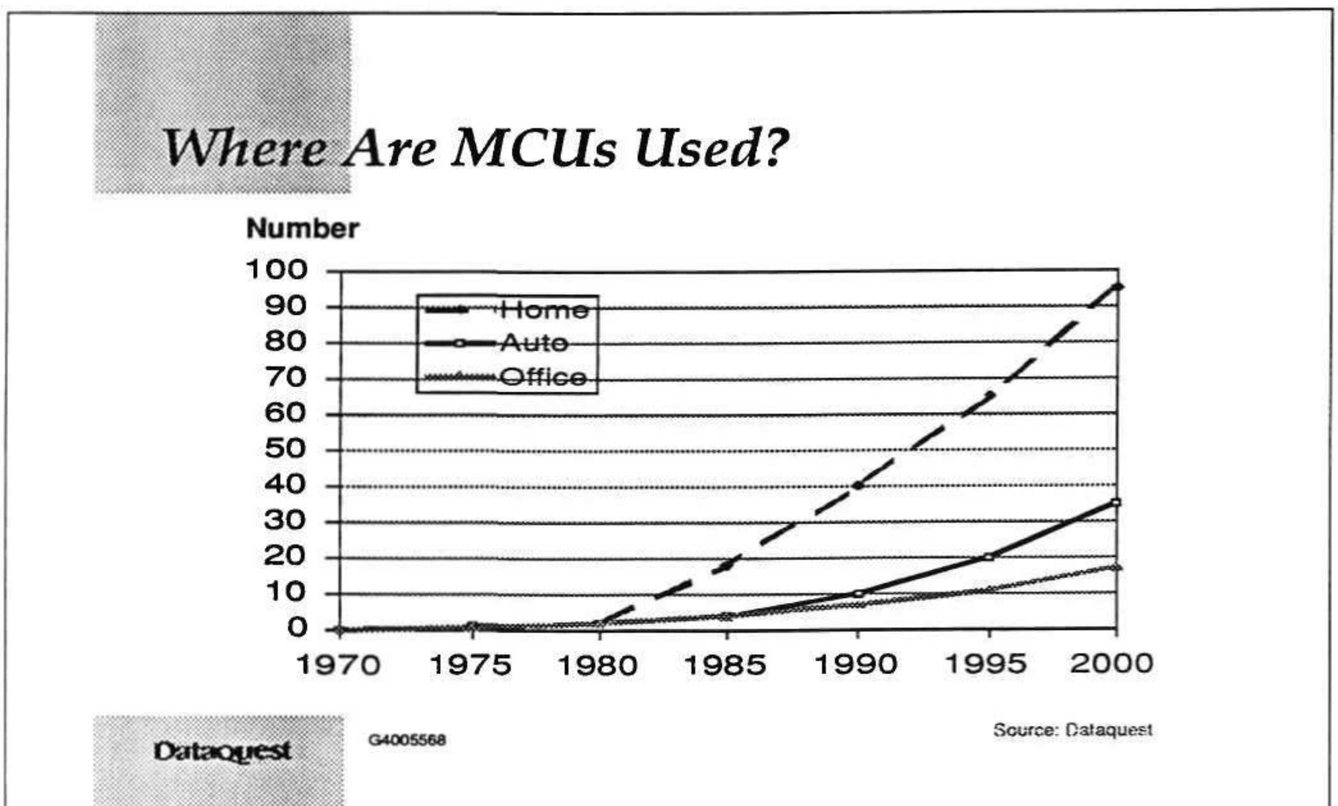


Figure 4

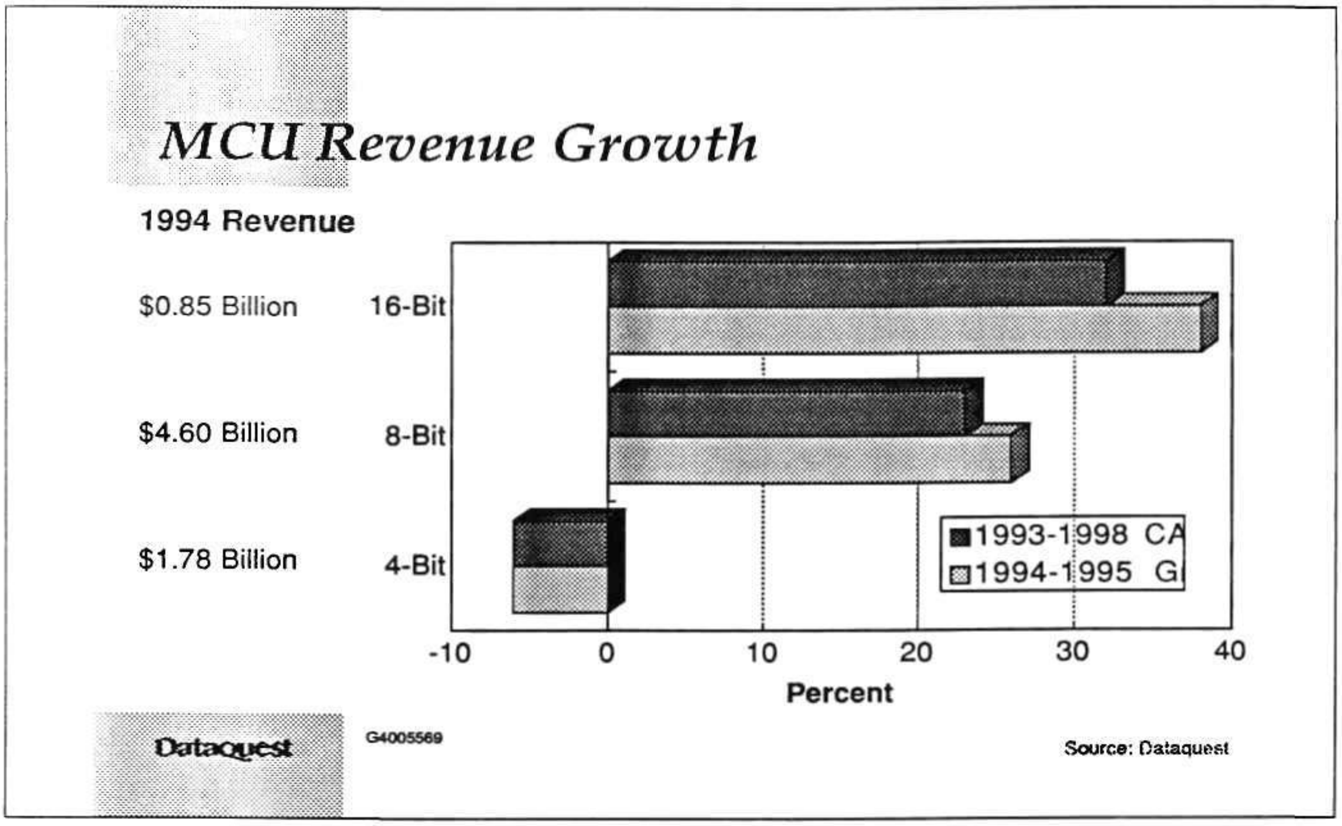

MCU Revenue Growth
1994 Revenue
$0.85 Billion
16-Bit
$4.60 Billion
8-Bit
$1.78 Billion
4-Bit
1993-1998 CA
1994-1995 G
-10
0
10
20
30
40
Percent
Dataquest
G4005569
Source: Dataquest

Figure 5

Memories

Jim Handy
Director and Principal Analyst
Semiconductor Memories Group
Dataquest Incorporated

Agenda: 1994 Summary; Forecast; Forecast Assumptions; Applications Drivers

1994 Summary

- In 1994 strong PC demand drove unheralded growth in DRAMs.
- A cold investment climate in Japan caused Japanese companies to postpone investment in capital equipment, causing a DRAM shortage. The shortage caused DRAM prices to stayflat or a little bit up for as long as nine quarters now, so 1994 ended up being an extremely profitable year for DRAM manufacturers.
- DRAM manufacturers are grappling with issues such as memory granularity, i.e., how many chips can you put on a system?
- Processor speeds are increasing so cache memories are becoming much more taxing to build.
- Consumer electronics, with about 17 percent of the market, is slow. The 1Mb slow SRAM, therefore, is selling extremely poorly compared to any previous generation of slow SRAM in recorded history. That market's not driving the demand for that part the way that it should be.
- PDAs are a cold market now. There should be a shift in the acceptance of PDAs in 1995, which will drive Flash consumption.
- Something else that further confuses the market is the emergence of several potentially hot technologies which cause people to wonder if the market could radically shift away from standard commodity devices over to these new ones?

Forecast

Revenue growth in 1995 is going to be weaker in DRAMs than it is over the long-term. Prices are staying astronomically high compared to their cost to manufacture. There will be a correction in the market, but if you look at 1994 and 1995 put together, it will still be a very healthy market. Because there was not the usual price erosion, this year we would have expected the market to be at about $12 billion just based on normal ASPs times regular revenues, and instead we're expecting 1994 to top out at about $21 billion.

Lower growth in SRAMs in 1995 than over the long-term. Two-thirds of all SRAM revenues come from slow parts, and most of those go into consumer electronics, which is currently in a slump.this will ease gently over the next five years, improving the long-term growth of the SRAM market. Another part of growth of the SRAM market comes from caches in PCs, which we're expecting to be widely accepted despite evolving changes in DRAM architectures.

In nonvolatile memories, the EPROM market should take a hit next year because of increased availability of Flash. The PDA market is developing slower than expected, and so that's also lowered our assumptions relating to the Flash market.

ROM and EEPROM are suffering from a bad consumer electronics market, but are expected to heat up soon.

Forecast Assumptions

DRAM and fast SRAM markets will be fueled by the continued health of the PC market and telecommunications. Users have found that more main memory means better use of their PCs, so they continue to add memory to their systems.

DRAM prices have been forced sky-high by a noncompetitive market where demand far outstrips supply, and the normalization of all of this will reduce revenue growth to more modest levels.

The Japanese market is due for an upswing, which will be coupled with the improved health of the consumer electronics market, thereby increasing demand for slow SRAM, ROM, and EEPROM.

Increased capital spending in Japan will result in higher DRAM production, loosening the supply constraints that have kept DRAM ASPs as high as they have been.

Hot new technologies like Flash memories will drive new end system designs. Systems are being designed because they're enabled by Flash memory. More portable devices will become available and as these devices become popular, their memory consumption will grow the overall market.

Applications Drivers

- DRAMs: PCs are more than 60 percent of the market and growing.
- Slow SRAMs, which are mainly used in consumer electronics and are the larger part of the SRAM market, are cold, although we're expecting them to heat up with the consumer electronics market.
- Fast SRAMs are hot. The fiercely competitive market for fast 32Kx8, which is the primary device for use in cache memories in PCs, has had a few participants drop out, so prices have started to firm up. Lots of cache will be used in the Pentium market.
- ROMs are waiting for the reemergence of a strong consumer electronics market.
- For EPROMs, PCs are still the top application.
- Flash is a glamour technology and it seems like a lot of start-up companies are coming about because of Flash technology. Flash promises an enabling technology for future generations of handheld equipment.
- EEPROM has a niche as the one-dollar-or-less rewritable memory device. It's expected to hold its own and follow the consumer electronics market

Conclusions

- DRAM undersupply well into 1995
- Fast SRAMs are going to be following the same path as DRAMs.
- Slow SRAMs, ROMs, and EEPROMs are waiting for the consumer electronics market to heat up.
- EPROM is still a strong market.
- Flash is growing but not growing quite as fast as we first thought.
- No PC bubble burst in 1995, and that translates into a good strong MOS memories market.

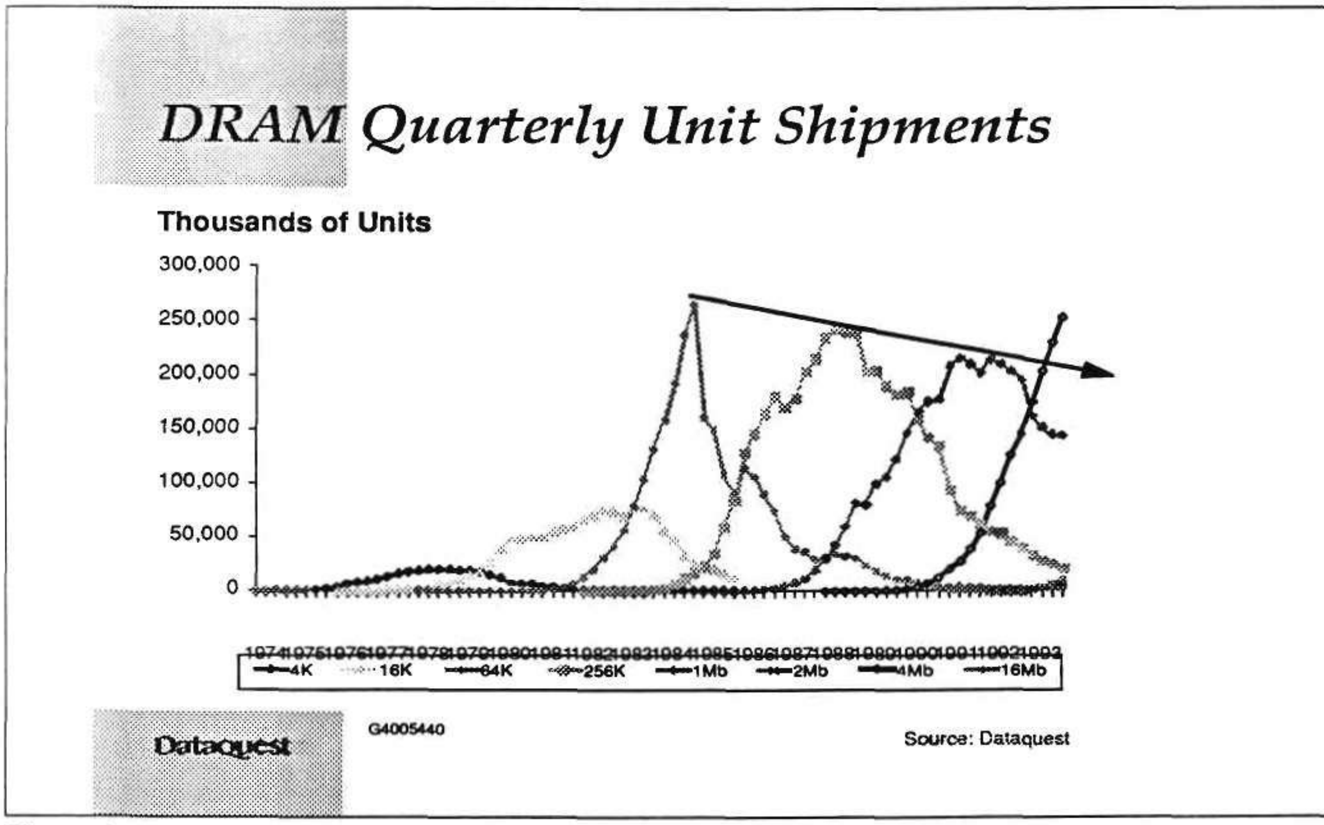


Figure 1

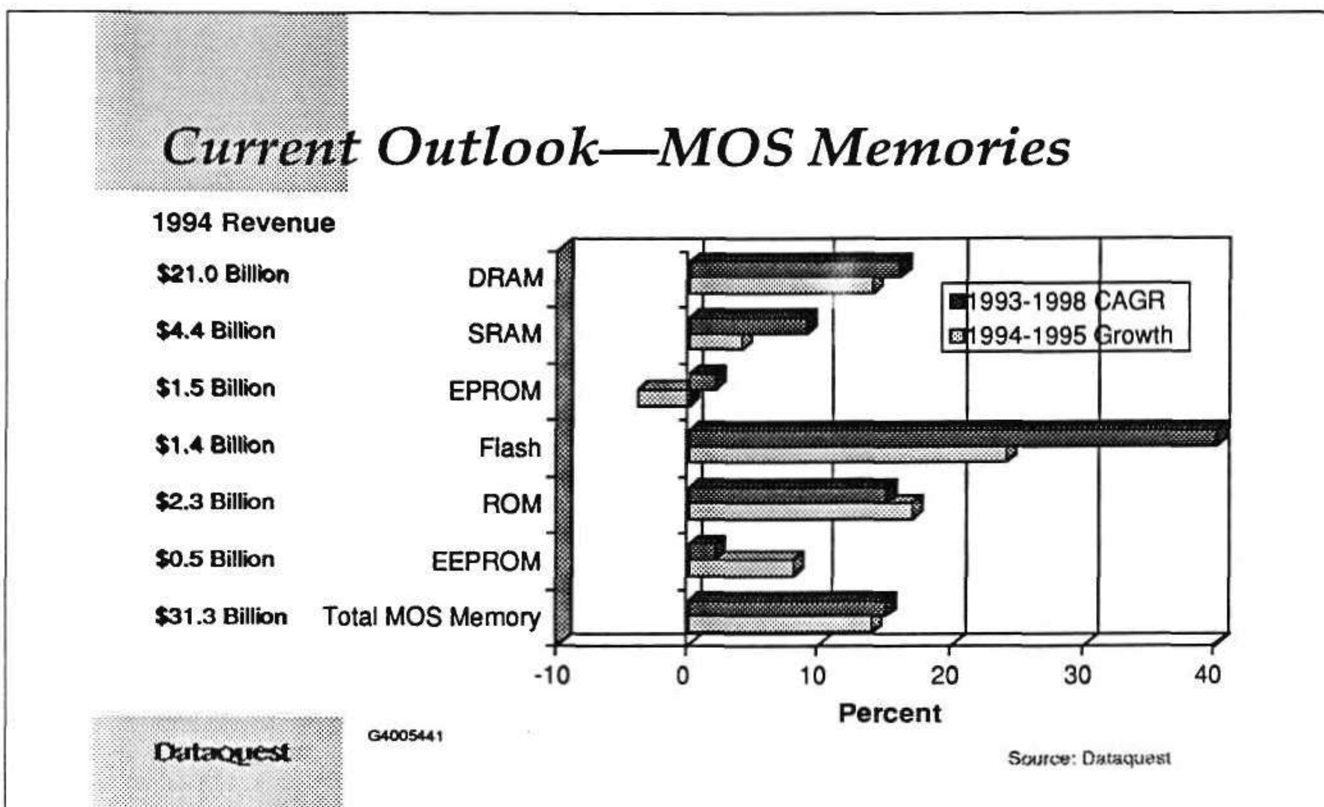


Figure 2

ASICs Forecast and Market Trends
Users Call the Shots

Bryan Lewis
Director and Principal Analyst
ASIC Service Worldwide
Dataquest Incorporated

Agenda: ASIC Forecast; Forecast Assumptions and Trends; ASIC Consumption by Application; User Wants and Needs Survey Results.

ASIC Forecast

- PLDs: overall don't appear to be growing very rapidly
  - MOS PLDs are fastest-growing segment of ASIC market, forecast to grow 20-21 percent in next five years, offer faster time-to-market
  - Bipolar PLDs are declining, being replaced by MOS technologies
- Cell-based ICs growing quickly at about 17 percent, starting to catch up with gate arrays.
- Gate arrays, a $4.2 billion market, are the largest ASIC market, provide good time-to-market, and have a good price structure. Will continue to grow at 145 clip for next five years.
- Bipolar gate arrays and bipolar PLDs are being replaced by MOS technologies.

Forecast Assumptions and Trends

PLD devices comprise simple PLDs, complex PLDs and field programmable gate arrays. Field programmable gate arrays and complex PLDs are growing rapidly because they are replacing simple PLDs as well as some low-end gate arrays.

We are starting to see a lot of high-volume applications in Japan, such as consumer applications migrating to cell-based ICs.

Because of reduced power consumption and high integration, bipolar gate arrays are being replaced by CMOS gate arrays and CMOS cell-based ICS.

Standard products are impacting the ASIC market as they replace ASICs in some cost-sensitive applications.

Our end-user data clearly shows that it is critical for manufacturers to use ASIC technology to differentiate their products.

ASIC Consumption by Application

- In North America over half of the ASICs are consumed in data processing applications, primarily in PCs and workstations.
- In the communications area, telecom and datacom are taking off rapidly.
- Military markets continue to contract.
- The consumer market in North America is becoming revitalized. Set-top boxes are clearly an area for future growth.

User Wants and Needs Survey Results

Dataquest conducted a survey of 500 systems designers in North America and Japan:

- North America leads Japan in technology utilization: printed circuit boards had more signal layers, were more complex, and used higher density ASICs.
- There is strong demand for ASICs in the 100,000-to-300,000 gate range.
- There is less user demand for BiCMOS technology than its perceived need from only a few years ago.
- In clock frequencies we are expecting a big increase in the 50-to-100 MHz range, largely because of data processing applications.
- Strong emergence of products in the 3volts/5volts and 3volts area.
- Strong demand for ball grid arrays. We forecast that in five years 40 percent of ASIC designs in North America will use ball grid arrays.

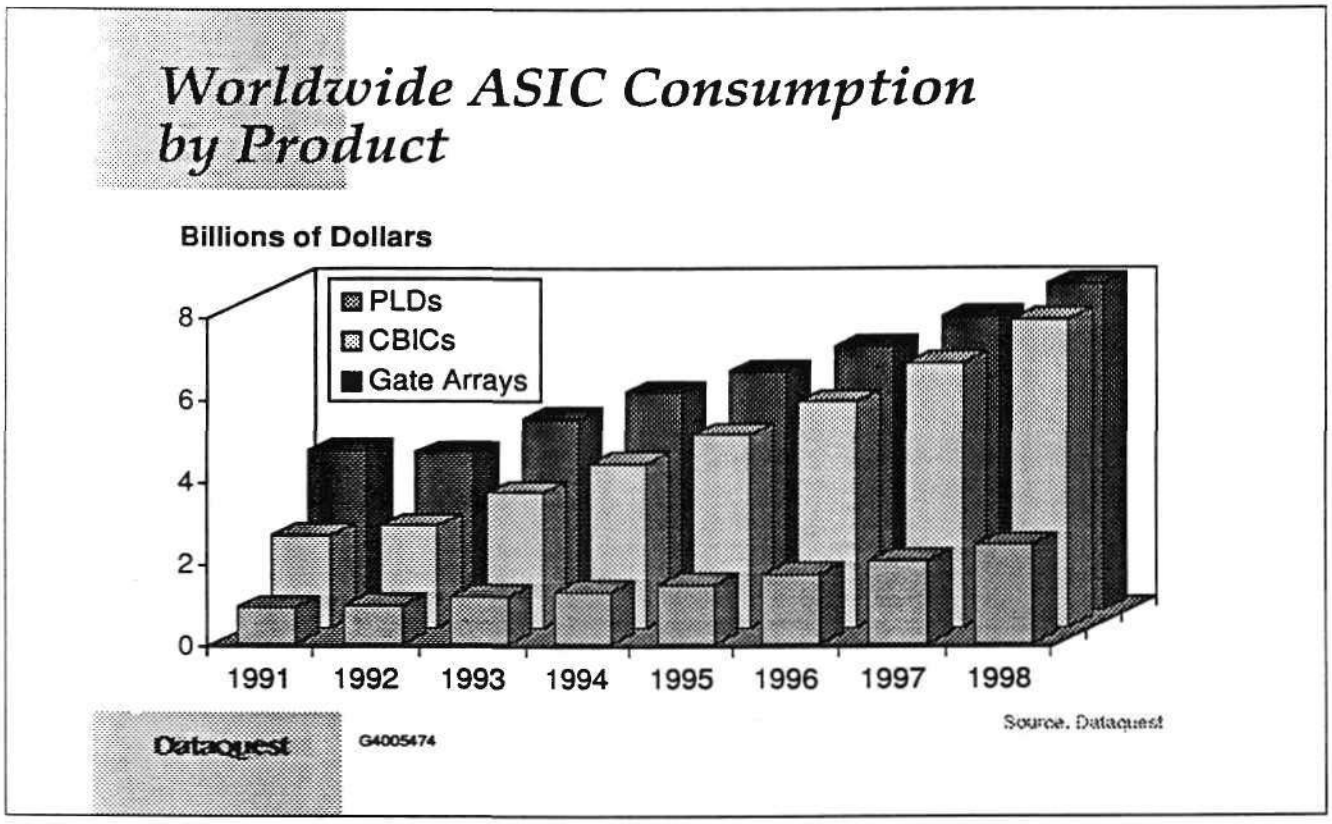
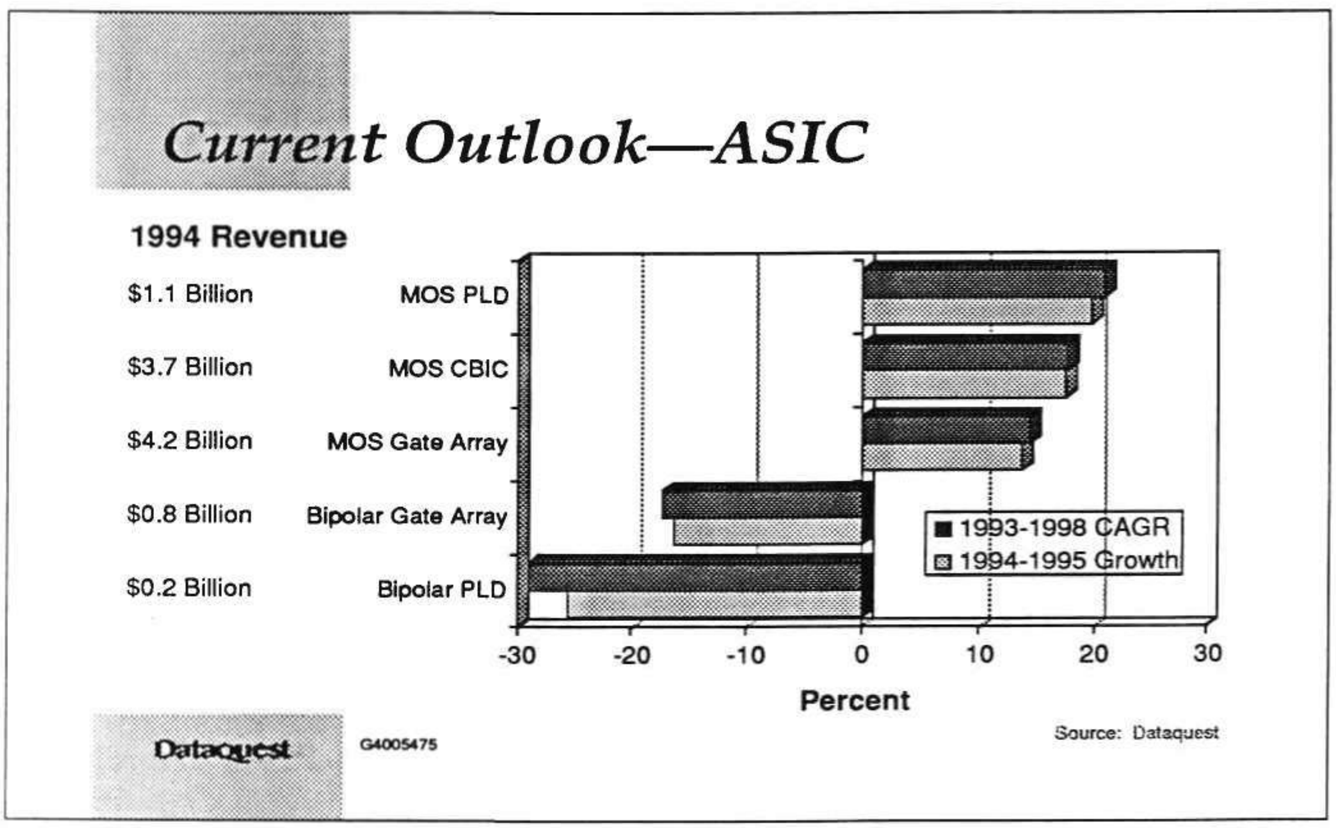


Figure 1



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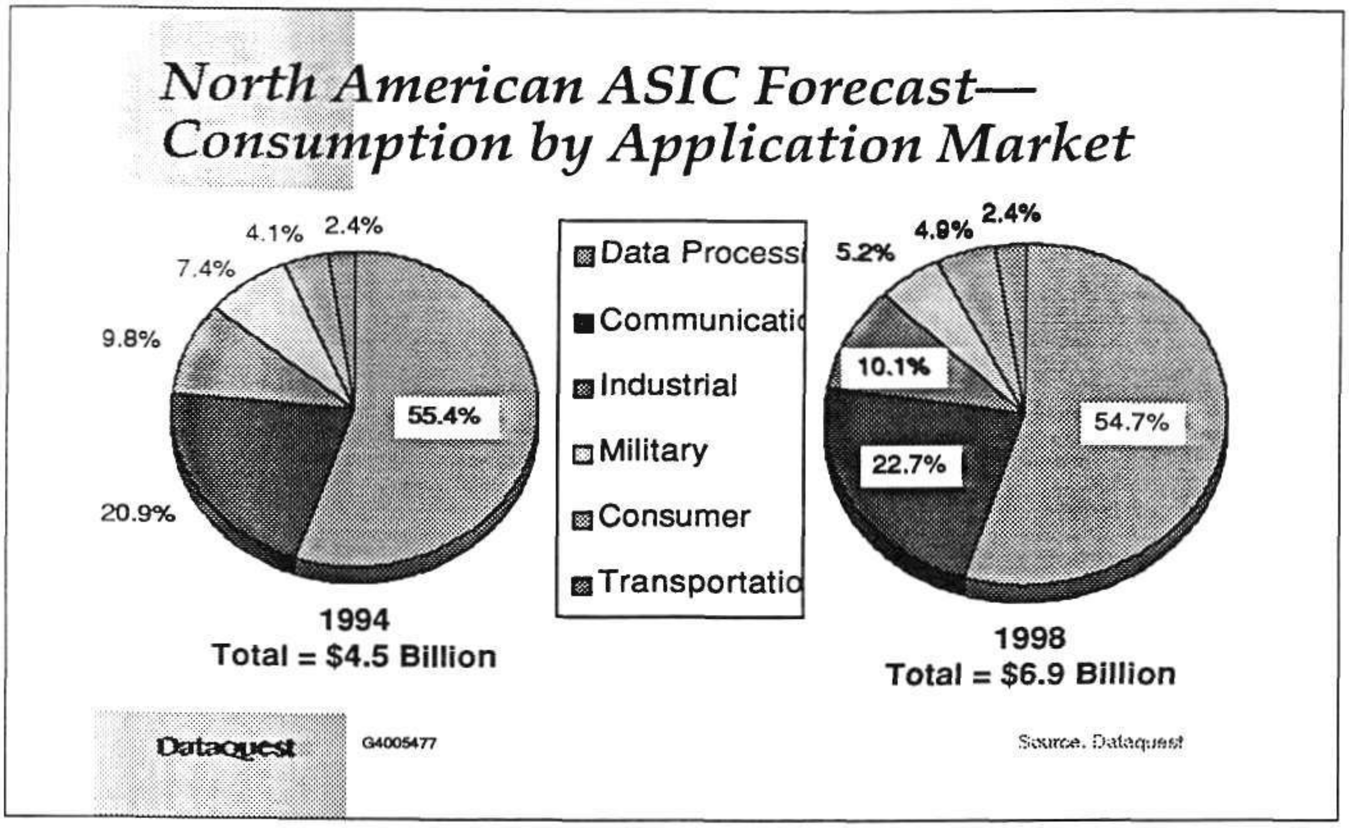

North American ASIC Forecast—
Consumption by Application Market
4.1%
2.4%
7.4%
9.8%
55.4%
20.9%
1994
Total = $4.5 Billion
Data Processi
Communicati
Industrial
Military
Consumer
Transportatio
5.2%
4.9%
2.4%
10.1%
54.7%
22.7%
1998
Total = $6.9 Billion
Dataquest
G4005477
Source: Dataquest

Figure 3

Analog and Mixed-Signal ICs

Gary J. Grandbois
Principal Analyst
Semiconductor Worldwide Service

Agenda: Analog ICs; 1994 Overview; Important Analog Functions; Applications; Growth Rate Comparisons

Analog ICs

With the convergence of the computer, consumer, and communications products, there's a resurgence in analog products.

Two different families:

- Linear ICs(older products):
  - Standard linears, such as amplifiers, comparators, voltage regulators
  - Specialty linears, such as consumer-specific products, automotive-specific, and linear ASIC
  - These products have made up the bulk of the analog product line and have been growing over the 1988 to 1993 period at only 6.3 percent compound growth rate.
- Mixed-Signal ICs:
  - The real growth is in the mixed-signal area, a product line that's grown at a 16.5 percent compound growth rate from 1988 to 1993.
  - The mixed-signal products are made up of data converters, mass storage kinds of products, a lot of computer-specific products, and mixed-signal ASIC.

1994 Overview

- Analog is growing at greater than 25 percent, up from a 21 percent growth rate in 1993. The consumer market has been a major factor.
- Linear ICs will grow 19 percent and Mixed-Signal over 32 percent in 1994 (vs. 24 percent growth in 1993).
- 1989 to 1994 compound growth rate of Analog is 14.7 percent, and our forecast for Analog from 1993 to 1998 is 14.7 percent. That's a little lower than the digital IC growth rate of 16.5 percent over the same period.
- Analog ICs represent about 17 percent of IC revenue and 44 percent of IC units.

Important Analog Functions

Four important functions:

Power in power supplies. Even digital electronics has to be powered. Power supplies are getting more and more complex. Switching regulators are followed by linear regulators, and more exotic kinds of regulation techniques to get higher and higher efficiency for the "green" revolution. Specialty regulators can operate off-line voltages and allow reduced size and weight through the smaller transformers.

Interface. Analog ICs provide interface on transmission links in communications. Anything from copper, fiber, or even the electromagnetic spectrum. Also, interface to power devices, electromechanical motors and solenoids, and electrical chemical devices. CRTs have to be driven by analog kinds of products. Analog components are used for special voltage or current, where impedances need to be matched.

Data conversion. As we go to a more digital world, data converters are increasingly needed to convert signals into digital. The dilemma for the Analog IC product area is that these data converters are increasingly integrated into digital products. So we don't see the amount of growth in the analog data converter area that we think is really happening in terms of data converters.

Signal processing. Consumer entertainment electronics is a big area for analog signal processing. Some of that will be taken over by DSP in the future, but a lot of it won't because the analog functions will remain low-cost, for the low-cost, lower-performance products. High frequency analog ICs will remain fairly important over the long term.

Applications

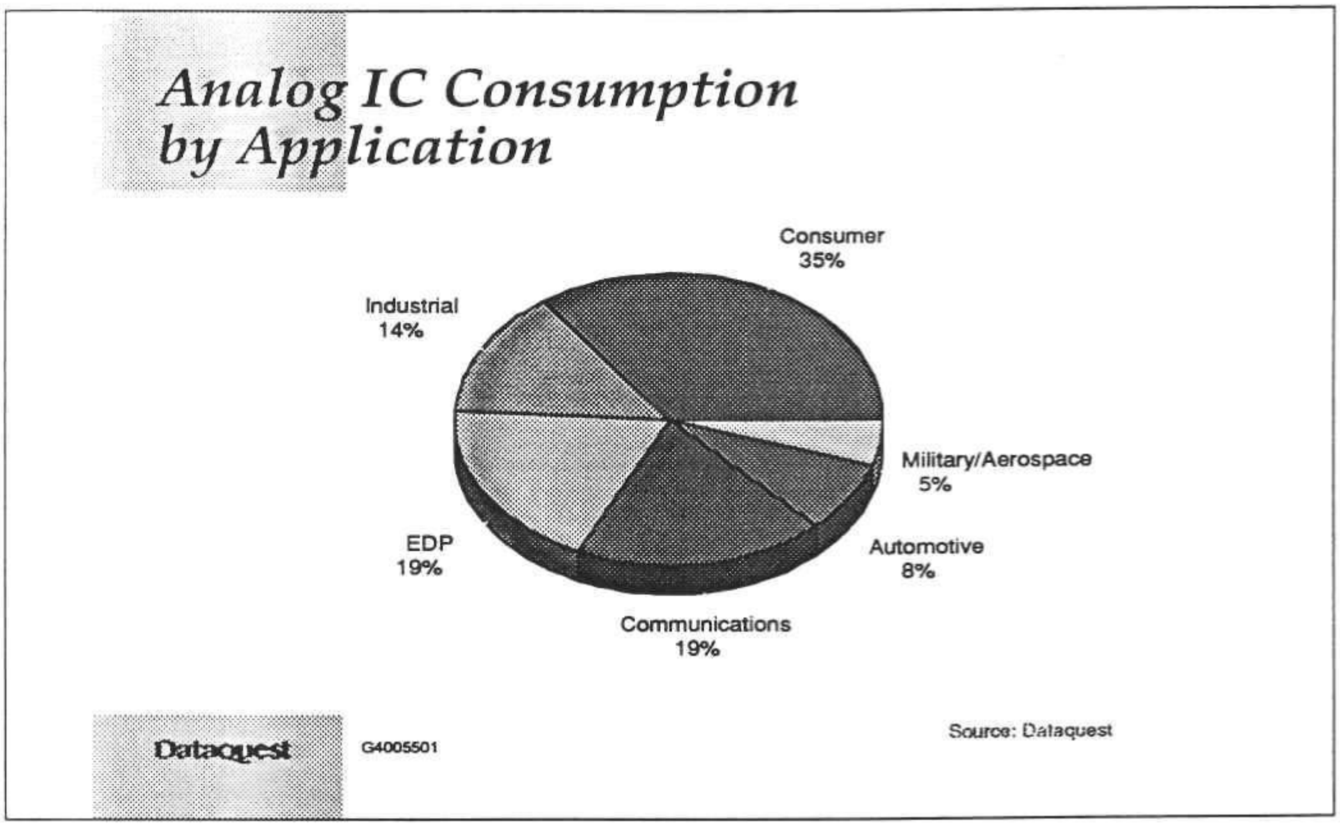
- Consumer market consumes over a third of Analog ICs and the consumer market of the past few years has been very strong, but the consumer market for Analog ICs in 1995 is only going to grow about 10 percent.
- The growing portions are the computer and data processing area, and communications.
- Analog ICs comprise 17 percent of the total IC pie, or 14.4 percent of total semiconductors.

Growth Rate Comparisons

- Mixed-signal has a higher compound annual growth rate and a higher 1995 growth rate over digital ICs.
- Digital ICs will show 15.9 percent growth in 1994 and a compound annual growth rate of 15.8 percent.
- Analog ICs will only show 11.6 percent growth in 1994 because of the slowdown in the consumer market to below 10 percent consumption of Analog ICs.
- Mixed-signal ICs aren't as affected by the consumer slowdown.
- However, the linear ICs see only 7 percent growth in 1995, due to this slowdown.

Summary

- Analog IC categories are expected to track total semiconductors fairly closely over the forecast period.
- Increasingly the Analog IC market is being driven by mixed-signal ICs and by the interface of the digital electronics world — audio, video, multimedia — all the new products.
- Analog ICs provide the smart control, the smart power needed to provide smart appliances and smart products in the future.
- Linear ICs, tied into the linear signal processing part of the consumer market, are showing lower growth over the forecast period.



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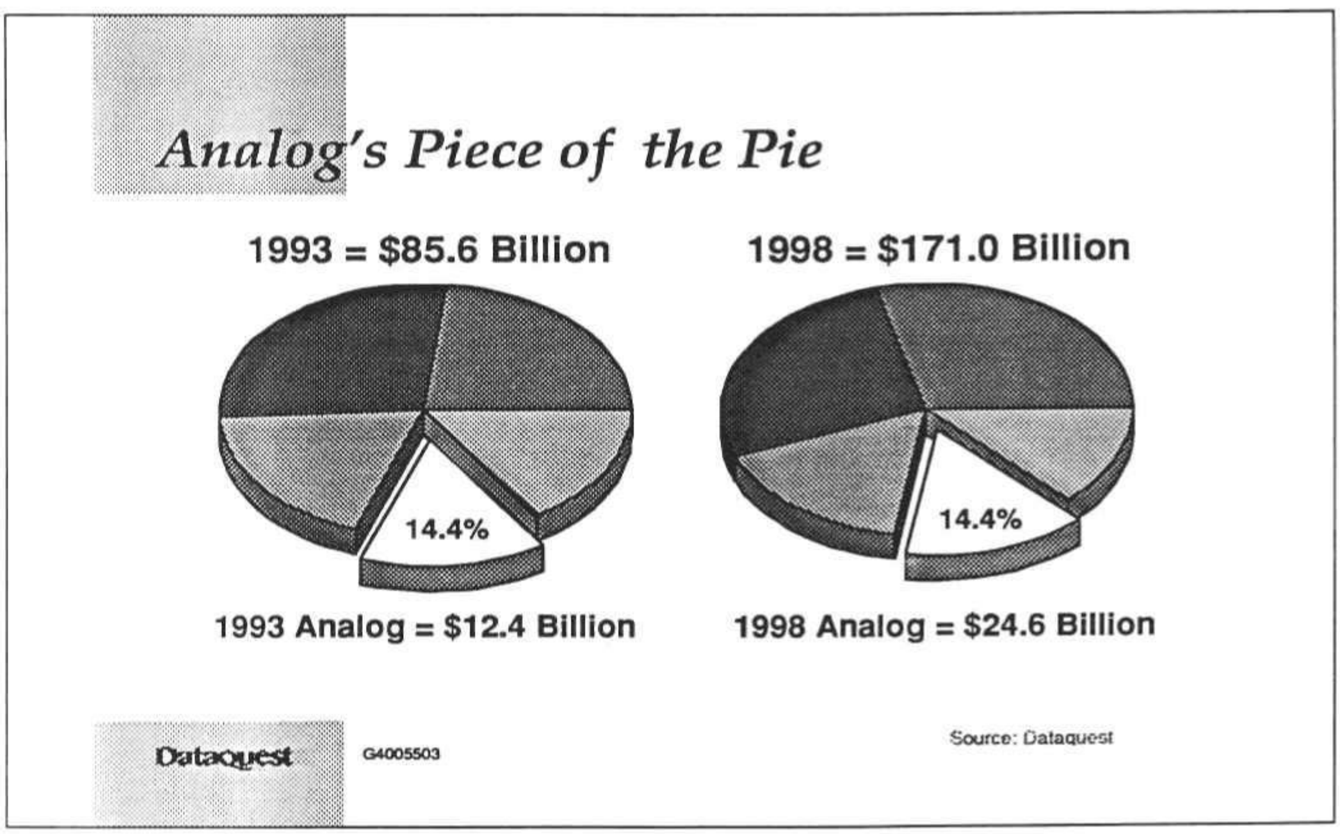


Figure 2

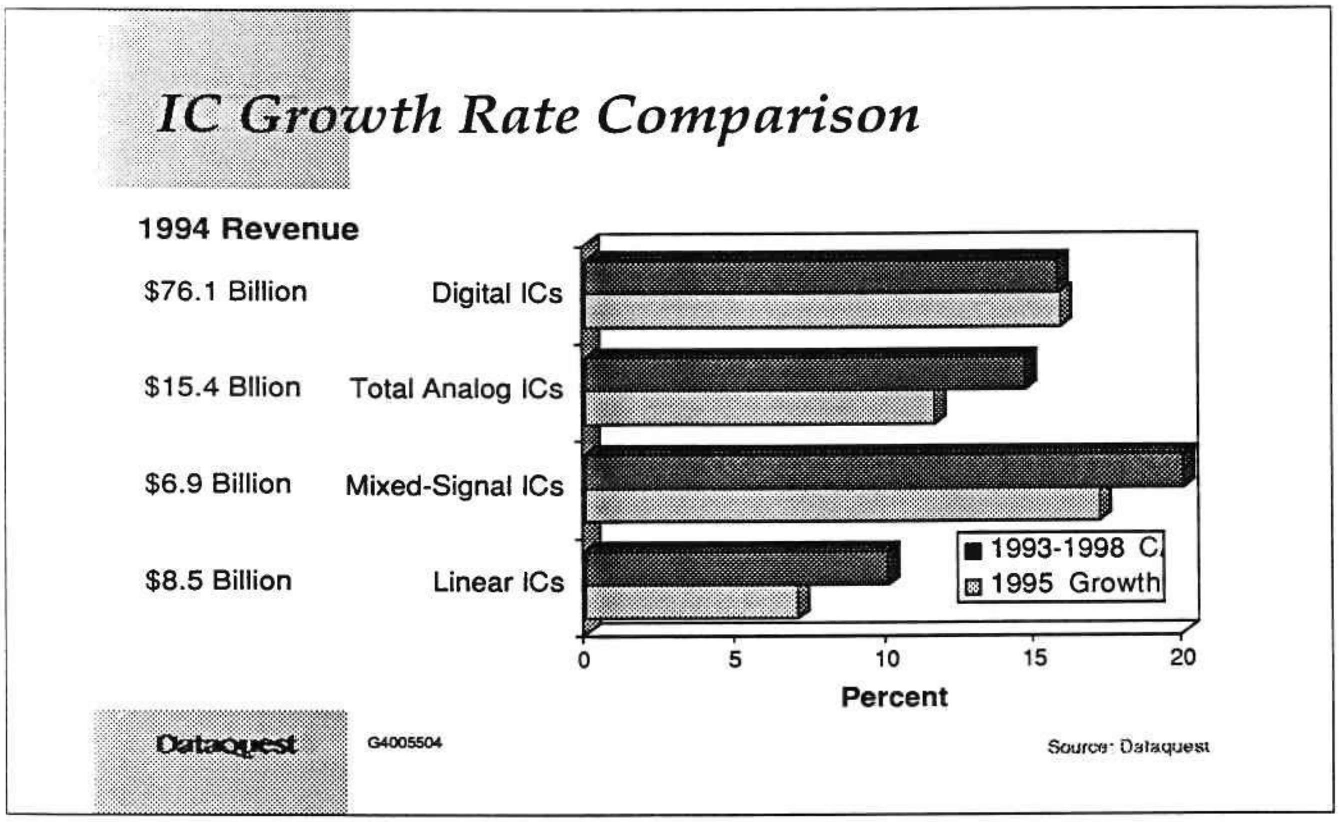

IC Growth Rate Comparison
1994 Revenue
$76.1 Billion
Digital ICs
$15.4 Bllion
Total Analog ICs
$6.9 Billion
Mixed-Signal ICs
$8.5 Billion
Linear ICs
1993-1998 C
1995 Growth
0
5
10
15
20
Percent
Dataquest
G4005504
Source: Dataquest

Figure 3

Pricing Trends

Mark Giudici
Director and Principal Analyst
Semiconductor Procurement Service
Dataquest Incorporated

Agenda: Supply and Demand; Pricing

Supply and Demand

Three distinct markets, in terms of lead times and pricing points:

Undersupply market, or an allocated market, with lead times of 13+ weeks. This would be the 4Mb and 16Mb DRAM, and some selected advanced standard logic products. The advanced market is getting more and more attention and there's a limited supply base of these products. As demand remains strong for these parts, the lower-power, higher-speed, higher-drive applications continue to put pressure on that, and that is why it remains in allocated mode.

Balanced product market, covering about a 12-week time frame. Here, prices decline slowly and predictably. This includes ASICs, primarily, EPROMs, and slow SRAMs. They're generally adequately supplied and should be relatively available for the next 12 months or so.

Oversupply market, with lead times of 8 to 10 weeks, sometimes off-the-shelf, very competitive pricing. Products include Flash memory products and many of the mature bipolar logic products. We see sporadic price cuts here, with lead times that are also sporadic as overproduction has exceeded demand in many cases.

Pricing

DRAM market. There are three distinct crossover points for the 16Mb part:

- The first one is occurring right now and this is for the 4Mbx4 16Mb DRAM. We see this product going now between $49 to $52 in the North American marketplace, and these parts primarily go into the workstation.
- The next crossover is a 2Mbx8 16Mb part. This will occur in the Q1/95 to Q2/95 time frame and as capacity for this device makes it through to the market. This flavor of 16Mb part goes into high-end PCs and also workstations.

- However the chip of choice in the PC market is the 1Mbx16 part, primarily because it allows for 4MB SIMM configurations. This part will not reach price-per-bit parity with the 1Mbx4 until the Q3/Q4 time frame of next year. Users are anxiously awaiting a 2 chip 4MB SIMM module.

Another critical system component is the microprocessor price curve. Our data shows that the nontraditional price erosion of the P5-60 Pentium part has quickly squeezed into the 486DX2 market, and into the PowerPC price range. This leaves the P54C-100 Pentium part to follow a more gradual price curve at the current point in time.

This scenario may change in the 1995 time frame if more competitively priced 486 products come to market and keep the overall system cost lower than anticipated; this in turn will keep the shift over to the Pentium platform from occurring as fast as Intel has planned.

This may cause a nontraditional price cut in the Pentium market in the 1995 time frame. Unlike in the past, we're seeing that competition is having a subtle influence in the microprocessor market, and price elasticity from both the semiconductor and the system markets will probably see more of this as production ramps up for both the RISC and the CISC supply base of these parts.

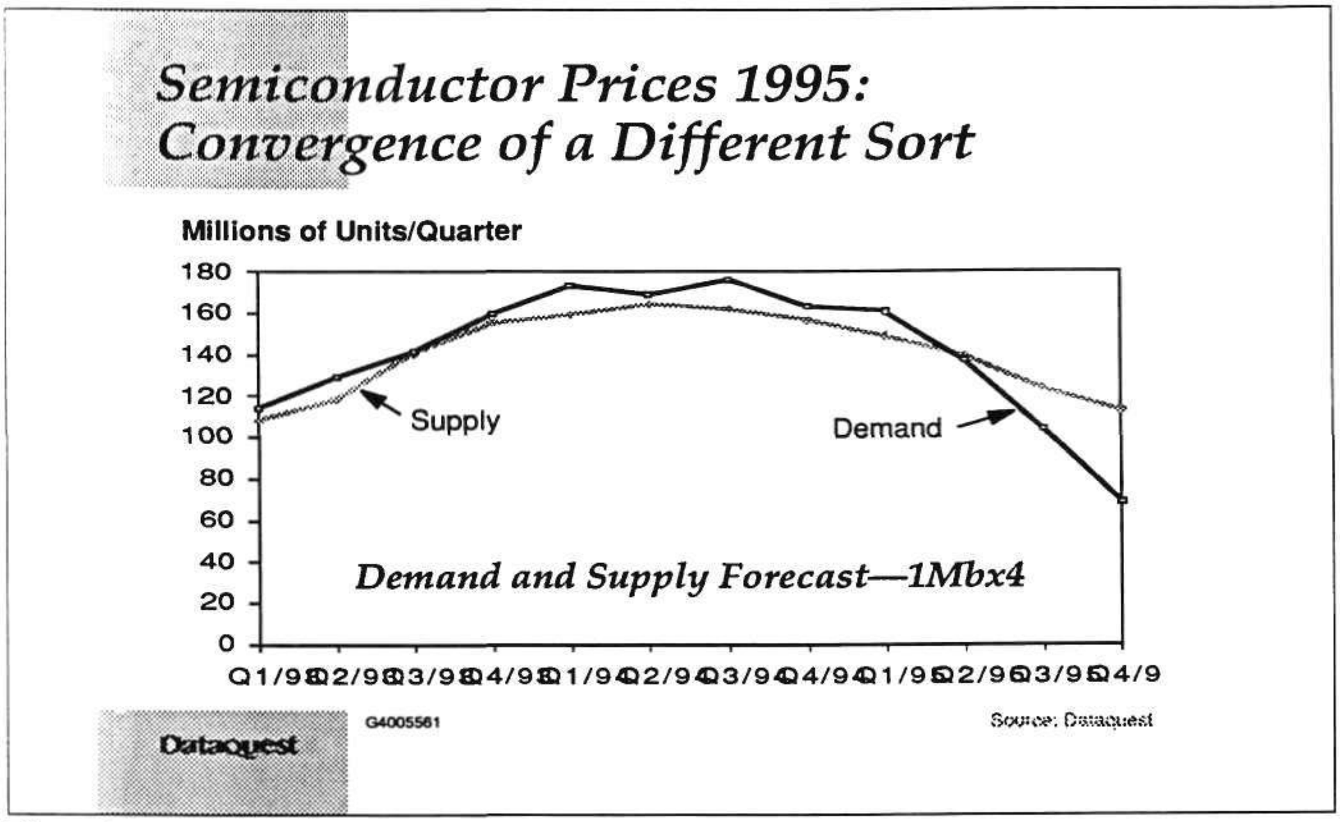
Summary

- Pentium price cuts will impact the entire PC food chain, including competing 486 and PowerPC products

- The lack of volume of 1Mbx16 DRAM parts will lengthen the price convergence of this part and may impede some PC market growth due to SIMM demand trends.

- We will continue to have a two-tier standard logic market where advanced logic will remain in high demand due to low power and high drive requirements.

- The 1994 capital spending will hit the market in 1995, leading to an overall downward price pressure



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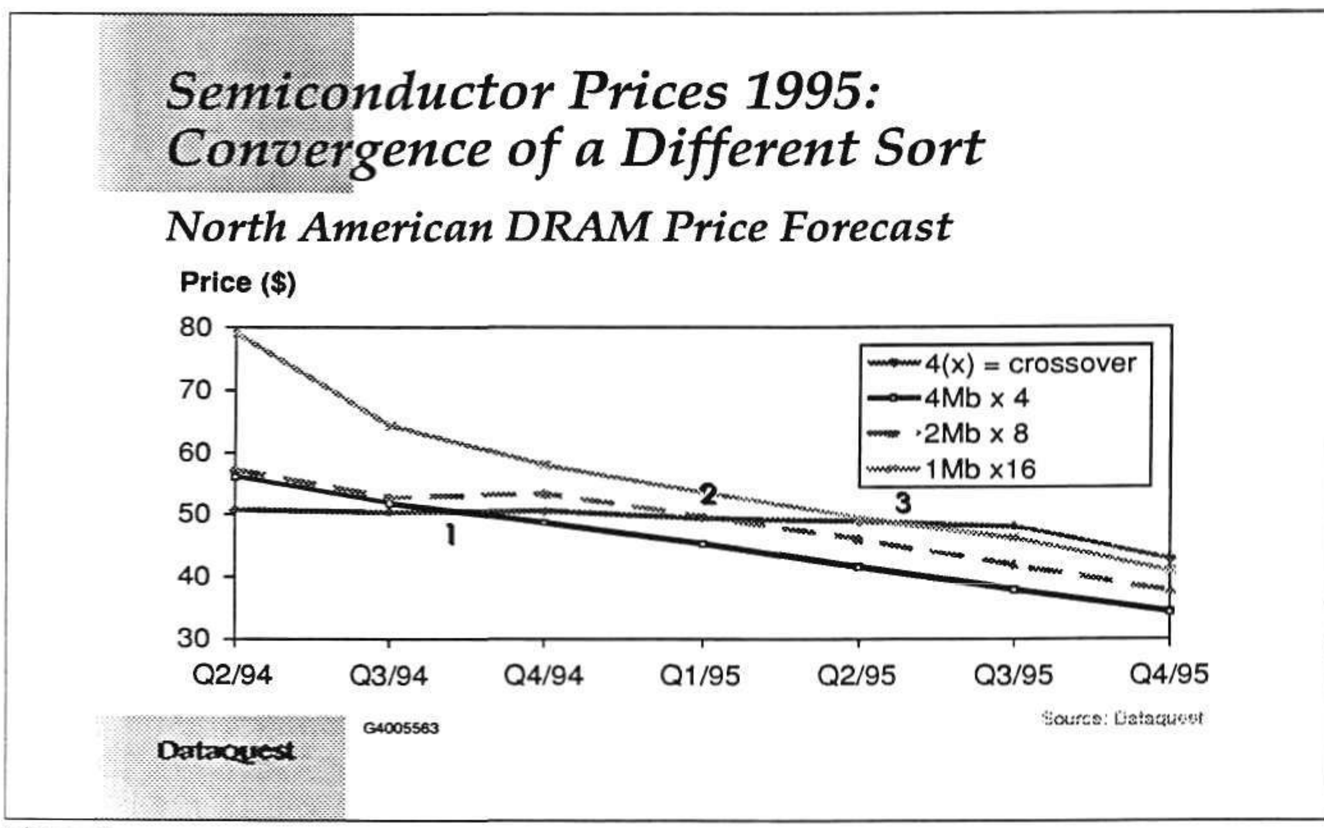

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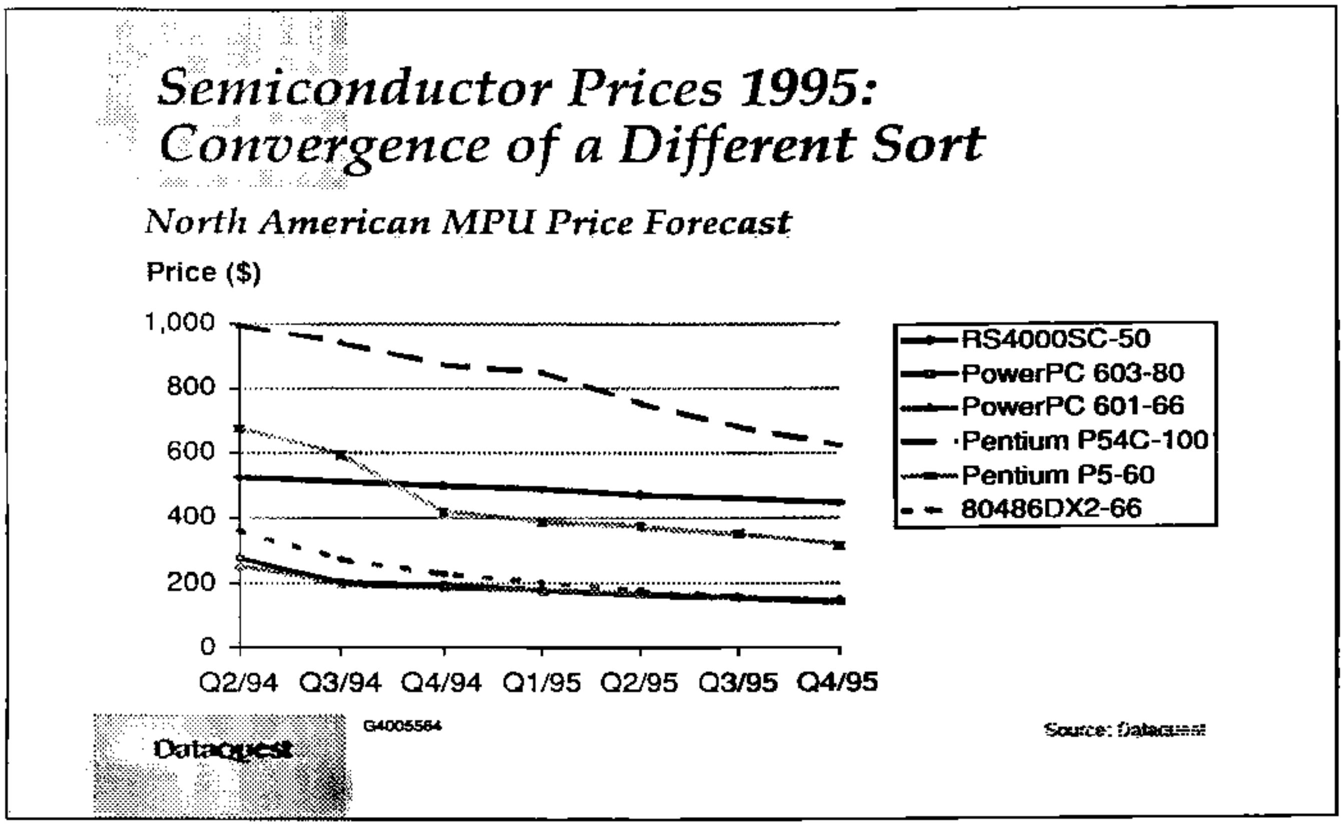

Semiconductor Prices 1995:
Convergence of a Different Sort
North American MPU Price Forecast
Price ($)
1,000
800
600
400
200
0
Q2/94 Q3/94 Q4/94 Q1/95 Q2/95 Q3/95 Q4/95
RS4000SC-50
PowerPC 603-80
PowerPC 601-66
Pentium P54C-100
Pentium P5-60
80486DX2-66
G4005564
Source: Dataquest
Dataquest

Figure 3

Wafer Fab Equipment Forecast and Trends in Capital Spending

Clark J. Fuhs
Senior Industry Analyst
Semiconductor Equipment Manufacturing and Materials Service
Semiconductor Group
Dataquest Incorporated

Agenda: 1994 Capital Spending Summary; Fastest Growing Equipment Segments

1994 Capital Spending Summary

- The capital equipment front-end equipment market is forecast to grow about 37 percent in 1994. This may even be revised upwards.
- Japanese companies are investing heavily in their semiconductor operations despite their weak economy.
- North American investment has been sustained and even the smaller semiconductor companies are participating in capital spending.
- DRAMs are driving this spending boom.
- Korean spending is up 75 percent, and foundry capacity in Taiwan and Singapore has tripled in 1994 to $1.2 billion.

Fastest Growing Equipment Segments

Wafer fab equipment has a compound annual growth rate of about 13 percent. We see growth of 40 percent in 1994 and 13 percent for 1995.

In-line wafer inspection systems and chemical mechanical polishing are increasing faster than the overall market.

Steppers and high-current implant depend heavily on DRAM investment, as their high growth in the 50 to 60 percent range this year shows.

High-voltage implant is the fastest growing segment and is DRAM-sensitive.

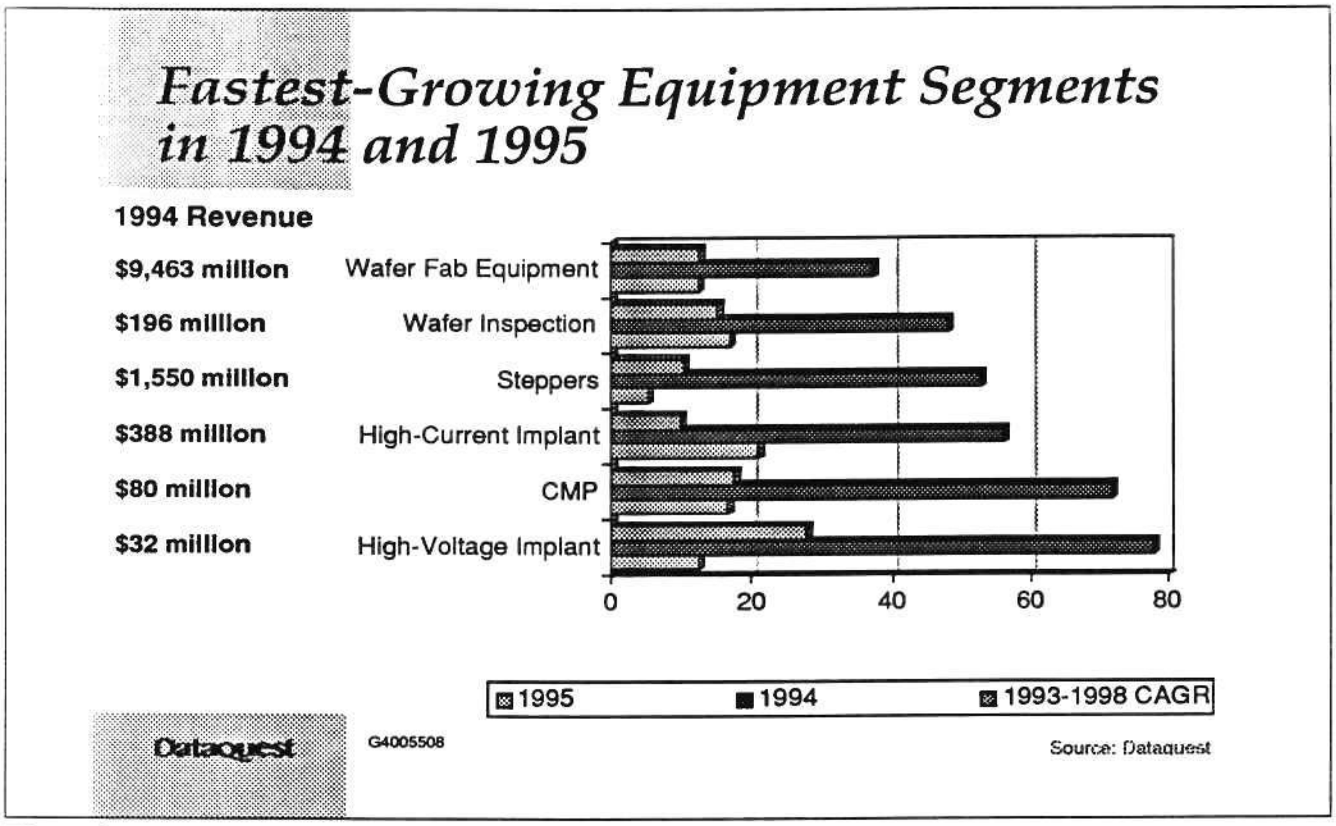
This considerable DRAM capacity coming on-line at the 16Mb level will cause a fall-off in demand for the 4Mb. The resultant declines in price-per-bit will cause memory profits to be squeezed. We are forecasting a 5 percent decline in the wafer fab equipment market in 1996.

Money is flowing so freely into capacity now that we expect excess capacity to occur perhaps as early as the first half of 1995.

How can this be reconciled to the existing memory shortages? An unanticipated manufacturing bottleneck exists for 16Mb DRAMs. The bottleneck is created because different testing equipment is needed to test a 16-bit wide chip. One indicator of this is the prober market, which is expected to grow at 40 to 35 percent this year.

Conclusions

- Strong equipment market is driven by DRAMs.
- Capital investment has caught up with demand.
- A manufacturing bottleneck has extended the DRAM shortage.
- Investments should stabilize in 1996 and 1997 and healthy growth resume in 1998.
- The equipment segments that supply multilevel logic should fare best in this market slow down as it is primarily a DRAM investment slowdown.



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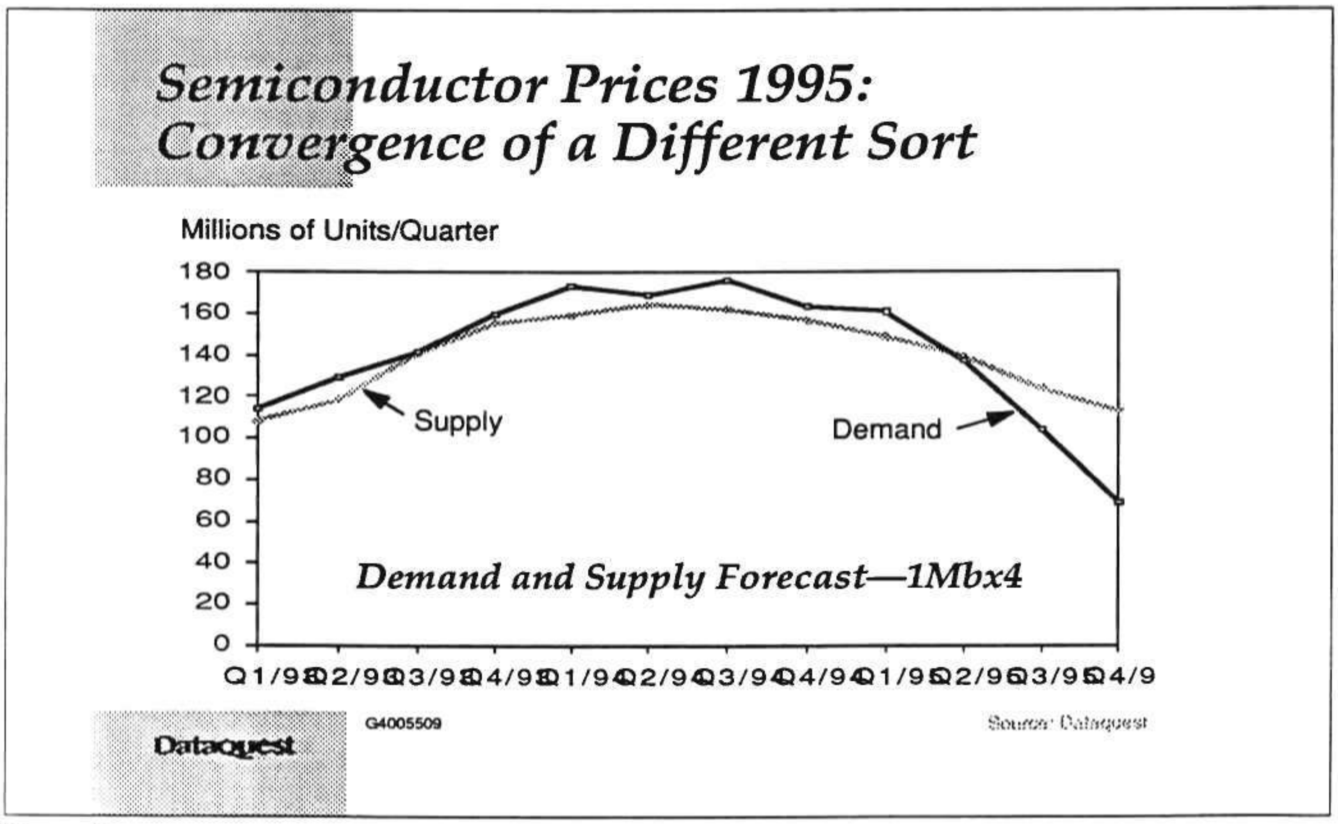


Figure 2

Asia/Pacific Markets and Forecasts

Daniel Heyler
Senior Industry Analyst and Manager
Semiconductors Asia/Pacific
Dataquest Incorporated

Agenda: 1994 Asia/Pacific Market Summary; Applications Trends; Semiconductor Forecast by Product and Country; Forecast Assumptions

1994 Asia/Pacific Market Summary

At approximately $5 billion, Taiwan is the largest Asia/Pacific semiconductor market. It grew at about 25 percent, and should sustain 15 percent share of the Asia/Pacific market for the next five years. Its growth is being driven by the PC industry. High-end electronic equipment and high-end PC production continues to move up the learning curve in Taiwan.

The Asia/Pacific semiconductor market is forecast to grow by 31 percent in 1994.

Countries such as Korea, Taiwan, and now Singapore, are investing heavily in capital equipment, and there is a 58 percent capital spending increase, due largely to Korean and Taiwanese manufacturing. Actual production is still insignificant compared to what's consumed. *But* this means there are opportunities for large U.S. and Japanese manufacturers to locate fabs within the Asia/Pacific region to take advantage of its very high growth.

China is currently the fourth largest market in Asia/Pacific. It's about a $1.5 billion market in 1994 with growth rates outpacing other countries in Asia. Southern China is booming. Infrastructure continues to expand. Actual investments in 1993 were about $60 billion. Contracted foreign investment is estimated at around $100 billion by the end of 1994.

There is ongoing economic integration between Hong Kong, Taiwan, and China, with an estimated 30 percent of Taiwan's computer industry already assembling at the final assembly stage in China (devices are being purchased and ordered from Taiwan). Those devices could eventually be purchased directly from within China itself.

Much of Asia/Pacific's phenomenal growth has been due to exports to Europe and the U.S., with capital generation through those exports. This is the beginning of a huge potential in Asia/Pacific, due to the possibility of large end markets for much of this new equipment that's going to be built.

Applications Trends

Applications drivers are primarily data processing, consumer, and communications.

Data processing. Consumer has been the largest application until now, but data processing should surpass consumer in spite of the large Japanese investment in consumer products in 1994 (on a revenue basis).

Consumer. The Japanese are positioning their entire consumer electronics industry to be production-based and design-based in Asia, not only for export but also for consumption within Asia. It also allows Japan to position themselves for a huge potential consumer electronics market within Asia/Pacific. Consumer electronics overall in Japan is moving toward high-end multimedia, while Asia/Pacific is maintaining its mid-level to low-end applications.

Communications. Communications is the third largest and it's the fastest growing segment. There is huge consumption of electronic communication systems being shipped to China and Southeast Asia. However, a new trend is that end equipment is being more and more produced within the Asia/Pacific region. In addition to China, other new countries have emerged, including India and Southeast Asian nations, which are striking alliances with large global telecommunications companies.

Semiconductor Forecast by Product and Country

Product:

- We forecast the semiconductor market to grow by 31 percent in 1994 and remain the fastest growing market in the world in 1995, growing about 20 percent.
- MOS Memories is growing faster than the worldwide market is growing. Asia/Pacific production should keep pace with worldwide PC consumption and Asia/Pacific production of PCs being shipped to the Asia/Pacific market should outpace shipments by the multinationals, which translates into increased consumption and increased market share for the MOS Memory segment.
- MOS Microcomponents is the second largest segment in Asia/Pacific, but it is surpassing memories. In 1993 and 1994, the actual purchase of microprocessors within Asia/Pacific began to shift to the market of distribution.
- PC manufacturers are focusing their production facilities in Asia/Pacific for the rapidly emerging Asian PC market.
- MOS Logic is the fastest growing segment. It's a $2.8 billion market, its growth being spurred by the increase in notebook computers. ASICs are growing quickly due to telecom applications.

- Analog and discretes are increasing due to the large growth in consumer electronics within Southeast Asia.

Country

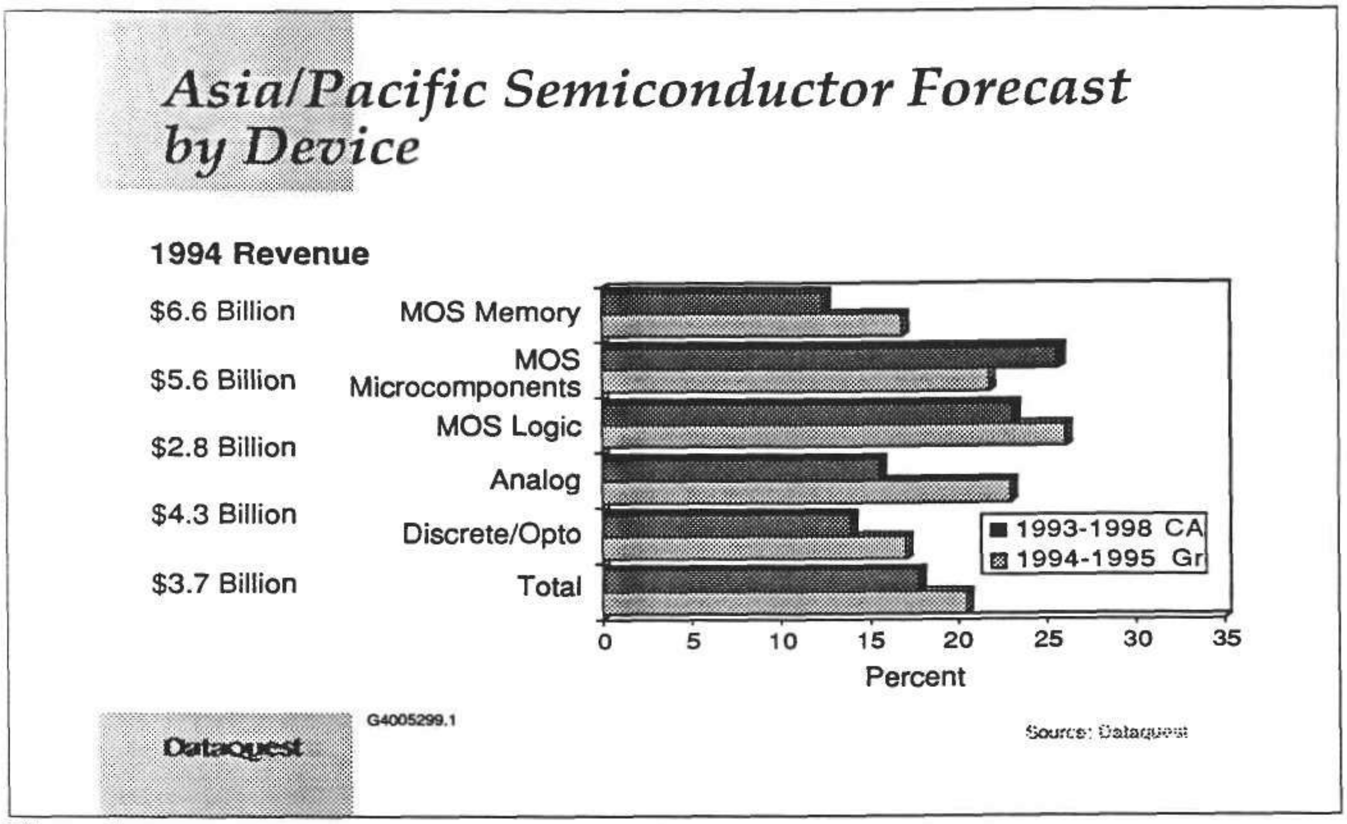
- Taiwan's market is being driven by huge growth in its data processing capabilities.
- The Taiwan market should be number one until 1998, and Korea will be number three, being surpassed by China.
- Acceleration in China's growth rate is phenomenal. Foreign investment continues to flow into China to produce locally, first of all for export, but also for local consumption.
- Korea is moving fast into the high-end of consumer electronics and is sustaining about a 17 percent CAGR.
- The other NIE countries are shifting investment into China and Southeast Asia to sustain their presence within Asia, and to sustain the phenomenal growth in their end markets.

Assumptions

- Continued importance of data processing worldwide. Asia/Pacific benefits tremendously from its emphasis on peripherals, motherboards, and disk drives.
- China's economy is continuing to grow in foreign investments, which also flow into Southeast Asia.
- Asia/Pacific's distribution of consumption is similar to the worldwide markets, i.e., data processing, communications, and consumer, which represent about the same share as theydo worldwide.
- Japanese and North American companies are targeting Asia/Pacific, not only for production, but for procurement as well.
- Electronic equipment production is continuing to accelerate due to investments and due to the emergence of new economies in Vietnam and other parts of Southeast Asia. India is a market to look at in 1996.
- High-growth end markets are driving future investments by foreign manufacturers, as well as the need to develop design capabilities and manufacturing within the region.
- Asia/Pacific will surpass Japan to become the second largest market in the world, probably by 1997.

- China's leading the growth.

- Asia/Pacific's semiconductor consumption will exceed its ability to produce devices for this tremendous growth, and that's creating opportunities for semiconductor manufacturers.



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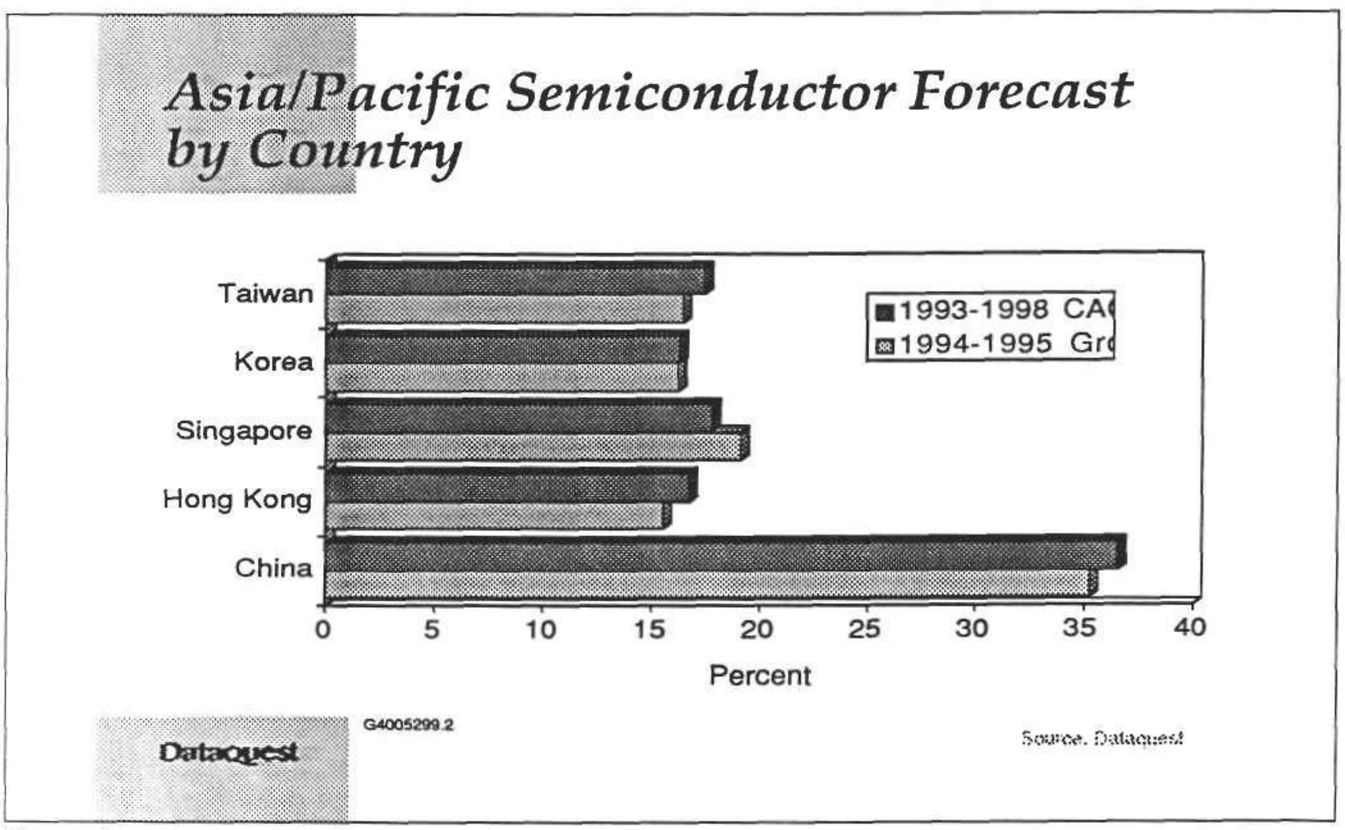


Figure 2

Solutions for the 10+ Million Transistor Chip

Walden C. Rhines
President and CEO
Mentor Graphics Corporation

Agenda: Next-Generation Chips—The Challenge; Design Productivity; Design Tools; How to Pay for Tools

Next-Generation Chips—The Challenge

What will it take to get to the next generation of chips—10 million random logic transistors? The real challenge is on the design side. What can you design? What productivity does it take? What will happen because of the change in technology? Where is the money going to come from for the tools?

Design Productivity

There should be an increase in productivity by a factor of 10 over the next five years. This will be due to:

- Predictability of semiconductor technology
- Decrease in product development time
- Design team size stability
- Reuse of what has been designed and from generators that make reuse possible through parameterized cells

Reuse

The problem is that libraries need to be developed if you want to reuse cells. And, in fact, the library process is now being formalized into the front end of the design cycle.

Today, in an ASIC library, there are ROM and RAM compilers. One generates a memory of whatever depth and width is appropriate and then uses random gates for most of the rest of the design or the cell library that is provided.

If you take major blocks of simulated logic and then do a total chip simulation as part of the standard design process, the design becomes much more predictable. You have moved into a higher level of abstraction, which is very important as you go above 10 million transistors.

Fighting hierarchy

But IC technology makes it difficult because as you move to deep submicron, the technology fights the hierarchy. Therefore, the industry has to get a new database technology that allows dealing with a transistor one at a time and also moving up the hierarchy.

The new database technology must be able to preserve the hierarchical structure, selectively flatten the data, and allow the design team to think about a million things in infinite detail.

Tools

Most of the exciting new products today in the electronic design automation industry are at higher levels of abstraction. Tools are being introduced in specific areas of design.

Interconnect dominates design tradeoffs

At the transistor level, particularly in the quarter-micron range, the interconnect has more effect on the design than the components themselves. There are issues of capacitive coupling, metal conductivity, noise, power density.

One of the net results is that designs do not fully utilize the fabs' capabilities. Designs today leave about 20 percent of the process capability on the table.

Tools

The impact of improving tools on the industry is enormous in terms of benefit because of the large cost of the capacity and the need to get more performance out of it.

Challenges for the semiconductor industry are opportunities for the EDA industry. Some tool requirements are:

- More sophisticated tools for timing driven layout
- Analysis to design for minimum power consumption
- Analysis of parasitic wiring effects
- Design, process, and concurrent work flow management
- Algorithmic verification that structure is equivalent to functional specification

How to Pay for Tools?

There is a need for many new tools, which are costly to develop. The total EDA industry spends about $300 million on R&D, about 20 percent of revenue. This compares to the $100 billion semiconductor industry that spends approximately $8 billion annually on R&D.

The computer industry has been cutting back on R&D, with the increase in low-cost PC manufacturing. There is not a base of technology being built up.

Therefore, the $300 million will not be enough to fund what is needed.

This is being solved through joint development. Partnerships are being set up between EDA and major semiconductor manufacturers in specific tool areas to co-develop these tools and take them to the broader market.

Summary

Product definition and design capability distinguish the high-margin producers.

Design re-use, automated cell creation, and design tools for higher levels of abstraction will solve the productivity challenges.

Interconnect will dominate design tradeoffs in the 1990s.

Co-development of next generation design software between electronic design automation companies and their users will be required.

10X Design Productivity in Five Years

- Assumes custom/ASIC design
- Product development total cycle time declining
- Design team size stable
- Requires re-use, generators, etc.
- Predictability of semiconductor evolution

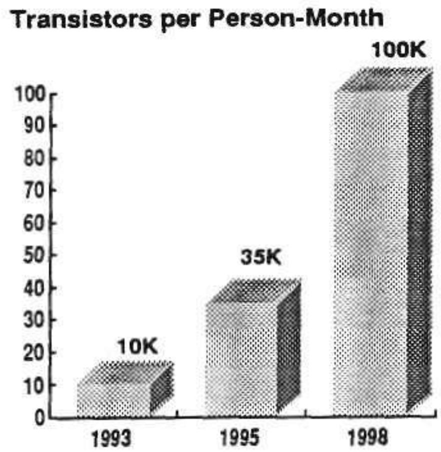


Figure 1

Libraries Facilitate Design Re-Use

- Simple to create generators
- Automated creation and characterization of models
- Process portability
- Ease of customization
- Library management

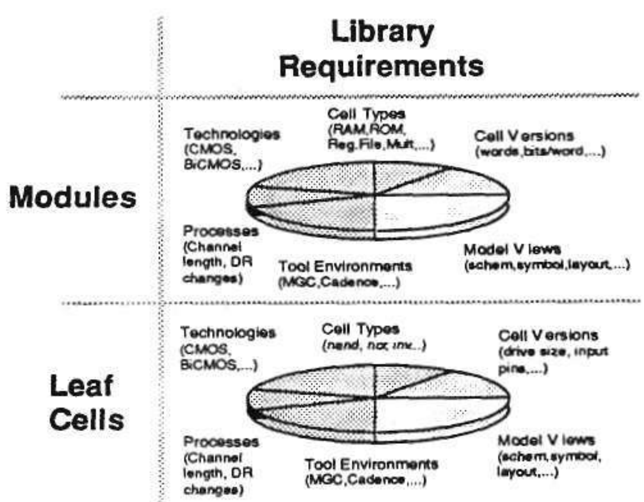
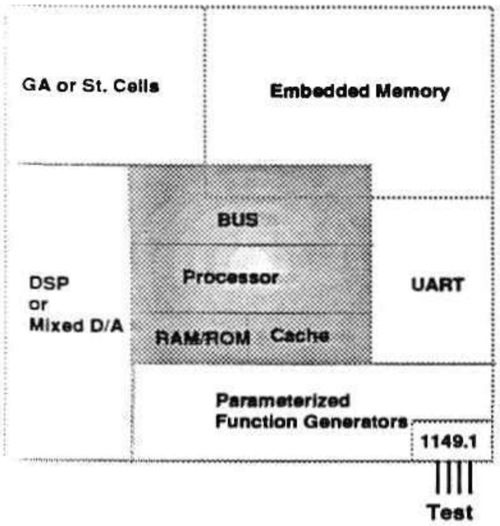


Figure 2

System-On-Silicon Methodology



- Libraries of intellectual property
- Pre-characterized blocks
- Move toward cell-based design
- Reuse design intent
- Multiple simulation models
- Full-chip design for test
- Differentiate in gate array or FPGA block
- Links to physical design
- Targeted at industry segments

Figure 3

Deep Submicron Designs Won't Fully Utilize Manufacturing Capability

- Algorithms for layout optimization are iterative
- Lack of characterized libraries of building blocks
- Design complexity increasing faster than manufacturing capability
- Inability to model submicron effects

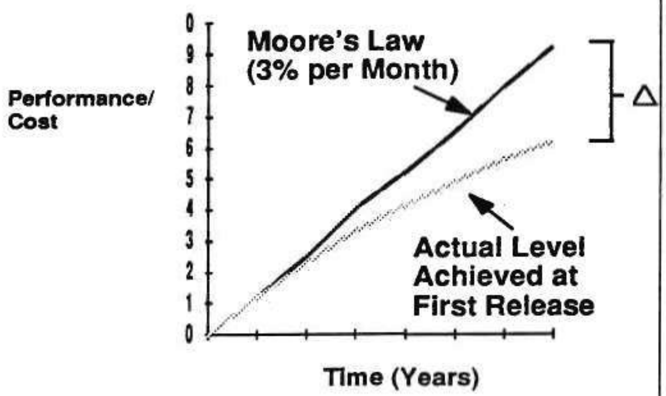


Figure 4

PC 2000: Chaos or Control

Jerry Banks
Director/Principal Analyst
Microcomponents Service
Dataquest Incorporated

Attributes of a PC in 1994:

- Processors are faster
- Mass storage is cheaper
- DRAMs are more expensive
- Local bus is mainstream
- The desktop is still x86-based
- $2,000 buys a nice machine

What do we see for the year 2000? Simply put, microprocessors will be faster, storage will be cheaper, and $2,000 will still buy a nice machine.

Each panelist will address the following issues: What is a PC?; What is driving chaos in the market-place?; What are the sources of control?; What are the trends for the 1990s?; What will the PC look like in the year 2000?

PC 2000: Chaos or Control

Carl Stork
Director
Windows Platform Definition
Microsoft Corporation

Chaos and Control

I would basically characterize the PC industry as controlled chaos. There are an enormous number of participants in the industry—software developers, system makers, add-in device makers and semiconductor manufacturers—which could be said to represent the chaotic element. The opportunity of succeeding in the high-volume PC market drives huge amounts of effort and investment by these companies in their quest for innovation. Competition makes all the participants work harder and do a better job.

The control element is provided by standard interfaces for software and hardware that ensure compatibility, which is the fundamental thing that keeps everything working together.

Definition of a PC

Today: laptops, desktop, and servers.

The only things that are needed are memory, a microprocessor, and the opportunity for people to independently develop software for it.

Things that may not necessarily be required in PCs: the system may be closed to add-ons by independent hardware suppliers (e.g., handhelds), keyboards, and hard disks. The ability to communicate, however, will be present in virtually all PCs.

Future Trends

PCs have become compelling. They are used for entertainment, reference, education, productivity, and communications. And the price is attractive.

Challenges. But there are a lot of challenges still before PCs really take off in the home, such as:

- PCs need to be friendlier, easier to set up and to use. A lot of the burden of this falls on Microsoft and Windows 95.
- PCs need to be cheaper. If we can get the price down low enough, the market for PCs could really explode.
- It needs to be a great deal easier for people to connect their home PCs to share peripherals and access the information highway.
- PCs will evolve to different form factors for specific kinds of functions.

Software will remain central. The operating system will provide an important infrastructure that people can count on, including access to communications and support of multimedia applications. The operating system will virtualize more and more hardware, thereby allowing for innovation and competing implementations for specific hardware features.

At the same time the operating system will continue to provide a standard interface for third party applications and there will be a thriving software industry for a long time to come.

There will also continue to be a thriving semiconductor industry for all kinds of components, such as audio, video, I/O, etc.

Predictions. It is impossible to predict what will happen in the battle between x86 and RISC processors.

- The x86 camp has the ability to block the RISC competition from achieving critical mass, if x86 manufacturers can continue to improve performance and keep the prices down.
- They also have the advantage • a single binary standard that software developers can count on.
- Lastly, there are many more opportunities for cool semiconductor products besides the CPU.

PC 2000: Chaos or Control

Jan Janick
Program Director
PowerPC Development
IBM Corporation

A lot of things will be said here today and the only thing I can guarantee you is that we're all going to be right and we're all going to be wrong.

Driver of Change

Technology drives the PC marketplace. Some of the technologies that will influence what PCs become between now and the year 2000 include: fiber, cable TV networks, set-tops, cellular networks and communications capability, Internet, HDTV, and microprocessors.

Emerging Consumer Marketplace

In the consumer market there is incredible pressure to increase performance, lower prices and cost, and improve capabilities. One of the things that the emerging marketplaces have in common is that there really isn't a dominant set of hardware or software players, which to a large degree adds a lot of chaos and confusion and unpredictability.

Trends for the 1990s:

- A trend toward RISC because it continues to show performance advantages over CISC
- Human-centric computing, which includes everything from improved ease of use to better operating systems, voice recognition, handwriting recognition, and multimedia
- Software is trending toward object technologies
- Communications will continue to move toward digital communications as well as touch communications, cellular, and Internet

The Year 2000

- Multiprocessing will be the norm
- Intuitive computing (for example, software that learns)
- Processor-independent/object technology
- Ability to access anything from anywhere

Some of the obvious predictions about PCs include:

- Faster processors
- More memory
- Wireless communications
- Multiprocessors
- Better video
- Speech recognition
- Higher performance

These system features will increase the design challenges. PC vendors face demands for increased system performance in addition to continued downward pressure on their margins. One of the roughest design challenges will be power or heat management, especially as it relates to the portable and handheld markets.

Key challenge to PC 2000

- Continued pressure for consumer prices at more complex design points
- Lower power
- Managing power and packaging
- Increasing performance
- Communications protocols
- Moving and processing data

PowerPC Agreement

We believe that the IBM/Apple/Motorola alliance addresses some of these challenges by:

- recognizing the need to partner in today's markets
- aligning with the right partners in terms of markets and skills
- defining an architecture
- generating a broad range of microprocessors with a scalable architecture
- enabling competition among the alliance members
- providing manufacturing capability
- making possible the management and funding of state-of-the-art technology requirements

The PowerPC architecture spans a broad range and can address the PC market, which is being pressured from above by higher performance workstations and from below by higher performance at lower costs.

What is Driving Chaos in the Market?

- There are a number of emerging marketplaces with unpredictable outcomes.
- One size PC does not fit all.
- By the year 2000, it will be difficult to even describe a PC.
- Can the software keep up with the hardware?
- Everything will have to be able to work with everything else.

Summary

I believe that things will look chaotic over the next few years and that by the year 2000, looking back, those who appeared to have been in control will be those companies that were flexible risk-takers and who focused on a marketplace solution and not a one-size-fits-all approach.

PC 2000: Chaos or Control

Craig Kinnie
Vice President
Director Intel Architecture Labs
Intel Corporation

PC Market Drivers

Low-cost MIPs. The open computer industry will continue to deliver low-cost MIPs to fuel next-generation applications. Volume CPU performance at any price point doubles each 18 months and the rate is accelerating.

High bandwidth and low-cost communications. The merging of computers and communications is the catalyst for next-generation applications. As the telecommunications industry emerges from a massive transformation, we can count on high bandwidth, or low-cost bauds, to go along with our low-cost MIPs.

Digital media. Lastly, the big thing that spurred digital media was the advent of the CD-ROM, which provides both capacity and bandwidth, causing the explosion of CD-ROM on the home scene.

The same thing will happen in the office, just in a different way. High bandwidth will be provided through LANs while capacity will come from media servers.

Challenges

Challenges in the area of media, such as cost and ease-of-use, have to be overcome.

The advent of the local bus, or more specifically, the PCI local bus, has had a significant impact on the cost, performance, and ease-of-use of the PC. Two additional open interconnect standards that will appear in the next few years and will advance ease-of-use and ease of connectability are CardBus and Serial Bus. Combined with Windows 95, these factors will promote true plug-and-play capabilities.

In the area of cost, Serial Bus will address the cost of media and communications connections, especially when combined with Native Signal Processing (NSP). NSP will provide an environment to run all communications and media processing on the main processor under Windows, thereby eliminating the need to add expensive, complex, and hard-to-use add-in cards to get these functions on a PC. With the additions of Serial Bus and NSP, media and comm will essentially become native to the Pentium PC.

Summary

From Intel's viewpoint, it is not a question of chaos or control, but rather opportunities for growth.

PC 2000: Chaos or Control

George Alexy
Vice President
Marketing
Cirrus Logic

At Cirrus, we tend to view the path toward the PC of the year 2000 as an evolutionary process of combined elements of control and chaos. Today's PC has certain elements of natural evolution and expected development, which represents the controlled aspect.

However, our industry needs to be on the lookout for new ideas and new market opportunities, which tend to introduce the element of chaos. It is the injection of chaos that creates opportunity and the adaptation of chaos that leads to the standards, which lead to significant new opportunities for growth in the PC market.

Source of Chaos

- Radical architectural innovations
- Paradigm shift in computing
- Revolutionary applications
- Convergence of markets and technologies

Radical Architectural Innovations. Options include fuzzy logic, neural networks, OOPS, reconfigurable systems, very long instruction word computers, CISC, and RISC. Some of these technologies will start to be incorporated in the PC as we know it today. We see more dedicated use of these architectures to serve a specific piece of the problem in building higher performance or lower power or more intelligent computers.

However, as long as the x86 supplier base continues to provide evolutionary enhancements and lower power, the PC market will remain in the x86 camp.

Paradigm shift in Computing. This could potentially have a very dramatic effect. There was the era of the mainframe, then the minicomputer, and now the PC. The question is, is there something that could displace the PC to become the high-volume drive of the semiconductor industry?

This is where I believe there is fertile ground for a new architecture that could open up new opportunities for new hardware and software development.

Revolutionary applications. We are seeing a vast expansion of the technologies and capabilities of the PC, including CD-ROM, Flash memory cards, multimedia, advanced graphics capabilities, ISDN, ATM, and wide area networks. These areas are within the category of "chaos" because there are a variety of standards that will have to stabilize before the industry can focus on supplying these elements in high volume at the right price points to make them ubiquitous.

Convergence of Markets and Technologies. This concerns the use of the PC architecture to address the consumer and communications market. Wireless communications is needed to address portable computers, and digital and mixed-signal electronics are needed to address multimedia applications.

These technologies will be applicable in next-generation wireless communicators and next-generation consumer electronics products. These new markets will have their own needs, but they will also try to apply the PC architecture in leveraging its volume price points into their own markets. This will open up new opportunities.

PC 2000

It will be characterized by the co-existence of chaos and control. We will see the controlled evolutionary path of the PC overlaid with chaos, which will provide the growth factor of the industry.

PC 2000: Chaos or Control

Lorie Strong
Vice President
Portable and Software Marketing
Compaq Computer

Today's PC

The typical machine for the mobile market is based on a 486 microprocessor with a drive size somewhere between 120 and 500 megabytes, both mono and color displays, Windows 3.1 as the operating system, PCMCIA that is far from meeting customers' expectations, and battery life at between two and four hours.

Next year we expect to see:

- Pentium-level performance coming into this market
- Mass storage at the gigabyte level
- Displays in color
- Windows 95 availability
- PCMCIA providing better compatibility
- Batteries lasting longer

Customers expect to buy a PC for $2,000, but get greater performance, functionality, and capabilities each year.

Features/Functions

In terms of **mobility and functionality,** Compaq offers:

- High-performance notebooks to handle things like presentations, word processing, spreadsheet, and database applications
- Value notebooks to address customers with more baseline needs

- Ultra-portables for students and people with high mobility requirements. these mobile devices are primarily in the commercial market.

Communications will be a key enabler that will determine whether mobility is under control or chaotic in the year 2000. The infrastructure is just being built, but as standards firm up, this will contribute to our successful transition to untethered communications.

Wireless technology trends in North America:

- analog cellular
- CDPD in trials
- one-way paging, with two-way on the way
- packet-data radio availability
- spread-spectrum wireless LANs emerging

Multimedia is being delivered currently on the desktop. The dilemma in portables is trying to deliver this capability and still provide some battery life. But it's coming to portables and we expect to integrate audio, full-motion video, and CDs that are externally connectable.

Mobile companions. We call our handheld portables mobile companions. We think that customers want to:

- carry information with them
- interact with Windows
- synchronize between their mobile deice and their desktop or network computer
- be able to send and receive e-mail

There are challenges in delivering these capabilities in terms of form factor, functionality, and price.

The Year 2000

Will Compaq and Intel resolve their differences? Will communications costs come down? Will Microsoft, Intel, and IBM improve their relationships?

I think that our end customers will demand that we get along and provide a compatible environment, and I think that this industry has the creativity to do so. The concept of computing at your own time and place of choosing will be here by the year 2000.

Highlights of Panel Discussion on Wireless Communications

Topics: PCS Market Convergence; Standards; Semiconductor Considerations; Customer Interests; Entry of Digital Technology

PCS Market Convergence

Narrowband pager-type PCS and broadband cellular-type PCS will converge. Narrowband will handle limited data, but directly offers nationwide coverage. Cordless operates in unlicensed spectrum and is an extension of the wired network. The major difference is the degree of mobility.

The forthcoming auction of 30 megahertz and 10 megahertz channels will be differentiated by area of coverage and type of bidder. Existing cellular companies will be for one type of channel in areas they do not already cover and can bid on a different channel in their existing coverage area.

Another set of spectrum with a more limited basic trading area basis is set aside for specific types of owners, such as women, minorities, and local telephone companies.

Standards

Standards will remain incompatible between CDMA, TDMA and analog, with analog remaining partly as a link between the other two. Motorola's Flex standard for one-way and ReFlex for two-way are becoming accepted by a number of vendors. The later has the advantage of compatibility with Lower Tier one-way systems.

CDPD is also used in cellular. Most of these are packet standards, instead of the circuit approach of Ardis.

Wireless standards are likely to evolve like computer standards, that is by adopting widely used standards, such as CDPD that is based on TCIP. In that way, computer users will not need to rearchitect their systems to incorporate wireless.

Digital standards take care of security through encryption and authentication.

Semiconductor Considerations

Standards do not have as much impact on silicon as on equipment. The fundamental need is very high-speed processing of signals, with use of all the speed that becomes available for more quality and features. The likely future includes many different standards. Owners of intellectual property behind the standards will need to charge very low royalties or the market will adopt competing standards.

The baseband processing will be on one chip soon, in half-micron technology and 40 to 80 mips. Integration will move toward the antenna until there are just a couple of chips and cost, space, and power issues disappear.

In needs from the semiconductor suppliers, equipment builders want power conservation to enable long battery performance while driving more features. Good quality with lower power output will reduce interference. Power usage will be lessened by lower voltages; smaller chip geometry; turning off less used logic; and minimizing switching. Silicon with CMOS and BiCMOS in the RF will displace gallium arsenide and other alternatives because of lower costs.

Customer Interests

Customers want very small, lightweight devices with battery lives of weeks or months. They also want "agent" technology to simplify the performance of repetitive operations and maintain the preferences of the user and interactions with the various services.

Information will be stored by category and possible directed to internal message centers.

Voice control of operations will be critical when devices become too small to hold keyboards. The technology must support both voice and data.

Entry of Digital Technology

Digital technology may emerge quickly because users are willing to buy new equipment for new features and performance. In the U.S., 28 million cellular telephone sets have been sold in total, with only 18 to 19 million subscribers paying the monthly fees for services.

Digital service prices are also expected to be lower.

Wireless Communications: The Second Revolution Unfolds

Masood Garahi
Chief Technology Officer
Destineer Corporation

Agenda: Destineer Background; Wireless Markets; Destineer Operations; Alliances

Destineer Background

Mtel has three subsidiaries:

- Skytel which offers satellite-based nationwide paging, with products such as Sky Pager and Sky Talk
- Mtel International, which is rapidly extending the services to Latin America and Asia
- Destineer began as Nationwide Wireless Network and offers two-way data messaging (narrowband PCS) using related pager technology. This pager technology is low cost, compact, high-speed and offers long battery life.

Wireless Markets

E-mail. 27 million users today, with growth to 40 million projected by 1998

Cellular telephone. 15 million cellular telephones today, with 35 million projected by 1998

Pagers. 19 million pagers today, with 32 million projected by 1998

Portable and notebook computers. 13 million computers today.

The market is divided into three segments:

- Dispatch (doctors, service providers, delivery), with about 20 million service professionals
- Knowledge workers: 27 million, who spend more than 20% of their time on the road
- Two-income households: 50 million people in two-income households with two or more children under 18

Applications include: personal messaging (peer-to-peer communications of electronic Post-It notes); mobile office professionals using e-mail and fax; information access and distribution; and transaction services. The transmissions are brief and will be selective, based on location, etc.

Terminal technology includes: simple one- or two-button inputs; pocket communicators, such as Sony Magic Link or Motorola Envoy; and full PDAs and notebook computers. The most important need is transceiver chips. The goal is a technology that can be embedded in security systems, utility meters, sprinkler systems, etc.

Destineer Operations

Destineer has a single Network Operations Center (NOC), so application providers can have a single point of access for nationwide communications. The system is dually redundant and has other security features. The broadcast porting is 24k bps on each of three 50 kilohertz channels. Next generation technology should provide 100 to 110k bps.

The NOC is the core messaging service for data delivery and includes e-mail, fax, paging, and some transaction support. It supports subscriber and object database and provide a variety of front-ends for X.400, Internet, and various terminal devices. Destineer is providing the necessary APIs to interface with the system.

Alliances

Destineer has a variety of alliances:

- Microsoft is an investor and application developer.
- Motorola is developing transmitter, receivers, and PMU messaging devices
- Wireless Access is developing subscriber products as a second-source
- Glenayre Electronics is providing infrastructure technology
- Kleiner Perkins is providing financing

Wireless Communications: The Second Revolution Unfolds

Michael Hames
Vice President
Semiconductor Group
Worldwide DSP Manager
Texas Instruments

Agenda: DSP Market Overview; Standards; Cellular Telephone

DSP Market Overview

Wireless communications in the 90s is like personal computers in the 80s — becoming affordable and forever changing the way people communicate. Microelectronic digital signal processing (DSP) is the enabling technology.

DSP semiconductor technology is following the trends of microprocessors. Latest generation DSP chips have about five to ten million transistors and can perform two billion operations per second. By the year 2000, 100 million transistors will be on a single piece of silicon.

Digitization will drive the growth of wireless communications because of the high bandwidth, better quality, compression, and lower costs. Digital terminals will grow from about 10 million now to 100 million by 2000. Many developing countries are moving directly to digital.

Standards

Standards will be a key to growth. Each competing standard has its own trade-off of availability and costs. There will probably be a fracturing with multiple standards. DSP allows the same terminal to support multiple standards.

Other enabling technologies are high-performance/low-power RF with submicron CMOS and BiCMOS; high energy-density batteries; and network enhancements.

Cellular Telephone

Cellular telephones are being driven to a handful of chips costing less that $50 with telephones selling for under $100. Technologies in all types of telephones, from cordless to high-power cellular will merge into similar devices. Stand-by and talk times will increase to weeks. Standards and semiconductor technologies will allow all needed differentiation on a single chip.

Summary

The standards that will emerge will be a function of:

- Infrastructure costs
- Regulatory issues
- Rate structures

In the future, wireless will be as common as wired telephones today.

TEXAS INSTRUMENTS

DIGITIZATION DRIVING GROWTH OF WIRELESS COMMUNICATIONS

- INCREASED CAPACITY
  - —CARRIERS DECREASE COST PER SUBSCRIBER
- HIGHER QUALITY, FEATURE, SECURE WIRELESS DEVICES
- LOWER COST AND POWER VIA SEMICONDUCTOR INTERACTION IN BOTH BASEBAND AND RF
- TECHNOLOGY OF CHOICE IN MANY DEVELOPING COUNTRIES

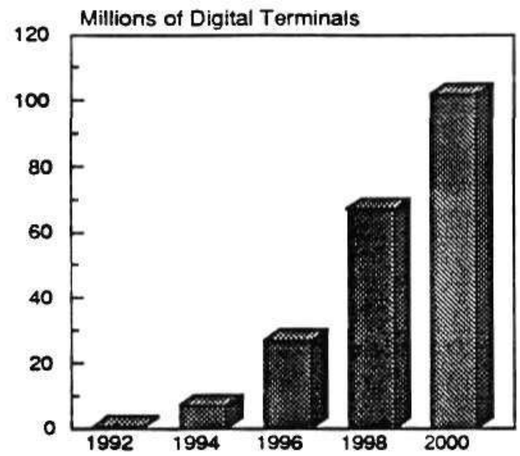


Figure 1

•TEXAS• •INSTRUMENTS

TDMA CELLULAR ARCHITECTURE EVOLUTION

	1992/93	1995/96	1998/99
BASEBAND	6or 7 ICs + memory chips	2 ICs + memory chips	1 Digital IC
RX/TX	> 150 discretes	3 ICs + discretes	1 AFE + transceiver IC
PA	Non-monolithic PA	Monolithic PA	Monolithic PA + power control
BATTERIES	5 cells	3 cells	2 cells

Figure 2

TEXAS INSTRUMENTS

SEMICONDUCTOR TECHNOLOGY IMPACT

1992	1994	1996	1998	2000
0.8 MICRON	0.5 MICRON	0.35 MICRON	0.25 MICRON	0.18 MICRON
4.5V-5.5V	3V-5.5V	2V-3.6V	1.5V-2.4V	1.5V-2.4V
18HRS STD-BY	36 HRS STD-BY	72HRS STD-BY	144 HRS STD-BY	>1 WEEK STD-BY
1HR30 TALK-TIME	3HRS TALK-TIME	6HRS TALK-TIME	12HRS TALK-TIME	> 1 DAY TALK-TIME

Figure 3

Wireless Communications: The Second Revolution Unfolds

Robert S. Sellinger
Director, PCS
AT&T Network Wireless Systems

Agenda: Overview of New Personal Communications Systems; Critical Success Factors for PCS; Development of PCS Markets; Wireless Data Market; Standards

Overview of New Personal Communications Systems

The coming December auction by the FCC of Personal Communications System (PCS) spectrum will see six new carriers in each major market and result in an explosion of growth in demand for equipment for subscribers, cell sites, and switches.

Critical Success Factors for PCS include:

- Full services comparable to cellular, including in cars at 100 kilometers per hour
- Rich voice and data features
- Compatibility with existing networks
- Technologies, especially North American digital standards (CDMA), that can evolve
- Improved voice quality through digital technology
- Cost competitive terminals

Development of PCS Markets

Initially, the competitive terms will be set by the two incumbent cellular services in each market. PCS has cost advantages at $400 per subscriber (with CDMA), compared to $800 to $1000 for GSM systems in Europe, $500 to $1000 for wireline access, and $1000 to $1500 for cellular.

The PCS market is expected to grow rapidly, reaching 10 million subscribers in from 5 to 9 years (depending on forecaster), compared to the 10 years cellular took to reach that level. Wireless penetration can be 20% (15% PCS, 5% cellular) by 2000, distributed among four or five successful carriers in each market. Data opportunities will be additive.

The cost for subscribers will be between wired and cellular: $30 to $40 per month. Usage will be 120 to 150 minutes at a cost per minute of $.15 to $.20.

Wireless Data Market

CDPD was recently introduced in cellular networks to provide a digital packet connection with data service. This will co-exist with existing voice services, be it digital, TDMA, or analog voice.

The five largest data markets will be fixed telemetry (5 million addressable subscribers), field service (2.9 million), transport (2.6 million), field sales (1.5 million), public service (835 thousand).

Of the total, about 75% will be packet data subscribers.

Terminals for vertical applications (point-of-sale, security and environmental monitoring) will be under $100.

CDPD is a very open standard that supports existing networks well. CDPD is very attractive for the PCS market and will best serve 65% to 75% of the market.

Standards

High Tier voice standards (IS-95 (CDMA), IS54 (TDMA), and PCS 18000, are derived from existing digital cellular standards. CDMA offers significant spectral efficiencies.

Low Tier voice standards, such as PACS and DECT, are more or less extensions of cordless telephony.

High Tier voice services will be mandatory for PCS carrier success. It will be mandatory to pick a standard that supports full mobility.

For data, CDPD has much to offer.

Summary

With a new spectrum to be awarded. there will be significant opportunities for the wireless industry in the next few years:

- Explosive opportunities for infrastructure providers and carriers, domestically and internationally
- Evolving standards
- Increasing competitive pressures, as the market will now have up to nine wireless providers
- Shorter time to market
- Lower cost equipment
- Higher quality service

Forecast of U. S. PCS Subscriber

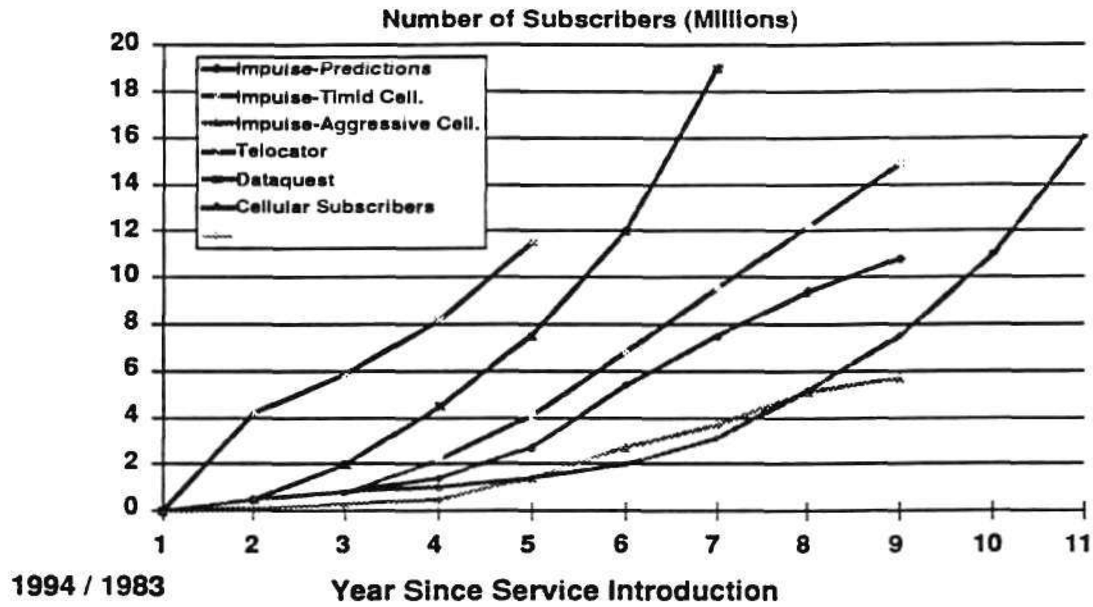


Figure 1

Personal Communications Service

Versus Local Exchange & Cellular Service

	Local Exchange Service	Cellular Service	Personal Communication Service*
Monthly Charge		$60 (apx.)	$30 - 40
Residential	$15 - 20		
Business	$35 - 45		
Monthly Use (Min)		75 (apx.)	120 -150
Residential	>700		
Business	>1000		
Erlangs		>0.015	>0.025
Residential	>0.06		
Business	>0.1		
Cost/Min	$.01 -.03	$.35 -.45	$.15 -.20
Market Penetration	Universal Coverage	5%	10-15%

* Estimates

Figure 2

Wireless Communications: The Second Revolution Unfolds

Daniel V. Romano
Vice President of Competence and System Development
Nokia Mobile Phones

Agenda: Overview of Cellular Development; Digital Cellular; Cellular's Future

Overview of Cellular Development

By the year 2000, we will not think of communications as fixed or mobile. Networks will have elements of both.

The first generation of analog cellular has achieved 5% to 10% penetration but still has needs for more coverage (the most critical success factor), more capacity in heavily populated areas, improved speech quality, and improved security.

Digital Cellular

The new digital second generation will provide capacity for 20% penetration, improved quality and security, and international roaming. There will be many types of phones tailored to the customers' needs and tastes. Within 10 years wireless will be a direct substitute for wired service.

Now, there are about 20 million cellular subscribers worldwide. Future growth will depend on segmentation to offer the business user more. While equipment costs have dropped rapidly, tariffs have dropped far less. Lower cost of ownership correlates strongly with penetration, as demonstrated in Scandinavia where ownership cost is less than $1000 and penetration is much higher than in high-tariff areas. The new lower-cost GSM service in Germany is growing rapidly.

Mobility is the primary driving factor, especially by increasing the effectiveness of the small business entrepreneur. Digital networks add value by international roaming and digital messaging. Mobility will give wireless an advantage over wired as the costs become similar.

Cellular's Future

The late 90s will be the Two Plus Generation with:

- Multiple services
- Large-scale cost optimization
- Digital cordless equipment
- Data and messaging
- Combination of digital and cordless equipment
- Customized services (the key)
- 20% to 40% penetration

The third generation will provide global communications, a wide variety of local services, and more than 50% penetration. The most important factor will be lower infrastructural cost.

The market in 2000 will be:

- Built on a number of emerging segments
- Complex and fragmented, as a result from the diversity of equipment and services
- Free of most technical problems, human behavior and cultural issues will dominate new services and applications
- Dominated by wireless solutions to personal communications

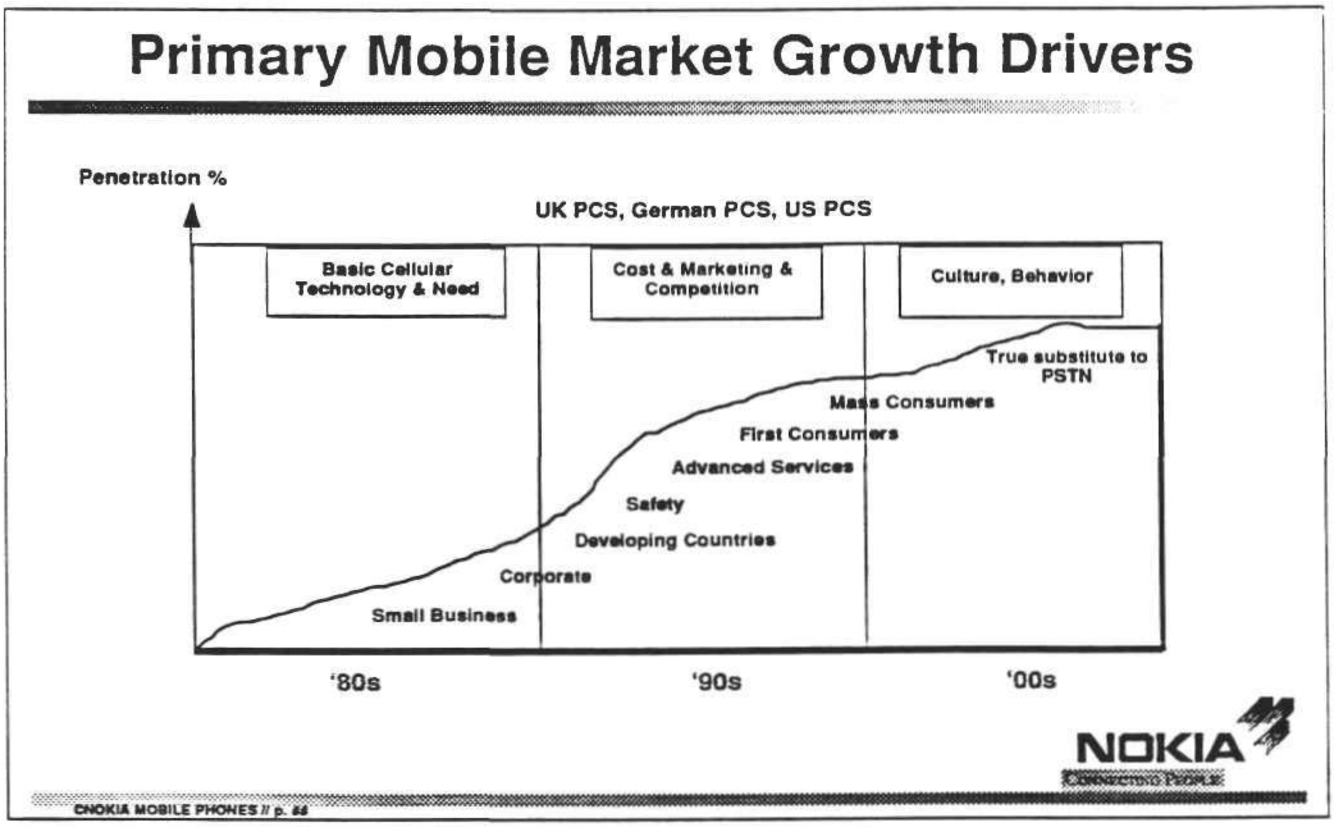


Figure 1

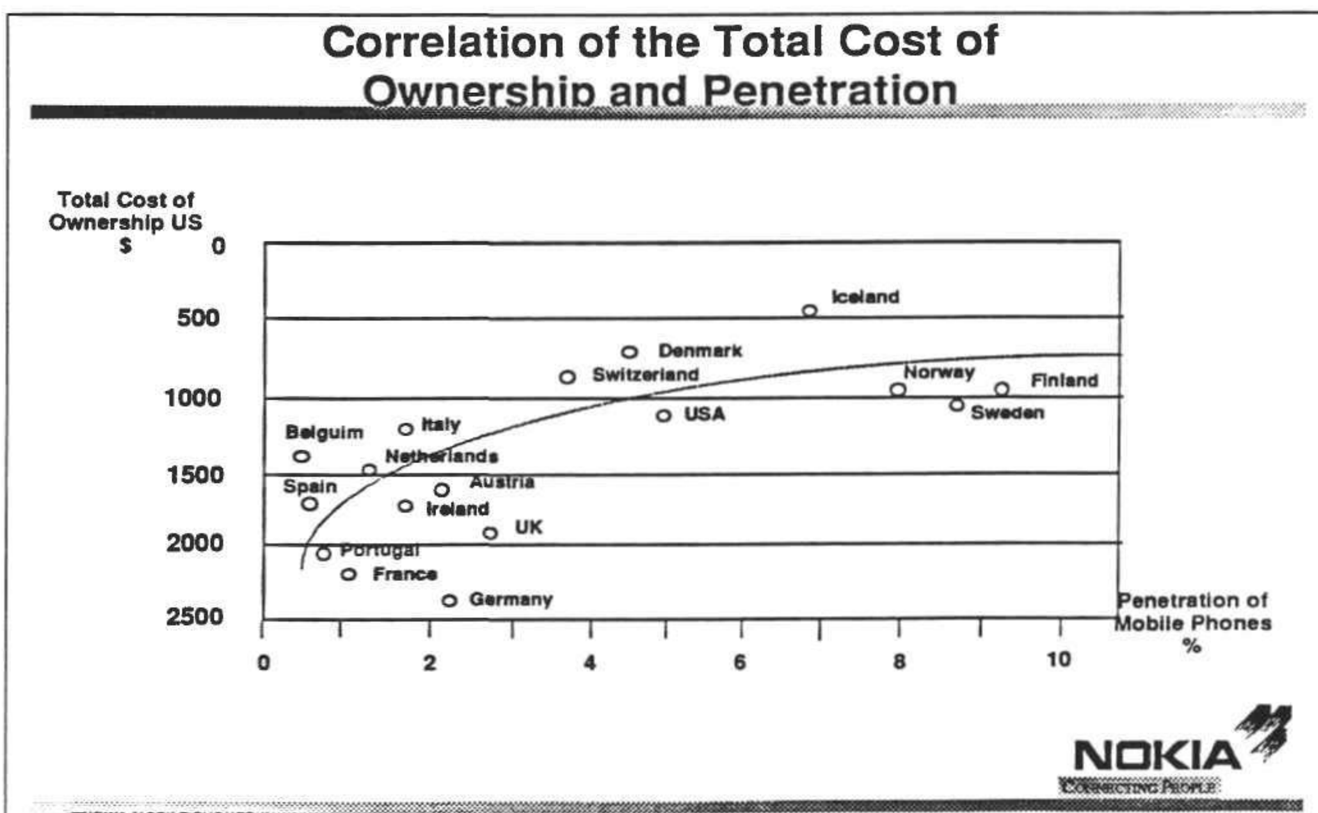


Figure 2

Future Manufacturing Strategies

Clark J. Fuhs
Senior Industry Analyst
Semiconductor Equipment, Manufacturing
and Material Service
Dataquest Incorporated

Agenda: Overview

Overview

Fabless companies emerged in the 1980s, taking advantage of the excess capacity in the market, and foundries began to emerge. Today, this has evolved into a bona fide manufacturing strategy, with the concept of the dedicated foundry.

Dataquest believes that semiconductor contract manufacturing is a permanent trend. Contract manufacturing is evolving along the lines of R&D centers: design, manufacturing engineering, and process design, with the equipment and material suppliers taking an increasing role.

Each R&D center provides expertise to the overall equation:

- The chip designers provide value-added solutions to systems.
- The wafer fabs provide manufacturing knowledge and the concentration of capital.
- The material and equipment suppliers provide process expertise, service, and automation systems.

The foundry is responsible for providing manufacturer requirements to each of the participants, so it plays more of an integrator role in the semiconductor manufacturing industry.

Future Manufacturing Strategies

Vinod Mahendroo
Managing Director
Global Corporate Marketing
Applied Materials

Agenda: Industry Trends; Applied Materials' Strategy

Industry Trends

Escalating capital and development costs are increasing. Therefore, the industry will see more and more partnerships and alliances as companies try to find ways to get involved in joint efforts and share risks.

Operating costs. One of the issues is an actual reduction of operating costs and the other issue is to extend the productive lifetime of the equipment in the fab. Competition requires minimization of fab operating costs.

Barriers to entry. In general, the cost issues are limiting the rate at which new semiconductors with fabs are being formed.

Global presence. In addition, customers feel that the market access issues require substantial global presence.

Equipment selection criteria. Customers want technology that works and is reliable; they want it to be cost-effective; and they want the lifetime of the equipment to be extended.

Total process flow. The industry is far more involved in the total process flow, and process control is a set of issues that ends up requiring at least co-equal ownership along with our customers.

Applied Materials' Strategy

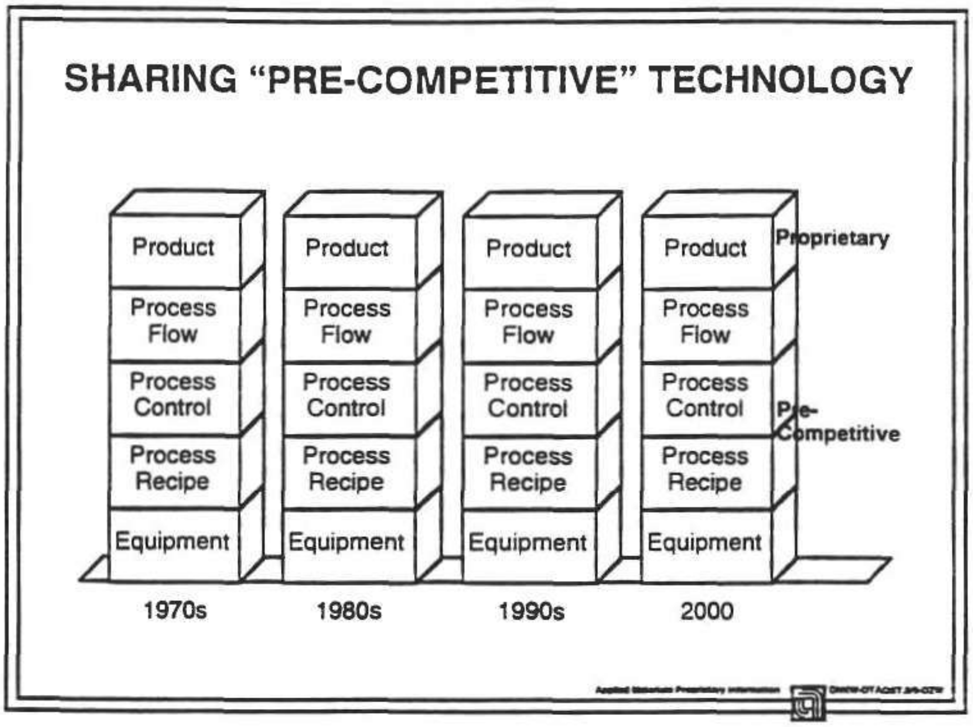
- Provide equipment that meets the technology, the reliability, and the cost requirements on a variety of different mainframes.
- Be able to offer a number of different applications on these mainframes. Essentially, this provides process integration on the same tool, resulting in greater leverage and a closer working relationship between us and our customers.

Conclusions

There is a smaller number of larger and more capable global fab companies.

There is a shift of responsibility from the equipment supplier to us, with the foundries and the semiconductor fabs doing a little less of what they used to do. This is in order to be able to focus on adding value and developing close partnerships that are sustainable and critical to the entire food chain.

The industry does have an opportunity in the long haul, through process integration and other creative means, to help extend the capability of our customers.



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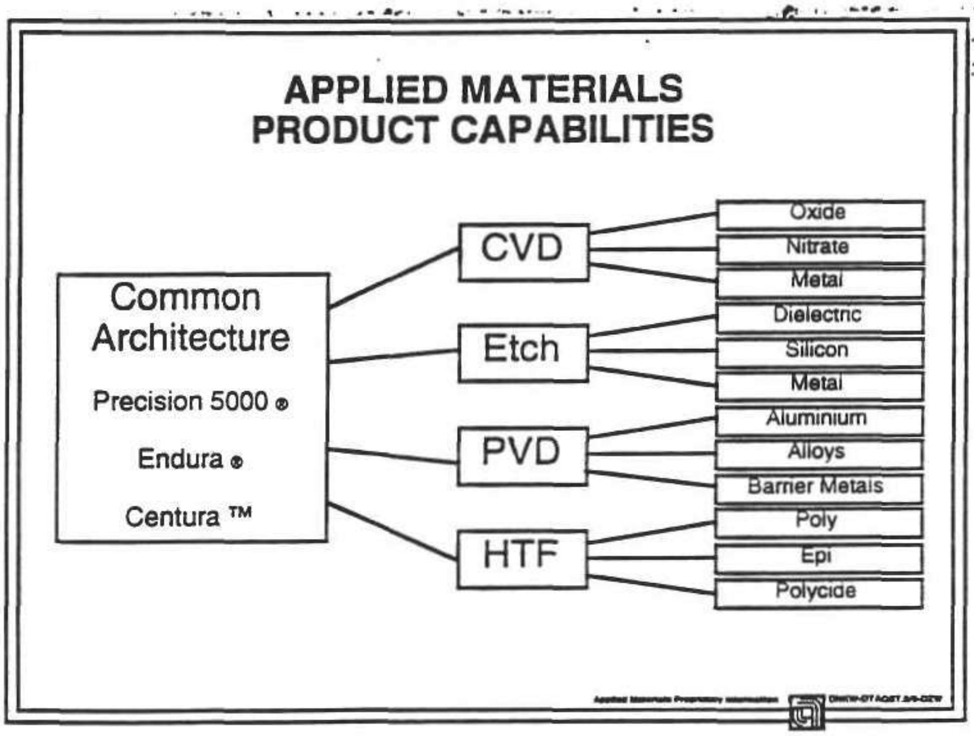


Figure 2

Future Manufacturing Strategies

John Dickson
Vice President
Integrated Circuits
AT&T Microelectronics

Agenda: History; Why Make and Buy? Critical Success Factors

History

AT&T Microelectronics manufactures its own silicon and re-sells them to other semiconductor companies. Prior to 1984, the semiconductor business within AT&T was a cost center, supplying silicon products to various product groups within the AT&T organization.

It was decided that the component manufacturing groups should go out and sell their products and technologies. At that time, AT&T had significant market expectations. As a result we built lots of factories and plants and lots of assembly and test capacity. Unfortunately, we didn't sell too many of the products and as a result AT&T had a excess fab capacity.

AT&T withdrew from the microprocessor business and aborted the attempt to be a major player in the MOS memory market and went into a tactical foundry supplier role. AT&T is still a supplier of foundry silicon in the marketplace. By the end of this year, AT&T anticipates to have revenue of close to $1.5 billion.

Why Make and Buy?

Market Factors:

- It is a volatile market.
- A key reason to look for partnerships is to manage financial resources and retain the capacity to satisfy customers' requirements re product and time frame.
- AT&T business is almost 100 percent on a custom basis.

Despite having three fabs within our organization, we still feel it necessary to associate ourselves with silicon suppliers in what we call "virtual" second sourcing. AT&T has a close relationship with a foundry supplier, or silicon supplier, using our process so that AT&T provides massive flexibility and upside capability to satisfy our customers' requirements.

Economic Factors:

- Focus on product design and development and understand the market in relation to the customer.

- Focus on the strengths of the company and let somebody else bring in the expertise in areas that are not considered strategic.

Critical Success Factors

- **Limited Relationships:** Set up a relationship with two partners or, ideally, one.

- **Strategic:** The relationship or partnership must be strategic. For that relationship to be successful, there has to be a shared risk and a shared benefit.

- **Fairness:** The relationship must be open, with both parties acting as a single company.

Future Manufacturing Strategies

Koichi Nishimura
President and Chief Executive Officer
Selectron Corporation

Agenda: Why Outsource?; Contract Business; Areas to Leverage; Services we Perform for Customers; Ideal Partnership

Why Outsource?

The industry is in a time-based competition. A company must be out first with the most, so it can get the highest margin. When the second company comes in, the margin drops and there is competition.

Time does not wait and management must figure out where to focus their resources: money, capital, human resources. Management must figure out how to conserve time and make the most of it. This is what management essentially does when they outsource.

There are three potential processes to outsource: Innovative products; the market to sell into; and manufacturing. Most companies can not do all these well. Most companies have to change, so they can leverage their resources and deploy them accordingly.

The basic premise is end users don't care who makes the product as long as it works and that the OEM stands behind the product. The customer wants it cheaper, better, faster, where they want it, and when they want it.

Contract Business

In the semiconductor business, the OEMs decided to concentrate on core competency—marketing innovative product development. They, therefore, decided to outsource some or all of manufacturing.

The semiconductor industry needs to continue to be a dependable supplier of parts and to obtain the best prices to build them and move them out the door.

The contract business represents 5 percent of the total manufacturing revenues, and is growing rapidly, more rapidly than the electronics business worldwide.

Contract manufacturers must make products cheaper, better, faster or they don't survive.

Areas to Leverage

Improve financial performance. Your return on asset will improve, if your supplier builds the hardware and orders the part turnkey. The supplier will carry your assets until they ship it.

Improve product and cost structure. Think in terms of total cost of ownership. Manage your own assets. Own the internal engineering expertise in order to stay competitive.

Time to market.
Equipment economics. You don't have to have idle equipment; you pay only for the share you use; you don't pay up front; you have access to technology.

Services We Perform for Customers

- Physical design: lay out boards, design for manufacturability, qualify products for FCC qualification
- Buy parts
- Build systems they (the customers) like
- Ship to distributors: shrink wrap, include printed materials, include floppies

Ideal Partnership

In the past, most relationships were transaction-based. Today, most of Solectron's relationships are defined by the closeness of that relationship, which results in long-term alliances. Companies can not be involved in a successful partnership, unless both sides bring something to the table.

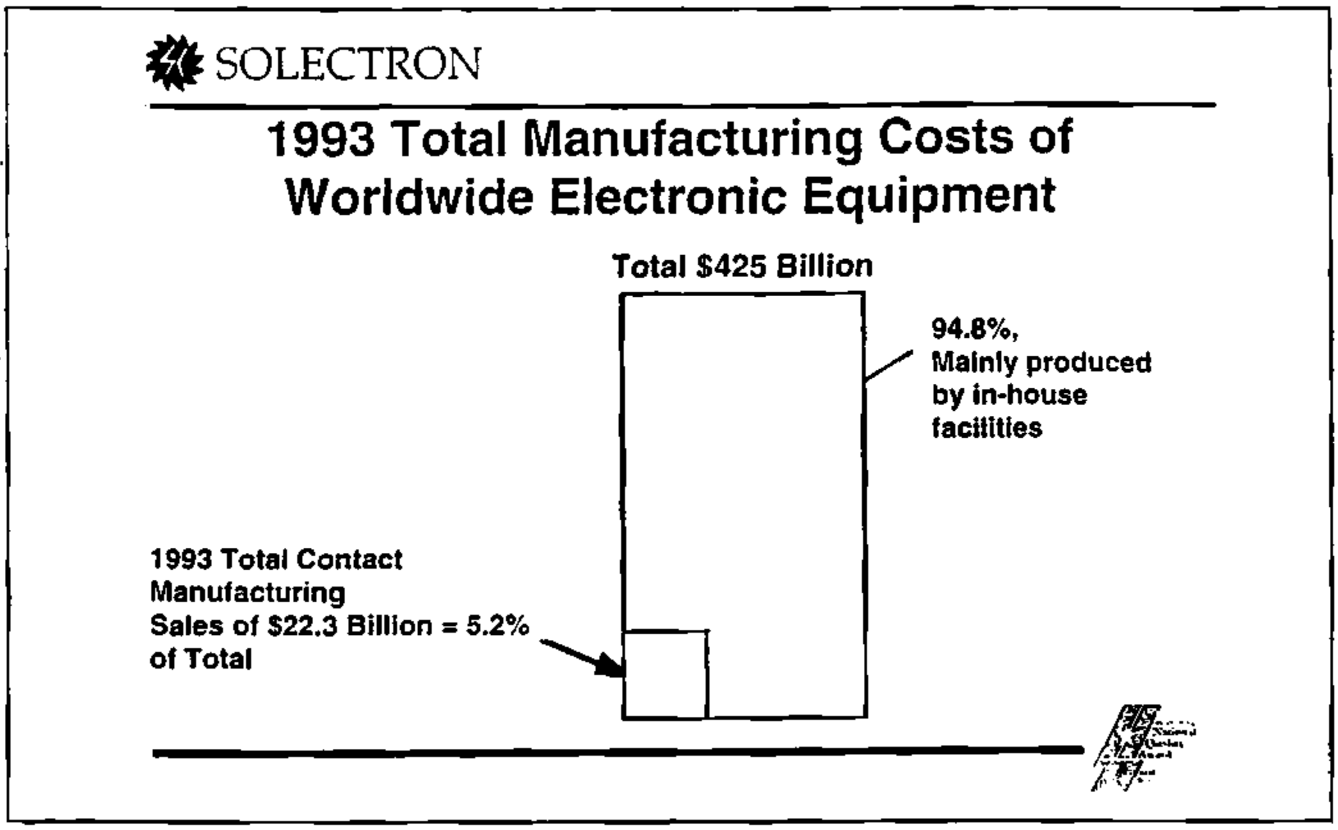
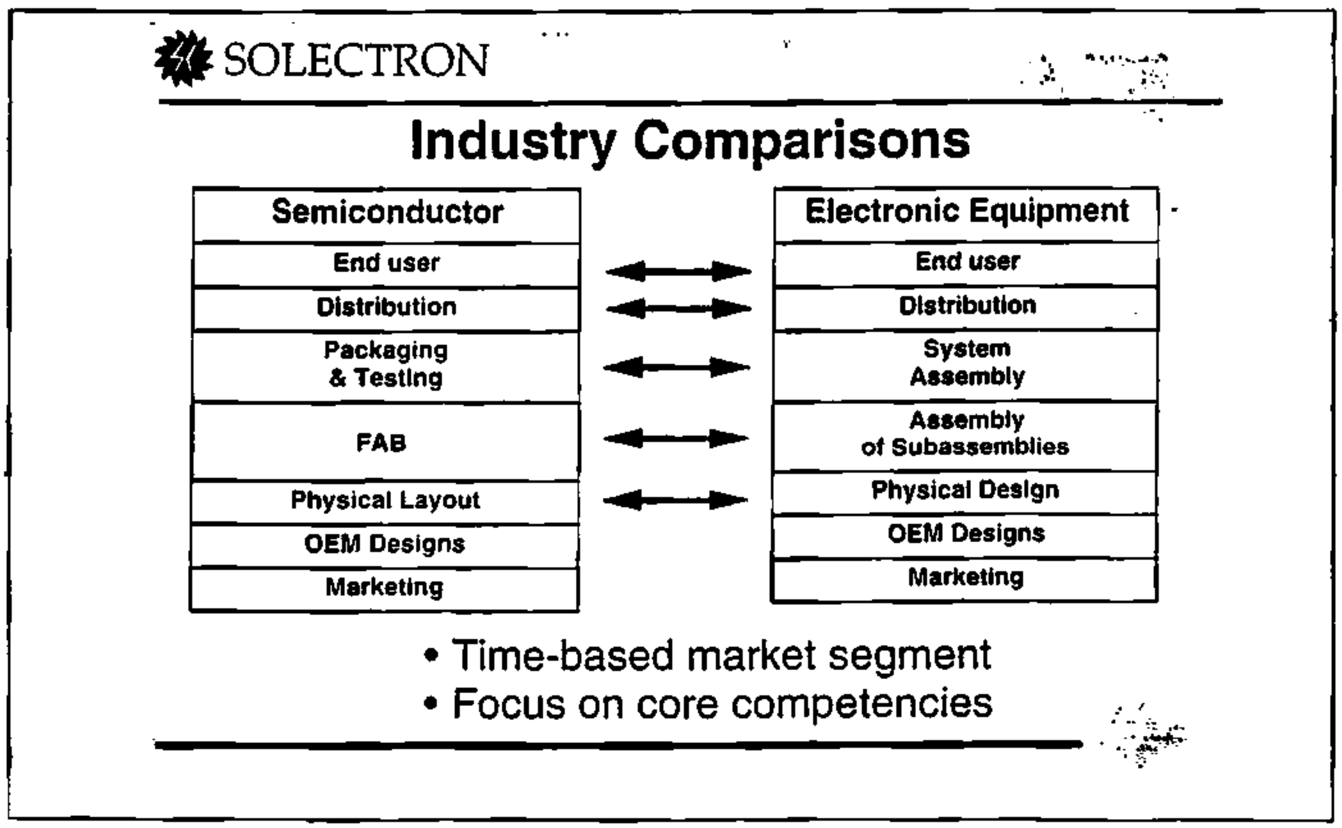


Figure 1



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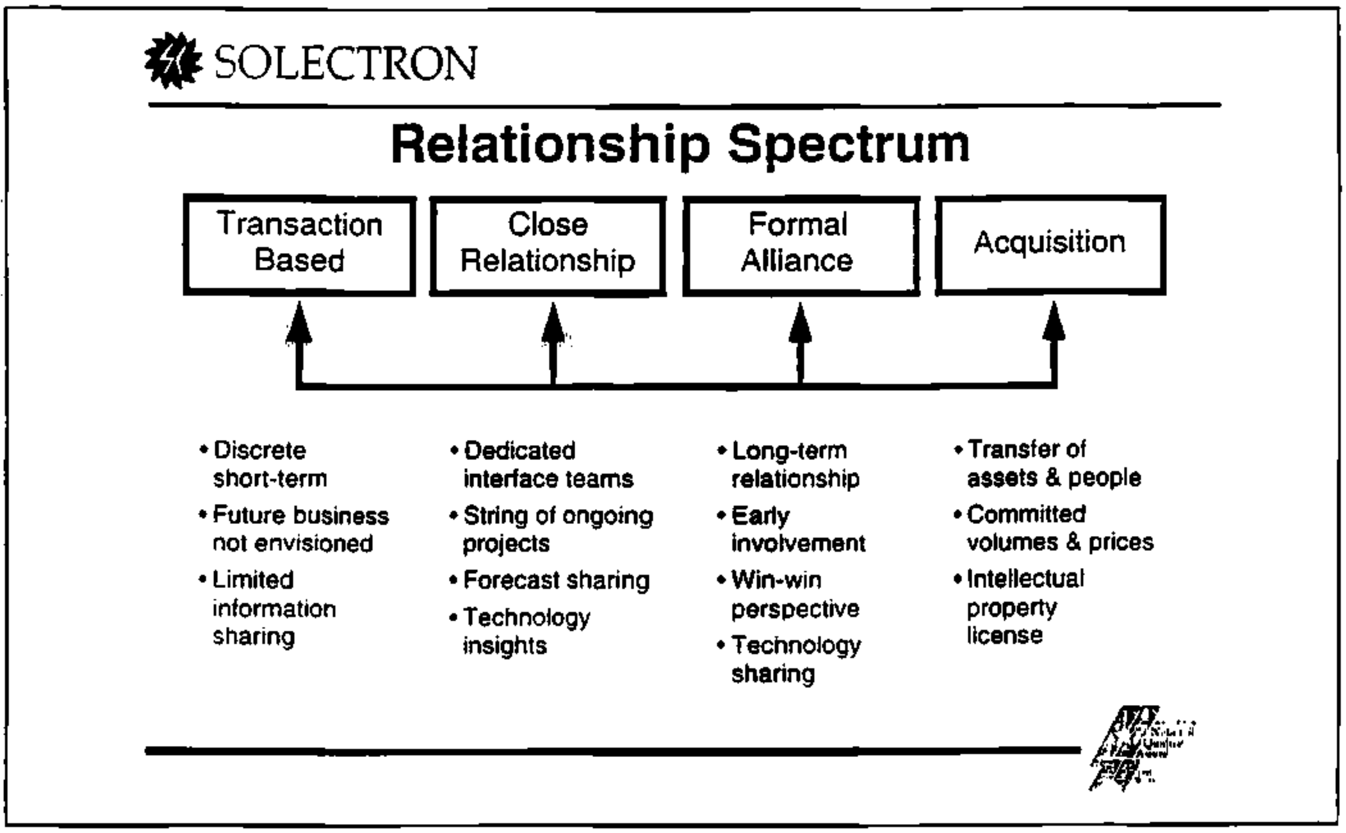

SOLECTRON
Relationship Spectrum
Transaction Based
Close Relationship
Formal Alliance
Acquisition
• Discrete short-term
• Future business not envisioned
• Limited information sharing
• Dedicated interface teams
• String of ongoing projects
• Forecast sharing
• Technology insights
• Long-term relationship
• Early involvement
• Win-win perspective
• Technology sharing
• Transfer of assets & people
• Committed volumes & prices
• Intellectual property license

Figure 3

Future Manufacturing Strategies

Donald W. Brooks
President
Taiwan Semiconductor Manufacturing Company

Agenda: A Model Foundry; TSMC Business Trends

A Model Foundry

Foundry Only: There is too much conflict in the foundry business in the areas of intellectual property. The cost structures or productivities can be optimized by focused, foundry-only companies.

State-of-the-art Generic Processes: These processes should be managed at the heart of the growth cycle, in contrast to working in older technologies.

Differentiate with Service: The model foundry will differentiate itself by offering services, such as purchasing, loading, data availability, quality, reliability.

Self-Funding: The model foundry will be self-funding, allowing it to sustain itself and grow.

TSMC Business Trends

Manufacturing: The most relevant is capacity and it should be added in a linear fashion. Invest in high technology because of the value-add that is being brought by the semiconductor industry.

Yield is a single item that represents the value-add the foundry actually contributes; it calls for continuous defect reduction. The lower the defect density, the higher the yields. There must be a continuing cycle of improvements to drive it down.

Service: Offer technical data; offer ASIC net list conversion to cell libraries; give early assessment of product reliability.

Technology: Includes memory and logic. The industry interfaces with its customers with a comprehensive chart of technology roadmaps, so that they know where the industry is going and when it will be ready to bring up new processes.

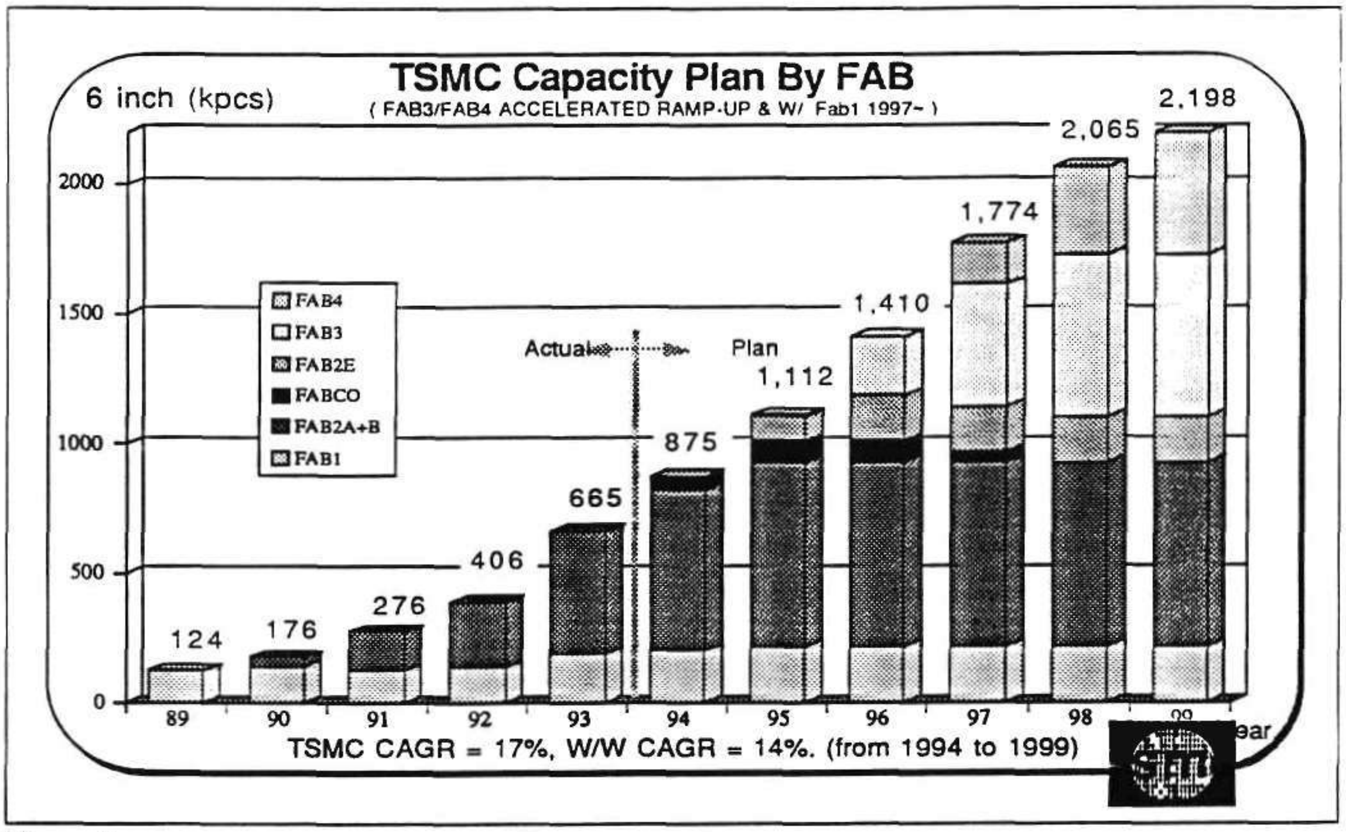
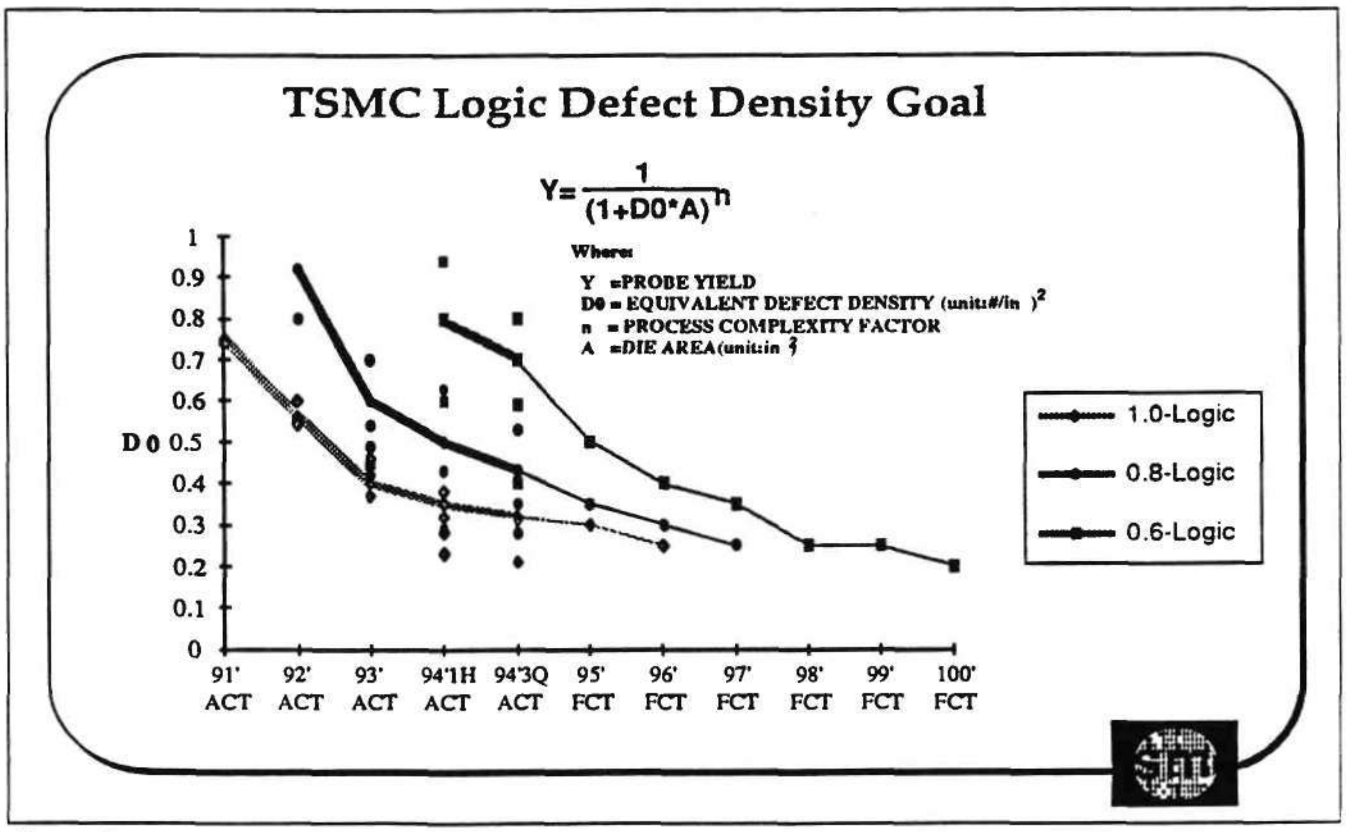


Figure 1



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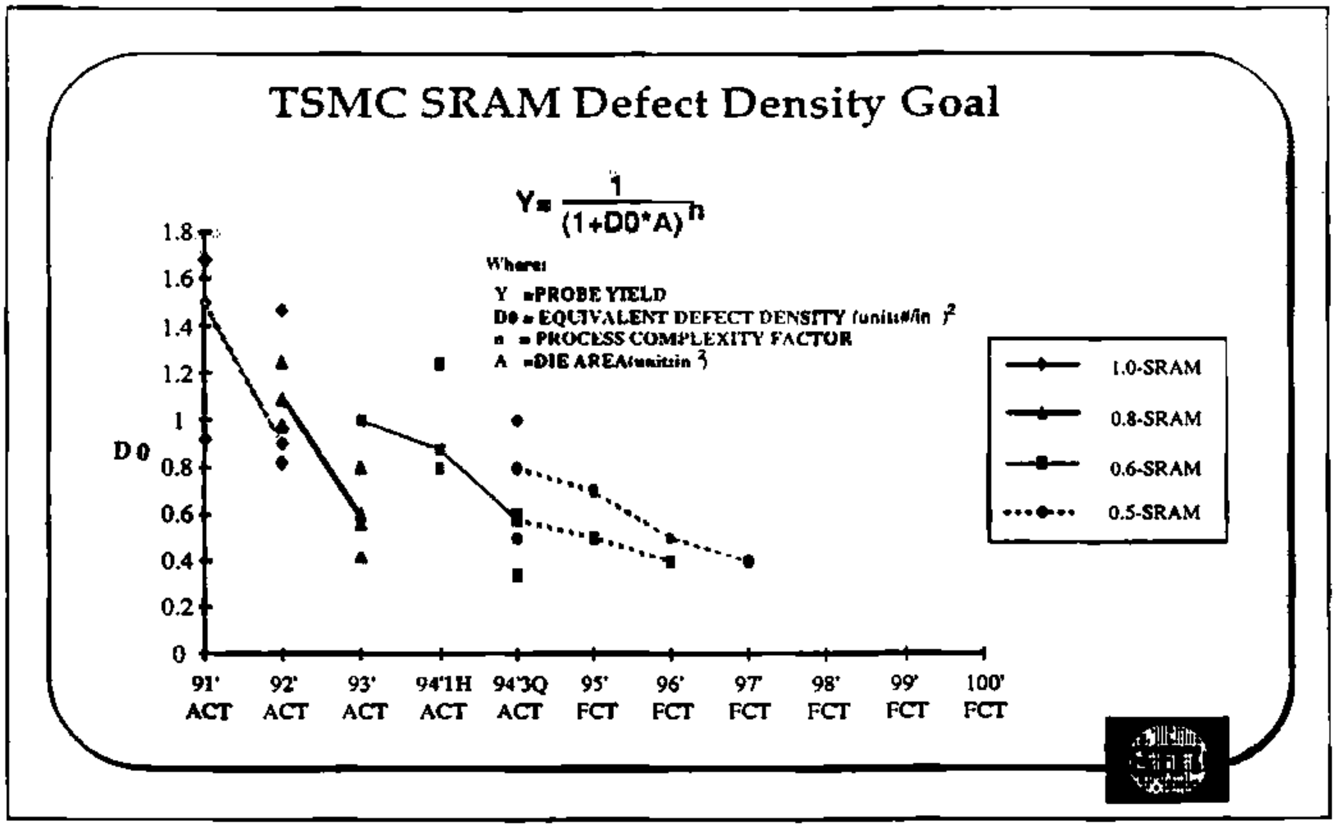

TSMC SRAM Defect Density Goal
Y= 1 / (1+D0*A)^n
Where:
Y =PROBE YIELD
D0 = EQUIVALENT DEFECT DENSITY (unit:#/in)^2
n = PROCESS COMPLEXITY FACTOR
A =DIE AREA(unit:in)^2
D0
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
91' ACT
92' ACT
93' ACT
94'1H ACT
94'3Q ACT
95' FCT
96' FCT
97' FCT
98' FCT
99' FCT
100' FCT
1.0-SRAM
0.8-SRAM
0.6-SRAM
0.5-SRAM

Figure 3

Future Manufacturing Strategies

Bernard Vonderschmitt
President and Co-Founder
Xilinx, Inc.

Agenda: Fabless Companies; Why Fabs are Preferred; Successful Foundry Relationships; Success Elements

Fabless Companies

The fabless industry is a $3.0 billion business.

The top six market leaders are Adaptec, Altera, Cirrus Logic, Cyrix, Lattice, and Xilinx.

Some companies with their own fabs also use foundries.

Why Fabs are Preferred

Management bandwidth of small companies is being challenged.

Unique skills are required: outstanding maintenance people and outstanding process people are needed to run the plants.

Facility obsolescence. Leading-edge products need to be manufactured in new, cost-effective fabs.

Customer demands. A proprietary product causes customers to require a firm to have multiple sources.

Capital. Capital is required to build fabs, which can cost between $250 million to $1 billion.

Fixed-Cost content. It makes for volatility of profits in the semiconductor business.

Various manufacturing locations. Only large companies can support multiple manufacturing locations.

Successful Foundry Relationships

Ideal Relationship:

- The added value is in design and in selling
- Should have a standard process
- Product should be easy to analyze from standpoint of yields and yield improvement
- Silicon content should be greater than $25 million
- Two or fewer mask sets

Difficult Relationship:

- There is not a mainstream process in place.
- Test parameters: analysis of devices is unique, or there is large number of parts being fabricated, with no correlation for analysis
- Many mask sets (over 10)
- Less than $1 million of silicon revenue per mask set

Success Elements

Unless a company is a huge operation, it is very difficult to interface with too many foundries. The logistics are a nightmare.

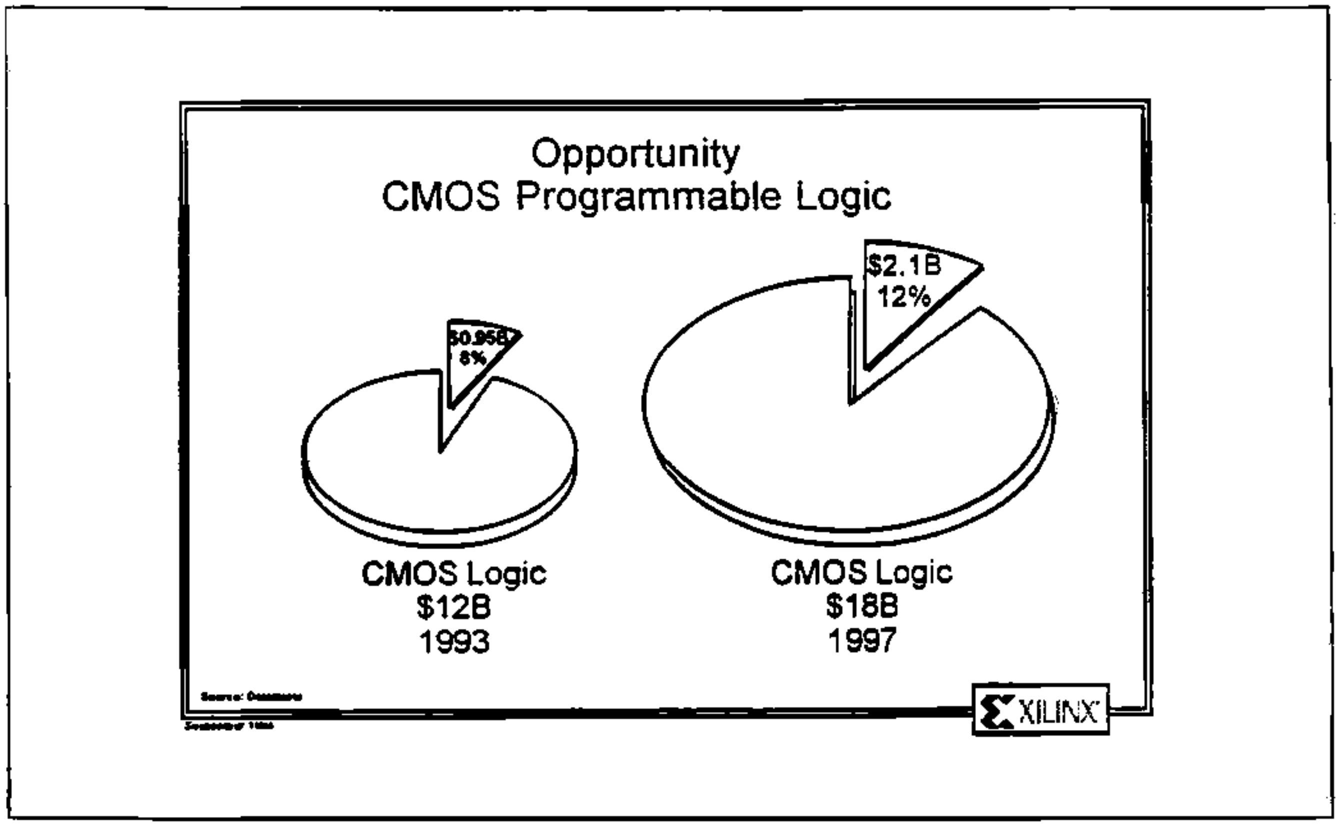
The technical personnel bandwidth a company has to interface with in involving all these foundries is very laborious.

The foundry relationship is very important and there has to be mutual respect, at both the management and technical interface levels.

The product is one that the foundry can use as a process driver.

Summary

Fabless or not, contributing factors for success depends on the relationship between the two companies and the type of products each has.



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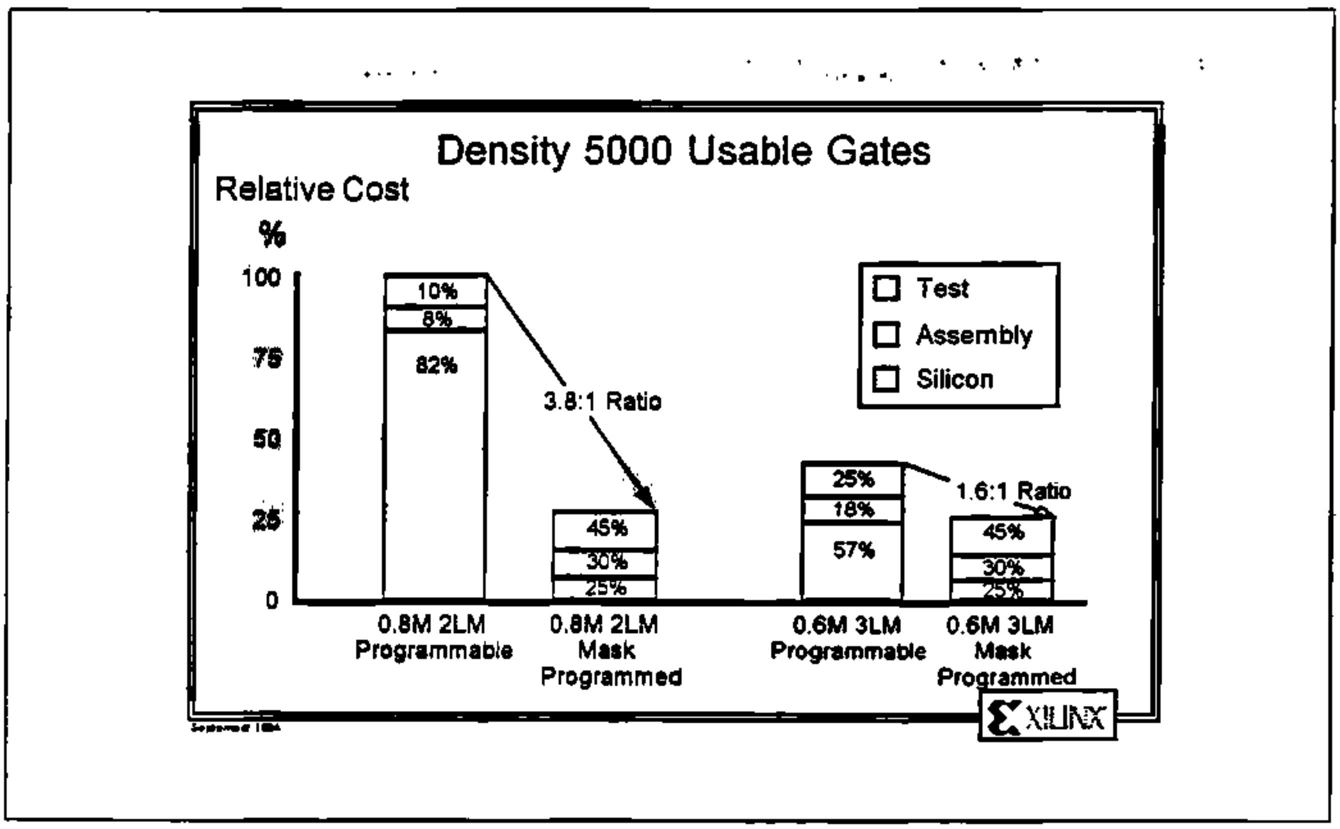


Figure 2

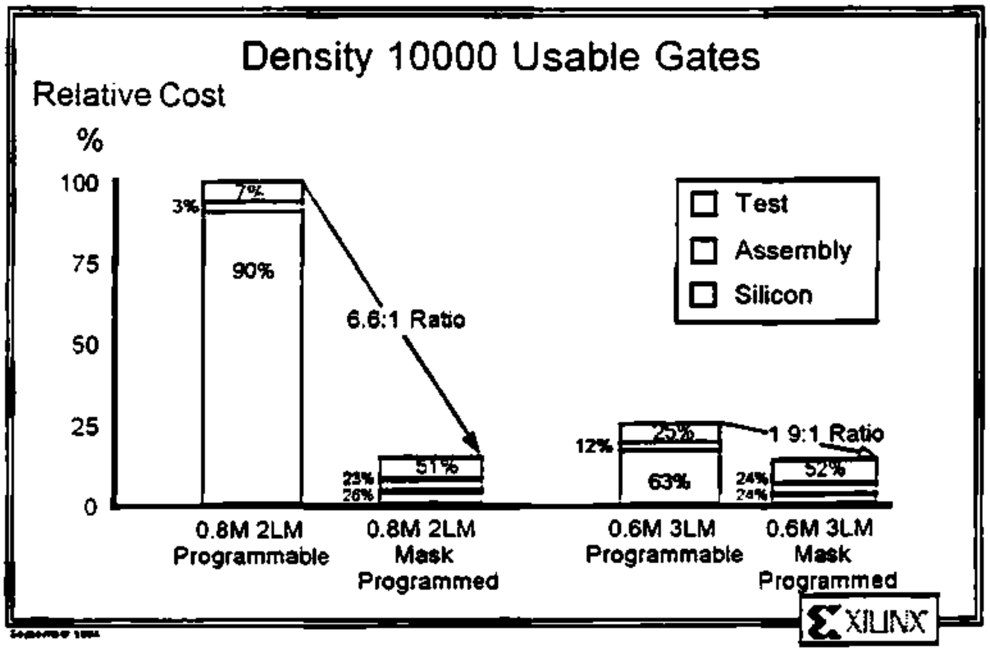

Density 10000 Usable Gates
Relative Cost
%
100
75
50
25
0
3%
7%
90%
6.6:1 Ratio
23%
26%
51%
12%
25%
63%
1.9:1 Ratio
24%
24%
52%
Test
Assembly
Silicon
0.8M 2LM Programmable
0.8M 2LM Mask Programmed
0.6M 3LM Programmable
0.6M 3LM Mask Programmed
XILINX

Figure 3

Funding Opportunities Along The Superhighway

William R. Hambrecht
Founding Partner, Chairman, and Co-CEO
Hambrecht & Quist Group

Agenda: Status of Venture Capital Activity; Information Superhighway Market Characteristics; Investors' Perspective; H&Q Specific Investments

Status of Venture Capital Activity

Venture capital benefitted from the technology revolutions in semiconductors and biotechnology that created industries that did not exist previously. Institutionalized flow of money stemming from ERISA and Nasdaq also provided funds for venture capital. The abnormally high returns attracted capital until returns dropped to normal. Unfortunately, too many companies formed in each niche. Pricing dogfights in these niches drove returns down and reduced the inflow of capital.

Now, the market is somewhat in equilibrium. It is:

- Being driven by the rate of return
- Conscious of reporting responsibilities to fiduciaries
- Expecting a rate of return quickly
- Institutional, with fewer risk-takers
- Backing opportunities that have already started and have good momentum.

Information Superhighway Market Characteristics

The information superhighway is a consumer market place. The emphasis is on easy, in contrast to "smaller, faster, better" that drives the high-tech market. The U.S. has many people who will not automatically adopt the newest, brightest technology.

A major consumer study showed these motivators:

- Customization, witness the move from network to cable channels
- Price, relative value. Consumers feel betrayed when cable is sold as ad free, and then ads appear later
- Privacy
- Variety of programming

A survey of executives in this business showed they:

- Underestimated the importance of customization and privacy
- Overestimated home shopping, video games, absolute cost and, especially, interactivity

Executives seem to have excessive desire for a "killer application" comparable to color in televisions. They are looking for single answers to questions like the nature of the set-top box, rather than the likely multiplicity of interfaces.

Investors' Perspective

From an investment perspective, we decided we don't care who wins. What is being delivered on the information superhighway is much more important than how it is delivered. The consumer market will evolve much more slowly than we are accustomed to in technology.

A big issue is, "Who will pay?" There will be real resistance to passing the costs to the consumer. Another issue is whether the channel will be the current cable systems, telecom companies, or modems on PCs. We feel there will be a variety of ways.

We want to invest in companies that are developing niches and parts of the highway, companies that are participating incrementally in the incremental growth of the superhighway. Don't put your bets on the all-or-nothing super applications.

We look at the enabling technologies for the superhighway and multimedia. The semiconductor area will enable the greatly increased bandwidth and processing speed that is needed. Venture capital will participate here as it has in the past.

Distribution is different with the big guys and multibillion dollar mergers. It is hard to imagine a role for venture capital here.

Content providers present an opportunity similar to software of 10 or 15 years ago. The market is growing exponentially, manufacturing costs are low, the margins are very high, and not much money is needed to get started. We divide this market in three parts:

- Applications, driving by knowledge of the industry being served
- Entertainment, a very different business, with opportunity, but difficult for venture capitalists
- Education, lots of opportunities, but revolutionary in that it changes the way people will be educated. Real innovation, knowledge of teaching, and questioning current products is needed.

The payoffs in multimedia content can be very large. CD-ROM is growing and is today's version of future multimedia. Current products are coming from technology companies but this will become like the book or movie businesses.

H&Q Specific Investments

Hambrecht & Quist's specific investment in this field include:

- America Online
- Advanced Fiber Communications (working on digital loop technologies for rural markets and to delver telephone service by TV cable systems)
- Adobe (an early investor and now forming joint ventures with Adobe and other companies to develop applications on Acrobat)
- Cascade (pre-Press software
- ESPS (drug application filing document handling)
- Access (horse betting information and algorithms)

We are looking for interesting content, perhaps with a different twist, such as advertising delivery to offset superhighway costs.

This is a growing market that is starting be become a river and will be an ocean. There are enormous opportunities to develop good businesses.

Can the Chip Market Live without the PC?

Gregory L. Sheppard
Director and Principal Analyst
Semiconductor Application Markets Worldwide
Dataquest Incorporated

Dale L. Ford
Industry Analyst
Semiconductor Group
Dataquest Incorporated

Agenda: Worldwide Electronic Equipment Market; Semiconductor Applications

Worldwide Electronic Equipment Market

The total market is over $670 billion, growing at 5.6% through 1998. Electronics represents about 3% of the GNP in developed countries, but as high as 10% in some Asian countries. Computers are 32% of the total; consumer products, 22%; communications, 20%; and, industrial 16%.

Asia/Pacific production of electronic equipment will equal that in North America by 1998. This area will continue to subcontract to the U.S. and Japan and will also have strong demand in its local markets.

Semiconductor Applications

Total semiconductor manufacturing is over $107, growing in double digits. Of the total, 46% is for computers; 20%, consumer; 16%, communications; and, 10%, industrial. PCs is the largest share, but consumer video is about $7.5 billion; automotive, $5 billion; premises telecom, over $4 billion; storage systems, $4 billion; consumer audio, $3.5 billion; and mobile and public telecom each about the same at $3.5 billion.

PCs will grow at 15% based on:

- corporate downsizing
- home offices and telecommuting
- computer-based education (including many multimedia PCs in homes)
- movement into many geographic regions
- increased acceptability, due to more user friendliness (semiconductor market is boosted by the influx of new users and by the requirement for more powerful semiconductors to make the computers more user friendly)

By 1998, the **computer market** will reach 86 million units and $182 billion.

- Nearly 33 million units will be for the desktop
- Notebooks and multimedia PCs will sell over 4 million
- Subnotebooks and palmtops will grow at 86% and 102%, respectively
- Supercomputers and workstations will have lower volumes and growth rates of 15% and 10%, respectively

For **storage** 3.5-inch rigid drives dominate, with 44 million in 1993 but their growth is about 10% average until 1998. CD-ROMs have growth of about 25% and volumes of about 6 million. The next generation of mobile products will move to 1.8-inch disks, growing at 192%.

In the **small and home office**, ink-jet printers have high volume and growth. Page printers have increasing capability at the high end and are becoming more competitive at the low end. Powerful computers may do more of the processing work, allowing cheaper printers. Scanners and digital video are growth opportunities.

In **communications**, intelligent hub ports and LAN cards combine high volume and growth through 1998.

- Wireless LAN cards and routers lead in growth.
- Modems are strong.
- Drivers here are office LANs, e-mail, and groupware.

- High speed transmission solutions will increase in LANs (100Mbps)and WANs (T1E1, ATM, T3, and frame relay).
- Digital cellular and cordless will dominate in 1998. Digital answering machines will also be a good market.

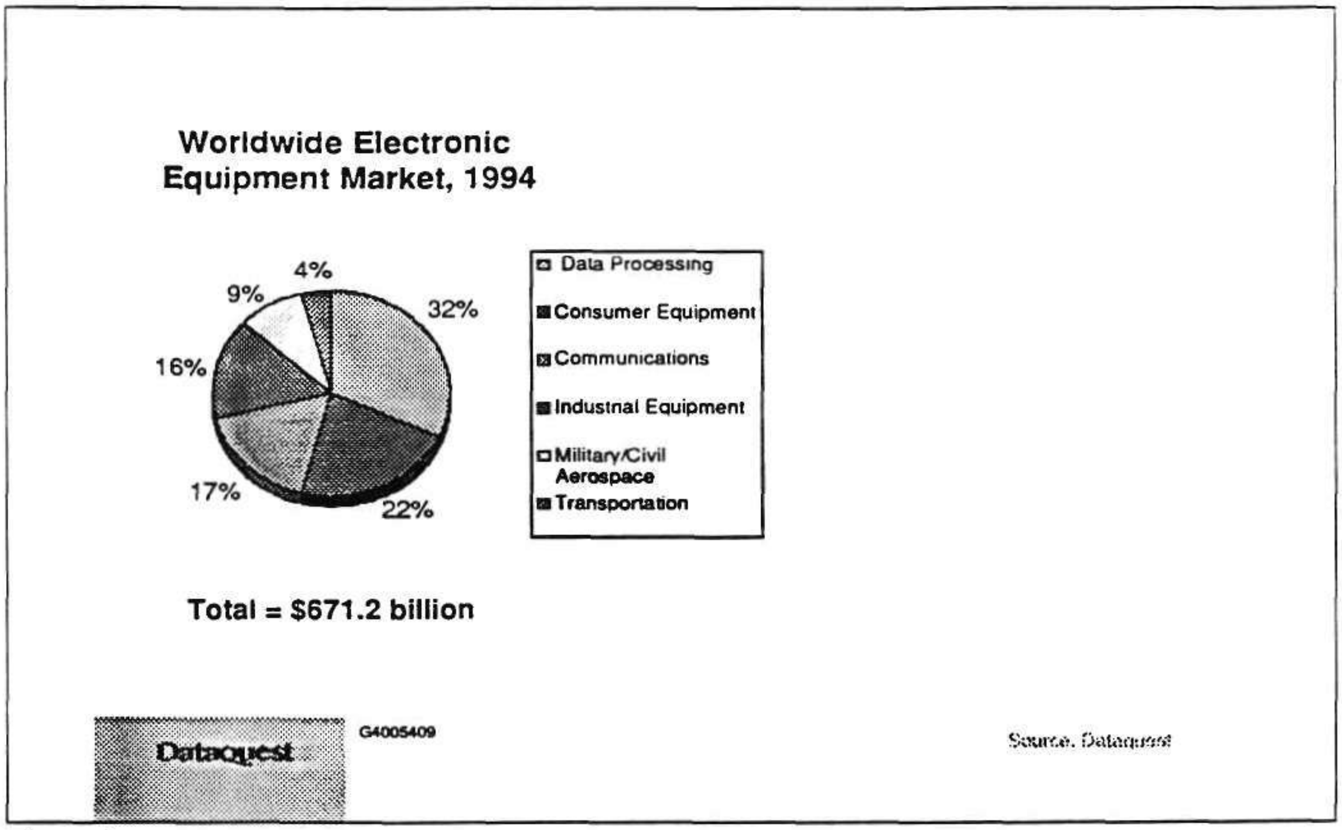
In **home video**, 32/64-bit games, digital set-top boxes, and camcorders will have high growth. Direct satellite broadcasting is emerging strongly. CD video has the potential to compete with VCRs. Key technologies include compression; integrated audio/video chip sets; demodulation; and DSP.

Most of the new or redesigned **automobiles** introduced each year are opportunities for new electronics modules. Engine controls, basic stereo, airbags, and ABS have the highest volumes, but the highest growth rates are in airbag controls, multiplex systems, CD sound, and security.

Medical and industrial instrumentation and controls have the same interests as other segments — portability, programmability, and networking. The question is whether more expenditures for electronics will decrease the overall cost of these operations through early detection and better quality.

Summary

- Electronics will continue strong through the decade
- PCs dominate, but there are many other high-growth, high-volume areas
- Wired and wireless communications and interactive consumer systems are hot
- The booming specific products are CD-ROM drives, ink-jet printers, intelligent hub ports, digital cellular telephones, digital cable and DBS, and air-bag controls
- Business success keys are planning, partnerships, and persistence



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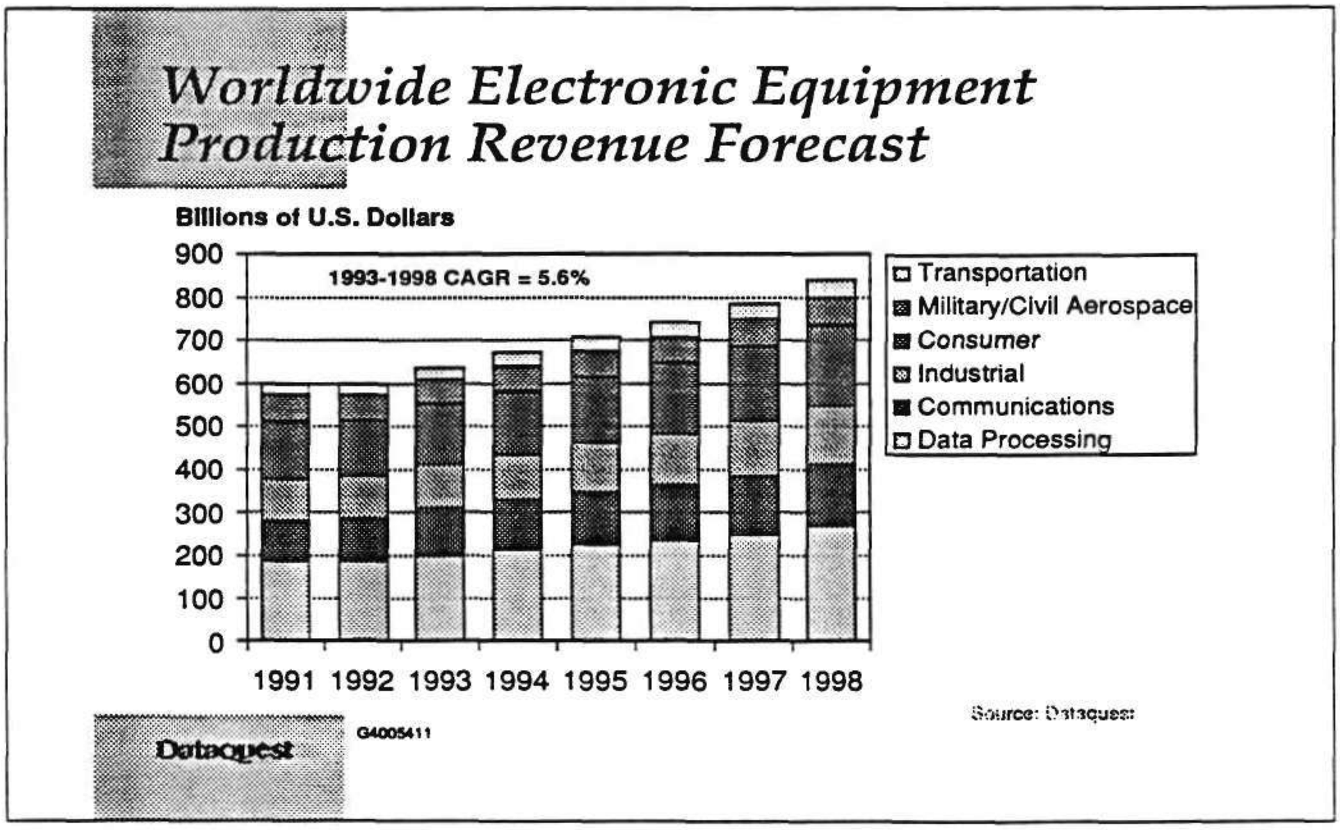


Figure 2

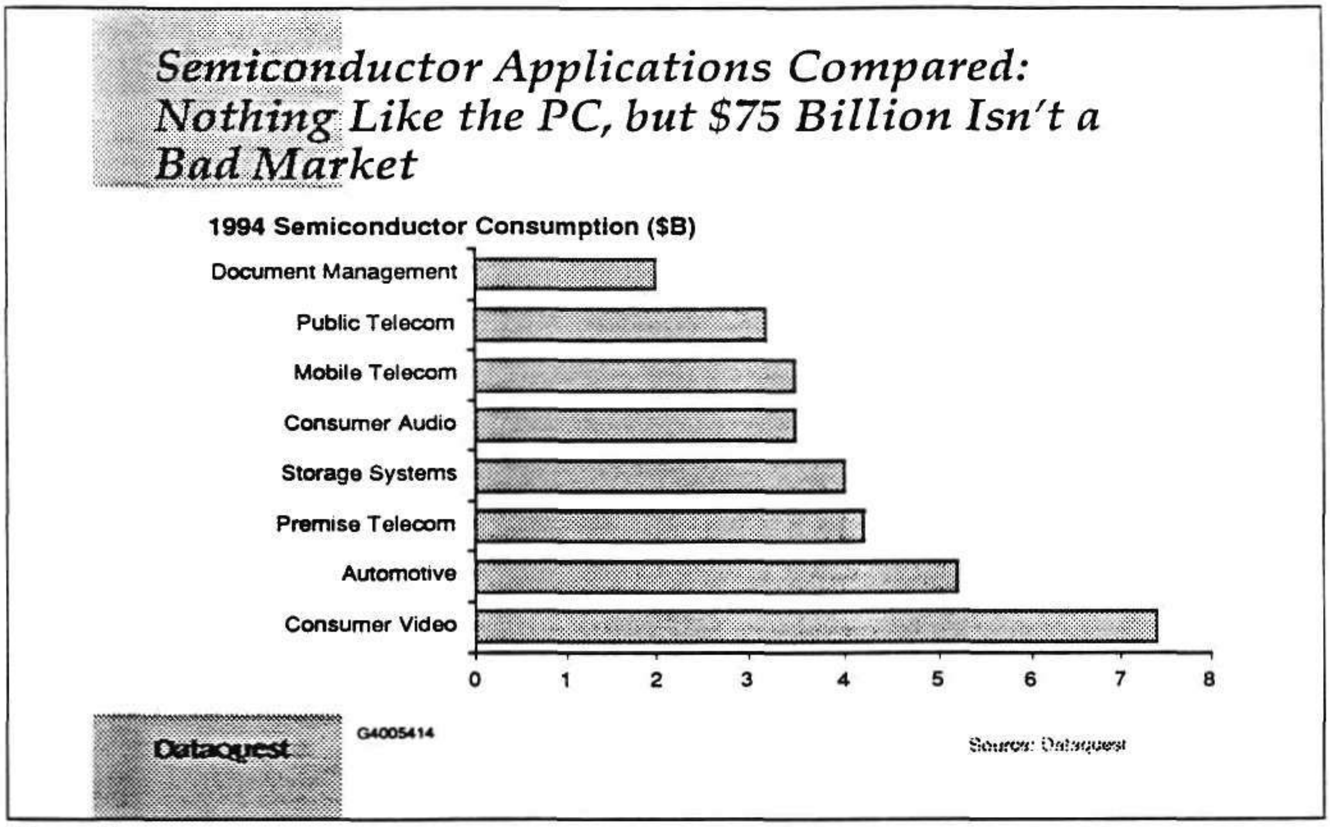


Figure 3

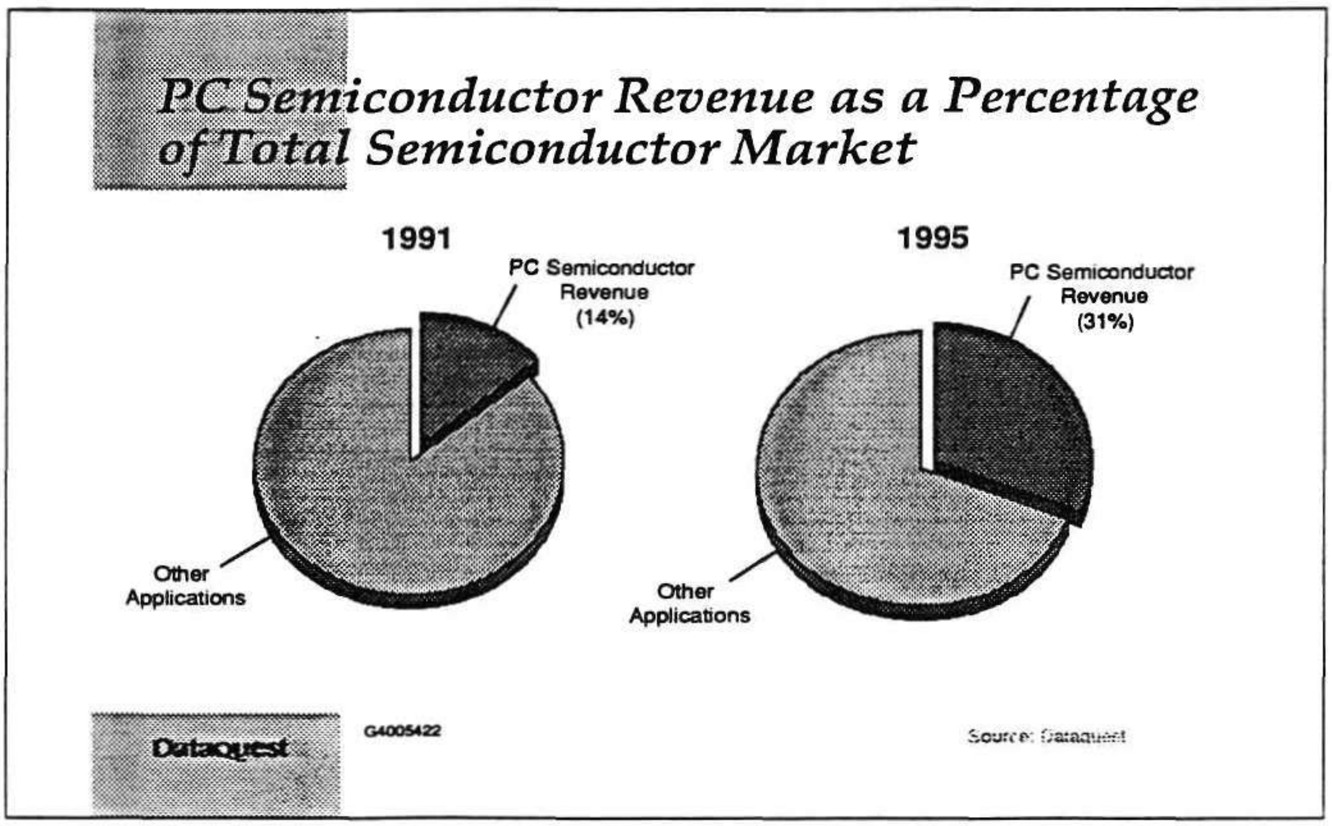


Figure 4

PCs Versus TVs: Catering to the Couch Potato

Doug Dunn
Chairman and CEO
Philips Semiconductors

Agenda: Multimedia Value-Added Chain: Philip's Polygram Participation; Implications for Semiconductor Companies

Multimedia Value-Added Chain

The industry's main objective is delivering information to the customer. The following represent the links in the value chain:

- **Content.** Includes artists, musicians, vocalists, authors, journalists, writers, and photographers—basically, all the people who create the content.

  This was a $52 billion market in 1993.

- **Packaging.** People who are involve in the editing, formatting, and integrating of advertising. These people include publishers; TV, cable and satellite network operators; film studios; and the music publishers.

  This represented a $68 billion market in 1993.

- **Distribution.** These are the distribution and the transport people, who soak up most of the dollars at $267 billion. Includes cable, telcos, satellite companies, movie theaters, retailers.

- **Site Access Providers.** This is where the set-top box begins to fit into the value chain, and is a $30 billion market. This sector is composed of set-top boxes, multimedia PC, CD-ROM, PDAs, TV, VCRs, CD, and CDI.

- **Audience/Advertisers:** Advertisers represent $130 billion of input into this value chain. No value has been assigned the audience.

Philip's Polygram Participation

Philips has across-the-board access to the value chain. It makes interactive titles/CDIs, produces video production equipment and TVs, produces movies, developed and invented CD and CD-ROM, owns cable companies.

Many of the features of this total value chain will benefit companies like Philips, who can show across-the-board access to this multimedia chain.

Implications for Semiconductor companies

- User access portion—$30 billion
- Set-top boxes—$500 million to $1 billion
- Silicon content small—perhaps 20 percent

The challenge to content providers and set-top box providers is to stimulate the market to get a bigger ramp-up than what is in the marketplace today.

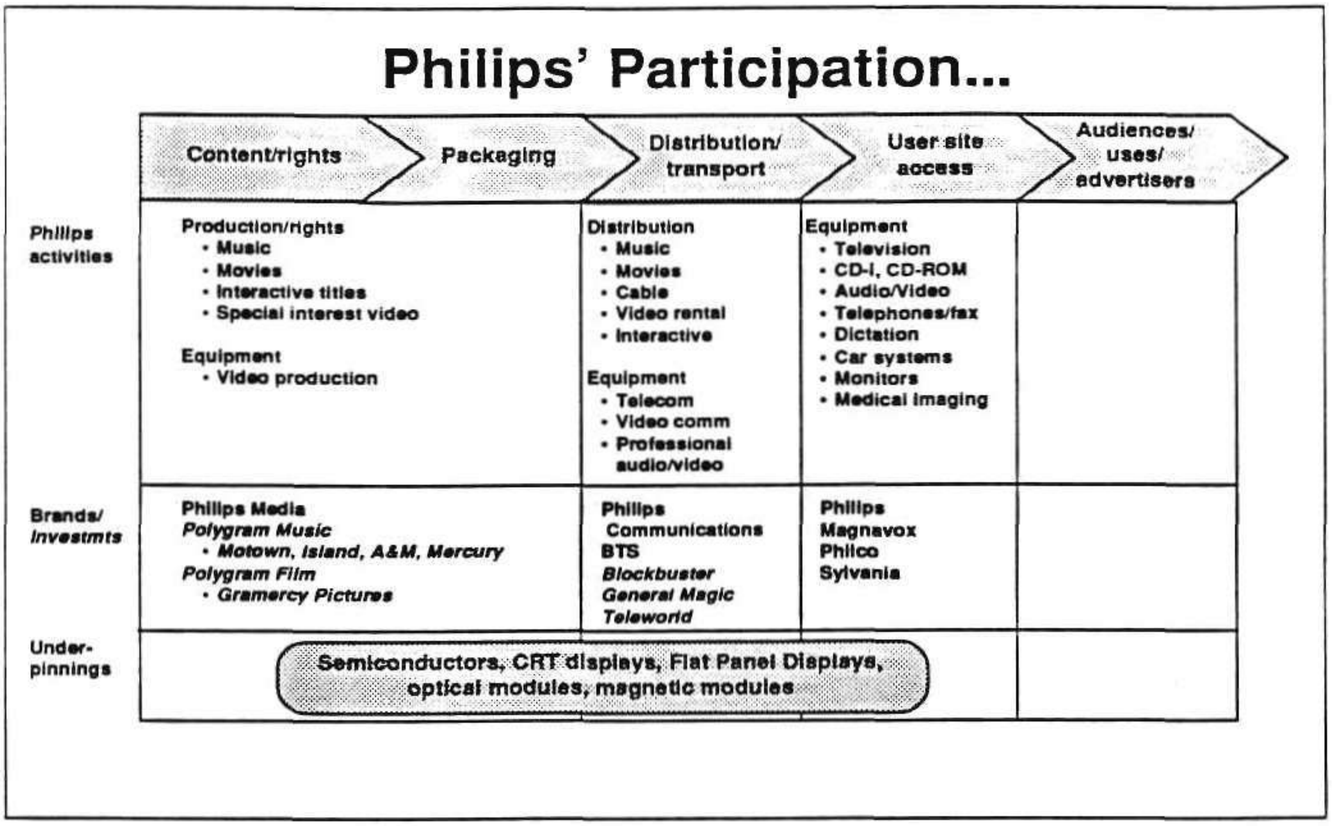

Philips' Participation...
Content/rights
Packaging
Distribution/ transport
User site access
Audiences/ uses/ advertisers
Philips activities
Production/rights
• Music
• Movies
• Interactive titles
• Special interest video
Equipment
• Video production
Distribution
• Music
• Movies
• Cable
• Video rental
• Interactive
Equipment
• Telecom
• Video comm
• Professional audio/video
Equipment
• Television
• CD-I, CD-ROM
• Audio/Video
• Telephones/fax
• Dictation
• Car systems
• Monitors
• Medical imaging
Brands/ Investmts
Philips Media
Polygram Music
• Motown, Island, A&M, Mercury
Polygram Film
• Gramercy Pictures
Philips Communications
BTS
Blockbuster
General Magic
Teleworld
Philips
Magnavox
Philco
Sylvania
Under-pinnings
Semiconductors, CRT displays, Flat Panel Displays, optical modules, magnetic modules

Figure 1

PCs Versus TVs: Catering to the Couch Potato

Ichiro Fujitaka
Vice President
Systems Application Engineering and General Manager
Microcomputer Semiconductor Business Unit
NEC Electronics Inc.

Agenda: NEC Electronics Organization; Set-Top Box Business; Three Issues for Silicon Providers

NEC Electronics Organization

Within the Microcomputer Semiconductor Business Unit there are three groups.

- Microproducts Group
- ASIC Group
- Systems Application Engineering: This is a new group, with the purpose of providing systems solutions. It focuses on high-end technology in emerging markets, and aims to drive the market based on the needs of the customer.

The Set-Top Box Business

Most customers—hardware manufacturers, cable companies—are requesting silicon vendors to integrate image handling, voice handling, game manipulation, and computer performance.

Most customers would prefer to pay under $300 per set-top box, and preferably under $100. It is impossible at this stage to provide it at this price at this time, so there is a huge gap between the silicon vendors and the customers.

Vendors need to focus more carefully on the customer structure.

Three Issues for Silicon Providers

- **Content**—still unclear what customers want
- **Cost of the Set-Top Box**—the consumer will not pay more than $500 for a set-top box.
- **How to support the set-top box business**
  - Need to evaluate strategies carefully
  - Issues of usage, failure rates, replacement parts
  - Possibility of modular approach for additional functions

Summary

A suggestion to close the gap between the customer expectations and semiconductor manufacturer realities is to gradually add simple functions on the CATV converter box, one at a time. Taking the modular approach, train the consumer step by step and ask them to pay $100 per basic box per year.

If we can establish this trend in the market, semiconductor manufacturers could establish a thriving business in the set-top box market.

PCs Versus TVs: Catering to the Couch Potato

Robert Luff
Chief Technical Officer
Broadband Communications Group
Scientific-Atlanta Inc.

Agenda: Scientific-Atlanta: Three Core Drivers

Scientific-Atlanta

Scientific-Atlanta is the dominant broadband end-to-end network provider. We sell technology to and manufacture equipment for the cable television industry and the Regional Bell Operating Companies (RBOC) industry.

We have approximately 70 percent of the head end, which is where signals are received, processed, and put on the channels.

We are the worldwide market leader in the actual optical electronics, laser transmitters, and optical node receivers. We are the second largest supplier of set-tops: the number one supplier of the advanced hybrid/digital set tops and second in analog set-tops.

Scientific-Atlanta is nearly a $1 billion per year company, with one-third of the revenues derived from outside the U.S.

We have been selected as the technology supplier for the two most visible high-technology demonstrations of broadband multimedia full service networks: Time Warner (Orlando, Florida) and the RBOC U.S. West (Omaha).

Three Core Drivers

Hybrid fiber/coax: Appears to be the adopted platform and will be launched to the public. It has massive bandwidth at a low price.

Coax already reaches 90 percent of U.S. homes. Therefore, there is current infrastructure in place to allow these services "without digging up America."

The advantages are cost, bandwidth, transparent network (as new services are added, it is only necessary to do installation in the head end and in individual homes, as opposed to replacing equipment in each optical fiber node).

Standards is still an issue and a risk. There are at least 37 items that have to be interoperable. These need to be resolved in order to jump-start content creation and drive wide cross-industry support.

Analog/Digital:

- Digital has the most channels, is the high-tech solution with its end-to-end digital transparency. However, it has diminishing returns, the highest cost per channel, and has a high technology risk.

- Hybrid analog/digital allows for continued transmission in analog, is cheap, is friendly, gives whole-house service (digital needs a set-top, which is an added cost).

Blueprint for the electronic superhighway—3 stages

- Networks and cable are increasing the bandwidths, supporting the existing set- tops, adding incremental advanced features and digital electronic program guide, and adding interactive offline Sega channels and interfaces to Internet.

- Digital broadcast can then be deployed—not video-or-demand or interactive—at a low cost (don't need lots of interactivity and the extra associated costs).

- It is full service, full interactive demand, and will happen between 1996 to 1997. This trend will accelerate or decelerate, based on the experiences of Time Warner and U.S. West.

PCs Versus TVs: Catering to the Couch Potato

Theodore M. Hoff
Senior Vice President and General Manager
Fox Interactive

Agenda: Consumer Business; Case Study—Video Games; Publishing Industry Request

Consumer Business

Technology does not drive consumer markets. Content, entertainment, information, consumer needs, and the needs of business are the drivers.

What the consumer is saying is, "Don't give me anything revolutionary." They want it to be easier, better, and with a higher quality than what they currently have.

Case Study—Video Games

A standalone industry, there are thousands of companies and retailers throughout the world whose livelihood is dependent on the consistent delivery of software for video games.

- The 16-bit cycle is mature and has penetrated over 20 million households.
- The 8-bit cycle has penetrated almost 30 million households.

Publishers believe that the cost of goods is so high that they must cut back on deliveries. This means the publishers are not hiring the developer and now the developer doesn't have the business to support the publisher. As a result, the retailer will only order 60 or 70 percent of what they previously ordered.

There will be a bloodbath in this business in the first half of 1995 because there is no safety net. There is no stable bridge between 16-bit and the next delivery system. The dedicated set-top companies, which have mastered the mass market for the last two generations, aren't ready yet. They must settle on standards.

The only opportunity for the publishers and for the software developers today is the PC. 20th Fox is plowing ahead in putting out every possible product they can on PC CD-ROM because it is the only game in town.

The publishers can't go back to the cartridge business because the cost of goods is too high and retailers don't want it; therefore, we must turn to the next generation of available hardware today, which is PC CD-ROM.

Publishing Industry Request

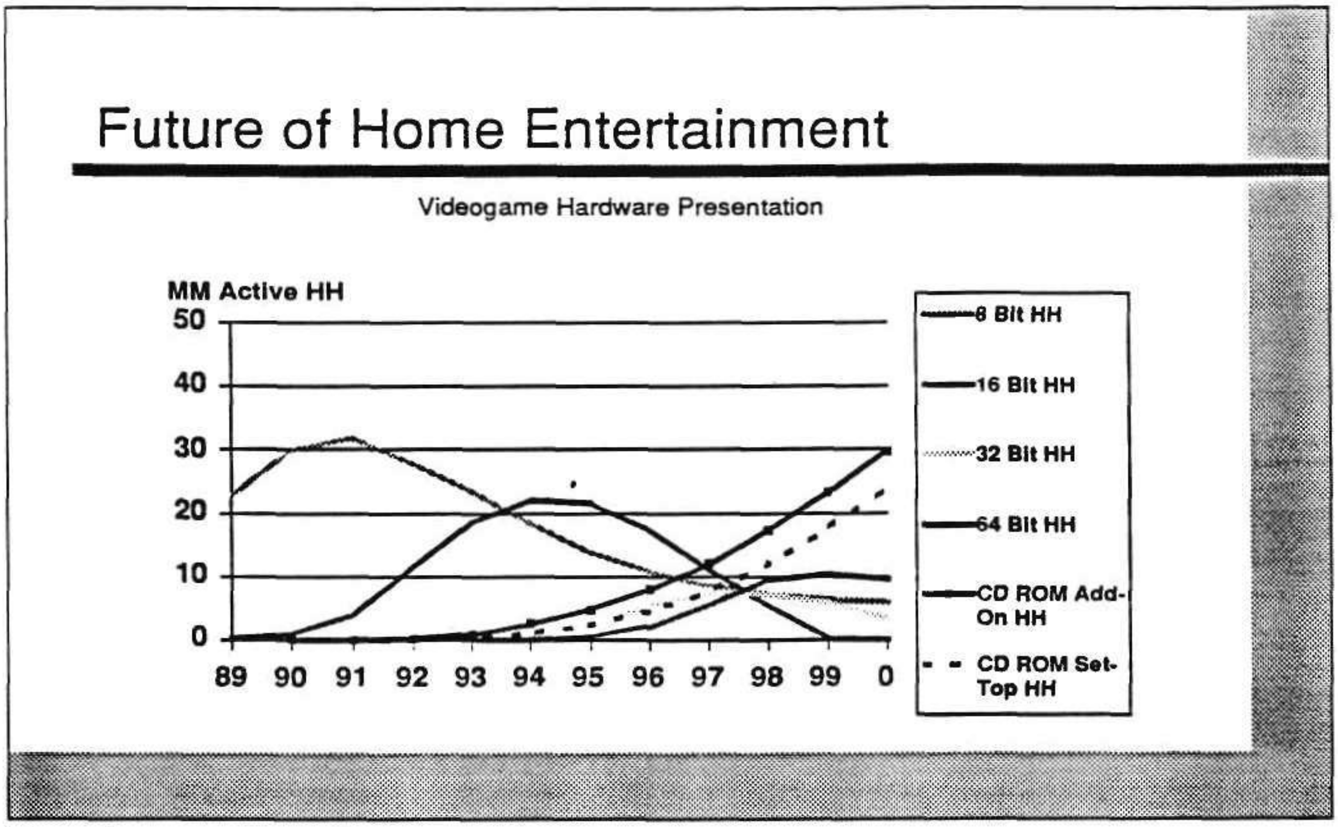
The publishing industry is requesting the semiconductor industry to:

- provide a transition in the marketplace, so we don't overwhelm the consumer or try to revolutionize this business

- give us a hardware vehicle that is consumer-priced, will play back CD-ROM products, and will receive delivery.

We have a multibillion dollar opportunity to sustain in the video game industry. The content providers are up to our knees in content, and we need to deliver our products on a PC CD-ROM.

We can deliver into either a TV or a PC because once it's into CD-ROM, we can bing that film to the consumer—either film clips or, with the MPEG standard, full motion, full screen, 30 frame-per-second film.



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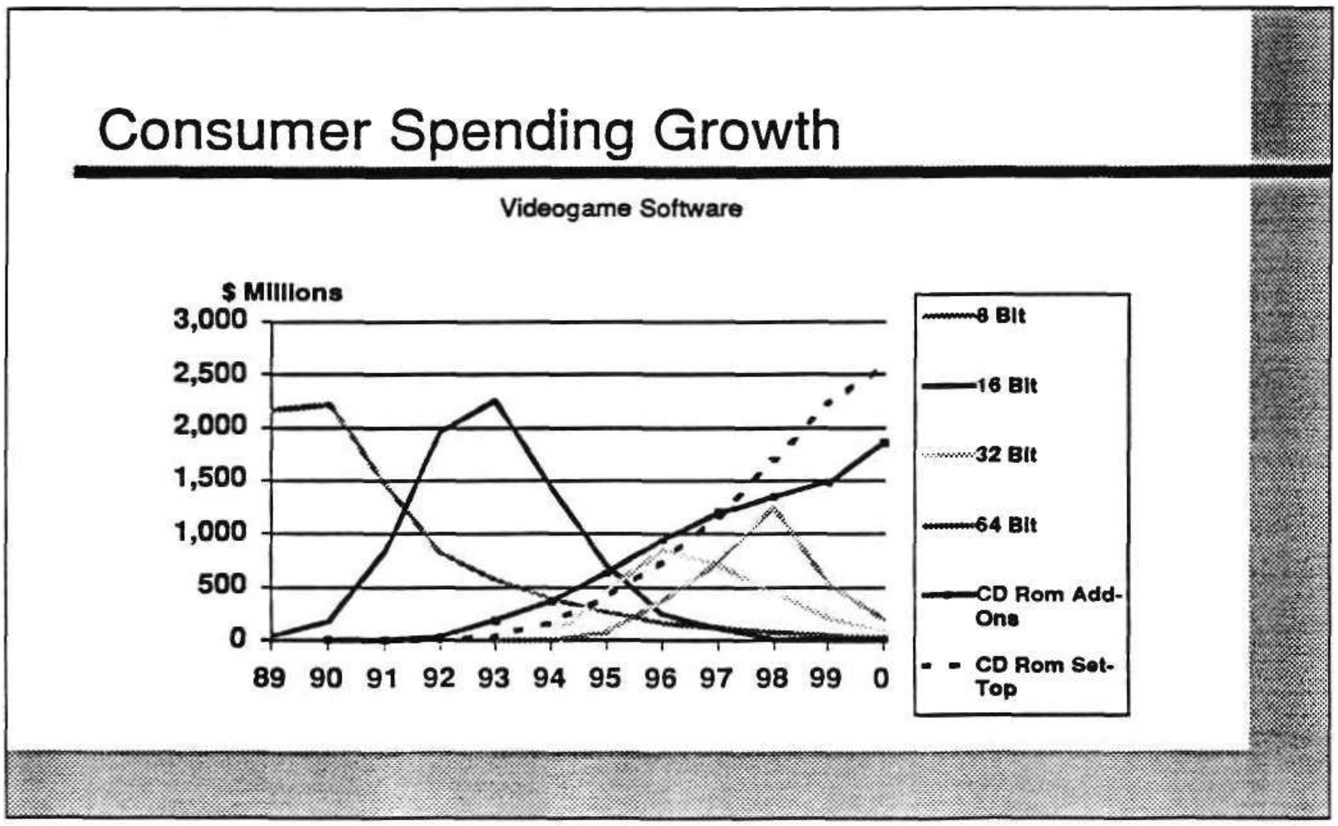

Figure 2

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Senior Vice President and General Manager
Fox Interactive

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Welcome and Conference Overview

Gene Norrett
Corporate Vice President and Director
Semiconductor Group
Dataquest Incorporated

Mr. Norrett: Well good morning ladies and gentlemen and welcome to our 20th anniversary of the U.S. Semiconductor Conference here in Paradise, and we sure are very excited to have you all with us today. This is the largest crowd that we've ever had attend a Dataquest Semeconductor Conference, and on behalf of the Dataquest management team and all of our associates we want to thank you for taking time out of your very busy schedules to be here.

The theme of our conference this year is the Semiconductor Horizon — Silicon Desert or High-Tech Oasis. We chose this theme because of the dichotomy in the semiconductor industry this year. To many emerging systems and fabless semiconductor companies, the extreme tightness of leading edge capacity makes these CEOs feel that the industry is extremely difficult for them to do business with and prevents them from achieving revenue and profit goals.

Conversely, for those lucky systems companies and medium- to large-size semiconductor companies that are receiving their precious chip allocations, the semiconductor industry is their high-tech oasis in the electronics desert.

Whichever type of company you are attending this conference, we hope that what we do here for you over these next two days will exceed your needs and your expectations, and that you will return to your offices having profited from the wisdom of our speakers.

This year we have changed our program quite substantially. In addition to a series of 30 minute presentations by Dataquest speakers, as well as industry executives, we thought we would switch over to a talk show or a fireside chat format. This we believe, will bring you closer to the issues that are really on your minds and facing this industry. So, on four different panels, we have brought here the leading experts in various parts of the electronics food chain, to discuss these issues and, hopefully, gain some insight as a result of having heard these discussions.

The first of these will be this afternoon, and the remaining three tomorrow. These panels will be managed and moderated by four of our semiconductor staff members. These are: Jerry "Monteil Williams" Banks moderating the panel PC 2000 — Chaos or Control. Following him will be Greg "Maury Povich" Sheppard, covering The Trends in Wireless Communications. Next is Clark

"Geraldo Rivera" Fuhs, who will be discussing The Future of Manufacturing. Lastly, we're going to have Jim "Phil Donahue" Handy, looking at The Future of the Set-top Box and, of all things, the Couch Potato. All of the moderators will be entertaining questions, not only from the panel members, but also from the people in the audience, and we encourage you, when you come up to the microphone to give us your name, and then state your question.

At this time, I'd like to give you a little information about the composition of the audience here today. We have six Chairmen or Vice Chairmen attending, we have 50 Presidents and CEOs, and we have approximately 100 Vice Presidents and Directors. These represent approximately 45 percent of all the attendees at this conference and we thank you for your support.

Tomorrow, your Master of Ceremonies will be Joe Grenier, Vice President and Director of our Semiconductor Equipment and Manufacturing Service, our Semiconductor Applications Service, and our Semiconductor Procurement Service.

In the foyer, we have the Dataquest staff, ready to demonstrate our new, user-friendly, electronically-delivered products on CD-ROM, and so forth. Please stop by that booth and see what we're doing. We also have on display, our semiconductor reports, which are contained in our various services, and you don't have to be a member of that particular service to purchase the reports. Also, you may purchase the Executive Summary and Transcripts from this conference, and we will have those ready for you in about 30 days. In the binders you will find some information about these reports. Also in the foyer, you will see a demo of our new tear-down service. In this service we are analyzing the manufacturing methods and cost for a variety of electronic systems, such as PCs, cellular phones, and also hard disk drives. This service represents a whole new endeavor for Dataquest.

In the foyer you will also see people demonstrating our DQ-Monday product, which is our weekly, online product that we are providing to our clients of the Semiconductor Services. Today, we estimate that there are about 25,000 people around the world, seeing this information every Monday morning.

There are also members from our Semiconductor Consulting Group, here in the audience and they can be indentified by the purple badges they are wearing.

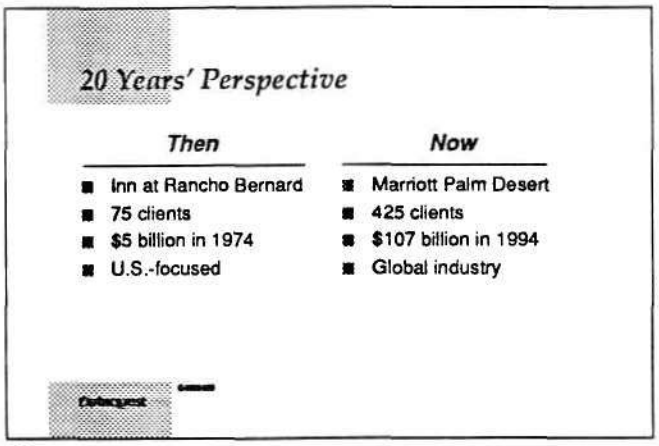


Figure 1

It's hard to believe that 20 years have passed since our first conference in the Inn at Rancho Bernardo, and I can tell you, things are quite different now. At that time, we had approximately 75 attendees, but as we all know, the industry was much smaller than today. Today we have over 400 people attending this conference, but then again the industry is much larger today.

Over the last twenty years we've increased the number of semiconductor conferences to three per year. In addition to our U.S. conference, we have a semiconductor conference in Europe in the first week of June, and we also have a semiconductor conference in Japan, around the second week of April. In total, we have annually 700 to 800 people attending our worldwide semiconductor conferences, and we thank you for your support. In 1974 the industry shipped about $5 billion. In 1994, we estimate that the industry is about $107.6 billion. In 1974 the industry was dominated by U.S. manufacturers controlling approximately 65 percent of the industry that, pretty much, had a U.S. and a European focus. Today, it is truly a global industry with factories, sales offices, and design centers all over the world. U.S. companies today control approximately 45 percent of the industry, Japanese about 40-42 percent, Europeans about 8 percent, and the Asia-Pacific folks about 7 percent.

To start this conference off, I thought it would be fun also to look at some of the important events that were taking place back in 1974. Some of the folks I've met here at this conference weren't even around then. But some of us who are getting white hair at the temples surely can think back to where they were approximately October of 1974, and what was happening at that time?

What I'm going to do is give you an idea of what was going on in the world and national news, the electronic industry, and then the semiconductor industry. Because of time constraints, I'm not going to go into each of these events but I'll just flash them up there, and let you think back to what you were doing at that time.

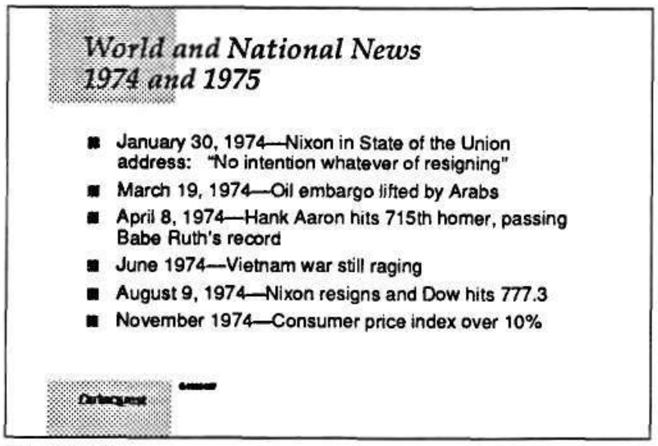


Figure 2

First, the world and national news. I was playing a game last night, talking to some of our clients, and asked them what were the really important things that happened that year? It was on August 9th, we had a president resign.

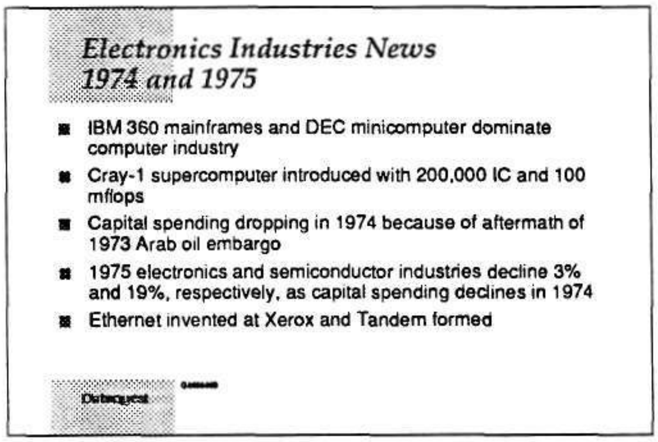


Figure 3

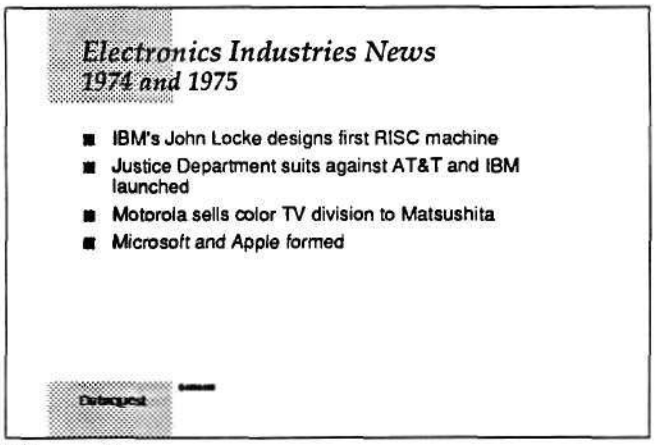


Figure 4

Now, from the electronics point of view, closer to home if you will, take a look at what was going on at that time. The industry was dominated by mainframe computers and we were beginning to see the minicomputer in the market. In fact, in that year, DEC jumped into the Fortune 500 for the first time. We were also faced with very difficult economic conditions, as well as a slowdown in the electronic industry and the semiconductor industry. I'm sure many of you will remember some of the decisions that you had to make at that time. They were very painful, weren't they?

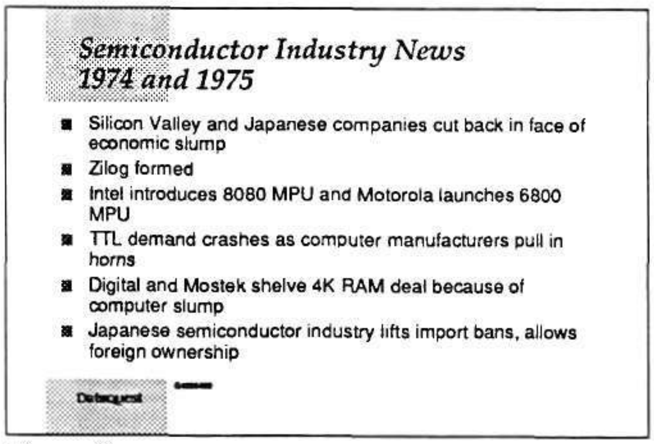


Figure 5

Okay, now the semiconductor news — hitting right home here. I'm sure you remember that the big semiconductor device families, in those days, were TTL, and 4K DRAMs.

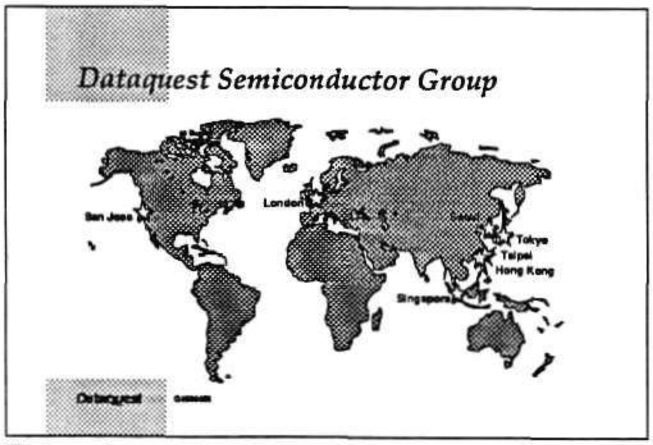


Figure 6

I'm now going to switch over to talking about what's happened to Dataquest over the last 20 years. As this slide shows, there have been many changes over the last 20 years. Today we have analysts spread all over the globe and the stars here show the locations where they are headquartered. Today, we have approximately 50 analysts, marketing managers, and consultants just following semiconductors. And in 1974, we had only three. We're very proud of our successes, and we want to thank all of you, our clients out there, for giving us your support over the last 20 years.

Next I'd like to roll into introducing Judy Hamilton, our President and CEO at Dataquest. Judy spoke to you last year and she is becoming much more familiar to many of the folks in the audience, as you come to our various conferences.

Judy is a 21-year veteran of the information technology industry. Prior to Dataquest, she was a partner and the National Director of Market Development for the Information Technology Operation of Ernst & Young. Prior to Ernst & Young, she was Vice President and General Manager of Computer Sciences Corporation, a Director of Systems Development Corporation, and founder and Chairman of Data Basics, a company that she sold to Systems Development Corporation.

Judy serves on many association boards, and is a frequent guest speaker throughout the industry. In 1993 and 1994, she participated in the prestigious Aspen Institute's Round Table on the Future of Technology. Please welcome Judy Hamilton.

President's Remarks

Judy Hamilton
President and Chief Executive Officer
Dataquest Incorporated

Ms. Hamilton: Thanks, Gene. And I'd like to add my welcome to all of you and thank you for being here, at this 20th anniversary Semiconductor Conference. I've been the President of Dataquest for two years and two months, so this makes my third Semiconductor Conference.

There are many of you that have been here for many more conferences than I have, but there are a lot of you who are new, and for you, I'd like to spend about 10 minutes giving an overview of Dataquest, and for those of you who have attended many conferences, I want to share with you some of the things that we're doing, that are pretty exciting, including an announcement of an activity that we completed this week.

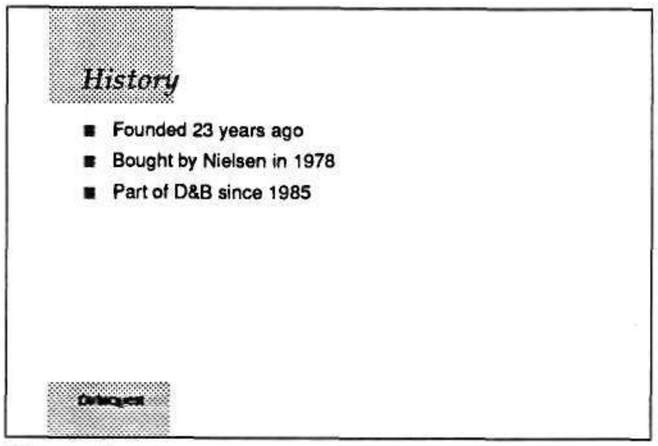


Figure 1

Dataquest was founded in the Silicon Valley in 1971, and started (believe it or not) as a copier market research firm. Dataquest quickly added semiconductors, but copiers was the original technology area covered. Over the years, we've added many more segments of the technology market. In 1978, the firm was purchased by A. C. Nielsen, and then became part of Dun & Bradstreet, when A. C. Nielsen was purchased by them, in 1985. So we're currently a wholly owned subsidiary of Dun & Bradstreet.

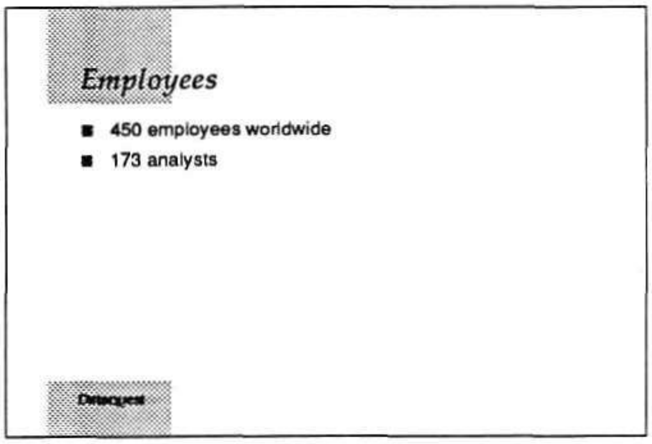


Figure 2

We have currently over 450 employees, worldwide, and of those, approximately half are either analysts or researchers. We're located in three different regions: Asia, Europe, and the United States. What we sell is the knowledge and the analysis of our people, the opinions of our people, as well as our statistics.

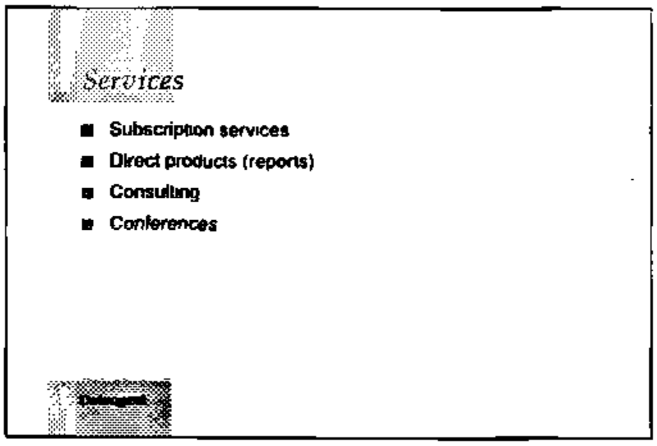


Figure 3

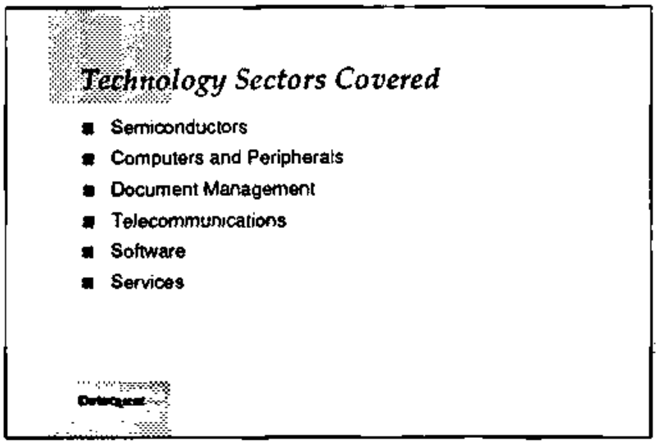


Figure 4

The way that we package all this is into subscription services, which are a predefined series of reports, available throughout the year, and complemented by inquiry or access to the analysts. We also do standalone reports, which we sell individually, and these are a good way for us to get into new markets.

For example, this year, we've done a series of reports on China that are a precursor to us doing a subscription service in that area. We do consulting, which many of you may not know, in all areas, and we have about 15 percent of our business currently in the consulting area.

And then we have conferences. In addition to conferences like this, that are associated with a service, we have one division that does nothing but conferences to which vendors are invited, to show their products and services. In the next couple months we'll be doing four of these in Latin America and three in China, just to give you an idea.

In addition to semiconductors, we cover a full range of services. We believe we're the only market research firm that goes from silicon to systems integration. We have more than 25 different product lines, but for the sake of our own organization and clarity, we divide into these six P&L areas.

Figure 5

We have offices in these different cities, and we also have sales agents throughout the world, so that, currently we're represented in three different regions.

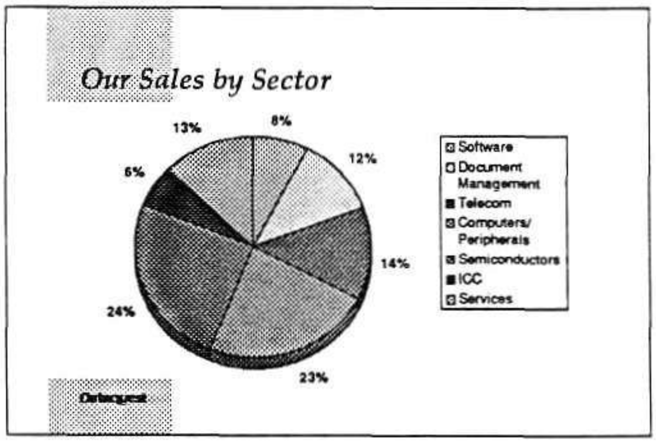


Figure 6

In fact, you might be interested to see how our revenue splits out by segment. You can see that semiconductors is approximately 25 percent of what we do. The fastest growing segments, in terms of our business, are software, telecommunications, and services. Our definition of services is systems integration, professional services, outsourcing, and traditional customer service.

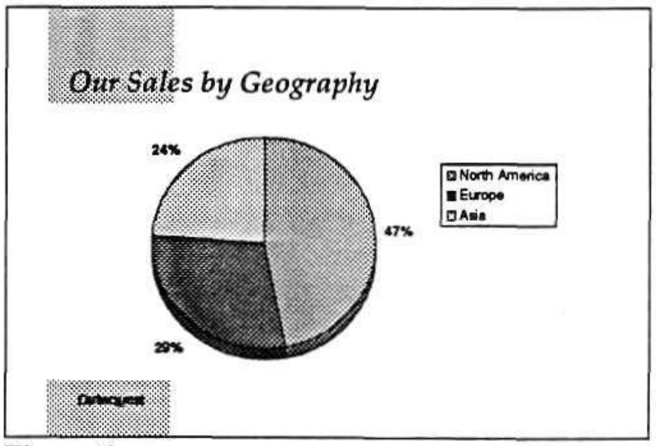


Figure 7

We consider ourselves a truly global company. As a matter of fact, 53 percent of our business, currently comes from outside the United States. Its pretty evenly divided between Europe and Asia. And most of our business in Asia, or at least a hefty percentage of it, has been based in Japan.

But we've found that the rest of Asia is growing the most rapidly for us, and we've felt, very much, that we needed to invest in our ability to provide information and opinions to you on Asia Pacific, outside of Japan. So I'm absolutely delighted to announce this morning that on Tuesday we signed an agreement to acquire the assets of the company that we believe is the leading provider of market research in Asia Pacific.

Figure 8

This company is called ResearchAsia, and its business dovetails very well with Dataquest's line of business. It's headquartered in Hong Kong, and has offices throughout Asia, including franchises in several Australian cities and in Beijing.

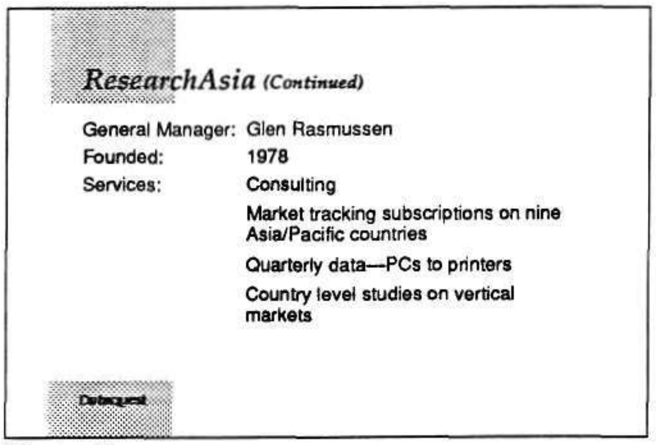


Figure 9

The company was founded by a gentleman named Glen Rassmussen, in 1978, so it has been around a long time.

Before founding that firm, Glen had been in Asia for well over a decade, working for IBM. ResearchAsia provides consulting, a lot of it in the services segment, it tracks the PC market, printer market, as well as some others, and does in-country tracking of end-user and vendor information in nine countries. So we are thrilled about this acquisition. It has not driven the stock of Dun & Bradstreet up by 12 percent, (reference pertains to prevailing rumors of Motorola acquiring Apple, which drove up Apple's stock,) but we still think it's a very important event in our ability to provide service for you, in Asia Pacific.

I want to spend just another minute telling you about some of the activities of Dataquest, over the last couple of years. I don't think it's any secret that Dataquest went through some hard times over the last few years. In a nutshell, the revenue flattened out, and whoever was controlling the costs didn't realize that. So, for about the same revenue that we had last year, we had 700 people and we're currently at 450 which should give you an idea of what we've been through.

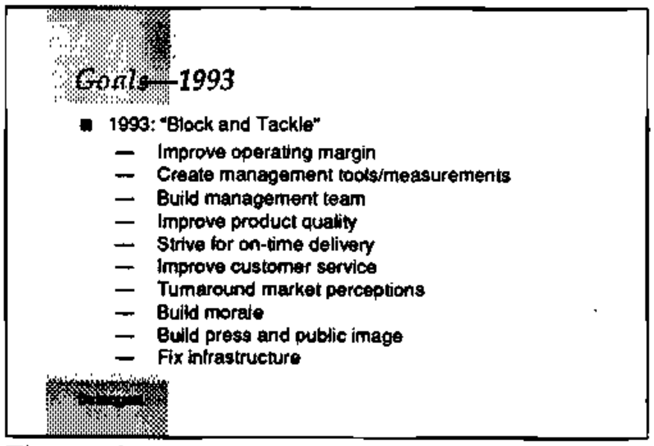


Figure 10

1993 was the year that I call block and tackle. We had to redo our infrastructure and regroup — get the quality up in our product, and get the things back on track, like on-time delivery, etc. We feel that we accomplished a good part of that in 1993, freeing us up this year to do more strategic things.

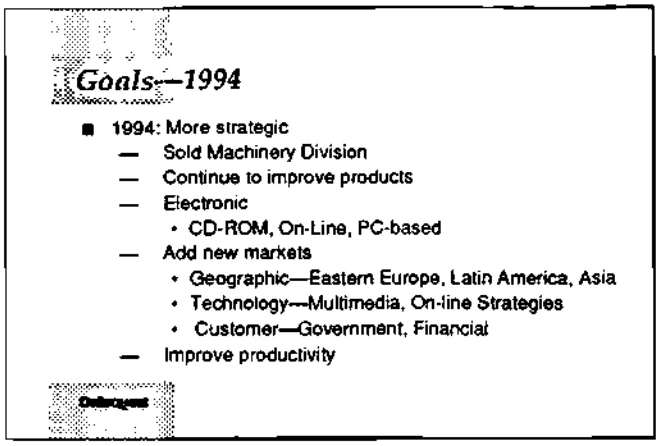


Figure 11

One of the things we did was sell a small division, a $6 million division, that was focused on the construction industry. It was, if you will, the provider of the blue book for the used construction industry. We sold that, in order to focus more on our main business.

We spent a lot of time on new products and new markets. And I think the thing that is most interesting and the most important is our foray into electronic delivery. We decided that one vehicle was not going to do it, that we didn't want to limit ourselves to just CD-ROM, or just online. So we've developed three different approaches, for three different market situations.

We have our CD-ROM in the marketplace. As of this month, we will be producing CD-ROM, on a monthly basis, and our intent is to keep updating our use of CD-ROM, to take more and more advantage of multimedia capabilities. Additionally, we're producing more and more of our information quarterly, available on the desktop PC, in a product we call Marketview. Also, we're exploring and presenting all kinds of online ideas, including developing the equivalent of a DQ-Monday newsletter in four other services, online, on a weekly basis.

We continue to work on productivity. We feel that we can do things better, all the time. So we have in-house teams working on that, and we're addressing new markets. With our acquisition of ResearchAsia, we intend to immediately piggyback on the work that they've already done in China, and construct a subscription service for the Chinese market this year.

So, I'll close with that. Again, I want to say welcome to all of you and I hope very much that you enjoy this conference. Thank you.

Keynote Address

Gary L. Tooker
Vice Chairman and CEO
Motorola Incorporated

Mr. Tooker: Thank you and congratulations to Dataquest on its first 20 years. Today I'm going to tell you about some trillion-dollar opportunities that we should see within the next 20 years — a trillion dollars in telecommunications equipment — or looking at it another way, a trillion dollars in wireless communications services and equipment

Your theme is a Palm Springs type of question — The Semiconductor Horizon: Silicon Desert or High-Tech Oasis? My answer is a positive one. I see a world of high-tech oases connected by a multiplicity of wired and wireless communications — a thriving world built on silicon and gallium arsenide.

Gene Norrett's recollections of what was going on 20 years ago set the stage. Yes, 1974 was a wild year — the kind of year that gave the semiconductor industry its boom-or-bust reputation. Sales set a record, despite the nose-dive at the end of the year that set the stage for a dreadful 1975.

But the news wasn't all bad. At Motorola, for example, we introduced the first complete family of associated microprocessor circuits that pointed the way to the kind of combinational technologies that have transformed the electronics industry. In 1974 we talked about 8-bit NMOS microprocessors that would enable the design of tabletop products with the computing power of the rooms of equipment needed a decade earlier. Today we talk about one-chip cellular telephones, with global capabilities.

A couple other trends in 1974 turned out to have a big impact on our industry. One was the concern over the environment, and the other was the effect of the Arab oil embargo. The auto makers realized they needed to design cars with lower emissions and better gas mileage.

The result was a microcontroller that would work under the hood of a car, one of the harshest environments possible for vibration and temperature. In today's era of combinational technology, one chip can guide a car's engine out of the desert and into the mountains without even breathing hard.

I'm not sure anyone in the '70s could really anticipate the changes that were taking place. The head of a distinguished mid-range computer company said in 1977, "There is no reason for an individual to have a computer in the home." The point isn't that one intelligent person failed to foresee what was going on. The point is that none of us can really predict the future.

We were also looking at the opportunities in telecommunications. We knew that semiconductors were the key. In the 1950s, Motorola had come out with a transistorized two-way mobile radio, which helped make us the leader in that business. In the '70s, we were doing lots of research into something called cellular telephone, which held great promise but was being held up by regulatory problems. A new industry called paging also looked interesting.

The Global Wireless Revolution: Now let's fast-forward to today. The semiconductor content of the typical digital cellular phone is greater than that of the average car ($129 vs. $110). We expect cellular to continue booming, and that's just part of the story. The digital revolution is transforming two-way land-mobile radio and paging, and technologies like personal communications and wireless data are just getting started. That's why I'm going to talk about wireless communications — the fastest growing market for semiconductors.

Today, this is what's different. We are in the middle of a communications explosion, driven by wireless and fed by massive amounts of silicon and, increasingly, gallium arsenide. How did it happen?

The end of the Cold War, coupled with a movement toward a market-based economies, has in recent years brought nations representing about four-fifths of the world's population into the global marketplace. These emerging nations have found that they need a new kind of infrastructure for the Information Age — a telecommunications infrastructure carrying voice, data, and image by radio and through wires. In this new globalized economy, the number of international phone calls has more than doubled in the last five years, from 23 billion to 47 billion.

We've heard about certain Asian countries where 98% of the people are waiting to get a telephone. The other 2% are waiting for a dial tone. Or in Vietnam, there was a story about a restaurant that was lucky enough to get a telephone. Next to the phone was a two-week sign-up board. If you paid the restaurant, you might be able to sign up to make a phone call in a 20-minute time slot a week from Tuesday.

Today, countries with 85% of the world's population have only 29% of the world's phone lines. Now there's an opportunity! Thanks to the semiconductor industry, there's good news for emerging nations — a telecommunications infrastructure can be implemented more quickly than it could a few years ago.

We keep hearing about orders for new systems in countries ranging from Argentina and Venezuela to Kazakhstan and the Ukraine; from Turkey and Qatar to China and Indonesia. And they're not just cellular systems. In China we have seen people create whole new ways to communicate using pagers. The conventional wisdom says you only use a pager if you can return a telephone call. But in China, where there are not nearly enough telephones, pagers are called "half-a-phone." People use pagers and code books to send messages. For example, the number 84 means the shipment has arrived, and number 98 means "Happy Birthday."

India is another enormous potential market for paging. Things are stirring. There are 900 million people there. Today, three million people are on waiting lists for telephones, and they can wait from one year to ten years to get connected.

Two-way land-mobile radio technologies are also becoming very popular in emerging markets. The dispatch systems first used by police, taxicabs or construction companies have evolved into shared digital systems that offer a wide range of services. Two-way land-mobile had 36 million subscribers last year, making it bigger than cellular. The Motorola Integrated Radio Systems, or MIRS, can include dispatch, telephone interconnect, short messaging and data capabilities in the same system.

What's happening on the service side? We are seeing rapid growth in a variety of personal communications technologies, especially in the densely populated areas in Asia. Microcellular systems, second-generation cordless telephone systems and wireless data networks are all helping to fill in the gaps and meet the exploding demand. As the pace of deregulation increases, we expect this trend to continue.

The best example that ties all of this together is the Iridium global communications system, which just completed its financing last month and is expected to be commercially available by the end of 1998. It will enable a person to make or receive calls over handheld pocket-sized telephones worldwide. The Iridium phone will permit users to interconnect with their cellular systems at home and with the constellation of 66 low-earth-orbit satellites while traveling. Services will include voice, data, facsimile, and paging.

Is there a market for these services? We think that if only one-half to one percent of all cellular subscribers use Iridium, it will be profitable. Today, there are almost half a million people willing to pay a significant premium to use nationwide paging. That's about 2% of the market. Global business travelers and government officials will find that Iridium is well worth the cost.

We see a world where the worldwide telecommunications industry could grow from about $1 trillion today to about $6.4 trillion by 2010. Most of that is on the service side, but about $1 trillion will be equipment. We think the wireless portion will be at least one-fifth of that total, or at least $200 billion. Looking at those estimates another way, we see wireless services and equipment as one-fifth of the total telecommunications industry, or more than $1.3 trillion. We think telecommunications will account for more than half the electronics industry.

To a great extent, the coming global communications revolution will be based on digital technology, and advances in semiconductor technology will be the driving force. Gordon Moore once observed that the industry comes out with a new generation of chips with four times as many transistors every three years. Today we have 16 megabit DRAMs that hold 500 pages of text. Under Moore's Law, in 20 years, a 64 gigabit DRAM would be able to store 27 sets of the Encyclopedia Britannica.

Microprocessor technology progresses about 5 percent per month, and shows an order of magnitude improvement every six years. Digital Signal Processors follow a similar trend. The increasing speed of processing has been a major driver of advanced wireless services.

All in all, the cost of computing has come down dramatically, and powerful devices keep getting smaller and smaller, consuming less and less power. We got pretty excited 25 years ago when Neil Armstrong sent his message from the Moon. Today's desktop computer is 1,200 times more powerful than the computer that guided the Apollo lunar lander to the Moon's surface.

I think everyone here can imagine a world in which you are in touch whenever you want to be — with just one device. If you don't want to travel to a conference like this, you could be next to a mountain stream, and with one device, watch the sessions, and take part in the discussions — all with one handheld device that combines two-way voice, data and image.

As new services evolve, you may own one phone number where you can be reached anytime. It will have a personal database with personalized screening lists and search priorities. You will be able to negotiate with service providers while keeping your personal number. When people call you, they will be calling a person, not a location.

The workplace will become increasingly wireless. Today, in the United States alone, 48 million workers are on the move, whether on an airplane or simply in another office in the same building. To serve these people, the so-called "mobility carriers" envision a seamless web of wired and wireless devices.

Today, it's voice service that pays the way for carriers. But we think there is a tremendous potential demand for data communications for those millions of mobile workers, whether they be globetrotters or corridor cruisers. Pagers have evolved into wireless answering machines. PDAs and wireless communicators are only in their infancy. But, in the years to come, we think they will become very popular with the millions of people who spend lots of time away from their desks and need to perform short-message data tasks or gain access to e-mail. Wireless data will make possible real-time two-way transaction processes that will pay the way for carriers.

There has been a lot of hype about PDAs, and a lot of disappointment that they didn't turn out to be an overnight sensation. This reaction is silly. It's the sort of thing that inspired Andy Grove to complain that "you people in the media bear a large degree of responsibility for being intellectually lazy."

The fact is that the real two-way wireless communicator isn't on the market yet, so it's pretty hard to judge market acceptance. Motorola will be shipping a product called "Envoy." As the name suggests, it marks the entrance into a new realm, not the last product. Our family of communicators will work on a variety of operating systems, and will be primarily a communications device. Later products will feature speech recognition, still images and graphics, and ultimately full-motion video.

This is an evolution taking place over a decade. History shows it takes about a decade for a new technology to gain broad consumer acceptance, be it television, VCRs or cellular phones. The folks who demand instant gratification will be disappointed.

What we are really talking about are wireless information skyways. Today we live in a world of private voice and public images. Let me clarify what I mean by that. Almost any individual can have an individual conversation on a voice telephone — wireless or otherwise. On the other hand, it's a world of public images, where only a few licensed broadcasters can transmit a television show or movie. It's broadcast, not narrowcast.

That's going to change. The real potential of the National — or Global — Information Infrastructure is that it will create a world of private images. Individuals will have access to image-based information and entertainment services. Those are what we call "pipes" that will deliver high-speed data as well as high-speed computing. And we have the potential to make it available to people on the move — to anyone, anywhere, anytime.

Think of it. Today, you buy a TV set that claims to be portable, and you plug it into a coax cable and a power outlet — or you buy a laptop computer and attach it to a telephone line. That will change.

This promise is based on three converging forces:

- The availability of bandwidth brought on by developments in fiber, signaling, allocation of spectrum, and satellites.
- The availability of computing power brought on by advances in the semiconductor industry.
- The emergence of competition and choice brought on by new telecommunications policies worldwide.

Applications. These forces enable us to envision a world in which people can talk face to face so that groups can interact and make decisions more quickly. Families are united though they live miles apart. Information access in the home and office make people more productive. Now envision the day when broadband wireless services are brought into line with broadband wired services. Then those millions of workers on the move will have the same tools as those who are stuck at their desks.

We can imagine a fundamental change in the nature of the workplace. Already, we see people spending more time typing e-mail messages than hanging around the water cooler. The computer has brought the world closer, but your neighbor is farther away. You're closer to people on the other side of the world than you are to the person in the next cubicle. The worker is in a network, and work is defined by the network, not the location. In the next 20 years, we'll find less and less reason to go to work at an office building. Rather than wasting time commuting, you'll work out of your home or spend more time with your customers.

What do these changes mean to a nation and its relationships with global corporations? We already have service companies in the U.S. where online transactions like billing and claims processing are performed in Europe or elsewhere. The greatest concentration of programmers outside of Silicon Valley is in Bangalore, India. The Asian students who came to U.S. graduate schools and stayed here to provide so much talent in our industry are increasingly going back to Asia. The U.S. — and the world — will never be the same.

We see new applications for wireless technology almost everywhere. Private land mobile communications today is used by all segments of the industrial, business, public safety, public service and transportation workforce. Going forward, law enforcement officers will have services such as two-way transmission of fingerprints, photos and warrants to and from people in the field. Imagine the advantages of the tactical use of live mobile video for hostage, arrest and surveillance operations. Wireless location devices can keep track of vehicles, personnel, prisoners or parolees.

As computers become more prevalent in education, the wireless LAN will provide a solution to the problems of classrooms without internally wired telephone systems. As the cost of computing drops, we can envision a wireless tablet in every student's backpack.

In the home, wireless networks will control everything from security, lighting and heating to sprinkler systems and stereos. Wireless applications extend to health care — for remote monitoring of patients, for example, and immediate response in the event of a crisis. Think of the benefits of transmitting visual signals and a doctor's instructions to support rescue operations, and transmitting high-resolution medical imagery and data from paramedics to hospitals.

To improve industrial productivity, wireless systems track personnel, inventories and vehicles. Efforts to conserve energy and control pollution are all made easier by wireless communications. On the highways, wireless systems can manage traffic, collect tolls electronically, pick out a good restaurant and guide you to your destination by the fastest route at the time.

That's just a sampling of what the wireless revolution is all about. We can project existing trends and predict that by the end of this decade, there will be well over 100 million cellular and PCS subscribers, up from about 32 million at the end of 1993. The paging industry should grow from 50 million to 150 million subscribers. The wireless data industry should come out of nowhere to reach as many as 20 million users.

Between the year 2000 and 2010, if these industries continue to grow at 25% a year, the world would have more than a billion cellular phones, a billion pagers, and 190 million wireless data services. Regardless of what ballpark figures you use, we are going to be surprised.

Spectrum. Of course, these new services will require additional space in the radio frequency spectrum. In the United States, the FCC has opened up much-needed spectrum for PCS, and the results of the first auction show it was one of the most profitable decisions the government ever made.

Digital cellular and private systems have been possible because of the ability to re-mine existing spectrum. Looking forward, we need another 155 megahertz of spectrum for industrial and public safety services, Intelligent Vehicle Highway Systems and satellite services. More spectrum means more flexibility.

Beyond that, substantial additional spectrum will be required for data, paging, image or voice systems that provide flexible broadband capability, increased capacity, satellite system interconnectivity and global roaming. I am confident that this spectrum can be found, if we allow ourselves to find imaginative solutions. What would broadcast TV be like today if the broadcasters had been restricted to using empty portions of the AM/FM spectrum? Re-mining of existing broadcast spectrum is a possibility for delivery of broadband data and video.

We think the market for semiconductors in the wireless arena will grow at a compound annual rate of 18 to 22 percent over the next decade. What type of semiconductors will drive this revolution? At Motorola, we like to talk about combinational technologies — products that perform many of the radio functions on a few chips, or even a single chip. New wireless systems require information compression, spectrally efficient modulation and advanced system architectures. Low-cost, powerful microprocessors, highly-integrated ASICs and low-cost memory devices make it possible.

PowerPC microprocessors have a single architecture that scales across the entire spectrum of communications, computing and embedded products. For example, the low power and high energy characteristics that are vital to portable and wireless products are found in the PowerPC603 family. The MPC500 series of embedded controllers couples high performance with low cost.

Conclusion. As we look to the future, the outlook is quite different from the pessimism of 20 years ago. The industry is much stronger today. There is much more cooperation at the precompetitive level through consortia such as Sematech. Organizations like the SIA provide a strong voice for the industry. Manufacturers are working more closely with the equipment providers.

We look forward to a world of high-tech oases connected by wired and wireless communications. We realize that after all these years, we've barely begun to tap the possibilities of the semiconductor revolution. The future is truly an exciting one.

Thank you.

The Semiconductor Outlook: Where are the Surprises?

Gene Norrett
Corporate Vice President and Director
Semiconductor Group
Dataquest Incorporated

Mr. Norrett: My speech will get into the Dataquest semiconductor forecast for the worldwide semiconductor industry, out to 1998, but specifically focus on what we think is going to happen next year. This presentation is the result of the work of our worldwide product, applications, and regional analysts, who are responsible for producing information, analysis, and forecasts in their particular areas. First of all, these forecasts are analyzed, they are totaled, then modified, retotaled and presented here in my presentation. You will also hear their in-depth forecasts in the presentations that they will present later in the morning.

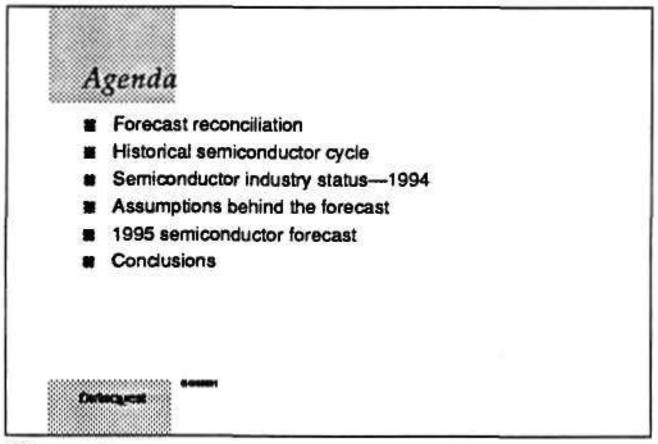


Figure 1

First, I want to talk a little bit about my agenda. Something that is painful for us but really I think important for us to do, and that is to look back to 1993 and tell you what we said about 1994, and then talk about where the surprises were. Then, I am going to talk about the historical semiconductor cycle and where we are in this cycle today. I think that once you get a picture of this you can kind of see where the industry is going to go for the next 6 to 12 months. Then I'm going to give you a summary of the status of the industry as we see it right now. Then I'll give you our assumptions for our 1995 forecast. Next year at this conference we will again compare our forecast versus actual and discuss the differences. Lastly, I'll give you our forecast for 1995 and draw some conclusions.

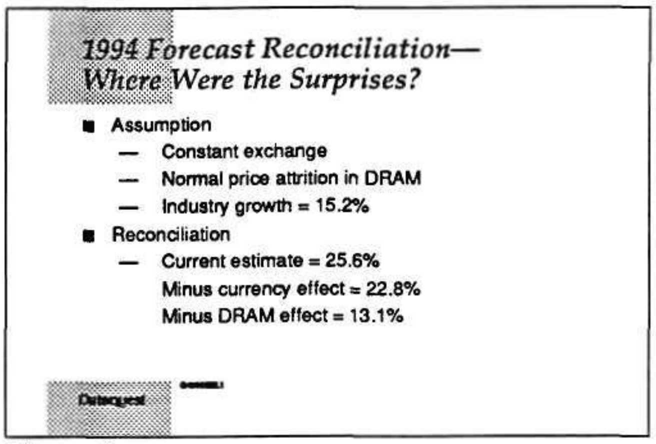


Figure 2

First of all the reconciliation. What I want to do is talk a little bit about where we were surprised, what we thought would happen and what actually happened. Before I do that, let me just review the assumptions that we made last year. We made two major assumptions. First is, as it always is, and many of you clients insist that we do this because you are dealing with these problems in your everyday business, and that is look at your business growth in a real sense, not with the currency fluctuations. So we assume a constant currency from about August or September of the current year through the following year.

The second thing is, we made an assumption about dynamic RAMs (DRAMs). We assumed that the DRAM price-per-megabyte was going to drop by 10 to 12 percent. We also then worked up our numbers and we concluded that the industry was going to grow by 15.2 percent. As you know, none of those forecasts occurred. The dollar effect of the appreciated yen was about $2.4 billion, and if we subtract this amount out of the industry, to try to get down to, if you will, the real terms, the result is the industry grew about 22.8 percent.

Now let's look a little at what happened to DRAMs. As I have said, we assumed a 10-12 percent decline, and actually it didn't happen; it went up, by about 7 percent. Really unusual for DRAMS — the semiconductor industry's most competitive product type — to go up by 7 percent. Nevertheless it did. The dollar effect of this, we believe, was about $8 billion. If you subtract this out of the previous number, what you end up with is growth of 13 percent. This actually turns out to be 1 percentage point less than the compound annual growth rate for the industry over the last 10 years including all of the foreign currency appreciation against the dollar. That was pretty surprising to us.

We were also surprised that the prices for the 486 microprocessor did not come under more competition this year and part of last year. We think Intel's competition's lack of capacity that Gary talked a little bit about, didn't allow for prices to drop. The result was that these competitors did not make a run at Intel. We were also surprised by the shortages in advanced standard logic as well as some of the discrete devices over the last 12 months.

So that you can get a much better look at our forecast for 1995, we are going to bring up our analysts and they're going to talk about their current assessment of the industry, their assumptions for the 1995 forecast, present their forecast, and give you some perspectives on what they think that particular forecast means to you all.

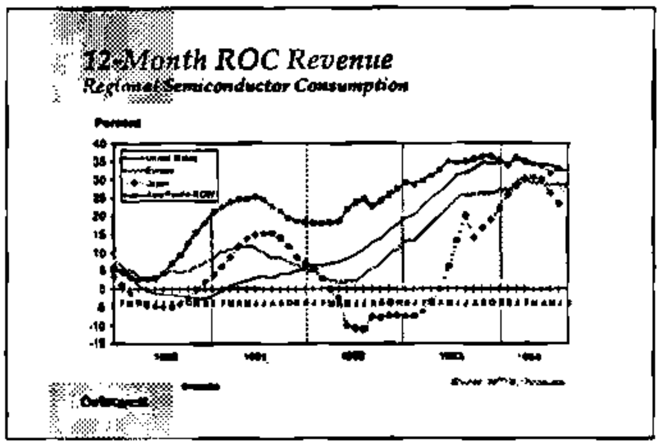


Figure 3

This is a very popular smoothing technique that we use to look at what the real underlying trend in the semiconductor industry is — I know many of you do this same analysis — not only for the total semiconductor industry, but also for the upstream and downstream industries. We use a 12-month moving average of the industry's revenues 12 months ago and we divide this into a 12-month moving average of the same period this year. What it does for us is tell us what the momentum in the industry is at the current time. It also has another advantage in that you can look at the December point and that tells you what the growth rate is for that particular year. Then you can also forecast out your own forecast by plugging it in to see where it's going to end up for the year.

We believe that all the regions of the world today are basically synchronized and driven by the pervasiveness of personal computers and personal communications. As you can see, all these curves have peaked and are turning down, but also notice that all of those curves are above the 20 percent growth rate mark. Very, very nice. That's 50 percent above the average growth rate for the industry over the last 10 years.

Also, notice that the fastest growing part of the world there is the Asia/Pacific region. Gary Tooker talked a little bit about that, and I'm going to talk a little bit more about it later in my presentation. We continue to be surprised on the upside in that particular part of the world. There are people that still believe that when the United States gets a cold, Asia/Pacific gets pneumonia. It's my belief that today those kinds of things have got to be reevaluated. We have to look much more carefully today at what's happening in this region, to see if the old relationships that used to exist between the United States and the Asia/Pacific region still hold true.

From our analysis, we think that all these curves are going to continue to show gradual declines over the next 12 months, but not precipitous ones. As our forecast for 1995 will show, we see these curves, except for Japan, remaining above the 15 percent level as we go out of 1995. The key message that I want to leave with you here is that we will see some shortages in 1995, but in general because of all the capacity that is being put in place, and all the improvements in efficiency, and getting yields up, we expect to see demand more in keeping with supply than what it was in 1994.

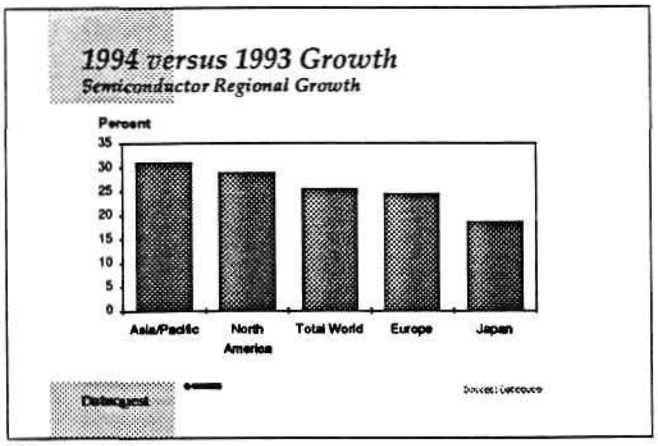


Figure 4

Let's just take a look at the Dataquest projections for 1994 by region. I'm going to talk about this chart as if 1994 is completed. However, some manufacturers say we still have a tough fourth quarter ahead. As this chart shows, Asia/Pacific is the fastest growing part of the world, followed by the United States and all the way to the far right is Japan, growing the slowest. No surprises. If you go back to our statistics last year, that's what we showed. The only difference is, the levels are higher than we had forecasted. Asia/Pacific continues to experience explosive growth due to personal computer demand in all parts of the region.

At the same time China is becoming an ever increasing factor in electronics manufacturing. For example, China produced 33 percent more electronics in the first five months of 1994 than it did in 1993. Also, Asia/Pacific is seeing increasing consumption of semiconductors in the Japanese factories that have taken up residence due to the effect of the appreciated yen.

At Dataquest, we research where the chip actually was consumed, and where it was manufactured. In this chart I show where the chip was consumed since it's important for us to be able to understand what's happening within the region. If you really understand this then you will be able to make decisions about making investments in a particular region. At the same time North America and Europe are experiencing continued growth due to the growth of personal computers as well as the increasing demand for higher electronic content in all of the toys that you are buying. Gary Tooker held up one of these very useful productivity devices that actually is changing many of the ways that we are operating our own businesses today.

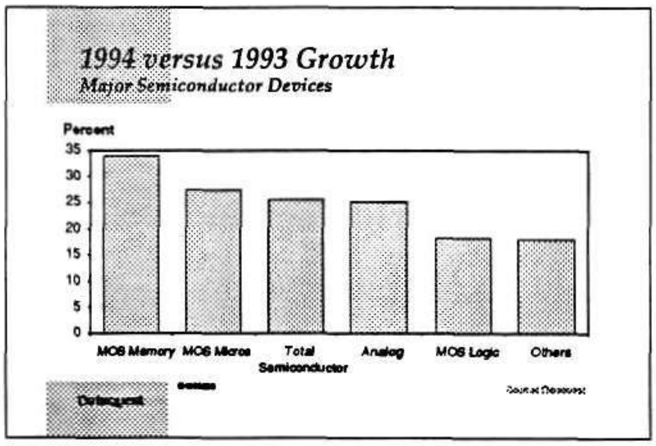


Figure 5

This is 1994 again, looking at it from a product point of view. Just like the twin towers in New York City, the bar charts for memories and microcomponents tower over the rest of the industry. Together these two product categories represent 53 percent of the total semiconductor industry. The 4Mb DRAM and the x86 microprocessors were the highest growth products in 1994. 4Mb DRAMs will grow approximately 29 percent, 486s 13 percent, and Pentium revenues are going to grow five-fold. So when you add those two product families together, what you end up with is 486s plus Pentiums growing at 45 percent this year.

In the MOS Logic category, the highest growth devices were cell-based ICs and PLDs, each growing 21 percent and gate arrays up 19 percent. In the Analog category, mixed-signal devices are growing at 33 percent, driven by personal communications and multimedia. And lastly, other semiconductors are growing approximately 17 percent, with the largest subcategory, discretes, growing at 19 percent. I'm sure this is not a surprise to Gary Tooker or to his peer at Toshiba because these two companies are the world's largest discrete manufacturers. It was a surprise to us.

1994 Industry Characteristics

- Semiconductor industry at capacity in 1994 because of past underinvestment
- PC, peripherals, and communication continue to be main engines
- Asia/Pacific, United States, and Europe leading the growth because of PC manufacturing
- 4Mb and 16Mb in short supply resulting from upgrades to Windows and underinvestment
- Capital spending is booming
- Profits rising throughout 1994

Dataquest

Figure 6

During 1994, demand has exceeded supply for most of the leading edge components. This has resulted from the past underinvestments in manufacturing capacity. Then, what results, of course, is angry customers and in many cases, some dislocations back through the food chain. For the fabless companies this capacity limitation has manifested itself in "chipmail", which is a form of high tech blackmail. Today we are seeing this situation lessening somewhat because of the considerable amount of additional capacity being put in place by the Koreans, the Japanese, and the Chinese manufacturers, who have traditionally been the largest suppliers of foundry services. With additional capacity coming on-stream, this will allow for more availability of foundry services in addition to allowing more devices to go to their own individual customers.

The Windows 3.1 explosion has also had a hand in the memory shortages as users have demanded more memory to handle all the advanced features of this powerful operating system. The other culprit in the memory shortage, as I've already said, is the significant underinvestment in Japan. And finally, regarding the underinvestment in 1992 and 1993, it seems like the industry has just awakened. We've had this boom in capital investment that I'm going to show you a little chart on and Clark Fuhs, who is responsible for our equipment and materials analysis, will go into in much more depth after the coffee break.

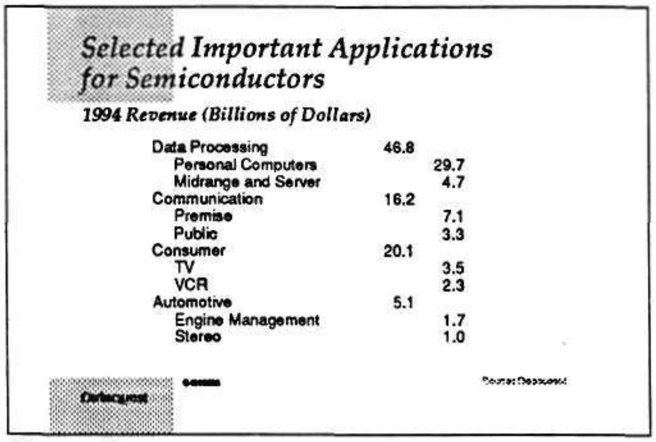


Figure 7

Thanks to our analysts in our Semiconductor Applications Services, I can give you this abbreviated list of some of the major applications for semiconductors. Gary Tooker talked about a whole long list; actually what we do with that kind of a list is we analyze the semiconductor content, project what we think the number of units will be for those end systems, and arrive at what we call our demand-side forecast. This is some of the work that is done in that particular group. Within the data processing category, which in itself controls approximately 47 percent of the total available market for semiconductors, we find that PCs, mid-range computers and servers represent 34 percent of the total semiconductor TAM. Never was it truer said that as the computer industry goes, so goes the semiconductor industry.

Premise communications systems is the next biggest category with 7.1 percent. Within this category we find a large demand for networking, modem, and line card chips such as SLICs and SLACs. Some of the other important applications are shown here.

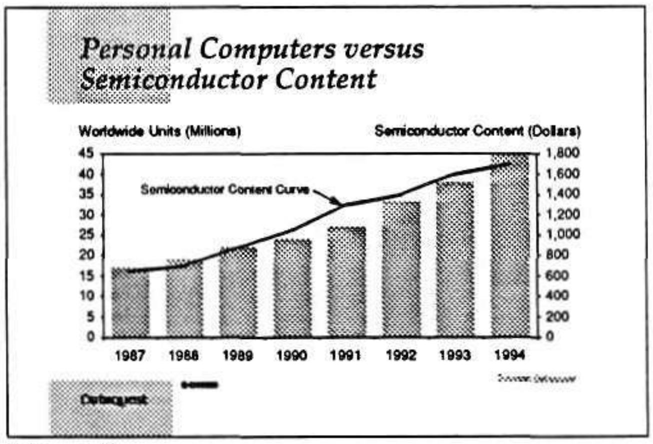
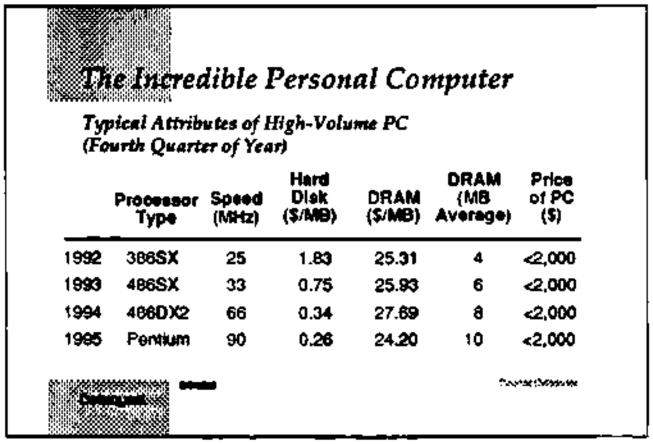


Figure 8

Here I show Dataquest estimates for worldwide PC shipments' estimated semiconductor content. In 1994 we expect 45 million units to be shipped worldwide, with the leading edge systems at the top of the pyramid having approximately $1,700 worth of semiconductors. This figure of 45 million PCs excludes multiprocessor PCs, as well as after-market boards and chips. The content content curve here has a compound annual growth rate of 15 percent. Very interesting. So, if you look at what's happening here, not only are we getting the growth in these very important productivity tools, but we're also getting the increasing content playing a factor. We are forecasting the semiconductor content to increase but certainly at a slower rate than what it has in the past five to seven years. We think that semiconductor content is going to continue to increase as PC manufacturers strive to produce more differentiated, value-added systems in order to survive the fierce competition in the marketplace today.



	Processor Type	Speed (MHz)	Hard Disk ($/MB)	DRAM ($/MB)	DRAM (MB Average)	Price of PC ($)
1992	386SX	25	1.83	25.31	4	<2,000
1993	486SX	33	0.75	25.93	6	<2,000
1994	486DX2	66	0.34	27.69	8	<2,000
1995	Pentium	90	0.26	24.20	10	<2,000

Figure 9

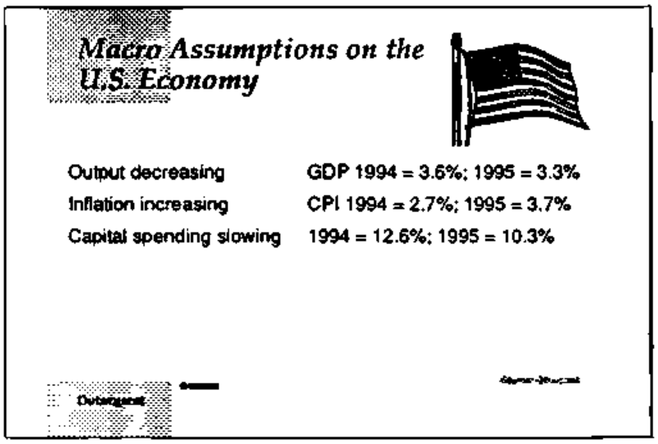


Figure 10

In this slide, I've tried to show you some of the pretty amazing things that have happened over the last two years and a projection out to 1995. Scanning this chart we see that over the horizon of this chart, processor speed has increased four-fold, hard disk drive prices per megabyte have dropped by 86 percent, the price per megabyte of DRAM has gone up, as I said earlier, in 1993 and in 1994, and we are forecasting a drop of 10 to 12 percent in 1995. While this all happened, the price of the PC has remained relatively constant, somewhere between $1,500 and $2,000.

This is a painful slide for some of the PC manufacturers in the audience. These year-to-year increases in price per megabyte of DRAM, have manifested themselves in increased revenue growth for the industry, as I said before, and at the same time have forced PC manufacturers to find other ways of reducing costs. So when I get asked the question, "When is it a good time to buy a PC?" Anytime. You get the functionality that you want for the price that you want.

Lastly, I would like to ask you all, "Which would you rather have been, a DRAM manufacturer or hard disk drive manufacturer over the last two years?" Of course, if we go back to the late '80s this trend certainly wasn't true.

In the next few slides I'm going to give you the variables that we consider when doing our semiconductor forecast. As is normally the case, we depend upon Dun and Bradstreet's (D&B) macro economic forecast and so those are the numbers that I am going to be presenting. These are Dun & Bradstreet's third quarter estimates for gross domestic product, the consumer price index, and capital spending for 1994 and 1995. In order to prevent inflation from rising, Alan Greenspan has raised interest rates five times this year. I sure hope that for the balance of this year, that Mr. Greenspan will not do the voodoo that he has done in the past. According to Dun & Bradstreet's economic forecasters, the net effect of all these tightening measures will be to lower GDP from 3.6 percent down to 3.3 percent. D&B is also expecting lower growth of capital spending. However, this slowing of capital spending is principally for new construction. D&B sees very good growth for facilitating factories and offices under construction, as well as those that are already completed.

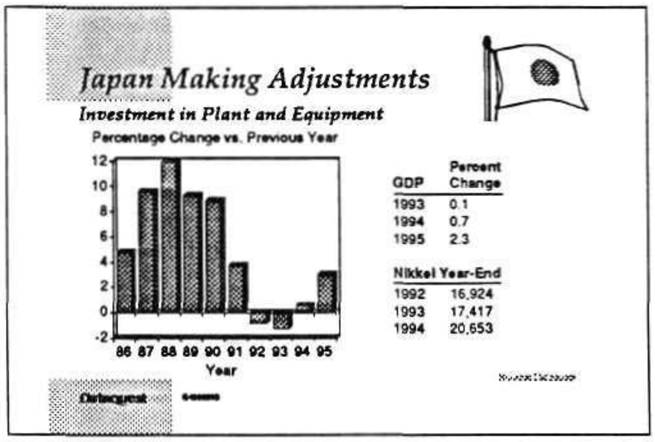


Figure 11

Still suffering from yen shock, Japan is dragging itself upwards, rather slowly, as a result of huge government spending. As Japanese businessmen have gained confidence, they're anticipating increasing their capital investments from approximately 1 percent this year to 3 percent growth next year. Investors have also gained confidence and have pushed the Nikkei up to the magical level of 20,000 early this year, but it has, in fact, trended down over the last six to nine months, hanging in around 19,700. Dun & Bradstreet is also forecasting GDP to increase by about 2.3 percent in 1995.

Figure 12

Unemployment in the combined Germanies continues to increase as the painful merger drags on. This statistic was fairly stable over the period of 1989 through 1991, but has accelerated with the falling of the Berlin wall. As you might expect with the rising unemployment, consumer prices are falling. However, the good news is that GDP is increasing as factories and offices have become much more productive and efficient through the use of electronics. Germany has had a voracious appetite for PCs and has moved quickly to re-engineer much of its economy. Germany has also experienced something of a boomlet in automotive sales, which has had a real positive effect on automotive electronics and the semiconductors that go into those electronics.

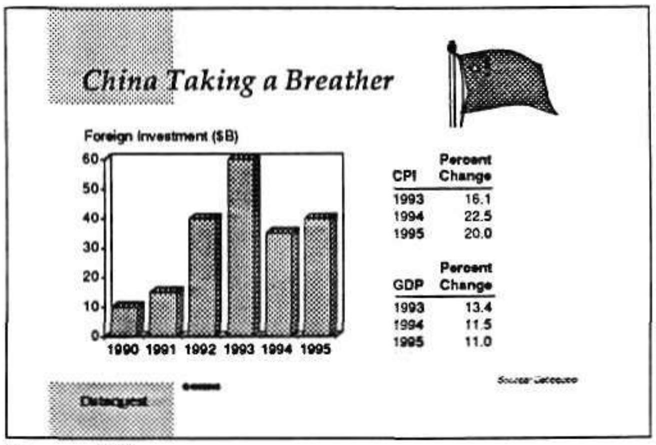


Figure 13

As I walk into the corporate board rooms of today, I can almost hear hearts pounding. The subject is China. And why not? Foreign direct investment is going through the roof. Manufacturing output has been rising by over 20 percent for the last four years. Alliances are being formed by the minute. However, with all of these positive factors you get the negative factors too. Beijing still has to solve the high levels of inflation, inefficiency, and considerable labor unrest. We hope that they don't solve it the same way as with the student uprising in Tiennemen Square.

My chart here shows moderation on all fronts as the central government tries to rein in this massive economy. Investment, consumer prices, and GDP will grow more slowly next year. At the same time, we see China continuing its rapid expansion into electronics manufacturing and consumption in 1995. Dan Heyler, our manager of Asian/Pacific semiconductor research, has just launched expanded coverage of China and will be giving some of his insights later on in the program.

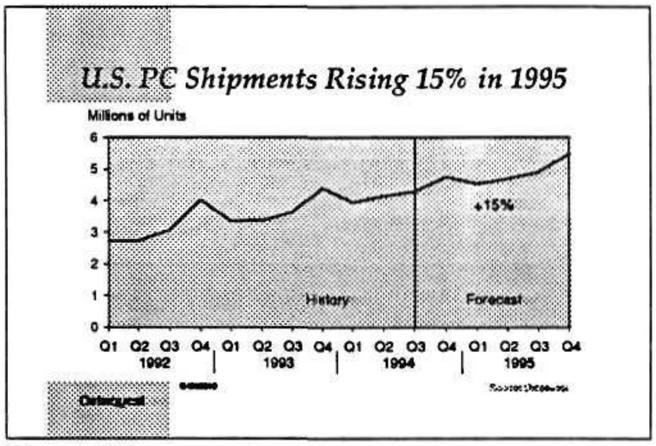


Figure 14

Now I'd like to transition to Dataquest forecasts for electronics and, specifically, PCs. Thanks to our PC group's quarterly statistic service, I have here their latest estimates. For your information, our knowledge of x86 quarterly shipments is an important factor used to correlate these PC statistics, as you might well imagine. It is a Dataquest food chain that enables us to provide you with what we think are the most accurate statistics on both processors and PCs in the industry. Overall, Dataquest is forecasting about a 16 percent growth rate this year in the United States and a 15 percent growth rate next year. As this chart shows, we're not forecasting much of a cycle here. We are looking for good growth in the fourth quarter of this year and very good growth in the fourth quarter of next year. Longer term we forecast that by the year 2,000 there will be 100 million PCs shipped. More than the number of TVs to be shipped in that particular year. And the principal reason for PC growth this year and next year is the growth of what we call the SOHO market, (small office/home office) and the portable markets.

1994 Worldwide Electronic Equipment Production Forecast

Billions of Dollars

	1994	1995	% Growth
Data Processing	213.7	226.3	5.9
Communications	117.3	123.1	5.0
Industrial	105.7	112.6	6.5
Consumer	145.8	153.0	5.0
Military/Civil Aero	59.4	59.7	0.6
Transportation	29.4	31.1	6.1
Total	671.2	705.9	5.2

Figure 15

Overall, we're forecasting total worldwide electronics to grow about 5.2 percent, only one percentage point less than in 1994. We expect desktop and portable PCs, high-end servers, and open architecture workstations to continue to drive the data processing industry. These systems, though having good growth rates, are forecasted to grow more slowly in 1995. In the emerging product categories of the data processing industry we look for high growth in subnotebooks, X Windows terminals, power laser printers, copiers, and PCMCIA cards. Consumer electronics is the second largest electronics category, and of course as we look out to the future we see consumer electronics and data processing blurring. However, the analysts in our applications services are watching this closely and we'll keep you abreast of any changes in our definitions.

Our projected $7 billion growth rate in 1995 in consumer electronics is going to come from greater than 30-inch T.V.'s, laser discs, embedded CDs, personal stereo systems, 16-bit video games, compact discs, and smart appliances. Communications is forecasted to grow by 5 percent. The highest growth markets include Ethernet, Token ring cards, modems, voice processing equipment, cordless, digital cellular phones, pagers, FDDI and ATM cards, and fax machines. Greg Sheppard will be addressing these industries in much more depth with his partner Dale Ford on Friday afternoon.

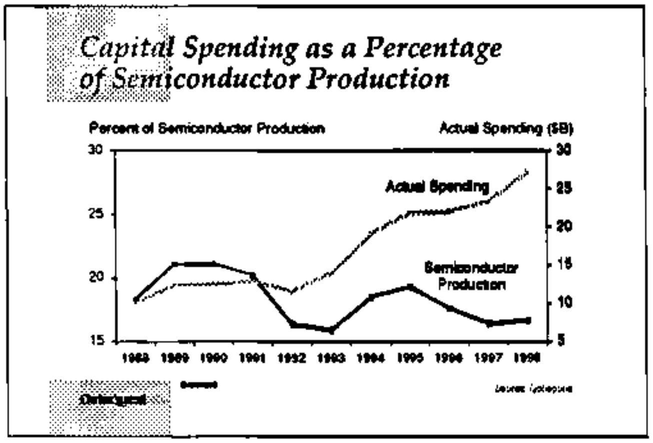


Figure 16

This chart is obviously one of the key determinants as to the accuracy of our semiconductor forecast. Semiconductor capital spending. To provide this forecast we survey the semiconductor manufacturers. After all, we think that they ought to know what they will be spending. So we ask them, twice a year. Then what we do, is we bring the data in-house, analyze it, and then finally, we produce our own forecast both on a regional basis and on a manufacturing basis. As you can see from either of these two lines, there was significant underinvestment in 1992 and 1993, and this has caused the capacity shortage that we have today. Over the long-term we have found that manufacturers have invested, and we think will continue to invest, about 17 percent of their revenues in expanding their plants. However, this didn't happen in 1992 and 1993. Since no one could have anticipated the drastic cuts in spending in the Japanese market and the Windows 3.1 spike impact on the industry, we now have our shortages.

In 1994, we estimate that worldwide manufacturers' capital investments will increase by about $5 billion to just over $19 billion, or a growth rate of 36 percent. Looking out to 1995, we're forecasting about a $2.6 to $3 billion increase, or a 14 percent growth rate to $22 billion. We sure hope that this will be enough capacity to meet the needs of the semiconductor manufacturers and also their end customers. Clark Fuhs will examine this in more detail also.

Worldwide Semiconductor Market

	1994		1995	
	Billions of Dollars	Percent	Billions of Dollars	Percent
North America	36,028	28.9	42,438	17.6
Japan	29,322	18.7	30,672	4.8
Asia/Pacific	22,957	31.1	27,051	17.8
Europe	19,296	24.6	22,686	17.6
Total	107,603	25.6	122,847	14.2

Slide 17

In the next three slides I'm going to present our forecast by product, by region, and for the first time, by country, because I think there are some interesting things happening on a country basis. Overall we're forecasting approximately 26 percent growth for 1994 and about 14 percent for 1995. No, the sky is not falling. The growth rate figure for 1995 is really a good one. I'd like you to remember three things about this number. First thing is that we're forecasting at constant exchange rates, as I said before. That's measured from July of this year. Secondly, the growth rate, as I've said, over the 10 years has been 14 percent, including all of the currency appreciations. Thirdly, we're assuming a 15 percent decline in price per megabyte of DRAMs.

From our perspective, the only region lagging behind and not achieving a double-digit growth rate next year will be Japan. Our analysis shows that the electronics industry in Japan is principally in large and mid-range computers, high-end consumer, industrial and communications equipments. It is our belief that these are not going to be growing at the rate of PC manufacturing, which is driving the faster growing parts of the world. Japan's low to medium range consumer electronics manufacturing is actually doing quite well. But these factories are now in the Asia/Pacific region. Hence, we forecast relatively low growth in semiconductor consumption in Japan. In the other regions, we see a continuation of 1994 with PCs, personal communications and other communications products, as well as peripherals driving the industry.

Worldwide Semiconductor Market

	1994 Billions of Dollars	1994 Percent	1995 Billions of Dollars	1995 Percent
Memory	31,539	33.9	35,427	12.3
Micro	25,468	27.5	31,801	24.9
Logic	19,099	18.2	20,954	9.7
Analog	15,475	25.2	17,275	11.6
Others	16,022	17.9	17,390	8.5
Total	107,603	25.6	122,847	14.2

Figure 18

MOS Memory, which is the largest segment, will enjoy a fifth straight year of revenue growth. We forecast that the DRAM revenue boom will continue strong through the first half of 1995. But as a result of strong capital spending in 1994 by the Japanese and Korean DRAM manufacturers, we expect revenue growth will slow in the third and fourth quarters. Demand for 4Mb DRAM will peak in the first half of 1995, after which demand will gradually decline as market shifts to the 16Mb. The result is that 4Mb pricing will decline quickly in the third and fourth quarters of next year. Since yields are still low on the 16Mb, the prices for these devices, will decline slowly throughout 1995, with most of the decline in the second half of the year.

We believe that the price-per-bit changeover to the 16Mb DRAM will occur at the end of the year of 1994 for some configurations. Overall we're forecasting a 13 percent growth rate for memories in 1995. Jim Handy, principal analyst for our Memories Group, will be discussing these as well as other memory devices in his forecast.

In the Microcomponent category, we're forecasting about a 25 percent increase. The principal driver, of course, is the x86 family and, specifically, Pentium-class devices. Windows 95, games, efficiency improvements, and multimedia will be driving users to upgrade their existing platforms. PowerPC and other RISC architectures are going to double next year. However, based upon our statistics, RISC MPU revenues will be only about 15 to 20 percent of all the x86 revenues at the end of next year. There is strong growth projected for Microperipherals in 1995 and one of the hottest areas, of course, is PC core logic chipsets. We expect those to grow about 20 percent. Jerry Banks is going to go into the reasons why they're growing that way. Analog will show a 12 percent growth rate. The Other Semiconductors category will grow approximately 10 percent, with discretes growing at the high end of that envelope.

Worldwide Semiconductor Market Forecast

	1994	2000
1.	North America	North America
2.	Japan	Japan
3.	United Kingdom and Ireland	China (Including Hong Kong)
4.	Germany	United Kingdom and Ireland
5.	Taiwan	Germany
6.	China (including Hong Kong)	Taiwan

Figure 19

The third and last look at our forecast is by country. I've added this slide to our forecast presentation in order to see some of the pretty important things that are going on. This chart shows our ranking of semiconductor consumption, not production, by country. We believe that by the year 2000, China, including Hong Kong, will be the third largest semiconductor consuming country, rising from sixth this year. This is, of course, inevitable, given the size of the country's population, the huge investments being made there, as well as all the technology flowing in from the alliances that have been formed.

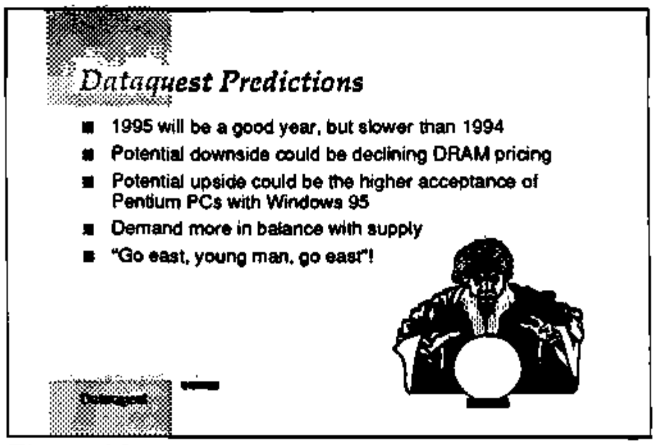


Figure 20

Finally, we predict that 1995 consumption will continue to increase, but at a slower rate, given the impact of the additional capacity and commensurate relief on prices. Demand will be more in balance with supply throughout 1995. Since most of you do scenario planning, we believe that an envelope around our forecast of 14 percent is appropriate, especially at this turning point in the industry. We believe that the envelope goes from 12 percent on the low side to 20 percent on the high side. Yes, I see more upside opportunity than I do downside opportunity. This is because the world's business community is looking to electronics to improve productivity and raise margins. Also, I believe that the Asia/Pacific region will continue to surprise us on the high side. Asia/Pacific is currently the third largest consuming region and we're projecting by 1997 Asia/Pacific will be the second largest consuming region for semiconductors.

No, the sky is not falling. Quite the contrary. 1995, we believe, will be another good year for semiconductor manufacturers as well as their customers and vendors. I thank you for your attention and please come back next year and we will do our reconciliation again.

Food Chain Forecasts: The Dataquest Vision

Microcomponents

Jerry Banks
Director and Principal Analyst
Semiconductor Microcomponents Service
Dataquest Incorporated

Mr. Banks: I'm Jerry Banks. Nice to see you all here today. I'm going to break this presentation up into two parts. We'll talk about microprocessors and microcontrollers.

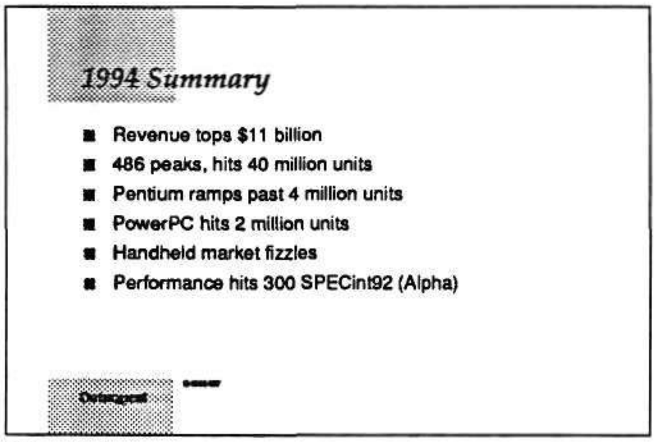


Figure 1

First, a summary of 1994. Microprocessor revenues will top $11 billion in 1994. That's a relatively mediocre year, only 31 percent growth for microprocessors this year versus the 60+ of last year. We expect 486 unit shipments to peak this year as we're converting to the next generation of microprocessor. We have both Pentium and PowerPC in their initial production ramps. Our forecast is in excess of 4 million Pentium units and 2 million PowerPCs, not too bad for either one. The handheld market is fizzling. I'm sure Gary Tooker will enjoy that one. Well, it did fizzle, I guess, in 1994 when you look at all the press. But I think that Apple Computer has to be commended. There always has to be somebody who cooks the first pancake. You know, it's either underdone or overdone. The next one is better, the next one after that is better yet. So, I can't wait to see the follow-on generations of the PDA families. On a performance basis in 1994, Alpha has proven that it is the SPEC performance leader bar none in just pure raw CPU performance.

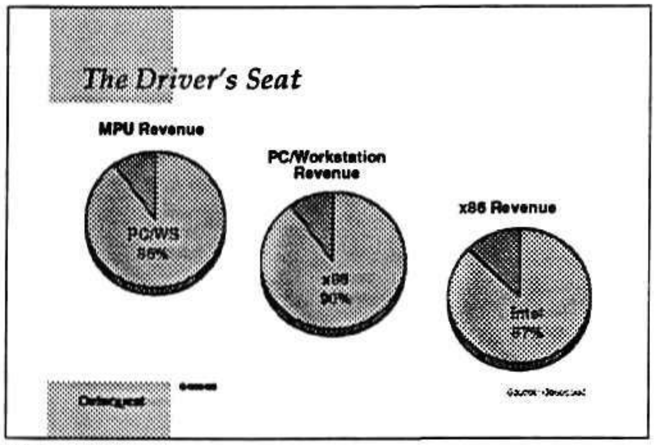


Figure 2

Now going through this, this may look a little bit too Intel-ish, but it's part of the driver, the reason for the forecast that we're showing next. To show the position of control. It's a unique position for a company to be in. If we take a look at total MPU revenue, PCs and workstations make up nearly 90 percent of total microprocessor revenue. And of that, 90 percent is x86 and, of the x86, of course, Intel has the dominant position there. So, we're showing it to you as a broad indicator as to why we think Intel is going to be successful in driving a very rapid transition of the mainstream processor for the desktop processor from today's 486, tomorrow into the Pentium processor.

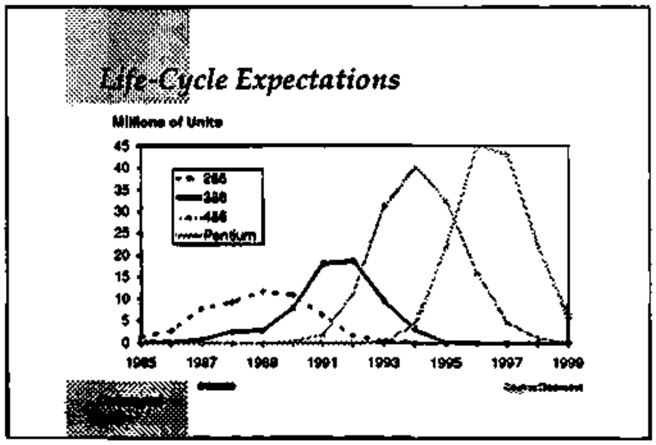


Figure 3

Let's take a look at that in terms of life cycles. It's actually the first time that we've shown this chart in a public forum. Going back to the introduction of the 286, 386, 486, and our projections for Pentium, each successive generation has higher volumes than the previous generation and we've had some broad life cycles. What's interesting here is that if you take a look at the point of introduction of the product to the point of high volume production, it's getting shorter and shorter every year. From the 286 onward, and then we take a look at Pentium, which was announced in I think March of 1993, and is already at a very high volume production ramp this year, and you think, wait a minute, this Pentium ramp is a little skewed here, because it's a much sharper slope than all the rest of them. We've taken the life cycle chart and normalized each of the processors according to their peak year of introduction, and their peak year of shipments. If you take a look at the slopes, you know the 386 slope is probably the sharpest of all of them. So we don't believe that our Pentium slope is unrealistic here.

What's going to happen in the next couple of years? We think that Intel is in a strong position to drive the x86. Also, considering that today's operating systems and applications are very x86 specific as well as, hopefully next year, Microsoft's operating system Windows '95 release, we think that it's going to be very difficult for non-x86 architectures in the short-term to try to gain a foothold in the desktop PC market. The word from Gary Tooker today, is that's not the entire marketplace, but that is the marketplace that Intel controls and that will be the dominant area for microprocessors. So that's why we think that Pentium will ramp very strongly. In fact, we lowered our forecast slightly for Pentium for this year. We did have it at the 6 to 7 million range, and we're closer to 4-1/2 right now. But our next year forecast was increased from 18 to in excess of 20 million units for the Pentium processor.

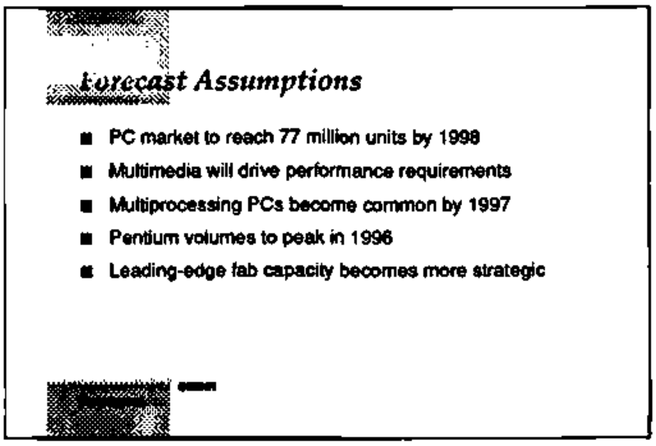


Figure 4

Our assumptions for the forecast. Our PC shipment forecast calls for 77 million units in 1998. But the opportunity for PCs into the PC marketplace is going to be 100 million units. Now, the higher number is due to the fact that our 77 million units do not include CPU and motherboard upgrades, doesn't account for multiprocessing systems, and then of course, the inventory that the PC OEMs have to purchase. So the 77 million actually translates into a 100 million opportunity in 1998.

We believe that multimedia is starting to coalesce into some sort of a definition. We kind of all know what multimedia is, but it definitely is a consumer of raw performance. We think that this performance driver will be driving the home market into higher performance processors. In fact, I would argue that today most of our children at home push our computers harder than we do running our word processing/spreadsheet applications at work. Now this continuing drive for additional performance, we think is also going to help spawn this multiprocessing market, which we are expecting to account for approximately 12 percent of computers shipped in 1998 on a unit basis.

We also expect that Intel will be introducing their P6, or whatever they are going to call it, in the middle part of 1995. This is again indicative of the fact that they're now having much shorter cycles between product introduction to high volume production. I think we'll see a Pentium volume peak point occurring in 1996 because once the P6 is introduced in volume, there'll be an active push to pull out the Pentium and move in the P6 product.

One of the critical things here is that the ability to invest in new state-of-the-art, high volume fabs is playing a very important role in the future of microprocessors. So you really have to have a lot of capital to be able to invest in the 8-inch, high volume fab to produce these large die in high enough volume to meet the demand of the marketplace. Not something easy for small companies to do unless they can partner with larger companies, like Cyrix and IBM.

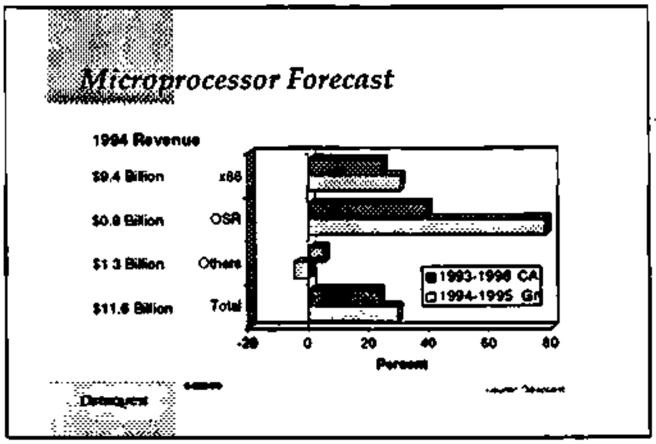


Figure 5

Now, here's our microprocessor forecast. As you can see here, something we call Open Systems RISC. A nice industry standard term. Everybody knows what it means? I heard a laugh. We counted here standard RISC platforms, workstation platforms, — I hope I don't miss any of them — SPARC, PA-RISC, PowerPC, MIPS, Alpha, all go into this category. It's very high growth for the RISC products. However, although growth is extremely important in planning your business, you have to keep it in mind that x86 revenue in 1994 is expected to be an order of magnitude higher than the combination of all the Open Systems RISC architectures. In fact, despite the fact that we have an expected compound annual growth rate far in excess of x86 processors, still by 1998, we expect on a revenue basis in this category, that x86 will account for more than eight times the combined revenue of the Open Systems RISC products. Taking a bite out of the x86 is not an impossible task but it's not an overnight process either. And if anyone is to succeed, they have to have plenty of capital as we mentioned before, combined with vision and patience to succeed in competing in this marketplace.

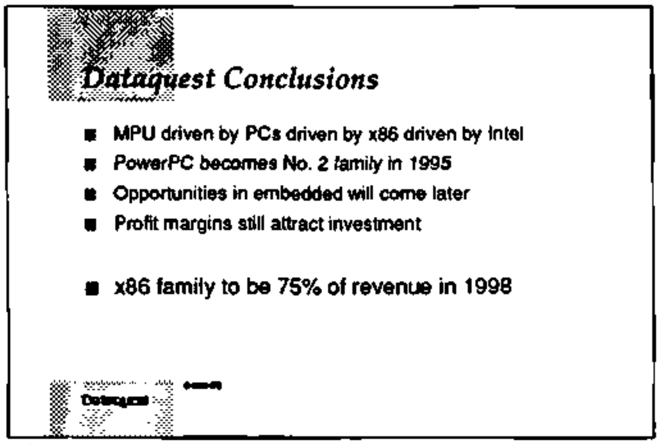


Figure 6

In conclusion, combining Intel's current dominant position on the desktop in this microprocessor market, with its vision and its work in developing or assisting at least in the development of next-generation standards, makes it a very formidable competitor. When you have such a large company out there trying to create its own next-generation market and then fill those sockets that it's creating with silicon, it amounts to a tough competitor.

The PowerPC, although it may be small by x86 standards, is expected to displace the 68000 next year as the number two microprocessor architecture in terms of revenue. In fact it won't be long before we'll just have to pull it out of that Open Systems RISC category and treat it all by itself, it's of such importance. It does have a tough long road ahead of it as far as competing in the desktop market, but we believe that it's currently best positioned to challenge the x86 hegemony.

Now, the less visible embedded 32-bit microprocessor market is currently completely dominated by Motorola with its 68000 family and 68300 family. They probably dominate 32-bit embedded as much as Intel dominates the desktop on the microprocessor side. But there are several challengers eyeing this growing market. I mean, it's very common to see a new RISC architecture announced talking about "I'm going to go after the NT operating system and I'm going to have a position in the embedded marketplace as well." Those two always seem to go hand in hand, whether it's embedded as a complementary or just a backup in case the NT market doesn't develop for them. But there are a lot of people eyeing this market. It has a few high volume, high visibility applications. People are going after laser printers. They are a classic example. But it takes a tremendous amount of applications and third party support. This is not an easy market to penetrate. It takes a very, very strong technical presence in the field to design these in and to support these products.

So the embedded market takes a lot longer to develop. The good thing is that once you're into it, you can typically own it. There are a lot of competition out there, but if you're designed in, it's very difficult to get your product designed out. We don't think that this market is going to produce sufficient growth opportunity in the short-term until these new PDAs/PICs, or whatever, start to take off, because that's when we think embedded, high performance processors will start to take off because these handheld products with their needs for high performance will drive the 32-bit embedded market. By the end of the forecast period, we expect that the x86 family still will control three-quarters of the microprocessor revenue in 1998.

I want to switch gears just a little bit. Now for the fun stuff — microcontrollers. How are microcontrollers fun? There are a couple of reasons. One. During Gene's talk I had an individual already come up and ask me a very impassioned question about microcontrollers. There are a lot of questions and a lot of interest in microcontrollers. Microcontrollers may no longer have the lead as the largest revenue category in the microcomponents business. Microprocessors took that over a couple of years ago. But from the number of design wins, and number of units shipped, there is no contest. In 1993, over 2 billion microcontrollers were shipped. Two billion microcontrollers. And of that, the 8-bit category grew over 30 percent, representing nearly 1.1 billion units shipped in 1993. When such a large market is growing that fast, opportunities abound. I mean there is opportunity out there to grow in 8-bit microcontrollers, and, as you might guess I'm going to expound on that a little bit more.

Figure 7

Now, what is a microcontroller? There is a very boring, mundane definition of microcontrollers. It has an ALU on board, it can branch, it has address generation capability. What really differentiates a microcontroller from a microprocessor by our definition, is it is intended to have the program memory residing on-chip, versus off-chip. That's really how we distinguish microcontrollers and microprocessors. And a more interesting definition, maybe the more realistic definition, is, the microcontroller is ubiquitous. It is constantly encountered. You run across microcontrollers without even knowing it. If it has a display, a motor, a switch, a timer, a sensor, a button — basically if there is power connected to it, it either currently has a microcontroller or it will have a microcontroller. So, if you are in the microcontroller business, and there is power applied to something, there's somebody for your salesman to go call on. There's a chance to sell a microcontroller.

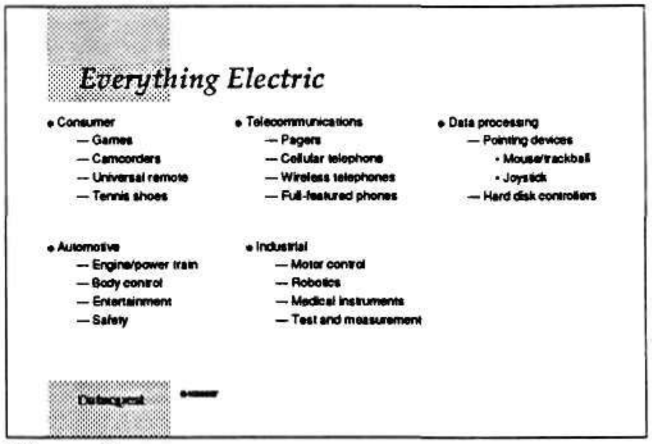


Figure 8

To reiterate. It's going into everything electric. Now, since I say everything electric, I'll come back and show you one caveat. Over here on consumer. One of my favorite applications in microcontrollers. When LA Gear first introduced the flashing tennis shoe — I think they called it their High Tech model — what they first used in that product was an 8-bit microcontroller from Microchip Technology which they used in its sleep mode. A switch would come along and wake the thing up, it would fire a measured pulse off to the light and flash the light and then go back to sleep again. So that's something where they had to bring power into the tennis shoe in order to use the microcontroller. You need salesmen with a good imagination in microcontroller industry.

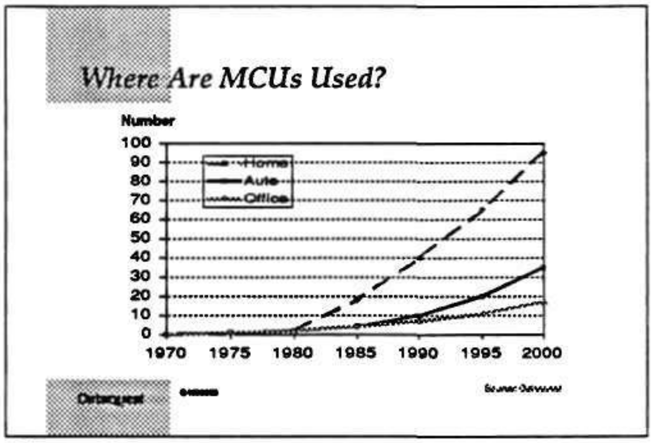


Figure 9

Now where are they used? Well, the office, you think, automatically they're used in the office. Yes, you do find them in the office. And it depends upon whether it's this Small Office/Home Office, or if it's a large corporation with a lot of shared resources. If you're sharing fax machines, and you're sharing printers and such, you don't have as many microcontrollers than if you own all that and have it resident in your own office. But we think the office market is a growing area, but not the highest growth area for microcontrollers.

Automotive, obviously, no maybe not obviously, but you see people going around with these keyless security devices. You know we're talking microcontrollers in those devices. A lot of electronics going into the automobile. The trouble is competing in the automotive market is really tough. If you don't have a position in their house, it's very very difficult to gain entry into the microcontroller market. But the home on the other hand. You know we all have entry to our homes and we can see what we use in our homes. The home market is where microcontrollers have really taken off. You have telephones, handheld and desktop, wired and wireless, all new thermostats, remote controls, televisions, stereos, microwave ovens, new washers, dryers, exercise equipment, pagers, motion detector security systems, it goes on and on and on and on. It's a very, very, long list and it's growing. Again, anything electric and some things that could be electric.

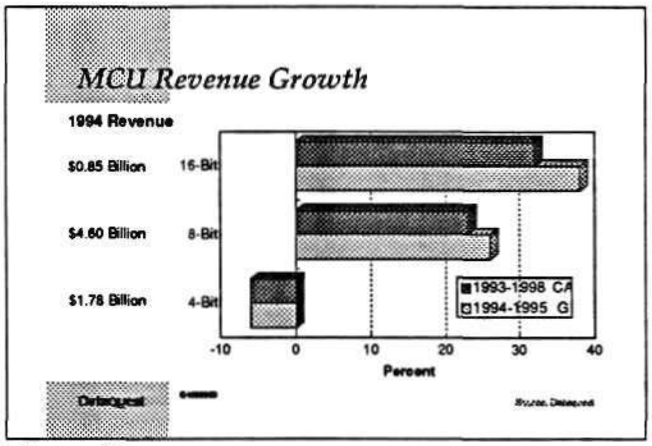


Figure 10

And where is microcontroller growth? Well all of the MCU areas, 16-bit is where the growth is in terms of percent in microcontrollers. We have again a disparity in overall size. You can see in 1994 we're expecting the 16-bit microcontroller market to be about $850 million compared to $4.6 billion for the 8-bit market. The 8-bit market is showing very strong growth as well. Although, the 8-bit market would be growing much, much, more except that as anybody out here who is selling microcontrollers will tell you they're absolutely capacity constrained. This is where the opportunity is coming in today. The biggest feature that you can offer in a microcontroller today is availability. You've got the right cost and you've got it available, the chances are you have a chance of competing for the socket.

One thing we talked about was Intel in microprocessors. When you talk microcontrollers, you cannot ignore Motorola. Motorola is the largest producer of microcontrollers and they absolutely, completely dominate the category. I've often been quoted as saying that the market and sales department in Motorola deserves an A+ for create and demand. In fact, I think they are largely responsible for creating the entire microcontroller phenomenon that is going on and how it's being pushed into the home. Unfortunately, from the operation side of the business there is something less than an A+ for meeting that demand, but I guess that's a nice problem to have. But the good news is that this opens up a tremendous opportunity for anyone who has access to an 8-bit microcontroller or who can gain access to an 8-bit microcontroller and has the willingness to play in this large but cost-sensitive market. If you can get it and you can identify the right feature sets, you can come to Dataquest and ask us. We'll help you identify the right feature set and provided you have availability, you can build a market for yourself in 8-bit microcontrollers.

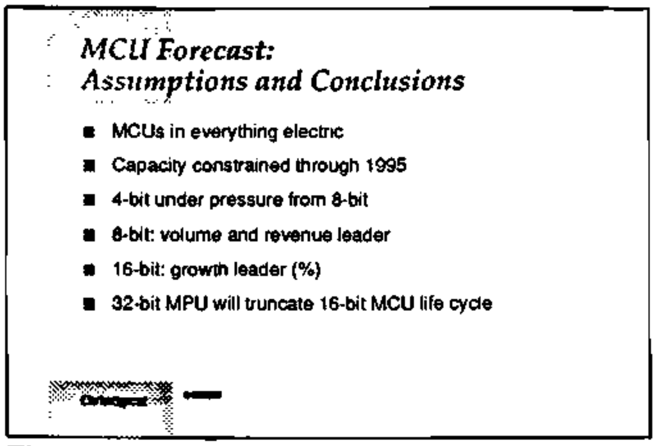


Figure 11

Now, in summary, I can't say this enough, I guess, maybe you think I can, but I don't think I can. Microcontrollers are going everywhere, and current sources of supply can't keep up with demand. Now the 4-bit market I didn't dwell on too much. It's saturated with suppliers. It's a well-understood, well-defined market. I think that as soon as more capacity comes on board on the 8-bit side, they will be taking over 4-bit sockets. I think the 4-bit's life cycle is being extended only because of capacity constraints in 8-bit. The 8-bit market is large, it's where the opportunity lies today, and where it's going to lie in the future.

The 16-bit market is showing very, very high growth, but over the long-haul I think that the 16-bit life cycle may be somewhat truncated by 32-bit microprocessors, as the invasion of these highly-integrated 32-bit processors, such as the previously mentioned 68000 family, 68300 family, and derivatives now of the 386 and 486, come into the marketplace. The reasons for this will be that 16-bit architectures provide a larger addressing range and what does that mean? Software people understand that they will inevitably make use of this larger address range and such a large amount of program code is not cost-effectively put on-chip. So, typically, you'll end up having off-chip program code and if you have it off-chip, and now with 32-bit processors coming down, which typically don't have on-board, on-chip ROM, it makes it much easier to come in and replace that socket. I don't think a 32-bit will ever compete with a 16-bit in a fully integrated fashion with on-chip ROM. But in those other applications where the software guys go out of control, as they are wont to do, we'll see the 32-bit processors with a chance to attack that market.

Memories

Jim Handy
Director and Principal Analyst
Semiconductor Memories Group
Dataquest Incorporated

Mr. Handy: I had a dream last night, a really bad dream. Twenty years ago I graduated from college (that was the year of the first Dataquest conference), but in this dream I was still in university and I was taking a test that was going to gauge whether or not I graduated. I looked at this test and I just couldn't answer any of the questions. The professor walked up, kind of looked down at me scowling, and said, "why do you have no clothes on?", and I looked at myself and I was completely naked! I went running out into the street and a car hit me. Now standing in front of the largest audience ever assembled for a Dataquest conference, and all of these CEOs and everything, if you see me looking at myself just to check and make sure I've got clothes on, you can understand why.

I'm Jim Handy. I'm the principal analyst for memories and I'm here to talk about the memory business and the question why are MOS memories important? Why do you need to watch them if you're not a memory supplier? MOS memories make up 30 percent of the total semiconductor business. The next runner-up is microcomponents at 23 percent, and although we expect that scenario to change, the importance of MOS memories will never change. Where MOS memory and microcomponents go, that's pretty much where the rest of semiconductors go. Pricing, volume, and price-per-bit are all important in this. There are two sides to the MOS memory market: there's the data processing side, which can also be construed to include telecommunications, and that's a very hot market right now; and there's consumer electronics, which hasn't been doing so well, and so we'll call that cold.

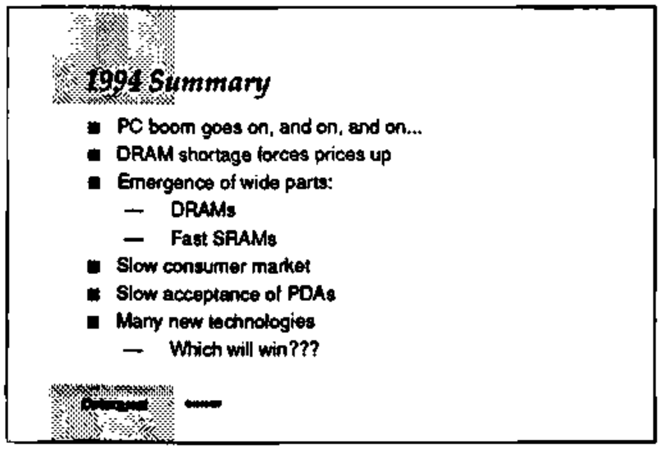


Figure 1

Nineteen ninety-four was really some year! Let's look at what's driving the MOS memory market. The PC market was a hot thing that was really driving it. The strong PC demand drove unheralded growth in DRAMs. At the same time, a cold investment climate in Japan, which produced nearly 50 percent of the world's DRAMs last year, caused Japanese companies to postpone investment in capital equipment. That caused the DRAM shortage. The shortage caused DRAM prices to stay flat or a little bit up for as long as nine quarters now, and with these two forces coming together, 1994 ended up being an extremely profitable year for DRAM manufacturers.

There have been some new twists in established markets. PCs continue to make up an increasing part of the overall DRAM market in amounting to over 60 percent of the total market, and so that means that the DRAM market now has to follow the needs of the PC market more than it's ever needed to before. Meanwhile you've got some issues with PCs — e.g., memory granularity issues. What that means is how many chips can you put into a system. How does this work? If you've got two megabytes per chip and you're playing into a 32-bit processor, then you're going to have to use DRAM chips that have 16-bit data buses and that's something that we haven't had before. It's a real problem for DRAM manufacturers. At the same time, speeds of processors are increasing and so cache memories are becoming much more taxing to build, and so you're seeing some very new architectures being designed into cache memories.

All of these are going together in the data processing sector and it accounts for 50 percent of the market. Telecommunications adds another 17 percent above that. But what is happening in consumer electronics, where you've got 17 percent or so of the market? Consumer electronics is kind of in the doldrums right now. One of the most amazing things that's happening right now as a result of consumer electronics is that the 1Mb slow SRAM is selling extremely poorly compared to any previous generation of slow SRAM in recorded history. That seems to be just because most of the applications for that device during this period in its life cycle should be in consumer electronics, and that market's not driving the demand for that part the way that it should be. PDAs are a cold market for right now. They will be hot in 1995. We're expecting to see a shift in the acceptance of PDAs in 1995. That in turn will drive Flash consumption.

Something that further confuses the market is the emergence of several potentially hot technologies. I've got several slides on those new technologies, which I'm not presenting here, and are at the end of my presentation in your book, so you can look over those and discuss those off-line with me if you need to later. But everybody's wondering, is the market just going to radically shift away from standard commodity devices over to these new ones? In some cases yes, and in some cases no, and there's a reason for each one of those. But for right now we'll talk about DRAMs.

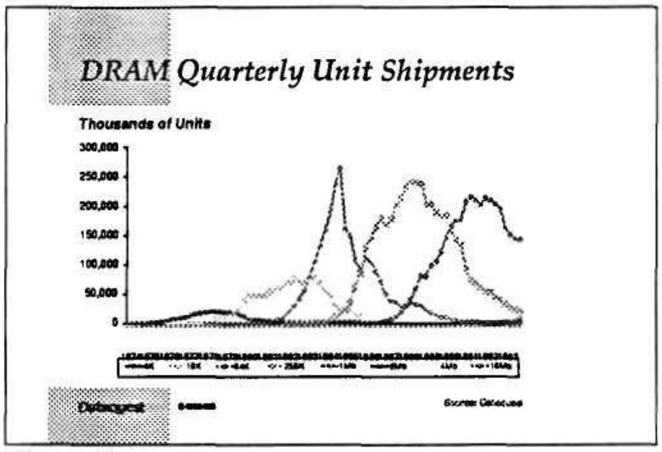


Figure 2

We've collected history for a long time on DRAM unit shipments. This is a chart of quarterly unit shipments of DRAMs by density. You can see that there's a peak on the 64K DRAM and successively shorter peaks going for the 256K and the 1Mb DRAM. A lot of analysts have construed that this is a trend, that this massive acceptance back almost 10 years ago for the 64K DRAM was fueled by the PC.

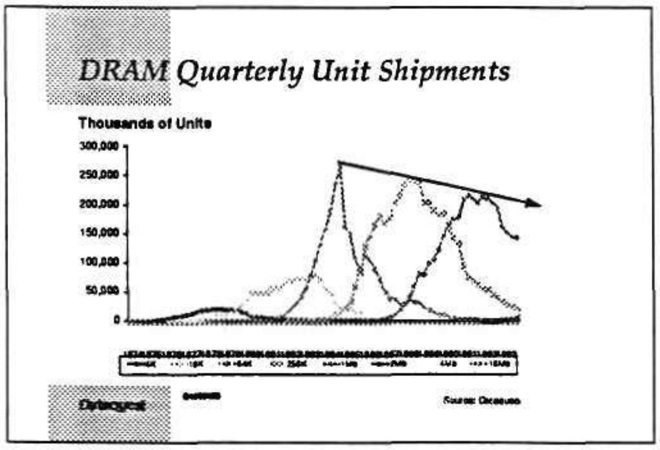


Figure 3

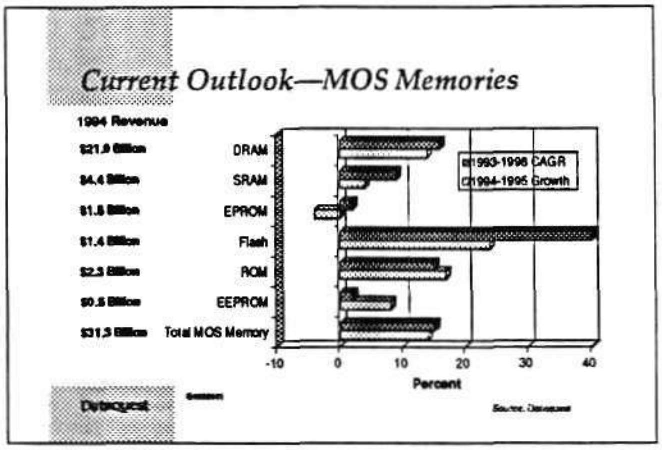


Figure 5

You can see that DRAMs have been constantly higher in unit shipments since the emergence of the PC and the final acceptance of it in 1984 than they were at any time prior to that. But still, why are those peaks getting shorter? Why are the skirts getting wider? This was being attributed to the increased costs of fab.

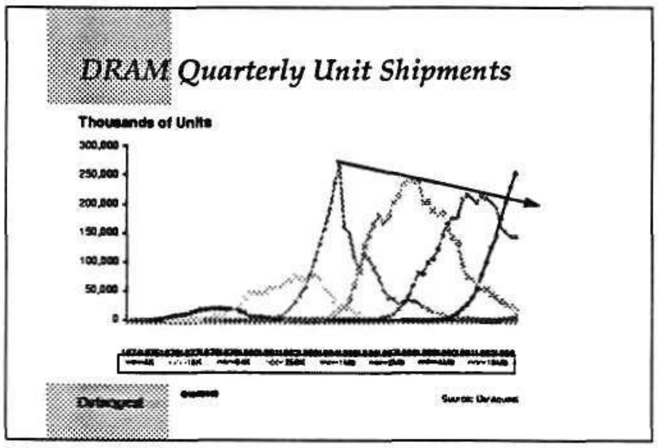


Figure 4

But we found out with the 4Mb density, which just popped into view there, that suddenly that's not the case. We've got unit shipments back up there for the 4Mb DRAM, which have, as of the quarter before last, exceeded the 64K density and broken that record, shipping over 260 million units in the second quarter. So we're basically debunking something that people thought was an industry trend in DRAMs.

What that brings us around to is, where is the market going dollar-wise? The revenue growth in 1995 is going to be weaker in DRAMs than it will be over the long-term. That lower, pale bar, is 1995 growth. The darker bar is what we see over the long-term. DRAM manufacturers are going to get their come-uppance. They've had glory days in 1994, and they will in 1995, because prices are staying just astronomically high compared to their cost to manufacture. When that starts to correct itself, that's going to take some wind out of the sails of the growth of the DRAM market. That doesn't mean that there's any lack of health in the market. It just means that a correction is happening, and if you look at 1994 and 1995 put together, it will still be a very healthy market.

We took a look at what would have happened if normal price erosion had happened in 1992 and 1993, just assuming that price had nothing to do with unit shipments, that is, the unit shipments would have been the same, but had the ASPs come down at a normal rate. We would have expected the 1993 DRAM market to top out at about $9 billion instead of the $14 billion that really sold. This year we would have expected the market to be at about $12 billion just based on normal ASPs times regular revenues, and instead we're expecting 1994 to top out at about $21 billion. So that would have been a very cold market had the prices come down on normal curves.

Moving on down to SRAMs; we're expecting lower growth in 1995 than over the long-term, but for a completely different reason. Two-thirds of all SRAM revenues come from slow parts, and most of those go into consumer electronics, which is definitely a cold market. The current slump in consumer electronics is expected to reach into 1995 and then ease gently over the next five years. So that will improve the long-term growth of the SRAM market. Another part of growth of the SRAM market comes from caches in PCs, and we're expecting caches in PCs to continue to be widely accepted despite evolving changes in DRAM architectures.

In nonvolatile memories, we're expecting the EPROM market to take a hit next year because of increased availability of Flash. Intel has recently reached a point where they're deciding whether or not to use all of the capacity that they had for Flash, whereas last year they didn't have enough capacity available. AMD is adding capacity. A lot of other players are looking to come on-stream. AMD and Fujitsu just made an announcement last week of a new fab that they're bringing on-line and we wish them luck with that. There's also a much more slowly developing PDA market than people were originally expecting, and so that's also lowered our assumptions for where the Flash market is going.

ROM and EEPROM are suffering from a bad consumer electronics market just like slow SRAMs, but they're expected to recover maybe a little bit faster because these devices are more traditionally used, and they seem to progress to the next higher density a whole lot faster than SRAMs do. Flash is hot, EPROM cool, ROM and EEPROM are expected to heat up soon.

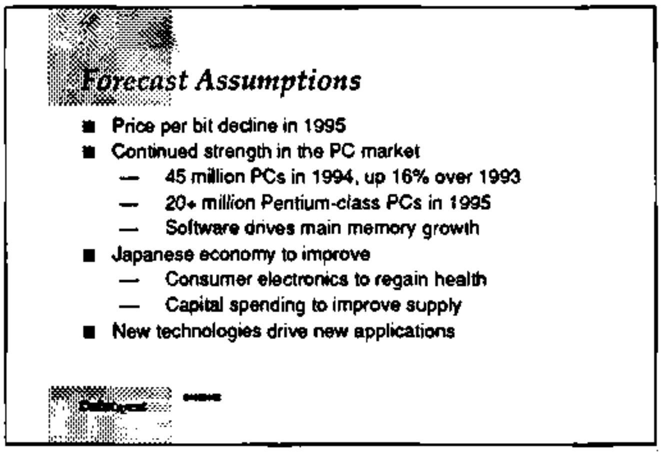


Figure 6

Our assumptions for the forecast. What is it based on? First, we think that hot DRAM and fast SRAM markets will be fueled by the continued health of the PC market and telecommunications. This will happen in the U.S., in Europe, and in the Asia/Pacific countries. Users have found that more main memory means better use of their PCs, and so they will continue to add all the memory they can justify to their systems. Not all of this is going to translate to the bottom line though, since DRAM prices have been forced sky-high by a noncompetitive market, where demand far outstrips supply, and the normalization of all of this will reduce revenue growth to more modest levels.

Second, the current cold market in Japan is due for an upswing, and this will be coupled with the improved health of the consumer electronics market, increasing demand for slow SRAM, ROM, and EEPROM. At the same time, increased capital spending, which we have seen really ramping up since November in Japan, will result in higher DRAM production, loosening the supply constraints that have kept DRAM ASPs as high as they have been for such a long time.

And then finally, hot new technologies like Flash memories will drive new end system designs. Systems are being designed because they're enabled by Flash memory. So more portable devices will become available, and as all of these devices become popular, their memory consumption will grow the overall market.

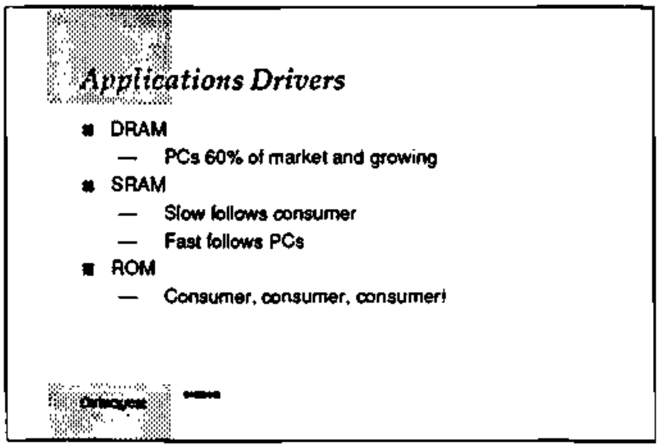


Figure 7

What are the application drivers for each one of the memory technologies? For DRAMs, PCs are more than 60 percent of the market, so that's a pretty clear one. If I haven't said it before, PCs are growing in their importance to the overall DRAM market. PCs are a very hot market and they're expected to continue to drive the DRAM market to a greater and greater degree. Slow SRAMs, which are mainly used in consumer electronics and are the larger part of the SRAM market, are cold, although we're expecting them to heat up with the consumer electronics market. Fast SRAMs are hot. The fiercely competitive market for fast 32Kx8, which is the primary device for use in cache memories in PCs, has had a few participants drop out, so prices have started to firm up. We're expecting to see an awful lot more cache being used in the Pentium market, which Gary showed is going to be growing an awful lot. ROMs, like slow SRAMs, are waiting for the re-emergence of a strong consumer electronics market, and recently difficulties in the games market have taken their toll. There are threats on several other fronts, for example CD ROM, yet we're not expecting ROMs to die over the term of the forecast.

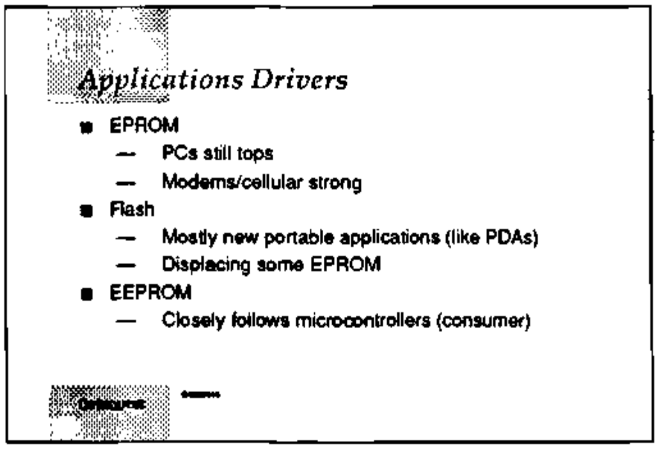


Figure 8

For EPROMs, PCs are still the top application, and despite the availability of Flash, they're still being used very widely in PC BIOSs. Flash is a glamor technology and it seems like a lot of start-up companies are starting in Flash. To name a few, ISD, Silicon Storage Technology, EUROM, SunDisk. These are all companies that are coming about because of Flash technology, and so a lot of venture capital is going into that. We're very bullish on the market. It promises to be an enabling technology for future generations of handheld equipment. And then finally EEPROM has a niche as the one-dollar-or-less rewritable memory device. And it's expected to maintain its own and follow the consumer electronics market, especially where microcontrollers are involved.

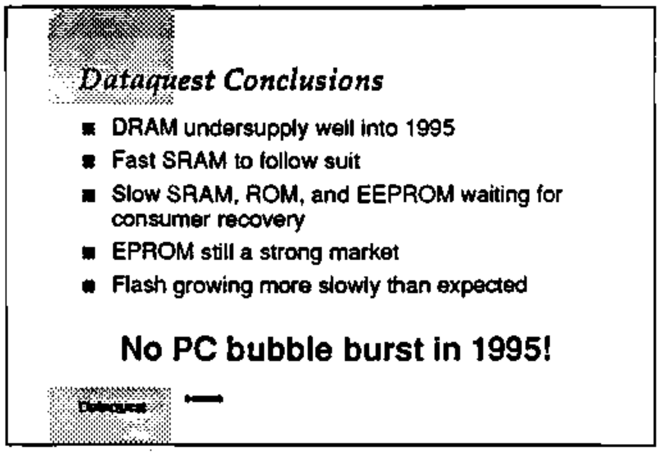


Figure 9

And so our conclusions: We're expecting a DRAM undersupply well into 1995. This flies in the face of what some stock analysts have been saying in the past week, which has caused Micron and TI stock to come tumbling down. But as far as our clients are concerned, the DRAM sides of semiconductor manufacturers have pretty much booked out first quarter of 1995, so that's a very healthy market for them. Fast SRAMs are going to be following the same path as DRAMs. Slow SRAMs, ROMs, and EEPROMs are waiting for the consumer electronics market, which is currently cold, to heat up.

EPROM is still a strong market. Maybe that's an overstatement, but it's very good for the companies that have decided that they're going to stay in there while other companies are bailing out. And then finally, Flash is growing. It's just not growing quite as fast as what we thought. Still, what we're looking at is no PC bubble burst in 1995, and what that translates into is a good strong MOS memories market and with the possible upside in consumer electronics, that means we're going to have other possible growth areas. We're very bullish on MOS memories.

My clothes are still on!

ASICs Forecast and Market Trends: Users Call the Shots

Bryan Lewis
Director And Principal Analyst
ASIC Worldwide
Dataquest Incorporated

Mr. Lewis: My name is Bryan Lewis and I've been with Dataquest for about ten years now, tracking the ASIC market. The title of my speech today is called "ASIC Forecast and Market Trends: Users Call the Shots." You might be asking yourself, what does he mean by users call the shots? We've gotten very many requests for information regarding end-user data or customer data, and today we are going to share some of that data with you after I run through the forecast.

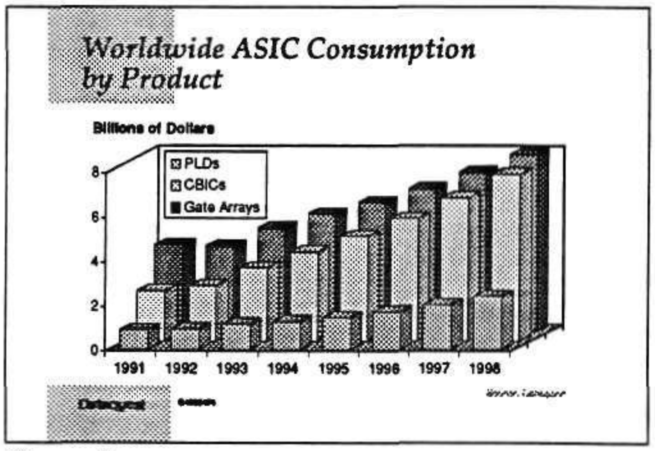


Figure 1

To get a quick idea of what different product areas look like in the forecast, you can see on the lower axis we have PLDs, in the middle we have cell-based ICs, and on the top we have gate arrays. This includes both MOS and bipolar technologies. So in the PLDs section you can see that it does not have a very fast ramp, and that's because bipolar PLDs are declining but MOS PLDs are growing very rapidly. Cell-based ICs are growing very quickly and they are starting to catch up to gate arrays. Cell-based ICs have a very small die size and are starting to penetrate some of the gate array markets. Gate arrays are the largest market. They provide good time to market and have a very good price structure. The PLD also offers very good time to market and that is why we are seeing a lot of growth in the MOS PLD area.

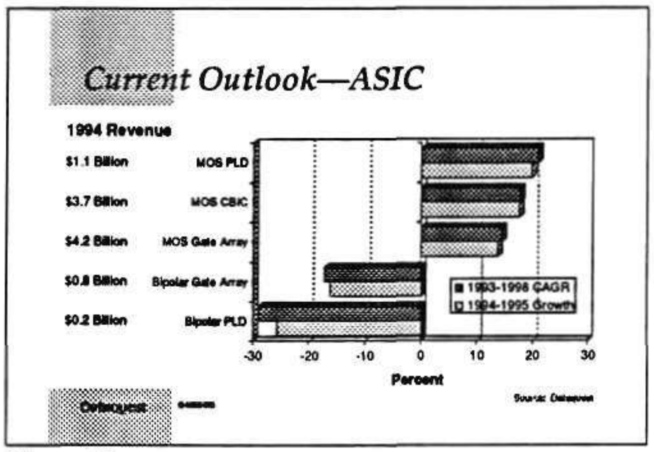


Figure 2

So to get a better grasp of it by technology, this chart shows, on the left hand side, the size of the different markets, as associated with the different technologies. You can see that the MOS PLD portion is the fastest growing market of the ASIC market. It is forecasted to grow in the 20 to 21 percent range for the next five years. Cell-based ICs are growing in the 17 percent range and starting to attack some of the gate array applications. You can see the gate array, the MOS gate array, is a $4.2 billion market, so this market has really taken off over the last five to ten years and it will continue to grow at a good 14 percent clip for the next five years. Now the markets that you do not want to be in are bipolar PLDs and bipolar gate arrays. These markets are being replaced by the MOS technologies, which takes us into our assumptions.

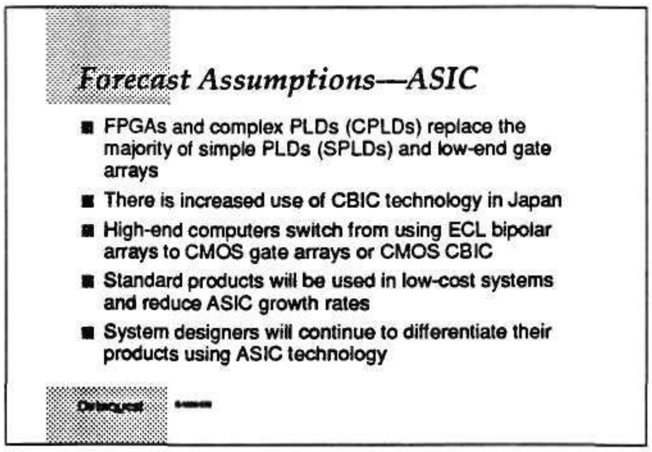


Figure 3

To start with, there are three types of PLD devices. There are simple PLDs, complex PLDs, and field programmable gate arrays. The field programmable gate arrays, as well as the complex PLDs, are growing at a very rapid rate, in excess of 30 percent. They are replacing the simple PLDs as well as the low-end gate arrays so that is why we see the big growth in the PLD market.

Now moving to cell-based ICs. We talked about how cell-based ICs have a smaller die size. In Japan we are starting to see a lot of the high-volume applications, some of them consumer, like the game markets, and disk drives, starting to switch to cell-based ICs. Japan historically has been very much a gate array country and now they are starting to push more into cell-based because of the small die size and better cost structure. So we see a big growth in our Japan numbers for cell-based ICs.

We talked about bipolar declining. Bipolar gate arrays have gone historically into high-end computer systems; ECL high-end computer systems. They are being replaced by CMOS gate arrays as well as CMOS cell-based ICs because of the reduced power consumption and high integration that CMOS offers.

Standard products will impact the ASIC market. They will start to pull the market down somewhat, so in very cost-sensitive applications, we will see chipsets come in and replace some of the ASICs that are in there. However, to differentiate your product, it is critical to use ASIC technology. Proven time and time again, customers are willing to pay more for more bells and whistles. It has been proven time and time again, and our end-user data clearly shows that to us. So we still believe that there is a lot of growth left in the ASIC market and it is still a very exciting industry.

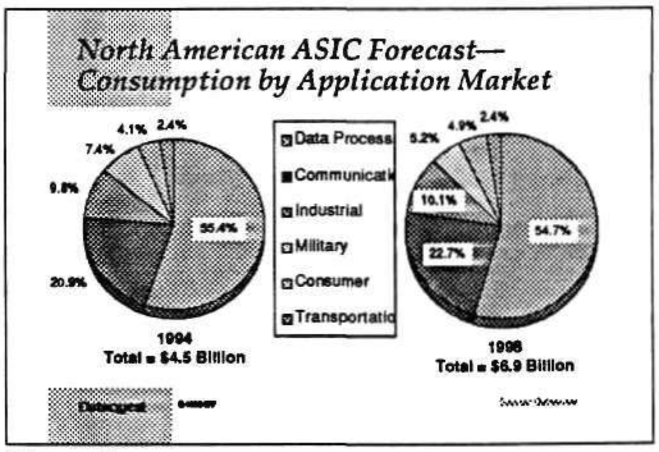


Figure 4

Where are all these ASICs going, you might be asking yourself. Well, this chart shows you in North America, that over half of the ASICs are going into data processing. Now ASICs are basically everywhere. They range in applications all the way from simple games,like Speak and Spell, all the way up to the fastest supercomputers of the world. However, the majority of ASICs are in the personal computer market and the workstation market in North America; you can see the high percentages in the data processing area.

Communications is slated for a lot of good solid growth. The telecom and datacom markets are taking off very rapidly. Military is starting to decline as the budgets contract even more. One of the areas that is quite interesting these days is consumer. People have talked about the consumer market leaving North America; well clearly that is being revitalized and is starting to come on stronger. I would even say we are probably conservative in the growth that we have here. Some of the set-top boxes are clearly an area of growth, where LSI Logic has just recently made an announcement with Hewlett Packard. Until the standards are set on these different products, we are going to see a lot of ASICs going into this marketplace, so it is an exciting new area.

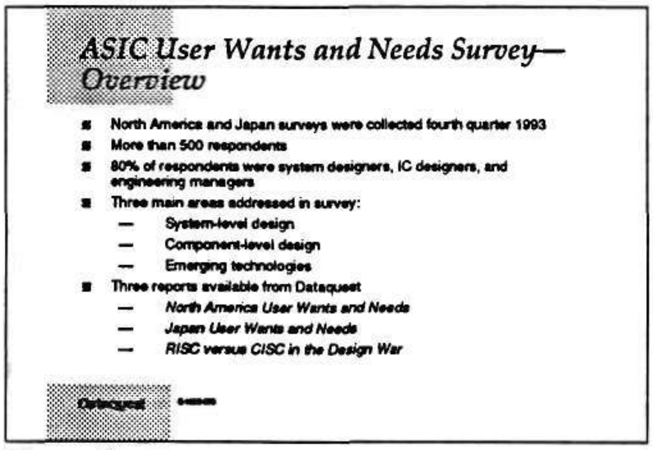


Figure 5

This brings me to an important part of the presentation in terms of looking at who are the different users of these devices. What are their characteristics? They are very different. The day that you can market a traditional ASIC, a general ASIC to everyone, has gone. You really need to understand thespecific needs of the users, so we have done a lot of research in this area and I would like to talk about that now.

The survey that we did in the fourth quarter of 1993 — and we will be doing that again coming up here in the first quarter of 1995 — generated responses from over 500 systems designers in North America and Japan who filled out these very detailed surveys. It really goes into three different areas, as you can see: the system design level, the component level, and emerging technologies. So we have written a variety of reports, and this one happens to be the one on North America. In the back of the report, it shows you the survey we used and then it shows all the trends for North America ahead of it. We went through a lot of detail in here looking at what is the board configuration, how many signal layers, what test, what packaging, what pin counts, what clock frequencies, what gate counts, etc. There's a lot of information in here. This is the North American report. There is also a Japan report that is out on display. Then we started to take vertical market looks at this information to really look at the profiles of these different users out there.

One report we wrote was CISC versus RISC and looking at North America versus Japan, what densities are they at, and what are the different clock frequencies. A lot of really interesting trends came out of that. There is a fourth report coming out shortly which will look at telecom and datacom and some of the consumer markets.

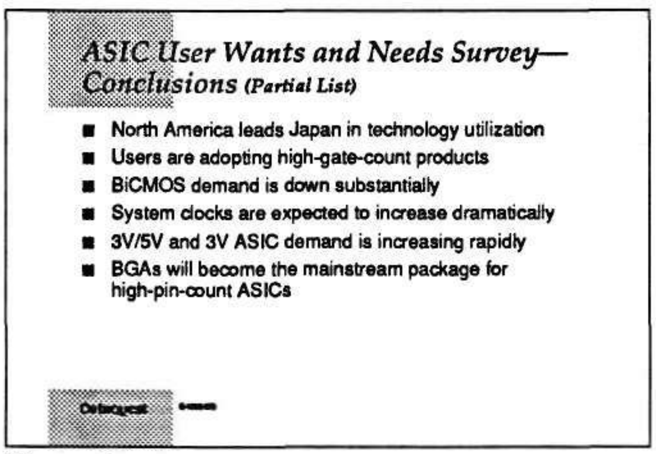


Figure 6

So to give you a quick peek under the tent, so to speak, let's look at some of the trends that we found here. We clearly found that one of the overriding issues was that North America leads Japan in technology utilization, meaning that the printed circuit boards had more signal layers and were much more complex, and the ASICs that were used were higher density ASICs. When you are targeting specific markets in each region it is really important to understand the regional influences as well as the application influence.

Now there has been a lot of talk about the million gate ASIC out there in the industry and how many million gate ASICs are being used today. Well, there are not that many million gate ASICs, but what we are seeing is very strong demand being created and a lot of designs coming up in the 100,000 to 300,000 gate range. That market is starting to take off. The design tools are there, the cell libraries are there, and we are going to start to see some real ramp-ups in some high density designs in the near future.

BiCMOS. There has been a lot of talk about BiCMOS over the years and maybe this might be the new technology that replaces CMOS. Well, we did this survey about a year and a half ago and asked users: Do you need BiCMOS? Forty percent of them said, about a year and a half ago, that they would need BiCMOS in their systems. Today when we did that survey, in the fourth quarter, we found out that this demand had dropped all the way down to 10 percent, so clearly BiCMOS in the user's eyes is not required anymore. CMOS is the mainstream technology, so my advice would be to not invest much in the BiCMOS area unless you have specific niches to address with it.

Clock frequencies was an interesting topic. We went through all the clock splits in the different application markets and while we did not see a dramatic increase from 1993 to 1994, we do expect a very strong increase in 1995. Jerry Banks has talked to you about 20 million Pentium devices being shipped in 1995 and those will be primarily in the 50 to 100 MHz range. We are expecting a very big increase in the 50 to 100 MHz range since, again, data processing is a big driver of the ASIC industry. So it it important that your chips can hit these different clock speeds.

3Volts/5Volts and 3Volts. We're seeing a strong emergence of products in this area. Now it varies by each application market, so we really have to look at that, but really its speed and density are some of the reasons you would use it, longer battery life, or if you have to go to a different architecture. If you catch me later I can talk to you more about specific applications regarding that.

Finally, looking at some of the packaging issues and pin-count issues, we have done a lot of work in that area. In 1994 we saw that only about 4 to 5 percent of the designs were in ball grid arrays. Today, however, we believe that there is a very strong demand for this product and that this is a very good solution to the packaging problems of today. We are forecasting that in five years 40 percent of the ASIC designs in North America will go into ball grid arrays, and 75 percent of the designs greater than 100,000 gates. So ball grid arrays are a package that is very important to the industry.

This is just the tip of the iceberg in terms of the information we have. User information is critical to market success and Dataquest can help you. If you get a chance, please come talk to me and we will tell you the trend information that we have to help guide your product decisions.

Thank you.

Analog and Mixed-Signal ICs

Gary J. Grandbois
Principal Analyst
Semiconductor Worldwide Service
Dataquest Incorporated

Mr. Grandbois: As the sign says I'm Gary Grandbois, principal analyst for the Semiconductor Worldwide Service. We cover all devices — memories, micros, ASIC, at a top line look. In addition, we've had Analog, Discrete and Optos to provide full coverage of the semiconductor market. Today, I am going to talk about Analog ICs to complete the IC overview.

Analog ICs, of course, have been around a long time, are a very old and venerable product line that people have started to count out or did count out as being a non-growth product category. But, it has held on, it's growing, and we think, with the convergence of the computer, consumer and communications products, that there's a resurgence in analog products. In order to understand the dynamics of the analog market, you really have to look at the Analog IC product category as two different families.

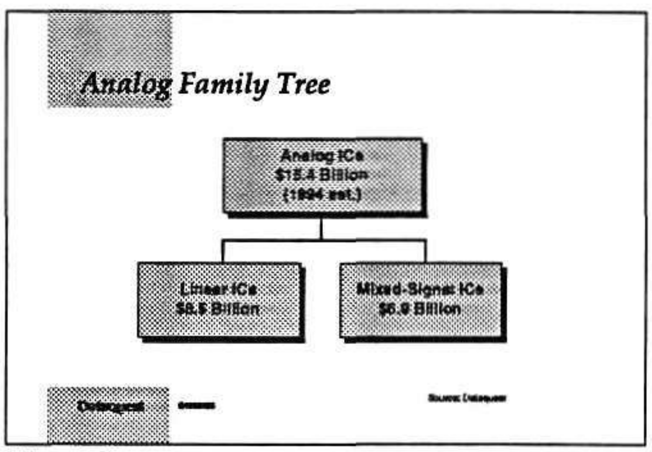


Figure 1

There are linear ICs, the older products in a sense. Standard linears such amplifiers, comparators, voltage regulators. Specialty linears such as consumer-specific products, automotive-specific, and of course, linear ASIC. These products have made up the bulk of the analog product line and have been growing over the 1988 to 1993 period at only 6.3 percent compound growth rate. So they've been a little slower. The real growth is in the mixed-signal area, a product line that's grown at a 16.5 percent compound growth rate, from 1988 to 1993. The mixed-signal products of course, mixed analog and digital, are made up of data converters, mass storage kinds of products, a lot of computer-specific products, and mixed-signal ASIC. Data converters being a very important product line and interface ICs.

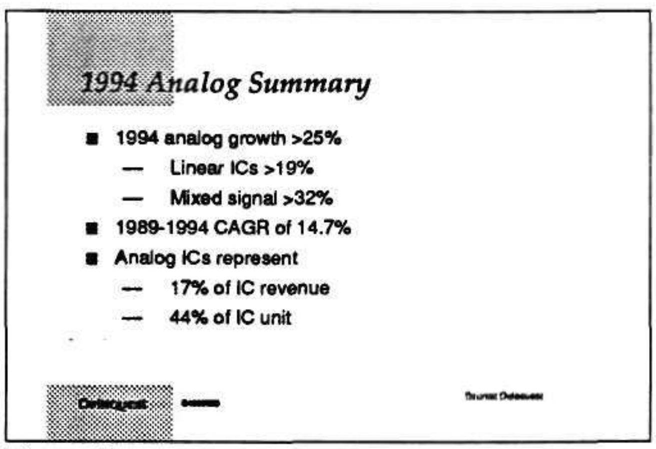


Figure 2

So what happened in 1994? Well, we see Analog growing at greater than 25 percent, following 1993 where the growth was 21 percent. So it's been two very good years. Part of the reason is that the consumer market over the past few years has been very good for Analog. That has driven the linear IC category very strongly— 19 percent growth in 1994. It was more than 19 percent growth in 1993. As I said before, its 1988 to 1993 compound growth rate was only 6.3 percent. So there's been a lot of activity there. And, of course, there is new interest in some of the high-frequency video amplifiers.

Mixed-signal, on the other hand, the driver of growth, has been growing greater than 32 percent in 1994 on top of 24 percent growth in 1993. So, it's a stronger product line. We expect it to be. It certainly is more intimately involved in the growth of digital electronics and especially digital electronics that's taking on analog kinds of functions.

So the 1989 to 1994 compound growth rate of Analog is 14.7 percent, and I think you saw in Gene's forecast that our forecast for Analog from 1993 to 1998 is 14.7 percent. So, it's clearly symmetrical. Now, that's a little lower than the digital IC growth rate over the same period of 16.5 percent.

Analog ICs have slipped a little bit over the past two decades. In fact, they probably slipped about a percent and a half per decade. So, if you go back to 1974, and that's been brought up a number of times today, we would see more than 20 percent of IC revenues would have been Analog. In 1994, it's down to about 17 percent. What is interesting is that the Analog unit growth is very substantial. Unlike digital ICs where the integration is more and more functionality per IC, that kind of integration is not happening in Analog ICs. Consequently, the average printed circuit board out in the marketplace has 44 percent of its ICs being Analog. Of course, they're not the biggest ICs on the board, but they are there nonetheless. And to coin a phrase, Jerry talked about ubiquitous, well then, Analog ICs are even more ubiquitous.

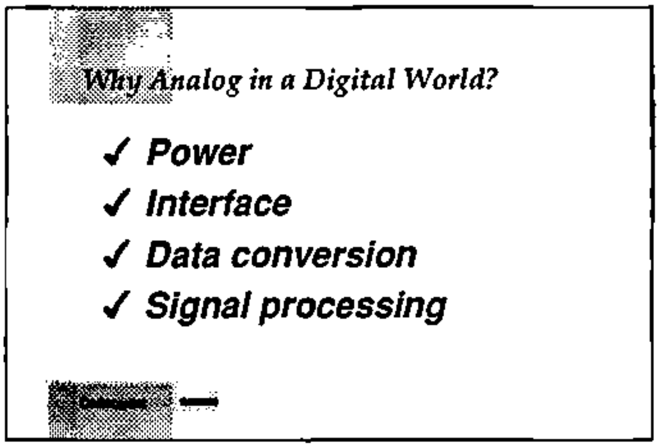


Figure 3

So, why this kind of growth in the teeth of a digital revolution? Well, there are really four areas that analog remains important in. The first is power; in power supplies. Even digital electronics has to be powered. Power supplies are getting more and more complex. Switching regulators are followed by linear regulators, and ever more exotic kinds of regulation techniques to get higher and higher efficiency for the "green" revolution. Specialty regulators that operate off-line voltages and allow reduced size and weight through the smaller transformers. Again, another specialty regulator would be the power factor correction circuit. So a lot happening in the power area. Also, when tied in with microcontrollers, Analog ICs provide the interface to drive power products.

Interface. Interface is very important and Analog ICs provide interface for instance, on transmission links in communications. Anything from copper, fiber, or even the electromagnetic spectrum. Also, interface to power devices, electromechanical motors and solenoids, and electrical chemical devices such as displays. And of course, CRTs have to be driven by analog kinds of products. So any time you need a special voltage or current, impedances need to be matched — these kind of Analog components are used.

Data conversion. Fairly obvious. As we go to a more digital world, we want to convert signals into digital. Data converters are increasingly needed. The dilemma for the Analog IC product area is that these data converters are increasingly integrated into digital products. So we don't see the amount of growth in the analog data converter area that we think is really happening in terms of data converters.

Last, but not least, would be signal processing, typically an important area for Analog ICs. Certainly consumer entertainment electronics is a big area for analog signal processing. Some of that will be taken over by DSP in the future, but a lot of it won't because the analog functions will remain low-cost, for the low-cost, lower-performance products. In using DSP you'll still need some previous and post DSP signal processing using Analog components. High frequency analog ICs will remain fairly important over the long term.

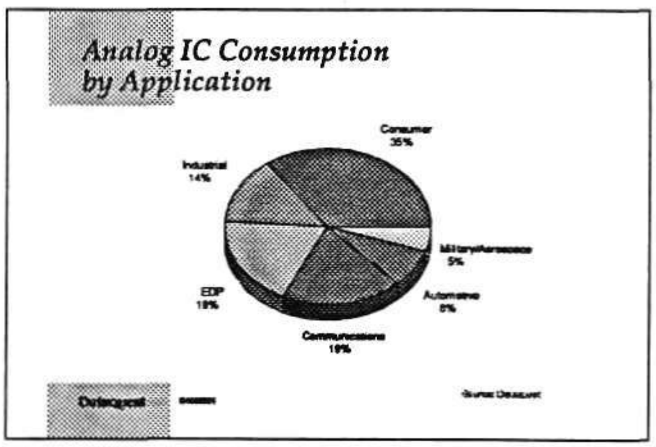


Figure 4

Now who uses Analog ICs? The consumer market consumes over a third of Analog ICs, and of course, then it drives the Analog IC market up and down. As I said, for the Analog IC area, the consumer market of the past few years has been very strong. So our forecast is predicated in many ways, on what's happening in the consumer market. We see that the consumer market for Analog ICs in 1995 is only going to grow about 10 percent. So, that corresponds to a lower forecast. The growing portions of the market would be in the computer and data processing area, and communications.

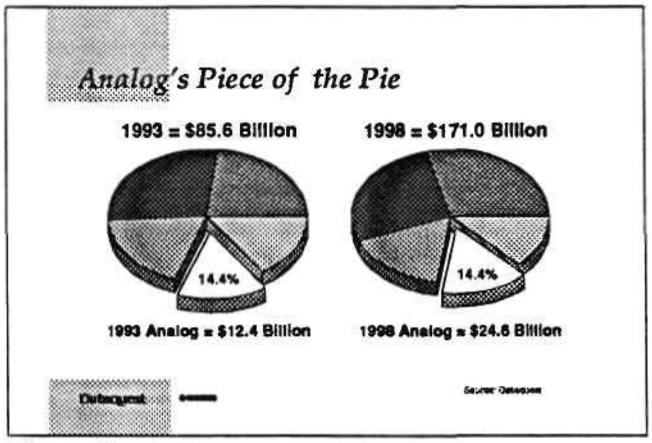


Figure 5

Now, we've looked at Analog ICs as being 17 percent of the total IC pie. In terms of total semiconductor, it's about 14.4 percent, down a little bit from the 14.6 percent in 1988. What our forecast says with a 14.7 percent compound growth rate, compared to the semiconductor growth of 14.8 percent, is that the Analog piece of the pie, essentially remains the same for the forecast period.

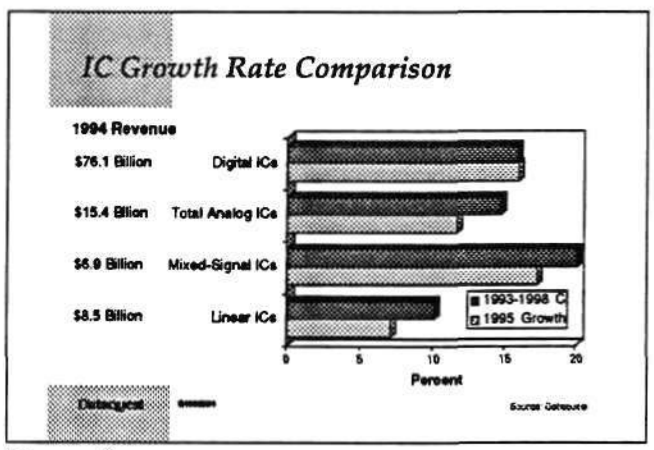


Figure 6

Now, for a comparison of the growth rates. You'll see the mixed signal in this case shows a higher compound annual growth rate and a higher 1995 growth rate over digital ICs even. Of course, it's only one tenth of the magnitude, so it certainly has room to grow. Digital ICs will show 15.9 percent growth in 1994 and a compound annual growth rate of 15.8 percent. Analog ICs will only show 11.6 percent growth in 1994 because of the slowdown in the consumer market to below 10 percent consumption of Analog ICs. Mixed-signal ICs aren't as affected by the consumer slowdown. However, the linear ICs that you see on the bottom, see only 7 percent growth in 1995 due to this slowdown.

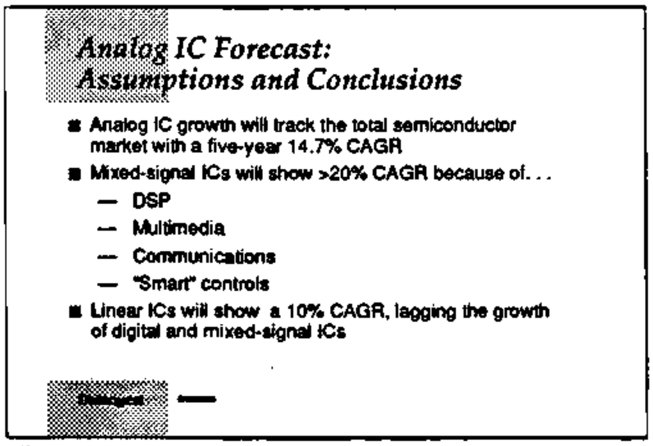


Figure 7

So, in summary, we see that the Analog IC categories are expected to track total semiconductors fairly closely over the forecast period. Increasingly, the Analog IC market is being driven by mixed-signal ICs and being driven by the interface of the digital electronics world — in terms of the audio, video, multimedia things going on — all the new products. In addition, teamed with microcontrollers, Analog ICs provide the smart control, the smart power needed to provide smart appliances and smart products in the future. Linear ICs, being tied into the linear signal processing part of the consumer market, are showing lower growth over the forecast period.

Thank you.

Pricing Trends

Mark Giudici
Director and Principal Analyst
Semiconductor Procurement Service
Dataquest Incorporated

Mr. Giudici: Good morning. I'm the Director of the Dataquest Semiconductor Procurement Service. Now when I was asked to get a title for our talk today I know most of us are familiar with convergence that was the theme of our last conference, so I will be talking about the convergence of, or the crossover of price-per-bit in the memory market, for 16Mb DRAMs in particular, and also where microprocessors are going and how they are affecting the marketplace. But before I go further, let me talk a little bit about Semiconductor Procurement Service and how it fits into the overall market research scenario here at Dataquest.

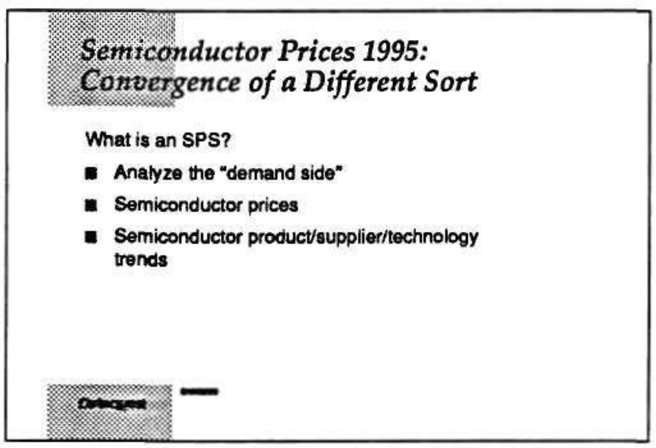


Figure 1

In the Semiconductor Procurement Service we analyze the demand side of the semiconductor market. This involves pricing, lead times, and inventory analysis, as well as outlooks into capacity utilization, and what it means to semiconductor users. We forecast North American semiconductor prices on a quarterly basis using user and supplier inputs, and also have input into our monthly DQ Monday pricing data that many of you are familiar with. By taking a user perspective, we regularly review the key supplier trends, product trends, and technologies that impact the design and procurement decisions of the major users of the worlds semiconductors.

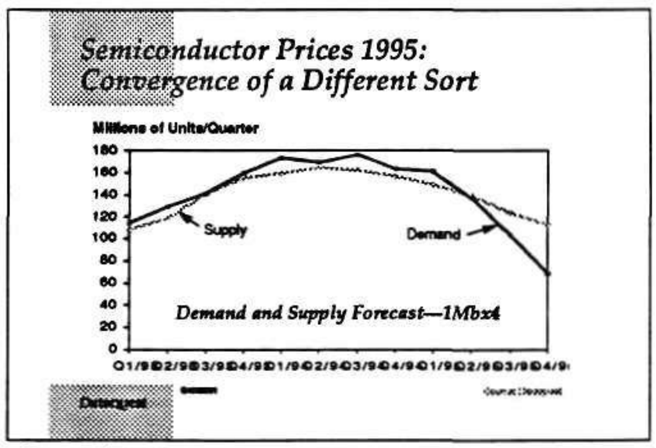


Figure 2

For example, this graph comes from an ongoing multiclient study that highlights how the demand for the critical 1Mbx4 DRAM will continue to exceed supply on through the second quarter of 1995. As capacity of the 16Mb DRAM increases over the next six to nine months, demand will quickly shift from the 4Mb to the 16Mb due to price-per-bit economics. The question is, when? As we shall see, this is the device, the 1Mbx4 device that is used by most of the major PC users as a benchmark in their price-per-bit crossover equations. But let's get back to the overall supply/demand picture.

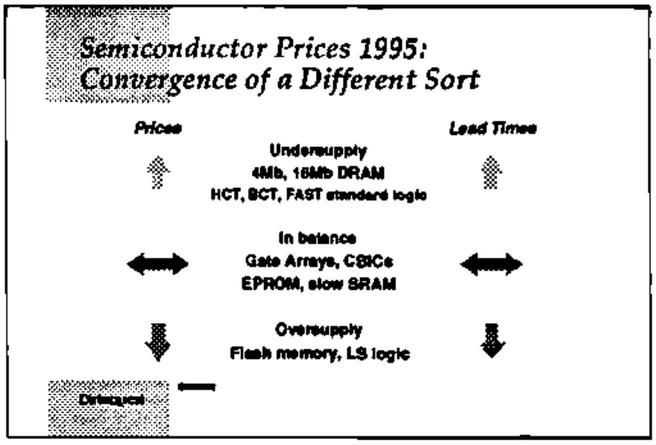


Figure 3

Right now we're seeing three distinct markets, if we use lead times and pricing points as guidelines. There's currently an undersupply market, or an allocated market, and these have lead times of 13+ weeks, maybe multiples of that in some cases. This would be the 4Mb and 16Mb DRAM, and some selected advanced standard logic products. Standard logic may not be the most glamorous of markets, but the advanced market is getting more and more attention and there's a limited supply base of these products. As demand remains strong for these parts, the lower-power, higher-speed, higher-drive applications continue to put pressure on that, and that is why it remains in allocated mode.

Then we come to the balanced product market where we have lead times in the 12 week time frame. Here, prices decline slowly and predictably. This includes ASICs primarily, EPROMs, slow SRAMs, and they're generally adequately supplied and should be relatively available for the next 12 months or so.

Then we come to the oversupply market. We see lead times under eight to 10 weeks, sometimes off-the-shelf, very competitive pricing, and if you wanted to name some products here you'd see the Flash memory products right now and many of the mature bipolar logic products in this camp. We see sporadic price cuts here with lead times that are also sporadic as overproduction has exceeded demand in many cases. We get a lot of questions about pricing in our service and one of the top ones is about the DRAM market. Let's take a look at that.

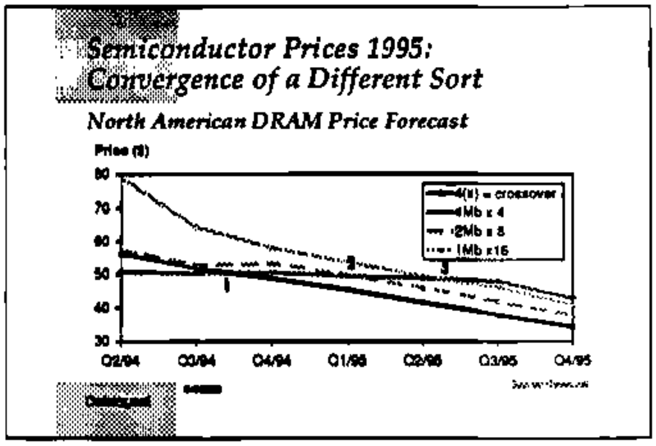


Figure 4

If you look at the purple line, that is the crossover point based on our last forecast of the 1Mbx4 DRAM part, 4(x), so overlaying the 16Mb products on this 4(x) crossover line, we see that there are three distinct crossover points for the 16Mb part. The first one is occurring right now and this is for the 4Mbx4 16Mb DRAM. We see this product going now between $49 to $52 in the North American marketplace, and these parts primarily go into the workstation. The next crossover is a 2Mbx8 16Mb part. Now this will occur in the Q1/95 to Q2/95 time frame and as capacity for this device makes it through to the market. There are some suppliers behind this curve, but the overall market will be here in the Q1 to Q2 time frame. Now this flavor of 16Mb part goes into high-end PCs and also workstations.

However, the chip of choice in the PC market is the 1Mbx16 part, primarily because it allows for 4MB SIMM configurations. That is where the demand is in the mass market for PCs. Due to manufacturing and test challenges, this part will not reach price-per-bit parity in our estimation with the 1Mbx4 until the Q3/Q4 time frame of next year. A lot of companies are trying to make this part. It's not because there's a lack of effort on the supply side. It's more of a challenge than a lot of companies had thought, and the users are anxiously awaiting a 2 chip 4MB SIMM module. But it's not there yet.

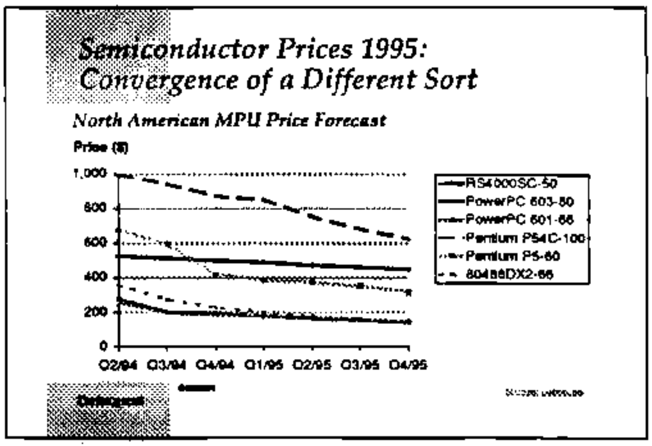


Figure 5

Let's look at another critical system component. This would be the high octane microprocessor price curve. Now as I said we use supplier/user inputs for our pricing surveys. This curve reflects that. As you can see, the nontraditional price erosion of the P5-60 Pentium part has quickly squeezed into the 486DX2 market, which is the purple line on the curve, into the PowerPC price range, which are the green and yellow lines. This leaves the P54C-100 Pentium part to follow a more gradual price curve at the current point in time. Now this is the current scenario.

This scenario may change in the 1995 time frame due to the fact that if more competitively priced 486 products come to market and keep the overall system cost of these systems lower than anticipated, this in turn will keep the shift over to the Pentium platform from occurring as fast as Intel has planned. This may again cause a nontraditional price cut in the Pentium market in the 1995 time frame. This is our forecast at this point in time. We're seeing that, unlike in the past, the competition is having a subtle influence in the microprocessor market, and price elasticity from both the semiconductor and the system markets will probably see more of this as production ramps up for both the RISC and the CISC supply base of these parts.

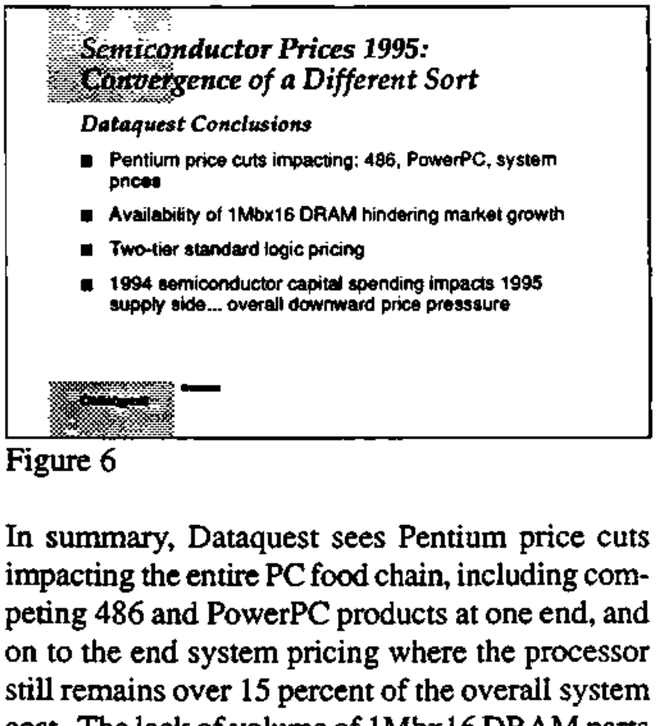


Figure 6

In summary, Dataquest sees Pentium price cuts impacting the entire PC food chain, including competing 486 and PowerPC products at one end, and on to the end system pricing where the processor still remains over 15 percent of the overall system cost. The lack of volume of 1Mbx16 DRAM parts will lengthen the price convergence of this part and may impede some PC market growth due to SIMM demand trends. We will continue to have a two-tier standard logic market where advanced logic will remain in high demand due to low power and high drive requirements. As Clark Fuhs will explain right after me in more detail, the capital spending that we now see in 1994 will hit the market in 1995, and in the case primarily of DRAMs we will see yet another turn of the cost/price decline spiral.

Thank you very much.

Wafer Fab Equipment Forecast and Trends in Capital Spending

Clark J. Fuhs
Senior Industry Analyst
Semiconductor Equipment Manufacturing and Materials Service
Semiconductor Group
Dataquest Incorporated

Mr.Fuhs: Let me be the first to wish you "good afternoon." I've been with Dataquest a little over a year. I'm in the Semiconductor Equipment Manufacturing and Materials group. We study fabs. I've spent ten years in the equipment business. I would like to review with you our wafer fab equipment forecast and trends in capital spending.

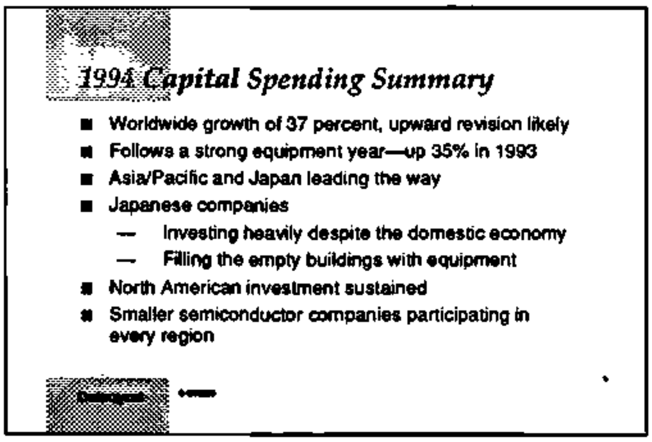


Figure 1

The times they are a-booming. We expect the capital equipment front-end equipment market to grow about 37 percent this year. Actually, we think it will be revised upward to more like 45 percent growth on the heels of a very strong 1993, up 35 percent. Asia-Pacific and Japan are leading the way. The Japanese semiconductor operations are among the most profitable in the Japanese companies and are winning the battle for internal capital. So they are investing heavily despite their weak domestic economy, for the last twelve months filling the empty buildings that they built back in the 1989-to-1991 time frame. North American investment has been sustained and even the smaller semiconductor companies are participating in capital spending, building new fabs in every region of the world.

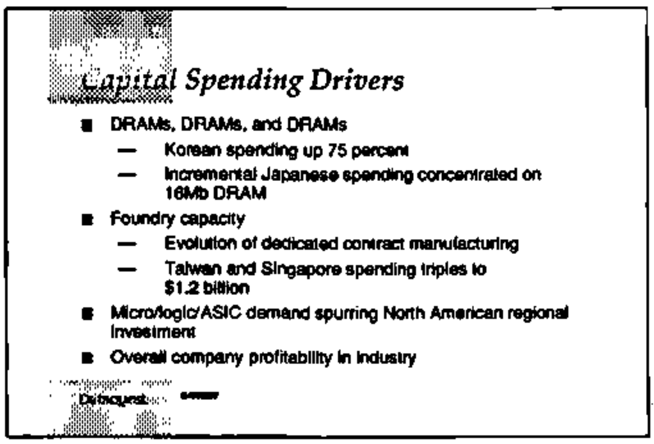


Figure 2

What is driving this spending boom? DRAMs, DRAMs and DRAMs. Korean spending is up 75 percent and any incremental Japanese spending is concentrated on 16Mb DRAMs. Semiconductor manufacturing is in the process of restructuring a bit with the evolution of dedicated contract manufacturing sites.

This is particularly evident in Taiwan and Singapore where foundry capacity spending has tripled in 1994 to $1.2 billion. Basic logic chip demand, and the pervasiveness of semiconductors in everyday life, is driving the U.S. spending. Profits are up, spurring more investment. You can't spend money if you can't make money, and I expect everybody is making some money right now.

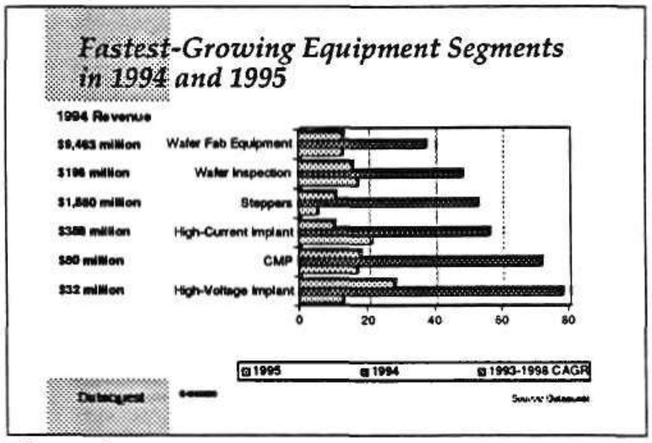


Figure 3

This slide shows which segments of the equipment market are growing fastest in 1994 compared to the overall market. This slide is different from other slides that you may have seen, as we include 1994 and 1995, since 1994 spending actually hits capacity in about six to nine months later. At the top, the green bar, shows the overall wafer fab equipment compound annual growth rate at about 13 percent, and that is about a percentage point below the compound annual growth rate of semiconductors. So the two markets are correlated.

This year, of course, we expect just under 40 percent growth, and next year we're expecting about a 13 percent growth. We believe our 1995 number is probably conservative.

In this graph we have two themes. First there are the segments of the market and the technology that are being more heavily adopted in advanced manufacturing, such as in-line wafer inspection systems and chemical mechanical polishing. Those are secular moves that are increasing faster than the overall wafer fab equipment market. In this good year, these segments will be growing faster than the market as well.

Second, and probably the most descriptive of the spending pattern this year, is what I call the DRAM effect. Steppers and high-current implant are two equipment segments that depend very heavily on DRAM investment. In fact, if you look at their long-term compound annual growth rate, it is actually slower than the overall market, but yet this year they will grow in the 50 to 60 percent range, a very good year for steppers and high-current implant. Note that high-voltage implant is the fastest growing segment. This segment is DRAM sensitive and is a secular move into the half micron technology, so we expect this market to grow upwards of 80 percent, and that is probably conservative.

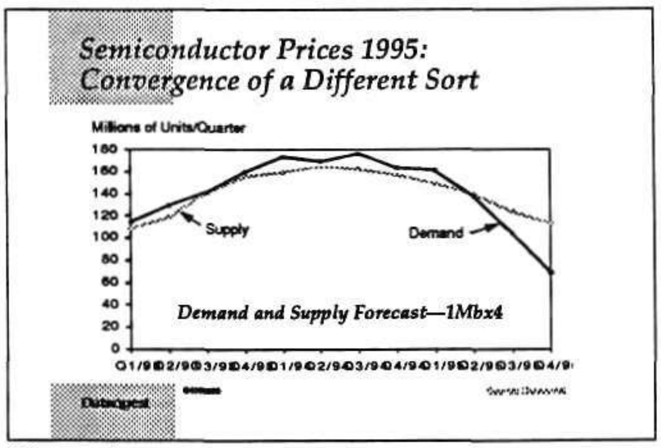


Figure 4

All of this DRAM capacity coming on-line at the 16Mb level will create a demand fall-off for the 4Mb DRAM as shown by Mark earlier. This will translate, from the capital spending and wafer fab equipment side of the house, to accelerated price-per-bit declines in 1995, squeezing memory profits and profitability and eventually leading to capital being squeezed in 1996 for DRAM investment. We are calling for about a 5 percent decline in the wafer fab equipment market in 1996 and about a flat 1997 before healthy growth resumes in 1998. Details of our wafer fab equipment market forecast are included in the binder but will not be presented here because I would like to actually spend a few moments talking about one other interesting point.

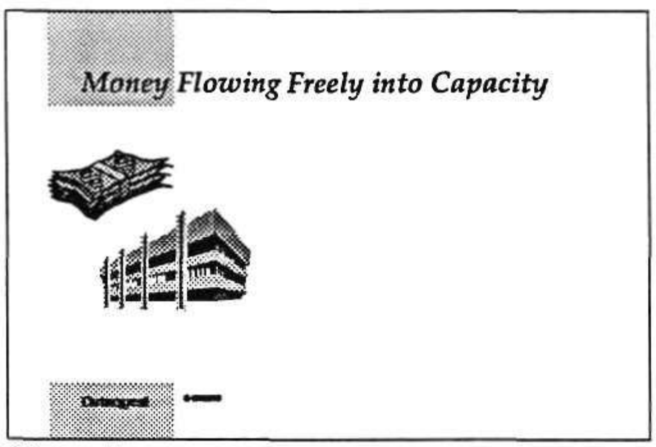


Figure 5

Money is flowing freely into capacity now. We get a bit concerned when we see growth rates of these magnitudes for a couple of years running, outpacing the semiconductor industry. Three months ago, we presented a model that concluded that by the end of 1994 enough capital had flowed into the fab in the form of equipment to create a net cumulative over-investment of equipment. This can be thought of as a leading indicator for excess capacity. The model basically showed that we could have excess capacity perhaps as early as the first half of 1995.

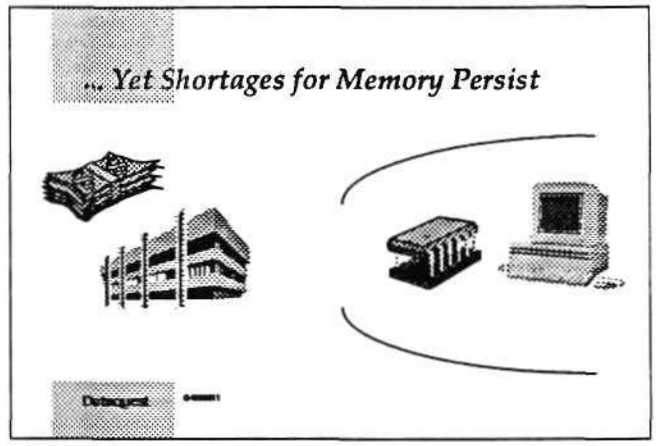


Figure 6

Yet, shortages for memory persist and as you have heard today, we do not see relief in many segments as early as the capital model suggests. We have often been asked why is one model saying one thing, and another model saying another thing? So with a little bit more investigation we have discovered something.

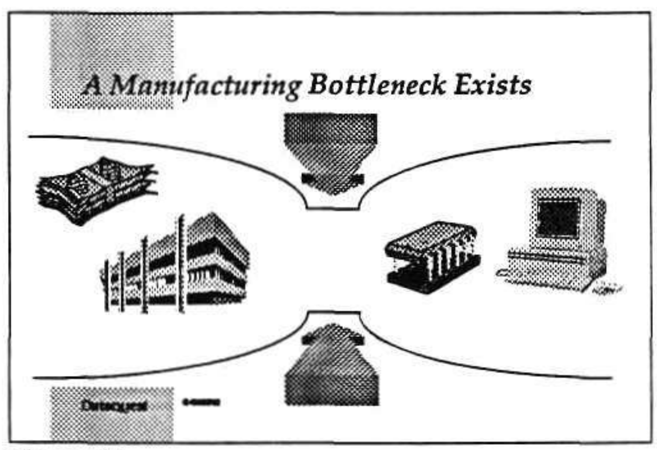


Figure 7

An unanticipated manufacturing bottleneck exists for the 16Mb DRAM. Now as far as we can tell, the yield and learning curve issues are normal for the 16Mb DRAM, relative to earlier generations. A wafer size change and investment patterns are very normal and, in fact, we believe the 4x4 16Mb yield is over 70 percent on 8-inch wafers today.

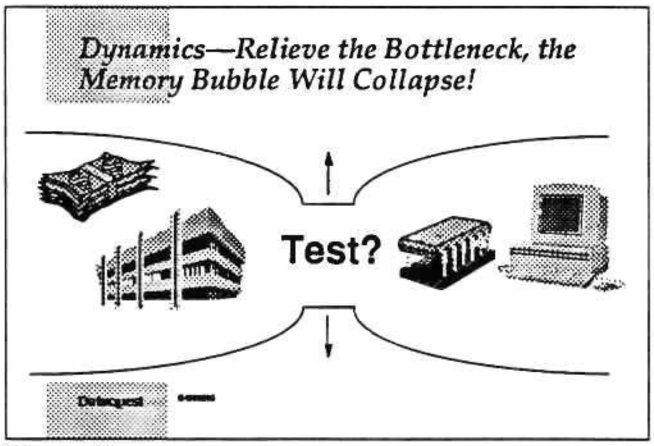


Figure 8

However, there is one exception to the 16Mb growth pattern as compared to earlier generations. For the first time, a 16-bit wide chip architecture is required for mainstream consumption. This demand has hit earlier than manufacturers thought and we believe they were caught flat-footed. The manufacturing bottleneck is created because different test equipment is required to test a 16-bit wide chip. Upgraded systems have slightly lower throughput, but we are now in the midst, in the last few months, of a buying binge of test equipment for this problem, so manufacturers are responding with some additional capital spending.

One indicator of this is the prober market; probers are sometimes attached to testers. The prober market is expected to grow 40 to 45 percent this year, and this is a market that never grows that fast. In fact, in the peak year of 1989 when the equipment market expanded nearly 60 percent, probers were only up about 28 percent and they are going to grow 40 to 45 percent this year. This points to a test shortage, specifically in 1994.

Furthermore, at a recent visit to Electroglas, a U.S. manufacturer of probers, we learned they have increased their export ratio from about one-third to one-half their business. This suggests that a near doubling of the Far East consumption, both in Japan and Asia-Pacific, has occurred in the prober market. These are typically systems with fairly low lead times. As these systems are put in place, test capacity will catch up.

What we understand as well, excess capacity at the tester level is currently being bought, so chips will flow and the memory bubble will burst resulting in a price decline. This phenomenon of an unexpected bottleneck has extended this particular DRAM cycle some five to nine months over what we would have normally seen from a capital model and by this stretching the onset of over-capacity into late 1995. This particular point brings the capital model in agreement with the supply-demand models presented earlier.

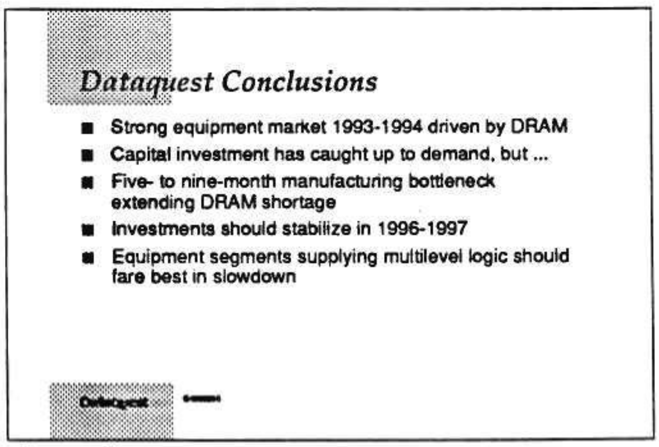


Figure 9

In conclusion, the strong equipment market in 1993 and 1994, in particular, is driven by the DRAM. Capital investment has caught up to demand, but a five to nine months manufacturing bottleneck — perhaps that could be a little shorter — has extended the DRAM shortage. Investments should stabilize in '96 and '97, before healthy growth resumes in '98. The equipment segments that supply multilevel logic supporting U.S. customers, should fare best in this market slowdown as this is primarily a DRAM investment slowdown.

Asia/Pacific Markets and Forecasts

Daniel Heyler
Senior Industry Analyst and Manager
Semiconductors Asia/Pacific
Dataquest Incorporated

Mr. Heyler: As Clark said, I'm based in Dataquest Taiwan and am responsible for managing Asia/Pacific semiconductor research, which we look at really from the entire span of the food chain, looking at applications and devices, as well as the individual countries. Today I'm going to look at all those sectors at a top level and give you some indications as to our forecast and what we plan to do in 1995 in terms of new research and new products.

We have analysts based across Asia/Pacific. I've been with Dataquest for six years and when we're talking about 20 years of semiconductor industry history, since I'm 31 years old, I grew up during the creation of Silicon Valley. We really see that Asia/Pacific has surprised us in many, many respects. So we are expanding our research in Asia/Pacific. This new announcement of an acquisition of ResearchAsia is extremely good news for us, particularly in our applications research which is what we currently produce.

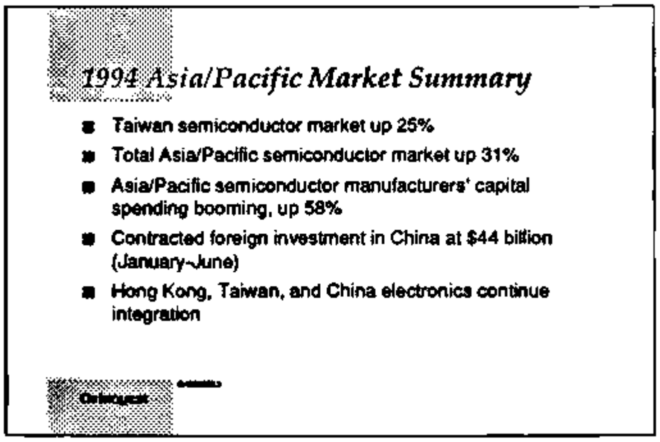


Figure 1

Taiwan is the largest Asia/Pacific semiconductor market. That market is approximately $5 billion in 1994. It grew at about 25 percent. Currently that is the run rate for 1994, and we expect it to sustain 15 percent share of the Asia/Pacific market for the next five years. There's a variety of factors that are happening there. First of all, high-end electronic equipment and high-end PC production continues to move up the learning curve in Taiwan. A number of desktop manufacturers, as well as motherboard manufacturers, have expanded their production and are moving into multimedia, while low-end manufacturing is moving offshore into China. Hence, its 15 percent share out through 1998 in terms of semiconductor consumption, obviously being driven by the PC industry there.

When we're looking at Asia/Pacific as a whole for 1994, we had forecast it to grow by 31 percent in our spring forecast earlier in the year. We have kept that forecast and the market is running currently at about 31 percent. When we say Asia/Pacific we mean the markets outside of Japan. I think when you're looking at Gene Norrett's previous statement about Asia/Pacific and how the Asia/Pacific companies are about seven percent of the worldwide industry, that means that they're shipping seven percent of the devices consumed on a worldwide basis.

Yet we hear so much about the Asia/Pacific region because largely it is a huge, consuming region, which means that semiconductors are becoming a political issue since imports are becoming severely high. Consequently, countries such as Korea, and Taiwan, and now Singapore, are investing heavily in capital equipment, and we see that 58 percent increase is largely due to Korean and Taiwanese manufacturing, now with Chartered Semiconductor and Tech Semiconductor coming online in Singapore. We see that these investments are expanding dramatically. When you look at the actual production it's still a drop in the bucket. That is, the deficit between what is consumed in Asia/Pacific and what is produced in Asia is greater; I mean the deficit is greater than what's being produced. It's going to take more than two to three years for that balance to be created. What it really means is that there are opportunities galore for the large U.S. and Japanese manufacturers that are currently shopping around Asia/Pacific looking for places to locate fabs within the region to take advantage of its very high growth.

China is currently the fourth largest market in Asia/Pacific. It's about a $1.5 billion market in 1994. Its growth rates are outpacing, as you'll see in some later slides, the other countries in Asia. Investment is slowing down largely because of the over investment in the past three years. The economy is growing still; it is the fastest growing economy in the world. Southern China is booming. Infrastructure continues to expand. If you look at the actual investments in 1993, there's about $60 billion. The contracted investments in 1993 were about $90 billion, so when you compare that with 1994, the decline in growth from $60 to $50 billion is not a large decline. It's a deceleration, but you're still talking about $50 billion in actual investments, with the contracted foreign investment probably estimated to be somewhere around $100 billion by the end of 1994.

Another kind of summary you see in 1994 is the continuation of three years of economic integration between Hong Kong, Taiwan, and China. This shouldn't be overstated or oversimplified. China is a big market, but there are diverse trends emerging throughout the China market that you need to look at individually. But the importance of Taiwan towards the electronics industry in China is one trend that has not been examined as deeply as it should be. We estimate that approximately 30 percent of Taiwan's computer industry is already assembling, in the final assembly stage, in China, which means devices are being purchased and ordered from Taiwan.

But we're seeing that the trend could change whereby those devices are going to be purchased directly from within China itself. So the combination of Hong Kong, with its financial banking, its marketing and export expertise, and shipment expertise, combined with Taiwan's large manufacturing base and engineering capabilities, are positioning the region for a large end market in China, which Asia/Pacific never really had. Much of Asia/Pacific's phenomenal growth has been due to exports to Europe and the U.S. with capital generation through those exports. We're just seeing the beginning of a huge potential in Asia/Pacific due to the possibility of large end markets for much of this new equipment that's going to be built.

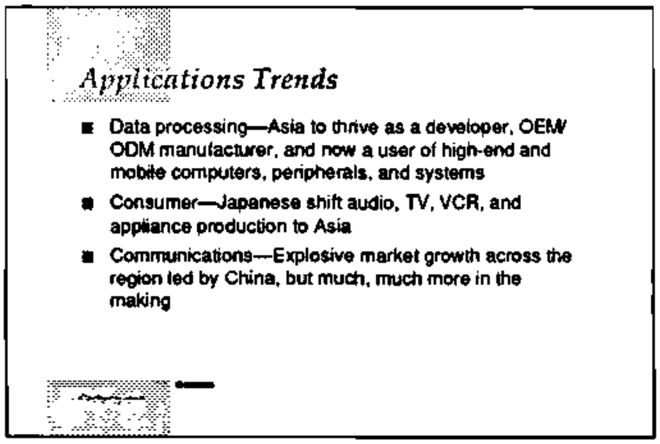


Figure 2

Within Dataquest we look at the entire food chain, as we said. In Asia/Pacific we do this as well. The applications area is really what we look at when we look at what the drivers are going to be within the region. The drivers primarily are data processing, consumer, and communications. Consumer has been the largest application until now. We forecast data processing to surpass consumer in spite of the large Japanese investment in 1994 (that's on a revenue basis). Communications is the third largest and it's the fastest growing segment. We're seeing huge consumption of electronic communication systems being shipped to China and Southeast Asia. However, a new trend is that end equipment is being more and more produced within the Asia/Pacific region. Because of the large infrastructure characteristics of communications, governments can require companies to build the equipment within the countries in order to allow for market share of those companies. That's been the case in China, where companies like Motorola and Alcatel have built there and they've taken the leading edge and have gained market share by doing that. In addition to China, there are a number of new countries that have emerged, including India and Southeast Asian nations that are striking alliances with these large global telecommunications companies.

In consumer, we had a conference in Japan earlier in the year and we found that we were listening to Japanese executive after Japanese executive talk about Asia/Pacific as their production center for consumer electronics. They're positioning their entire consumer electronics industry to be production-based and design-based not only in Asia for export, but in Asia for consumption within Asia. That enables companies to counter fluctuations in the yen and enables them to counter trade friction with the United States and with Europe. It also allows Japan to position themselves for a huge potential consumer electronics market within Asia/Pacific. We've seen that consumer electronics overall in Japan is moving toward high-end multimedia, while Asia/Pacific is maintaining its mid-level to low-end applications.

What does all this application information mean for semiconductor consumption? I think first and foremost we see that the total market in Asia has been accelerating for the past three to five years. It peaked in 1993 with a 45 percent growth rate. Our numbers accounted for the large amount of Japanese manufacturing that had actually shipped production to Asia/Pacific, and some devices were being purchased from Japan but consumed in Asia/Pacific, so we've tried to account for that actual shift in trends taking place for the consumer electronics applications. We forecast the market to grow by 31 percent in 1994, which is a deceleration, but still the fastest growing market in the world, in 1995 growing about 20 percent.

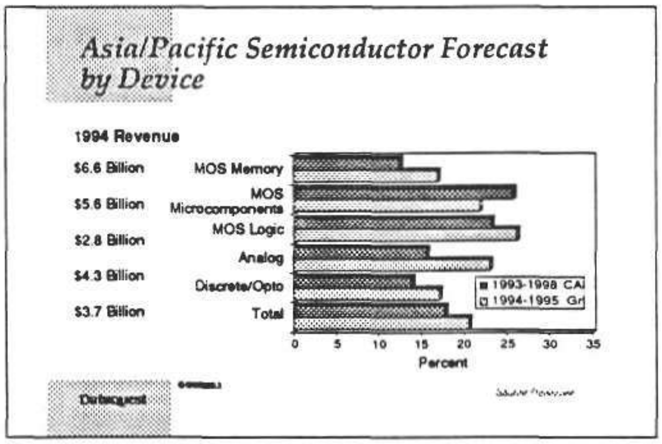


Figure 3

MOS memories is shown here growing over the next five years. It's growing faster than the worldwide market is growing. There are a number of trends that Jim Handy has pointed out that apply to Asia/Pacific, namely the importance of PCs. We expect Asia/Pacific production to keep pace with worldwide PC consumption, first of all. Second of all, we expect Asia/Pacific production of PCs being shipped to the Asia/Pacific market to outpace shipments by the multinationals, so that in turn translates into increased consumption and increased market share for the MOS memory segment.

MOS microcomponents is the second largest segment in Asia/Pacific, but it's surpassing memories for a couple of reasons. What was interesting in 1993 and 1994 is that the actual purchase of microprocessors within Asia/Pacific began to shift to the market of distribution. In other words, Intel's microprocessors were being built, being consumed in North America, whereas previously, at the 386 level, they had been actually purchased within Asia/Pacific. We saw a change because of inventory issues, the shipment speed, and pricing advantages of actually purchasing the microprocessor within the site of distribution. That caused a slow-down for companies such as Intel.

However, as we see in the 1995 to 1998 time frame, a couple of trends are happening. First of all, the end markets for these PCs, for the Acers, for the Mitacs and for the Compaqs, are focusing their production facilities in Asia/Pacific for the rapidly emerging Asian PC market. Shipments from Singapore to North America in the first half of this year were half of what they were previously in 1993. What that means is that Compaq, Apple, and others like AST, are no longer exporting from Asia/Pacific nearly as much to Europe and North America as in the past, and that these facilities are increasingly important for Asia/Pacific consumption.

MOS logic here is the fastest growing segment. It's a $2.8 billion market and that trend again relates to what I mentioned earlier about microcomponents picking up because of the increase in notebook computers. ASICs are growing quite quickly due to telecom applications. Analog and discretes are increasing due to a large growth in consumer electronics within Southeast Asia.

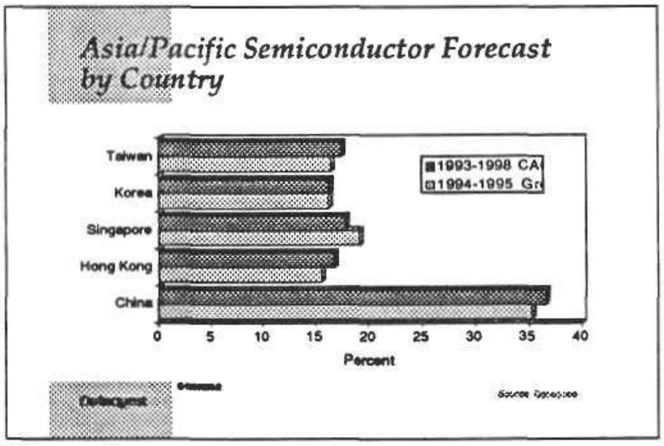


Figure 4

This is my last forecast slide and then I'll go to some of the summation and conclusions. We track the markets not only by applications and devices, but we also get into country-level research. We try to position our analysts throughout Asia/Pacific to get into the local issues and local trends. Each Asia/Pacific market and country is extremely diverse and when you look at this market here, Taiwan is being driven by a huge growth in its data processing capabilities. We expect Taiwan to be number one until 1998, and Korea will be number three, being surpassed by China.

Acceleration in China's growth rate here is phenomenal. A number of factors are involved. Foreign investment continues to flow into China to produce from China, first of all for export, but now it's moving into local production for local consumption. Another issue is that Hong Kong is growing in Southern China and it's continuing to grow not only for export, but also it's an important place for disk drive and peripheral manufacturing as well. So what you're going to see here for these five countries is Korea moving fast into the high-end of consumer electronics and sustaining about a 17 percent CAGR. All of these other NIE countries are shifting investment into China and Southeast Asia as well to sustain their presence within Asia, and to sustain the phenomenal growth in their end markets.

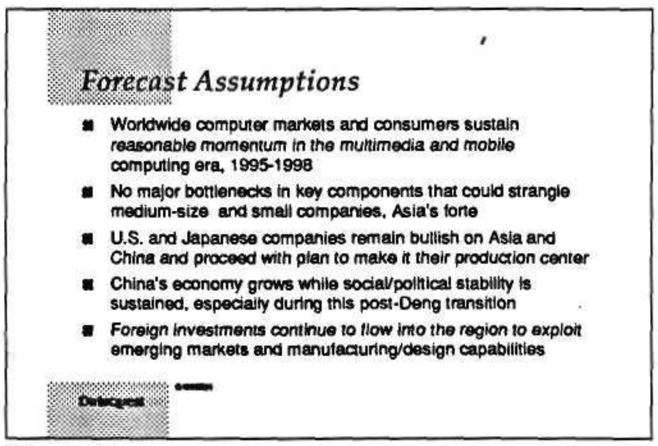


Figure 5

Some of our assumptions are that we continue to see the importance of data processing worldwide. Asia/Pacific benefits tremendously from its emphasis on peripherals, motherboards, and disk drives. We expect Singapore to continue to be the world's center for disk drive manufacturing. It represents 60 percent of production. We expect it to expand to become about 80 percent of worldwide disk drive production. Seagate and other manufacturers have made recent announcements to expand their presence in Southeast Asia.

Second, it's important in Asia that there are no major bottlenecks, particularly in the CPU area, and we've seen some challenges and new entries into the CPU markets that are satisfying the demand there. China's economy is continuing to grow in foreign investments, continuing to flow into Southeast Asia as well.

Figure 6

My last slide here (again we're tight on time so I just want to hit the key points — I'd be happy to have discussions at the end of this presentation as to some of the more critical issues). Asia/Pacific clearly represents a distribution of consumption that's very similar to the worldwide markets. In other words, data processing, communications, and consumer represent about the same share as they do worldwide. That means that investments from

Japan, North America, and Europe are going in at a gradual pace, but when you combine all those investments together, phenomenal future growth in the market will occur.

Japanese and North American companies are really targeting Asia/Pacific, not only for production, but their procurement and design patterns are changing as well. Buying from Asia/Pacific enables them to have an advantage in prices, and advantage in end markets.

Electronic equipment production is continuing to accelerate due to these investments, and due to the emergence of new economies in Vietnam, Southeast Asia, and, we believe, India is a market to look at in 1996. There are also high-growth end markets that are driving future investments by foreign manufacturers, as well as the need to develop design capabilities and manufacturing within the Asia/Pacific region.

Asia/Pacific will surpass Japan to become the second largest market in the world. We had initially forecast 1996, but just purely because of a yen appreciation, it's going to be pushed out probably one year to 1997. China's leading the growth and Southeast Asia is equally fast in terms of its consumption of end equipment. Consequently, Asia/Pacific's semiconductor consumption will exceed it's ability to produce devices for this tremendous growth, and that's creating opportunities for semiconductor manufacturers. Taiwan has forecast $6 billion in investment in 1995.

That's the conclusion of my speech. Thank you.

Solutions for the 10+ Million Transistor Chip

Walden C. Rhines
President and CEO
Mentor Graphics Corporation

Introduction: Walden C. Rhines happens to be a neighbor of Dataquest in San Jose. Prior to joining Mentor, he spent 21 years with Texas Instruments and most recently he was Executive Vice President of TI's Semiconductor Group. Please give Wally Rhines a nice warm welcome.

Mr. Rhines: Thank you very much. It is always a pleasure to come to a Dataquest conference in the middle of a boom in the semiconductor industry. Spirits are high, everyone is happy. The thing that is unique about this one is that this is one of the few times in the middle of a boom that people are talking about the downturn the second half of 1995; DRAM prices dropping, weakness in Flash memories and so on. That is a very optimistic sign. Instead of the usual, at this point in the cycle, when prices are high and everyone is happy, that is just the time when we all decide that the paradigm has shifted and that demand is going to grow forever and things will be wonderful. That is just about when the surprise crash hits. This time I think people are prepared for it, and, as a result, it probably won't happen.

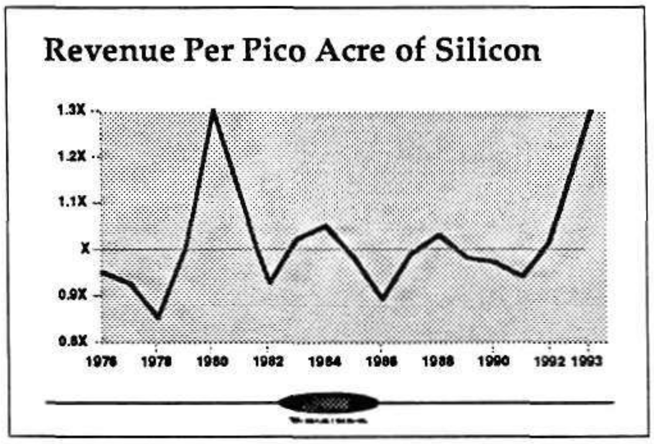


Figure 1

Let's look at another set of data that I have shown at a number of conferences. I pull this out every once in awhile to remind myself of one of the greatest constants in history. The fact that back to the silicon transistor, the revenue per unit area of silicon has been an absolute constant, referred to as revenue per pico acre. This is something that surprises people because there is a lot more technology in a unit area and there is a high probability this cannot continue forever. Some of the free market conditions, free intellectual property and other things have changed. Capital equipment per unit area has been increasing as a percent. At the peak of the boom in Japan, the cost of a unit area of silicon was the same as the cost of land in downtown Tokyo and that has now changed — silicon is higher priced than the unit area of Tokyo land.

The lesson to be learned here, if you look back through history, is the divergence between types of suppliers. There have always been suppliers who were well above the line and those below. The ones above the line tended to be people who provided products that were sole source. Those below the line tended to be those who provided products that are multisourced. The other benefit of sole source products is that when the drop or rise occurs, the slowest change comes in proprietary, sole source products. Even with ASICs that follow the same learning curve as DRAMs, there is a delayed reaction in drop of prices. In updating this, I was projecting 1994 — actually we left off 1993 on this chart which I believe was about 1.2x, but the lesson is the same.

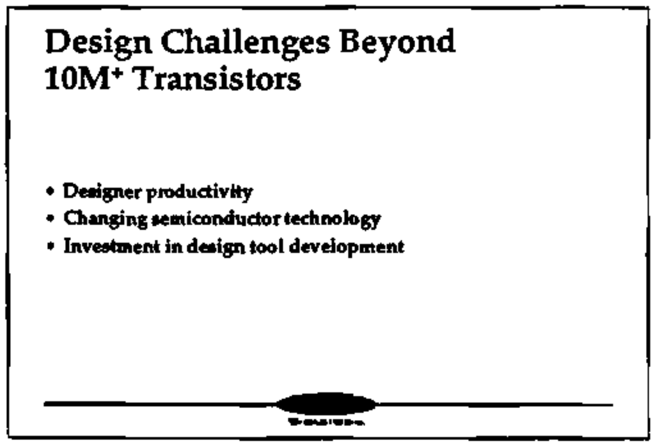


Figure 2

Let me talk today about three things that need to happen to get to the next generation of chips. Here we are talking 10 million random logic transistors, not total transistors. In fact, from a total transistor point of view the 64 Mb DRAM will pass 100 million transistors and be in prototypes within a year or so. The real challenge here is on the design side. What can you design? What productivity does that take? What will happen because of the change in technology? Where is the money going to come from for the tools?

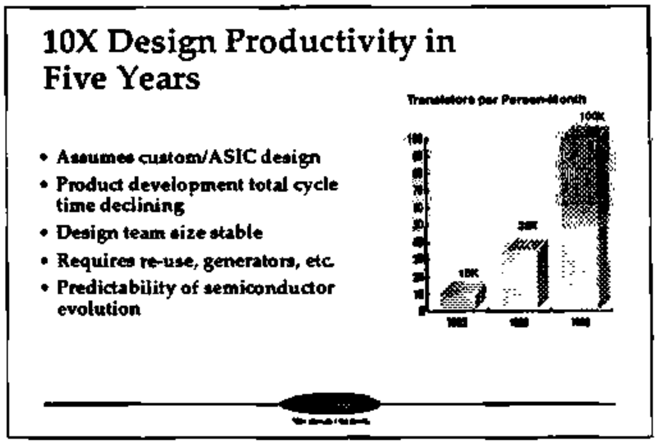


Figure 3

First, the productivity side. If you go to a conference like Michael Slater's Microprocessor Forum, and he hands out folders with chips on them, you will notice that the leading edge microprocessors all are just about the same size. A SuperSPARC is the same size as the latest 486 and so on. Why is that? If you look carefully, you will find that they are all 17 mm x 17 mm, which is the reticule size of that generation of stepper, and the reason is that if you allow 17 mm x 17 mm, your engineers will fill it up, given that opportunity. That means you can predict what the leading edge chips will be in the future, since you know what the design rules will be. The technology is very predicable.

The only thing that is uncertain in terms of how many transistors you have available to you is design team size. I am assuming that product development time will decrease, not increase, for development of new products. There will be a growth in concurrent engineering, but it will be slow. It will not be the big impact in the short term. The big impact in productivity will be a factor of 10 over 5 years, which is what the technology will allow, coming from reuse. Reuse of what has already been designed, and generators that make reuse possible through parameterized cells.

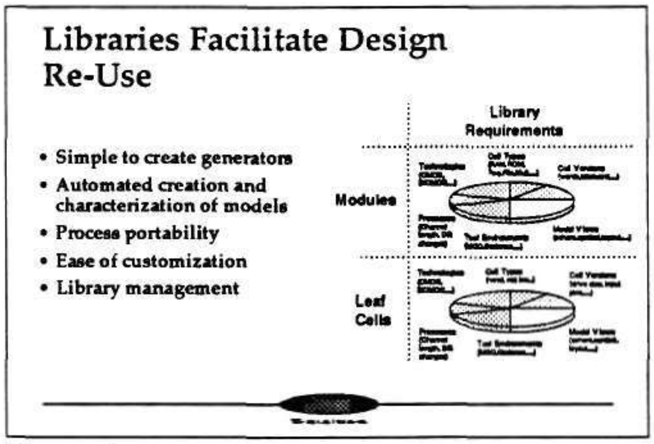


Figure 4

The problem is that libraries need to be developed if you want to reuse cells. If you have ever been involved with an IC design group, you say to one of the designers, "As you do this design, please document your design. Develop cells so they can be reused. Make sure they are categorized, and get the librarian to look after them". Somewhere during the design cycle, the designer comes to you and says, "Do you want the product out on time or do you want a good library?" That is where the library normally ends.

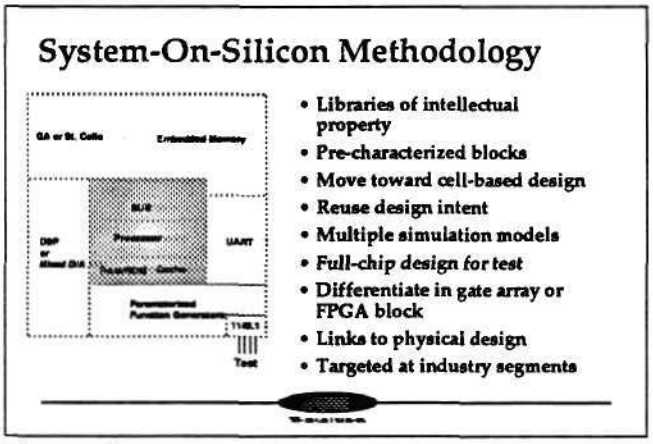


Figure 5

Recently what has been happening is change in that approach. The library process is now being formalized into the front end of the design cycle. One of the reasons this library task is so difficult is because of the magnitude of the data. Just having a single function is quickly multiplied when you go from modules for that function, down to leaf cells, but in the actual physical layout it is not uncommon to have a thousand different elements to cover all of the drive sizes, the different design tools that you have to work with, and the different technologies, much less making them technology-portable, which is a critical requirement.

The tools being introduced by EDA suppliers currently are addressing those issues, allowing automated characterization of the cells, making them process-portable, and automating this part of the process so that you can realistically reuse technology.

If you take a look at the next generation of leading edge ASIC class design it clearly is moving in the direction of building blocks that you put together. Today, in an ASIC library, an ASIC vendor will have ROM and RAM compilers. You can generate a memory of whatever depth and width is appropriate. Then you are stuck with random gates for most of the rest of the design or you use the cell library that is provided. What has happened in the last year or so is the true availability of the opportunity to put embedded cores in the ASIC.

When Mike Hames speaks tomorrow, he will very likely address the availability of embedded DSP cores in an ASIC design flow. It is still very limited. There are a limited number of processors that can be handled that way and a limited number of functions. What really needs to happen is to take major blocks of simulated logic that you put together and then do a total chip simulation as part of the standard design process. Once you do that, the design becomes much more predictable because you are dealing with already characterized blocks in the design. Dealing with those higher level pieces of design, instead of dealing with gates, you now have moved into a higher level of abstraction, as it is referred to in the industry, or moved up the hierarchy.

That is a very important need as we go above 10 million transistors, because it is very difficult to deal with more than 100 things at once for most people. Years ago when a designer designed a flip-flop or something like that, there were a fairly small number of transistors. You dealt at the physical level, the data base was reasonable, and you could go ahead and make design tradeoffs and keep everything in your head at once.

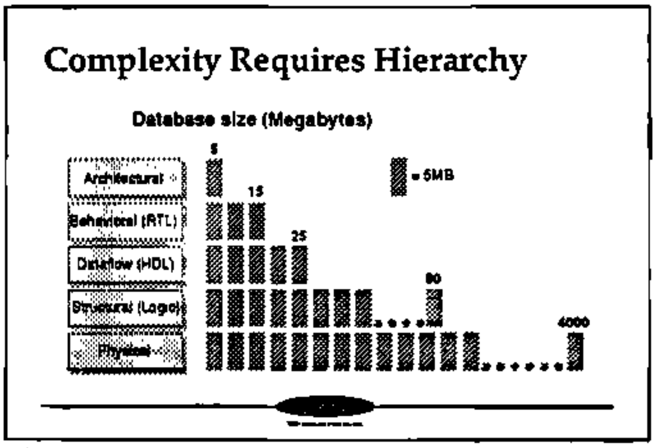


Figure 6

As we grew to a larger number of transistors, it was necessary to deal with gates and groups of gates. You then move up to a logic level and do the design at that level, to get a smaller database and a fewer number of things to deal with. What has happened in recent years is moving to the next level, the dataflow level. Hardware description languages, particularly VHDL and Verilog, take the database size down quite a bit, and for most designers, you hope that most of the design work will occur at this level and mistakes will be made at this level. You do not want to have to deal with the enormous mass of terabytes of data getting down to the physical level. Ideally, one would have hoped that people would keep moving up the hierarchy and you would get silicon compilers that would automatically compile everything down and generate the gates from the description in the VHDL and then generate transistors and so on.

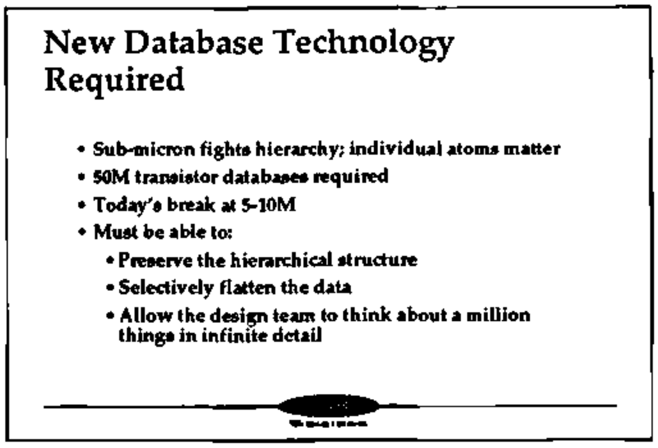


Figure 7

Unfortunately, something is happening in the IC technology that makes that very difficult. That phenomenon is deep submicron design rules. As we move to deep submicron, all of a sudden we have a technology that instead of helping with the process of moving to a higher level of abstraction in the hierarchy, the submicron dimensions actually fight the hierarchy. Individual atoms matter; wire lengths and lead resistance, and other things that did not matter in the past now take on significance.

The industry is going to have to get database technology so you can deal with a transistor at a time and at the same time move up the hierarchy and deal with hardware description languages and even higher levels of architectural abstraction. Flattening the data means looking at the design all the way down to transistors. Hierarchy means looking at blocks that are put together. You have to be able to do both, which means we need a new class of database technology, and EDA companies are very much aware of that and are developing products to, in fact, serve that need.

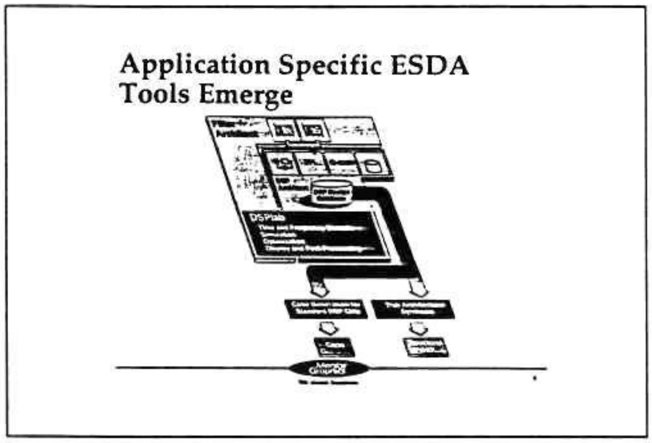


Figure 8

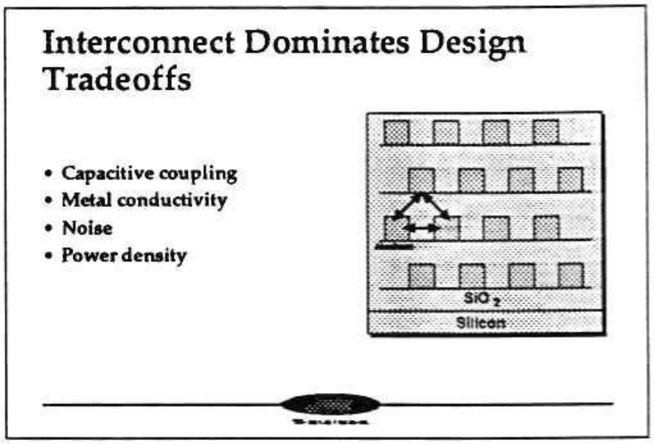


Figure 9

Just because you are dealing at the transistor level does not mean that we will not move to higher levels of abstraction. Most of the exciting new products today in the electronic design automation industry are at higher levels of abstraction. For example, "ESDA" is the description for these higher level tools for "electronic system design automation." These tools are being introduced in specific areas of design. The domain specific tools (in this case, digital signal processing) provides an environment where a designer can describe an algorithm or function he wants to support. He can write it in a high level language like C or do it in an algorithm language and then perform tradeoffs. He can also look at what happens if he does it in a standard DSP. It will automatically generate the microcode for the ROM on a DSP. What happens if I do it in an ASIC or in a custom design or partition it differently and trade off those things? That is a very necessary part of doing advanced system designs in the future and probably one of the fastest growing areas for new tools.

At the other extreme, at the transistor level, the reason we have a major problem as we move below half-micron, particularly as we get to the quarter-micron range, is that we move into a domain where the interconnect on chips dominates the design decisions. We have been adding a level of interconnect per generation, as we have moved down from 1.2. to 1.0 micron to 0.8 micron and it is fairly common to have four-layer interconnect now. The aluminum leads have an insulating oxide between them.

A lot of problems occur that didn't occur in the past. In fact, for almost 100 years a schematic of an electrical circuit had lines on it that symbolized the connection between two components. That connection was assumed to have zero resistance. It connected those two together. That was a valid simplification up until deep submicron design. It is no longer valid. Suddenly, the interconnect has more effect on the design than the components themselves. Some people have found this out the hard way.

Before I left TI we beefed up our transistor, almost doubled the speed in our 0.08 micron process and some of the system chips we ran increased 10 or 20 percent in performance as a result. We were expecting a lot better. The reason was the interconnect was eating up the performance gain. The problem is that, you have leads above each other, and when you have leads next to each other, you turn on one of these and it is 0.25 micron away from the next one, then you inadvertently turned on the next one at the same time.

There are a lot of physical effects that have to be modeled. You have conductivity effects where suddenly the length of time for a signal to propagate across the chip is more significant than the time it takes to be switched through a gate or a transistor. In fact, over a 15 year period we have seen, or will see within the next few years, a 100 times decrease in the ratio of gate delay to wire delay. We have experienced a factor of 100x in what was important, the propagation through a gate vs. the interconnect on the chip.

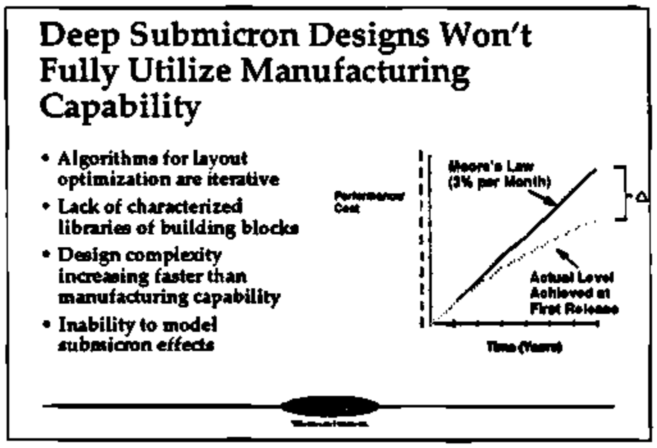


Figure 10

There are a lot of other factors for which there really are not good tools to model today, noise and power density, electromigration and so on. One of the net results of all this is that despite these billion dollar fabs and the great expense we go to, designs will not fully utilize their capability. In fact, designs today leave about 20 percent of the process capability on the table. They do not take advantage of it. Moore's Law moves up a line where technology advances about the rate of 3 percent per month. If you look at designs and see where they are relative to using that technology, the gap is widening.

It is widening partly because the algorithms for layout on a chip are iterative. You guess a layout, you look at the result, you see how it is, you try again and improve upon it. You look at what you did, you build from that point, you try again, you continue to iterate. You can continue to improve it forever, but you never get to the perfect result. The problem is sooner or later you have to ship the thing, so you cut it off and say that is it, that is all I am going to do. As we move forward, as you get characterized libraries, you get rid of some of that, you can get better performance with a given amount of effort. As we overcome our inability to model some of the submicron effects, you also get some improvement, but overall the impact of improving tools on the industry is enormous in terms of benefit because of the large cost of the capacity and the need to get more performance out it.

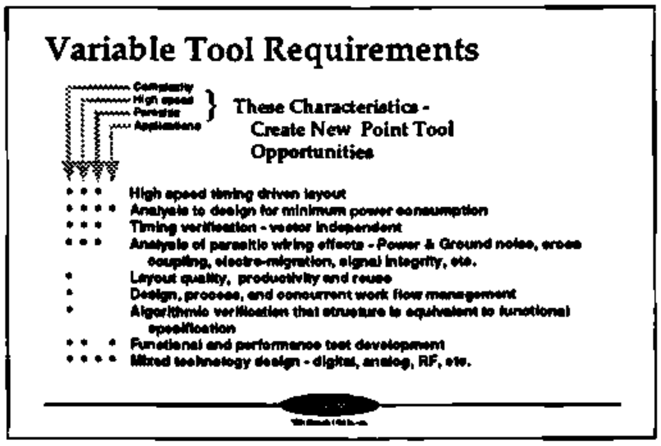


Figure 11

There are going to be quite a few opportunities created here. These challenges for the semiconductor industry are opportunities for the EDA industry, because these are all of the new things that design engineers are going to want to buy in the coming years that they did not buy before. You will need to start getting more sophisticated tools for timing driven layout. These have made their way to the market, but we are still in our infancy on power analysis and all sorts of parasitic effects. The electromigration and signal integrity that you need require one of these advanced databases to be able to look at where on the chip the lead lengths are longer than a centimeter. "Please show them all to me and let me optimize them," you might say. Variety of tools will be required that will make the design process more complex and more expensive.

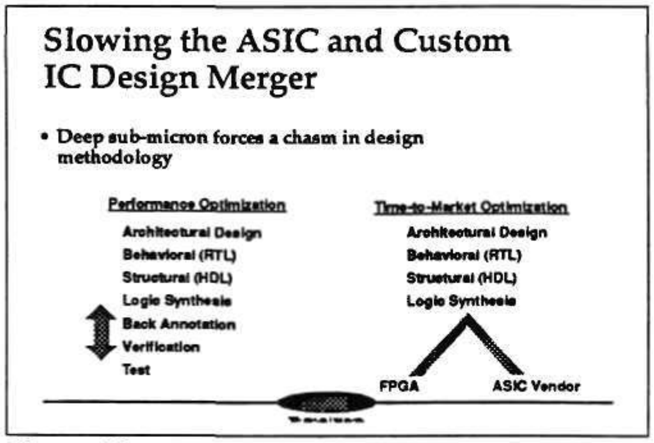


Figure 12

Another phenomenon in the industry is the way we do designs. For quite a few years, we have seen the ASIC methodology growing and the full custom design methodology shrinking as a percent of the total, and a lot of people thought these two were becoming the same thing. Basically everything is going to be designed with an ASIC-like methodology, sort of a "structured custom" approach, and it will all be one big design process. In fact, as we get to deep submicron, we are finding out that ultimately you fall into one of two groups.

The most important thing to you is performance optimization. Either you need to get the fastest chip or lowest power, or some other performance feature, at a given time, in the market, or you are focused on time to market. The second group must be the first to market.

If time to market is the most important thing, then you use an ASIC methodology and you do a design down to the logic level and you give it to your local ASIC vendor and he or she finishes it off. That leaves a lot of performance on the table because you didn't do all this iteration through the layout step.

If the performance is the driving force then you are in the custom design business and you need to control the layout portion of the design and you iterate. A lot of the fabless IC companies who used to do ASIC design are now doing full custom design for exactly that reason — to get competitive differentiation.

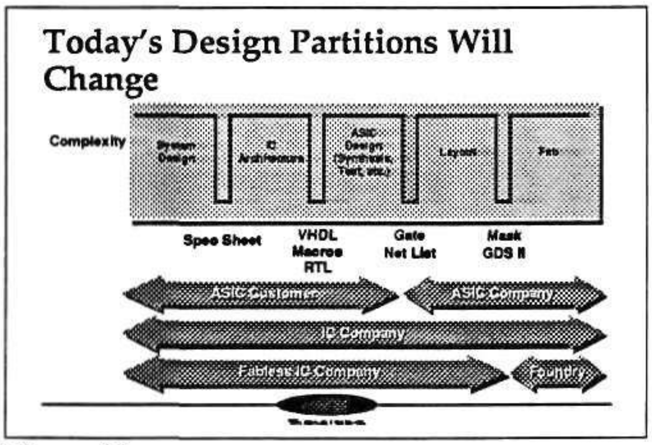


Figure 13

The other thing about the way we operate is the way we hand off data in a design. Typically as you work on design data through the process from left to right, the complexity of what you are dealing with has points where we can describe fairly simply the design at one state. You come to a point where you have a specification of some sort that is a minimum in the data complexity or you write a

VHDL description. That is another way that we can communicate with each other and hand the design to one another.

The common way today in ASIC is through a net list. You give your vendor the net list and they give you back chips. We have several different ways to operate in the industry. The semiconductor or IC companies tend to do everything from definition down through fabrication. The ASIC customers hand off at the net list level and then the ASIC supplier does the rest of the layout, gives them a back annotation file and they approve it. Then they build chips. An increasing number of fabless IC companies are going the extra step, doing the layout, optimizing the design, and then they give the semiconductor supplier, the foundry, or whoever is running the silicon, a pattern generator tape in a GDS II format. This is sometimes referred to as customer-owned tooling. Basically, they run the silicon for you to a defined process and that is how you get your design. That part of it probably will not change.

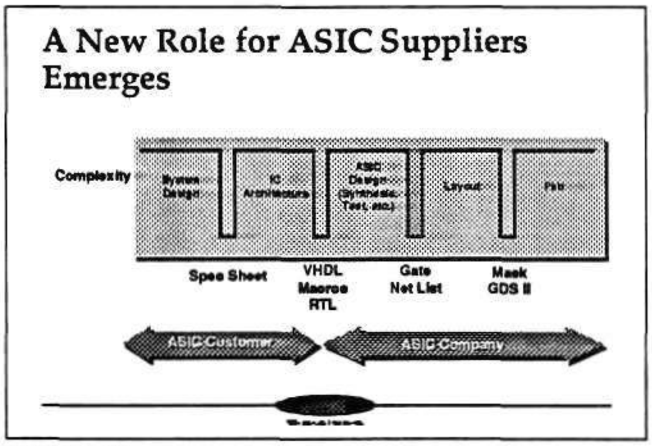


Figure 14

Over the period of the next five to ten years, maybe sooner, I do expect another part to change. That is the role of the foundry or the ASIC supplier that builds the ASICs. In order to route the chip the foundry needs to get back into the data further upstream, more and more ASIC suppliers are going to get into the business of looking at logic synthesis, doing tradeoffs, and eventually getting designs from customers written in a hardware description language like VHDL, instead of getting net lists from customers. Hopefully, that will increase some of the semiconductor manufacturers' value.

Figure 15

In the area of where we are going, we have a problem in the industry. This deep submicron design capability is creating the need for a lot of new tools we have not had before and it costs money to develop them. The total EDA industry — Mentor, Cadence, Synopsis, and ViewLogic, and so on — together spend about $300 million on R&D, which is about 20 percent of revenue. This is pretty high for an industry, but a nit compared to the $100 billion dollar semiconductor industry that spends something on the order of $8 billion a year in R&D, or the $670 billion electronic systems business.

In recent years the computer industry has been cutting back on R&D and design automation development because we have shifted from a model of the DECs and the IBMs more to the low-cost PC manufacturers and so R&D has been declining. So we don't have this base of technology being built up.

Yet we have a tremendous dependence of semiconductor companies on design as a differentiator. Therefore, the problem is that $300 million is just not going to be enough to fund what has to be funded to get the advantage needed out of the next generation of technology. The way that is being solved is through joint development. In my company and other companies I know, partnerships are being set up with major semiconductor manufacturers in specific tool areas to co-develop tools and then take them to the broader market. Without that, I believe the fabs will end up building silicon that is even more underoptimized and that will be very costly to the industry.

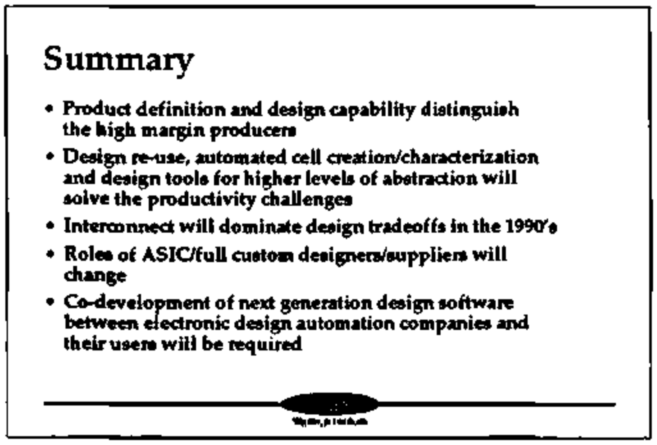


Figure 16

Let me summarize. First, product definition and design, as compared to manufacturing efficiency, provide the most distinguishing capability of the high margin producers. This has been true historically, and I believe it will be in the future. We need design reuse, we need the automated tools to create cell libraries, and we need the tools to deal at a higher level of abstraction in order to solve the productivity problems that exist, and I believe this part will be done very effectively in the next few years.

Interconnect is going to dominate design tradeoffs through most of the 1990s and change the paradigm of how we design ICs. The role of ASIC versus full custom versus the fabless IC companies will change. We will have movement of the partition and finally a codevelopment of the next generation of electronic design software. There will be cooperative development between EDA companies and IC manufacturing companies or system companies.

Thank you very much. Questions or comments?

Question: We asked you to talk about this really tough area of the 10+ million chip. Do you think that the ability for your industry to make more money will be to work doing partnerships with these leading edge chip companies in the United States or spreading your tools out to these growth opportunities at Asia/Pacific that are not pushing the technology as much as they are here in the United States?

Mr. Rhines: I don't think that it is either/or. Clearly sales outside of the United States are very important. For Mentor, just about half of our sales are outside of the United States, and the fastest growing region is Asia /Pacific. That will provide growth but in general it tends not to push the leading edge as much as other areas.

The tools that will be used five years from now will be developed on leading edge processes. Only the companies that participate in those early developments will be able to generate the technology and the revenue base to grow. As a result, we work closely with leading edge users wherever they reside in the world.

Question: We have seen a lot of startups over the last 10 years in your industry. Given the fact that you now have to form partnerships in order to share the development cost to push the technology, do we think we will see fewer new companies entering the tools industry?

Mr. Rhines: The electronic design automation industry is probably the most fragmented industry in the world. The barriers to entry are very low. If you can afford a workstation and a garage in Palo Alto you are in business. It is a business that can make you fabulously rich overnight. You just grow a little and then you sell out to Mentor or Cadence or whoever. It is an algorithm that cannot go on forever, but I think it has actually helped the industry and has been a source of new technology and kept us current. Over time I do expect consolidation to occur. I don't think we can remain fragmented indefinitely. In mature areas like printed circuit board design Mentor has been number one, with just 15 percent of the total market. I don't think that is stable. I think over time there will be consolidation in those areas. In leading edge areas, I would expect a continuation of new startups and a relatively fragmented industry much longer.

PC 2000: Chaos or Control

Moderator

Jerry Banks
Director/Principal Analyst
Microcomponents Service
Dataquest Incorporated

Panelists

Carl Stork
Director
Windows Platform Definition and Business Development
Microsoft Corporation

Jan Janick
Program Director
PowerPC Development
IBM Corporation

Craig Kinnie
Corporate Vice President and Director
Intel Architecture Development Laboratories
Intel Corporation

George Alexy
Senior Vice President
Marketing
Cirrus Logic Inc.

Lorie Strong
Vice President
Portable and Software Marketing
Compaq Computer Corporation

Dataquest Speaker: The first panel that we are going to have this afternoon will be the PC 2000: Chaos or Control. Around Dataquest for the last six months we have called this panel PC Chaos and we threatened to use that on the brochure, but we think that maybe this Chaos and Control is a broader way of looking at this challenge. I would like to have Jerry Banks come up and introduce his panel.

Mr. Banks: Ladies and Gentlemen, good afternoon. This afternoon we have assembled representatives of some of the real sources of power in the PC industry and I would like to just go ahead and get into this program and let them do the talking. The order of speaking was established by a completely random drawing.

Now in order of their comments, here is our panel. You'll get a more detailed introduction in a few minutes and there is a very detailed biography of each of them in your binders. From Microsoft we have Carl Stork, director of Windows Hardware Programs. From IBM we have Jan Janick, program director of PowerPC Development. From Intel we have Craig Kinnie, corporate vice president and director of the Architecture Development Labs. From Cirrus Logic we have George Alexy, vice president of Marketing, and last but not least we have a representative from Compaq, Lorie Strong, vice president, Portable and Software Marketing. I think you'll agree we have a pretty good representation up here.

The format is each panelist is going to make ten minutes of opening remarks and then we'll have a Q&A session. If necessary, questions from me, but hopefully questions will be led by you and all I'll have to do is point. Then as time permits, we're going to allow each panelist to make a few closing remarks.

First, I get to make a couple of remarks, as I am the moderator. Just try to take a look at PCs in 1994. It's real, real, simple. Processors are faster, mass storage is cheaper, much, much cheaper every day. DRAMs are more expensive, local bus has become mainstream. Multimedia is still the buzz word looking for a meaning, but I think we would find a few different definitions of multimedia as we went through the audience out here.

The x86-based desktop is still king and $2,000 buys a pretty nice machine. What do we see for the year 2000? I think the only certainties we really have are that microprocessors will be much faster and mass storage will be much cheaper, and $2,000 will probably still buy a pretty nice machine. Beyond that I think everything else is up for grabs including who the major players will be. Well, I'm done, that wasn't too painful was it?

Leading off is Carl Stork of Microsoft. We've already corrected his title up there. The Windows Platform Definition and Business Development. Carl has been with Microsoft since before DOS and will be there when we assume DOS bites the dust sometime next year with Windows 95, right Carl? That's hopefully a pretty safe assumption. His long history of involvement with the PC makes him a well-suited speaker for today's topic. Without further ado, Mr. Carl Stork.

Mr. Stork: Thank you Jerry. Jerry gave us a few questions to help prepare the panel and I'll try to do my best to answer those questions. I'm sure you'll be hearing some additional view points from other people in the panel.

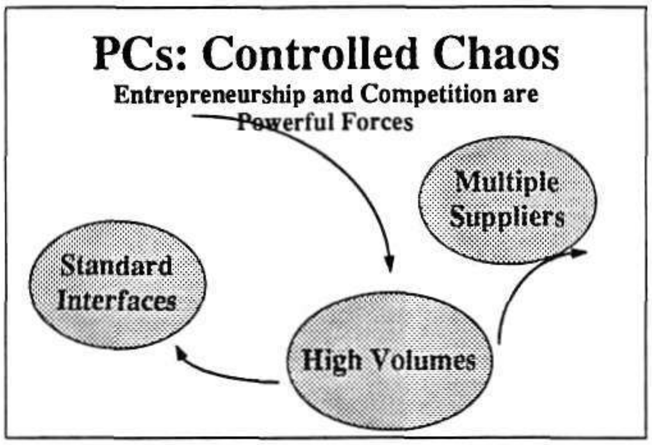


Figure 1

My first comment is that I'm not sure that chaos or control is the right question or that the outcome is either chaos or control. In fact, I would say that what characterizes the PC industry is controlled chaos. There is an enormous number of players in the industry, literally 5,000 or more software developers, hundreds of system makers, literally thousands of add-in device makers, and hundreds of semiconductor makers. All of these people are participating in the industry, in one sense in a chaotic fashion, but in another sense in a controlled fashion. I think this is entrepreneurism or capitalism at its best. Lots of people are independently trying to figure out, how can I make a product that's a little bit better, that's a little bit cheaper, that's a little bit faster, or that introduces some new feature within the constraints of the marketplace, while still being compatible with large numbers of systems and large amounts of software.

The amount of effort and money being invested in creating innovation is phenomenal. Of course that's all driven by the high volumes in the PC market that lead to tremendous economies of scale, very low costs, huge levels of performance and also enormous opportunities. If you come up with the next great idea, you can sell millions of units. There is a huge amount of freedom in the industry to participate. There is almost no place in the industry that lacks multiple competing suppliers.

You might say, gee, why is Microsoft making that statement? The truth is, there is competition for us in every business in which we're present just as there is for every one of our panelists. Those competitors make us all do a better job. It makes us work harder, and if we don't, other companies establish their products as standards and establish de facto standards and get to high volumes. It happens every year in every technology area. The fundamental thing that keeps everything working together is that there are standard interfaces for software and standard interfaces for hardware that ensure compatibility. So in this chaotic marketplace we benefit from these large volumes and a tremendous amount of innovation.

What is a PC?

Always:

- **Microprocessor, RAM, display**
- **Open to independent software suppliers**
- **Standard software environment**

Sometimes:

- **Open to independent hardware suppliers**
- **Keyboard**
- **Disk**
- **Connectivity/Communications**

Figure 2

What is a PC? Today there are two or three kinds of systems that people commonly think of as PCs. There are laptop machines, such as the one here that we're using for PowerPoint, there's the typical desktop machine, and there are servers. Over the course of the next few years you're going to see far more form factors and far greater variety as to what is included and not included in a system, but they are still fundamentally PCs. The only things that are needed for something to be a PC is there has to be memory, there has to be a microprocessor, and there has to be an opportunity for people to independently develop software for it.

I listed the presence of a display on the slide because I think some kind of an input-output device is needed but I'm not sure there necessarily will be a display in all of these systems. There may well be embedded PCs that we have in our homes that don't actually have a display, so maybe I should delete it from my slide.

Things that aren't necessarily required in PCs: some PCs are open to independent hardware suppliers to add devices through various buses and slots and connectors. In the future there may be PCs that are closed systems where there really isn't an expansion opportunity. Handheld devices are an example of that, and there may be future special-purpose devices.

Keyboards: the majority of PCs have keyboards, but over time you'll see more PCs that may not have a keyboard. Hard disks: hard disks are generally present, but again, I think they'll be opportunities for PCs that don't necessarily have a hard disk, particularly for entertainment uses. And finally connectivity and communications: while not required I think virtually every PC is going to be communicating on a regular basis with other PCs, whether over a network, phone line, wireless, or infrared, and whether in a home or in the office.

PCs are Compelling Today - for Home and Office

$1,500 - 2,000 Buys a Very Compelling Device
- **Entertainment**
- **Reference**
- **Education**
- **Productivity - work or hobby**
- **Communication**
- **"The PC is IT"**

Compelling for any home that can afford it

Figure 3

As Jerry said, PCs are very compelling today. $1,500 to $2,000 buys a nice, fully-featured PC that I think is appropriate for every home with school-age kids. My daughter, who just started fourth grade, told me that at the start of school her teacher asked if the students had access to a PC at home, and in her class of 26 students there was only one child that did not have a PC at home. While her class is not representative of the entire country, it demonstrates the trend.

The combination of multimedia capabilities on standard PCs, CD-ROM for reference purposes, games, communications to the Internet, CompuServe, doing your taxes and finances, and bringing work home, make the PC a very compelling device and it is at an attractive price point. In fact, it is probably fair to say that last Christmas season was the first time when the whole PC package had become so compelling that you no longer needed to be a hobbyist or an enthusiast to say, "Wow this is really something I've got to have". You no longer needed to be in a high socio-economic class to buy a PC.

Challenges for PCs in the Home

- **Make them easier/friendlier**
  - Plug and Play and Windows 95
- **Make them cheaper**
  - $500 is a magic consumer price point
- **Make it simple to have lots of them**
  - Share peripherals, files, costs
  - Communicate
- **Make it simple for them to connect to the information highway**
- **Let them evolve to specific functions**
  - Entertainment PC - 10 feet
  - Den/study/homework PC - 2 feet
  - Phone/communications?
  - Run appliances?
  - Etc.

Figure 4

We do have a lot of challenges to make PCs really take off in the home. This slide lists some of the key challenges that I see. We need to do a lot more to make PCs easier to use, easier to set up, and friendlier and more approachable. A lot of the burden falls on Microsoft and Windows 95. Windows 95, which was formerly known by the code name "Chicago," is the next major version of Windows. Windows 95 will take us a step on the way to more ease of use, but certainly not all the way.

There is a lot more that we have to do in ease of use. Plug-and-play, which is an effort that Microsoft, Compaq, and Intel began about 18 months ago to automate the configuration process of the devices that are in a PC or are connected to a PC, will also help. But beyond that there is still a lot more work to be done to make PCs friendlier.

PCs are going to need to get cheaper. One interesting question is how many PCs will be typical in a home? Do you purchase one PC that all your kids can use or do you put a PC in each kid's bedroom? In the long run you probably want each of your children to have a PC in their bedroom because you want them to be working on their homework at the same time. You might want a PC in your family room to play games, one in your kitchen to answer your phone messages, one in your den to do work.

Clearly, if were talking $2,000 to $3,000 dollars per PC, I don't think people will be putting five or six PCs in their homes. But if we can reach $500— I am going out on a limb, I don't know whether PCs can really hit $500 — but if they were able to hit these price points you wouldn't see only 100 million PCs in the year 2000, you might see 500 million PCs being sold in the year 2000. The market could explode a lot more than any of us predicts if the prices can get down to those kinds of levels.

Another thing that is required to make PCs reach a higher market share in the home is to make it far easier for people to connect them to communicate with each other in the home, to be able to share printers, share peripherals, share your link to the Internet or to the information highway and communicate among the different PCs.

I don't know what it is going to take to make that happen, whether it's some kind of really simple cheap infrared networking or whether it's just phone wiring connecting all the PCs with a little hub in your basement. We clearly have to make it much easier for people to have a lot of PCs working together. We need to do a lot more to make it simpler for them to connect to the information highway. Today that means doing a good job of high speed Internet access. Who knows how this will evolve?

I think the PC will evolve to different form factors for specific kinds of functions; an entertainment PC that you have in a family room, a homework/study kind of PC, maybe various other kinds of PCs.

Software Will Be Central

- Operating system will provide infrastructure
  - Communications
  - Multimedia
  - Access to storage
  - Etc.
- Operating system will virtualize hardware
  - Enable innovation in hardware
- Operating system will provide standard application environment
- Thriving third party applications market
- Thriving component market, but active competition and fast product cycles

Figure 5

Software will remain central. Obviously, that is why I work at Microsoft. The operating system will provide important infrastructure that people can count on, including access to communications, support of multimedia kinds of data in viewing and creation, access to storage and many other things.

The operating system will continue to virtualize more and more hardware. What I mean by virtualize hardware is that the software view of a given feature will be through standard interfaces allowing for innovation and competing implementations of specific hardware features. With each new version of Windows and Windows NT, we virtualize more hardware, creating more degrees of freedom for semiconductor makers and system makers, and I think that trend will continue. At the same time the operating system will continue to provide a standard interface for third party applications and I think there will be a thriving software industry for a long time to come.

There will continue to be a thriving semiconductor market for all kinds of components for PCs; audio, display, video, I/O, etc. Windows fosters competition and innovation. A thriving component market, but active competition and fast product cycles. That's certainly true. We're seeing 6 to 12 month life cycles for components and the latest graphics chip and the latest system designs, I don't see any change in that.

Some Other Thoughts

- Business/Work PC will thrive, too, but big growth in the home and internationally
- Impossible to predict x86 vs. RISC
  - Depends on execution by x86 vendors
  - There is value to the industry in a single binary standard
  - x86 has competition
  - Can RISC create a compelling advantage?
- Lots of places to make cool products around the CPU
  - MPEG
  - Speech
  - Communications for home and info highway
  - Home control
  - Integration
  - Cost innovation

Figure 6

Lastly, a few more predictions. I focused on the home PC both because that is where the biggest growth is and because Jerry's questions seemed to target that. The use of PCs in large organizations and business will thrive too, although the largest growth opportunity is in the home and in international markets. It is impossible to predict what is going to happen over the five or ten year horizon in the battle between x86 and RISC processors. The x86 vendors have the ability to continue to dominate the market. If the x86 manufacturers continue to improve performance at the rates they have been and if they keep the prices low, they can block RISC systems from ever achieving critical mass. That's my personal opinion, not a Microsoft position. There are significant benefits to having a single binary standard to which a software developer can count on and which a customer can count on and which the industry can target. So, as long as the performance gap doesn't get large, the value of the single binary standard will mean x86 remains dominant.

An interesting point is how many different companies make x86 CPUs. There are seven companies today, Intel of course, AMD, Cyrix, TI, IBM, a company in Taiwan called UMC, and a company that has been working on it for a longtime called NexGen. That is pretty amazing, and these are seven companies that do independent x86 designs. So there is a lot of competition in x86 CPUs.

My final point is that there are lots and lots of opportunities to make cool semiconductor products besides just in the CPU. Thank you very much.

Mr. Banks: Next up is our soccer player, Jan Janick of IBM. He is at the Somerset facility, home of the IBM, Motorola, Apple alliance. Jan is the program director when he's not playing soccer. I'm saying this because you'll see when Jan comes up he just hurt himself, but he very, very gamely is still going to make his presence here on the panel. He is the director for the most talked about competitor to the x86 architecture, the PowerPC. Actually with initial volume shipments expected to reach, maybe breach, the two million unit point in 1994, the PowerPC has achieved very rapid growth in the non-x86 marketplace, although these volumes are small compared to the x86. The PowerPC alliance has positioned itself to be a long-term player in the microprocessor war and would like to be considered an industry standard architecture well before the year 2000. Jan is very well qualified to come up here and tell us why this will happen.

Mr. Janick: You're going to hear a lot of opinions today, a lot of projections, and there are a lot of questions, there are a lot of answers, there are more opinions, and about the only guarantee we can give you is that we're all going to be right and we're all going to be wrong. I'm here to share with you my view and my opinions and some of my predictions on the evolution of PCs from today through the year 2000.

I believe that the big driver of change in the PC marketplace is technology. I believe there are a number of emerging technologies. It is also true that we tend to set very high expectations of emerging technologies and the technologies don't really influence PC design until we get the capabilities, both hardware and software capabilities, to match the level of expectation and to get those capabilities to match to a price point that allows us to sell them in a high volume way.

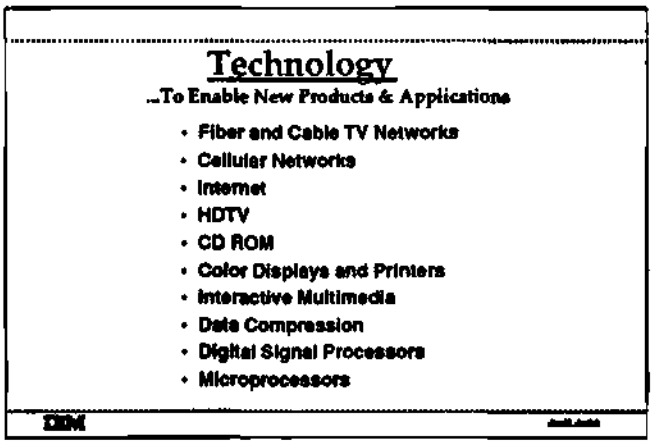


Figure 7

This is a list of a number of technologies that I believe will have a big influence on PCs and what PCs become between now and the year 2000. Certainly fiber and cable TV networks and the whole emergence of the set-top marketplace, cellular networks and cellular communications capability, Internet, HDTV, and a number of other emerging technologies.

At the bottom, last but not least, is microprocessors. Microprocessor performance also enables a set of additional emergent technologies like video compression, handwriting recognition, voice recognition, etc., when you match the ever-increasing performance capabilities of the processors to a well-tuned set of software.

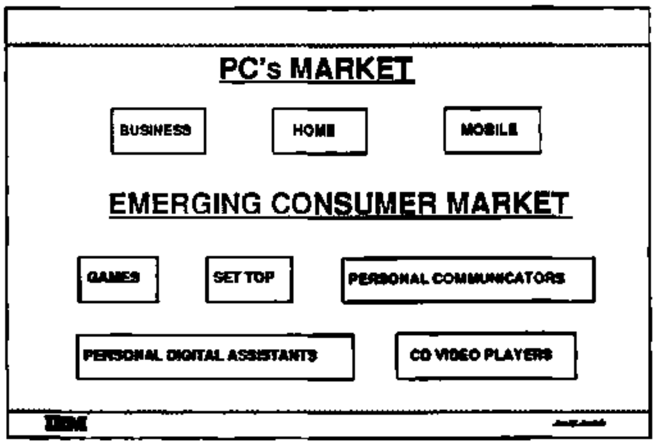


Figure 8

This is a very simplistic view of the PC marketplace: really split between home, business, and mobile or portable systems. What I really want to focus on is the emerging consumer marketplace because I believe some of the marketplaces that are emerging are going to have a great effect on the PCs of the future. Below the line, the emerging consumer markets, there is incredible pressure to increase performance, to drop price and cost, and to improve capabilities.

Let's pick games as an example. In a game marketplace there is very high pressure to improve performance of the processors and improve performance of the video capabilities. In general what you are seeing is that electronic games are trending to a software model that looks much more like an operating system and a set of applications, and is also a good example of a marketplace where there isn't a dominant processor or a dominant set of operating systems or applications.

In fact, all the emerging marketplaces have that in common, really a market where there isn't a dominant set of hardware or software players, which to a large degree adds a lot of chaos and confusion and unpredictability as to how those will come out.

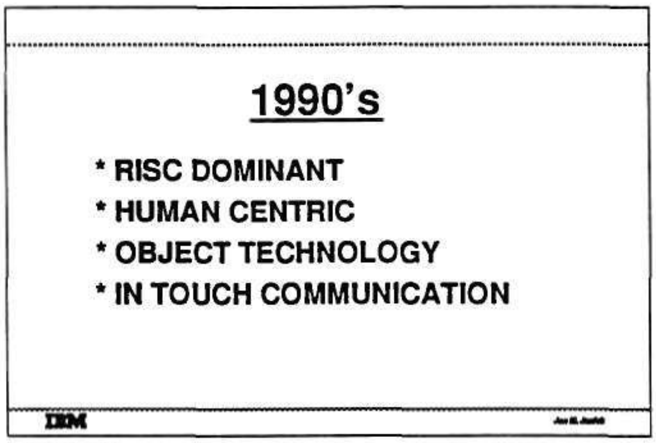


Figure 9

Now, this is what I view as kind of the trend for the 1990s and I think my first bullet may get some counterpoints against it, but I believe that RISC is the trend in the processor industry. I think RISC technology continues to show performance advantages over CISC. I think even the CISC architecture chip suppliers are seeing a trend towards more RISC technology and more RISC design kinds of implementations while holding their CISC instruction set compatibility. I think the alliance between Intel and HP, with their PA-RISC architecture also confirms a trend towards RISC dominance in the marketplace.

I think human-centric is another key trend in the 1990s. Human-centric computing includes everything from improved ease of use, better operating systems, voice recognition, handwriting recognition kinds of capabilities and the very general area we like to call multimedia. From a software standpoint, I think there is a trend towards object technologies and in communications, in touch communications, Internet, cellular, and a continued focus on digital communications.

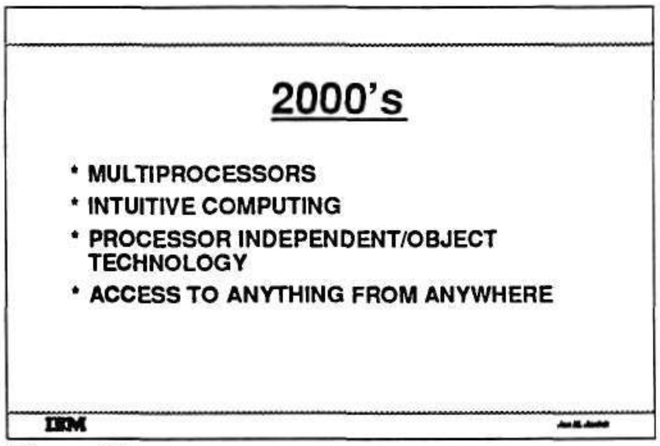


Figure 10

So here are my predictions for where that trend will take us to the year 2000. I think from a processor standpoint, multiprocessing will be the norm. I think that the RISC technology has a lot of headroom and the predictions of VLIW or other emerging processor architectures will not be a dominant factor until considerably past the year 2000.

Intuitive computing: Intuitive computing is the follow-on or what's next in human-centric computing. It's agents, it's software that learns. A good example I like to use is we all get a lot of e-mail. The amount of e-mail we get continues to increase. I would very much like to encourage Microsoft or others to write applications that are smart enough to learn which e-mail messages I want to read, which ones I don't, which ones I need to forward to which people, and really help me manage what

I view as an ever-increasing trend and traffic pattern in e-mail.

I think from a software standpoint, we will get to processor-independent/object technology. I think that operating systems and applications both will have to be efficient at MP and be exploitive of MP capability, and I think from a communications standpoint, access to anything from anywhere is the right target. That puts a big challenge on media, on high-speed I/O with new protocols, as well as on the communications infrastructure.

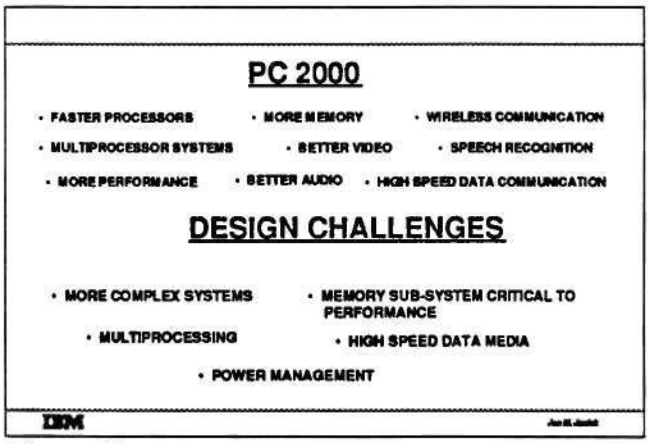


Figure 11

Now there are some things that are pretty easy to predict when you talk about PCs. Faster processors, more memory, wireless communication, multiprocessors, better video, speech recognition, more performance. These are the things that are easy to predict, but let's talk a little about what kind of design challenges those present.

In an environment where PC vendors continue to feel downward pressure on margins as well as a lot of focus on expense to revenue, we are pushing on them the requirements of more complex systems, of multiprocessing, of high-speed data capability and protocols, of memory subsystems and I/O subsystems that are critical to system performance. As the processor frequency and performance continue to improve, we are going to see greater and greater effects on its overall system performance due to the memory and I/O design.

And last, and probably one of the toughest, is power management or heat management as we continue to put more transistors and faster transistors in silicon and we put more silicon in PCs, there will be a real challenge for packaging at both the desktop as well as in the portable and handheld marketplace.

We talked a little bit about this being the twentieth anniversary of Dataquest and I kind of looked at the design challenges and said, twenty years ago if I was a mainframe designer I would probably have the exact same set of design challenges. It is interesting to see that after twenty years this is now in the hands of the PC designers.

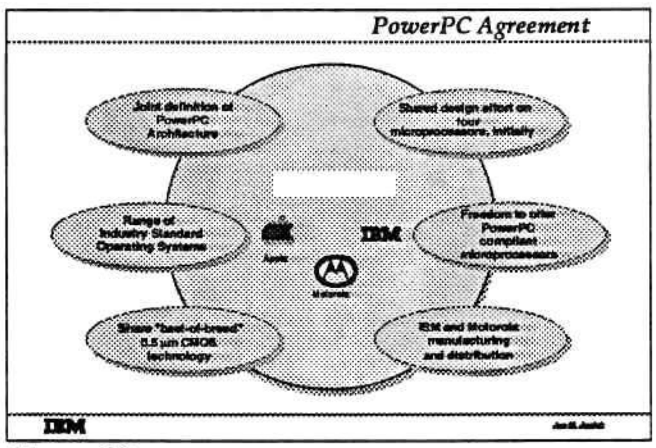


Figure 12

Let me tell you a little bit about the alliance and how we believe the alliance addresses some of the challenges. First of all the alliance itself is a recognition that to make a difference in the industry and to make changes, you need to partner up with the right partners, bringing in the right markets, and the right level of expertise. We believe we've done that by aligning Apple, IBM, and Motorola. We set off to define an architecture which we call PowerPC. We've done that. We set off to design four microprocessors, initially. We've done that.

But the real intent is to generate the broadest range of microprocessors across the broadest most scalable architecture. To do that, all of the companies also have the ability and the freedom to do processor designs outside of the joint Somerset effort and you see that in places like the embedded controller marketplace where we are doing PowerPC-based embedded controllers independently at both IBM and Motorola.

Also, critically important, to continue to compete as you have heard, is having manufacturing capability. A lot of people tell us that the fact that they can buy processors from two different sources is very important, and of course, managing and paying for the ever-increasing costs of keeping up or staying ahead of state-of-the-art technology requirements.

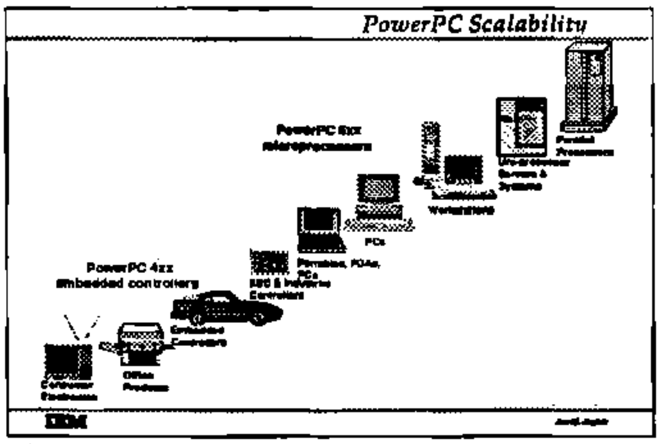


Figure 13

We believe that the PowerPC architecture spans a very broad range. I think a couple of interesting things to focus on in this chart is that with PCs in the middle, there is pressure coming down from the top or what we call convergence of the workstation marketplace with the PC marketplace and, in fact, we believe we've got a big hand in making that happen. It is also interesting to note that the same processors that we will put in high-end workstations will go into very massively parallel systems and give, again, a very broad range of performance across a single architecture. Coming up from the bottom into the PC marketplace is again an ever-increasing request for higher performance and lower costs.

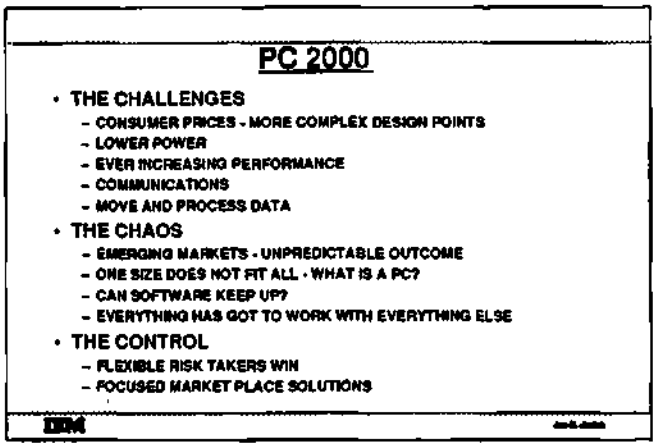


Figure 14

So what do I see as the key challenges to PC 2000? Continued pressure for consumer prices at more complex design points. Lower power; again, we talked about as we put more and more transistors running higher and higher frequencies in silicon, managing power and the packaging required to do that are some significant challenges. Ever-increasing performance, communications protocols, and the ability to move and process data are all key challenges to the PCs in the year 2000.

What do I believe is driving the greatest chaos in the marketplace today? First of all there are a number of emerging marketplaces with some very high and some very low expectations and really an unpredictable outcome. I do believe that one size PC does not fit all and in fact, it is going to be very difficult by the year 2000 to really describe what a PC is.

There is ever the challenge that the hardware team continues to put on the software, and that is can the software keep up? Can the software take advantage of the capability and performance that we believe silicon can provide? And in the end, it is critical that everything works with everything else. So as these emerging marketplaces come to being, it will be critical that they participate in playing in the current marketplaces as well.

If there is any control to be had, I think as we go through the next few years, it won't be visible. I think things will tend to look very chaotic, will tend to move very slowly, but I think by the year 2000, if we take a step back, the people who appeared to have been in control will be those who are flexible risk-takers and those that really focus on a marketplace solution versus a one-size-fits-all. Thank you.

Mr. Banks: Thank you Jan. Next up is Craig Kinnie. I think it is incorrectly stated in your binders that he is corporate vice president and director of the Intel Architecture Labs. I believe he is corporate vice president and director of the Architecture Development Lab, which is part of the Intel Architecture Labs. Craig is responsible for providing architectural leadership and direction to Intel and the PC industry, a pretty tough task. I think it is his job to make sure that their applications and hardware are in place to take advantage of the performance of the next generation of x86 processors. Basically when the PCs come out, make sure there's a home for it.

To this end, his group has come up with the exchangeable card architecture, PCI (Peripheral Component Interconnect), and TAPI (Telephony Applications Programming and Interface). As it is Craig's job not just to forecast the future but to help shape the future of the PC, I think this makes him an excellent additional panelist and I welcome Craig Kinnie.

Mr. Kinnie: Well, it is an exciting time in the computer industry and I'm really pleased to be here today to share Intel's perspective with you on the future of the PC. In order to understand what the PC will be like in the year 2000, it is important not to focus on the machine, but to focus on the applications that will control and evolve the machine in its direction.

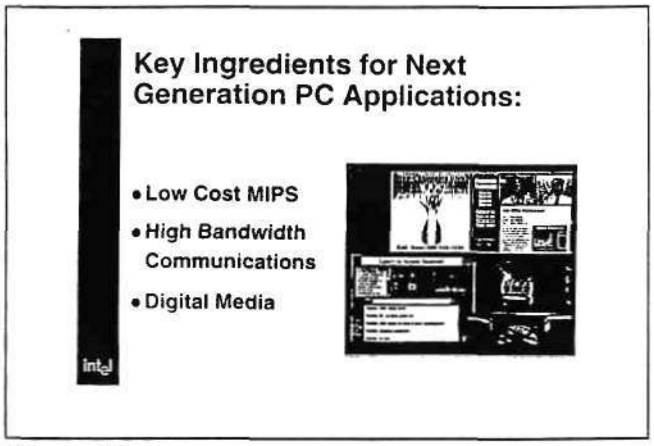


Figure 15

As we go around the industry and talk to customers and users, we've come to believe that there are really three major ingredients that will form the basis for next generation applications that will then fuel the growth of the PC market. Those ingredients are listed here. Basically, it is low-cost MIPs. Anybody you talk to will say that next generation applications have an insatiable appetite for MIPs. Next is high bandwidth, and I should add low-cost communications. Essentially the merger of computers and communications is the catalyst for next generation applications.

The last is digital media. This is the key ingredient that adds to the capability to bring new users and new uses to computing, things that are needed to grow the market for all of us. What I would like to do is briefly explore these three areas, talking about what is happening to the PC to better support each of these major factors.

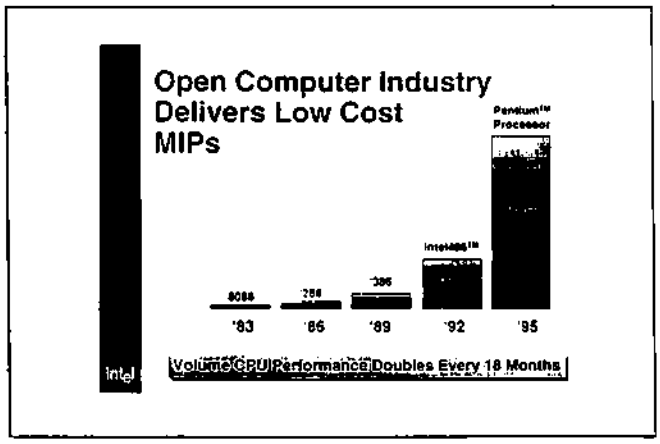


Figure 16

First of all, the open computer industry has and will continue to deliver low-cost MIPs. They have done an outstanding job of that in bringing computing to the tables and desktops of everyone and the rate is accelerating. At this point in time, today, the volume CPU performance at any given price point doubles every 18 months and this shows no sign of slowing down. So I don't think we have a problem here in fueling next generation applications.

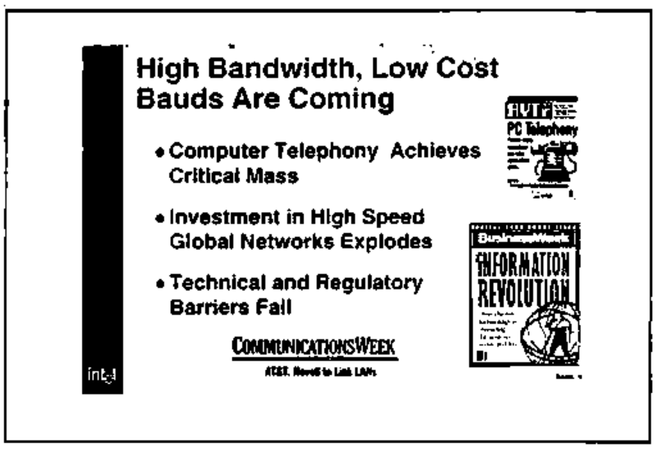


Figure 17

Secondly, as the telecommunications industry emerges from a giant transformation, one thing that we can count on, probably the only thing that we can count on, is that we'll have high bandwidth, low-cost bauds to go along with our low-cost MIPs.

The evidence is everywhere that this is happening. We have the merger of telephony and PCs happening, amplified by the TAPI announcements and the work between the telephone companies and the PC companies.

We have investment growing in all sectors in communications bandwidth and capability in all sectors of the economy and globally. Technical and regulatory barriers are falling everywhere except perhaps in the U.S. congress. The only real question that is left here is when, not what or that it will happen, but when. It was stated earlier this morning, perhaps it has more to do with the regulatory environment than anything to do with technology.

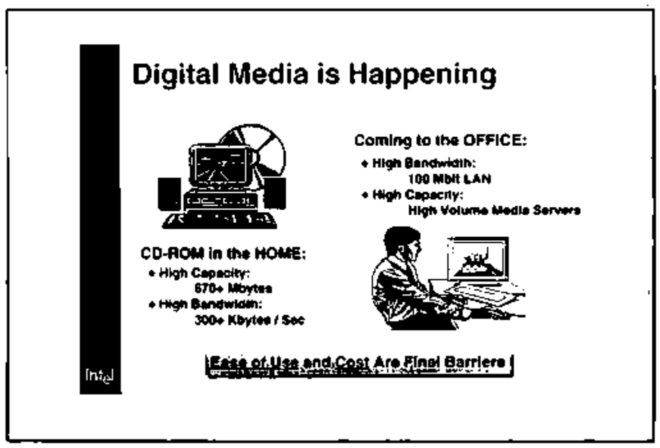


Figure 18

The third major ingredient is digital media. Digital media is finally happening in the PC industry. It is happening in the home. While a whole lot of us were out working and trying to make it happen at business it happened at home while we weren't looking. The thing that happened there was the CD-ROM. The CD-ROM did a couple of really important things. In hindsight, it provided capacity and it provided bandwidth for media and put it in the hands of an individual decision-maker who could decide to buy it. Those two factors turned out to be important and the CD-ROM explosion resulted.

Now media is about to happen, we believe, in the office from the very same two factors but in a different way. High bandwidth will come from high-speed LANs that are being installed in corporate America today, the 100 megabit Ethernet is an example. The capacity will come from media servers built out of standard high-volume servers that are available at very reasonable prices and will be installed on networks from which you can access CD-ROMs or you can access external services or higher bandwidth communications links outside the company.

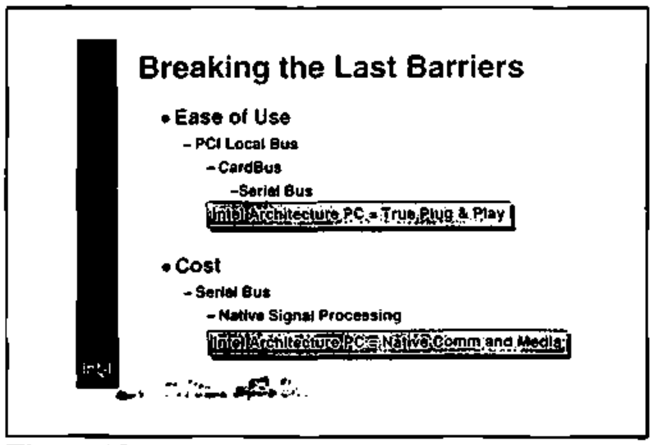


Figure 19

However, in the case of media, we still think there are a couple barriers to overcome. The areas of cost and ease-of-use are still a problem in order for media to become ubiquitous. So let's talk a little bit more about what we're doing to address the problems there. First, in the area of ease-of-use, probably the major factor that's happened over the last couple of years, in fact transformed the PC, was the advent of the local bus, in particular, the PCI local bus. PCI had a significant impact on the cost and performance and ease of use of the PC.

Over the next year, two additional open interconnect standards will appear on the scene. First is CardBus. CardBus is an internal name for a specification that the PCMCIA committee will announce later this month, which is essentially the union of PCMCIA and PCI. I believe they are going to call it PC Card 32. This will bring all the capabilities of PCI to notebook computing, but I think it will also become a very important factor on the desktop, in that we'll finally have an end-user upgrade paradigm for the desktop that doesn't require you take the covers off the box, and yet you can expand any of the major I/O subsystems within the PC.

Next is another bus that will come, I believe, next year. Compaq, Intel, and Microsoft are working together to create a specification with other industry leaders that will bring Serial Bus, which is yet another step forward in bringing ease-of-use to the PC and allow ease of interconnect for the neophyte users that are confused by the maze of cables in the back of the PC, which should account for a lot of us. When these factors are combined with Windows 95 from Microsoft and its plug-and-play capabilities, the Intel architecture PC will have what we've always desired, true plug-and-play.

In the area of cost, particularly cost of media and comm., there are really two significant things happening. Again, Serial Bus will address cost of media and communications connections, especially when it is combined with the other major factor I mentioned here, which is native signal processing (NSP). I know that is a new term, and I don't have a lot of time to describe what it's about, but basically native signal processing provides an environment where you can run all of the communications and media signal processing on the main processor under Windows.

This capability will be available on Pentium processor PCs beginning in Q1 of next year and will greatly reduce the cost of adding media and comm functions to the PC as well as the complexity. You will no longer be faced with having to add expensive, complex, and hard to use add-in cards to add these functions to the PC in the future, which therefore will lower the cost and improve the ease-of-use of media and comm in the PC.

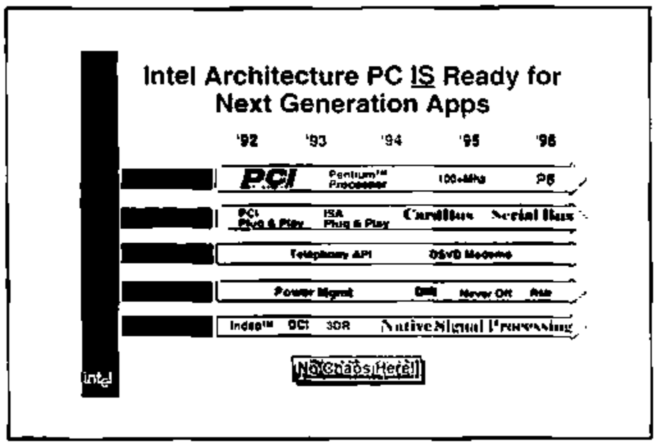


Figure 20

With the additions of Serial Bus and NSP, essentially media and comm will become native to the Pentium PC and achieve the second goal that we had of reducing the cost. So to summarize, I would like to perhaps assert that the Intel architecture PC is ready for next generation applications in that it has been rapidly evolving over the last few years as it has added several new standards, hardware and software, to accommodate higher speed processors and new kinds of media and comm capabilities. As I pointed out, the three major factors I think will be a big change over '95 are CardBus, Serial Bus, and Native Signal Processing. In our view at Intel, it is not a question of chaos or control, we don't see any chaos here, only opportunities for growth.

Mr. Banks: Thank you Craig. Now we'll hear from George Alexy. George is responsible for corporate marketing and product strategies for what I think I can safely say is the most successful, fabless semiconductor company in the world. Cirrus is a broad supplier of chipsets to the PC market and absolutely dominates the graphics controller market. George has a long history involving semiconductors for the PC and should provide us with some valuable insights this afternoon.

Mr. Alexy: Thanks, I really appreciate the opportunity to speak to this group and with a fantastic panel of peers with such a variety of perspectives, although when I listened to the presentations before me, there is a common theme to all of this with possibly a little different spin that you might expect based on our backgrounds and our focuses in the market.

Much the way Carl talked about controlled chaos or chaotic control, we really view this path toward the PC of the year 2000 as an evolutionary process of combined elements of control and elements of chaos. If you look at the PC today, it generally has a natural evolution that we can expect and anticipate without giving it a lot of thought. That's more the controlled aspect of it. What we tend to look for, though, and what I think our industry needs to look for, are the new ideas and the new market opportunities and applications and the new underlying technologies that can inject chaos. It is that injection of chaos which creates the opportunity and those things will affect the PC and that controlled evolution of the PC.

So it is really important to understand the sources of chaos and the role a company chooses to play in that. It is really important to stimulate that, important to the new ideas and the approaches sometimes referred to as the bleeding edge of technology while others try to target more of the leading edge of technology at a later point in time, because it is the adaptation of the chaos that leads to the standards, that in turn leads to significant new opportunities for growth in the PC market and our industry.

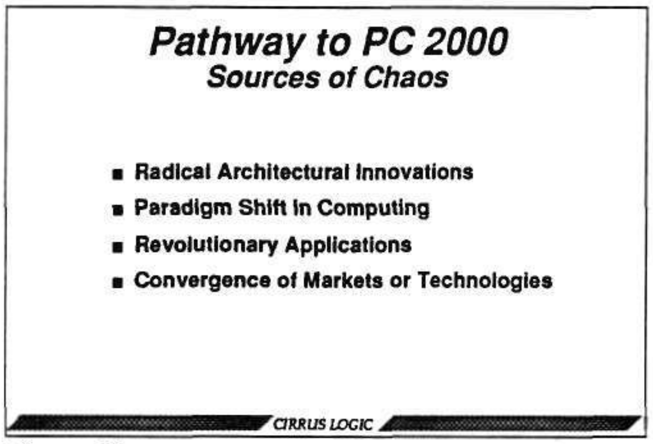


Figure 21

If we all look at the sources of chaos, there are four of them that I came up with in thinking about this presentation and I'll highlight them here and then spend a little more time on them. The first would be what I might call the radical architectural innovations and the radial changes in CPU architecture or the PC architecture itself.

Possibly more important is what I refer to as a paradigm shift in computing. This is not the way the computer works itself, but is how the person uses the computer, the services and capabilities that they look for from the machine, and the implications that has on the design implementation, the software, and the fundamental underlying architecture.

On top of that we have revolutionary applications, and these are things which we categorize as revolution and chaos within the evolution where new capabilities come into the PC as we know about it today and inject their perturbations into the architectures and the future programs that we would see for PCs.

Lastly, I would highlight the convergence of markets and technologies as these again are the areas where we try to apply the PC architecture to gain, as was mentioned earlier, the volume economics of the PC and apply it to other markets. These other markets will have separate and different needs and will then have an impact of their own on the PC architectures of the future. We need to try and comprehend those as we go forward. Now I would like to take just a little bit of time just to give a little more background on each of these.

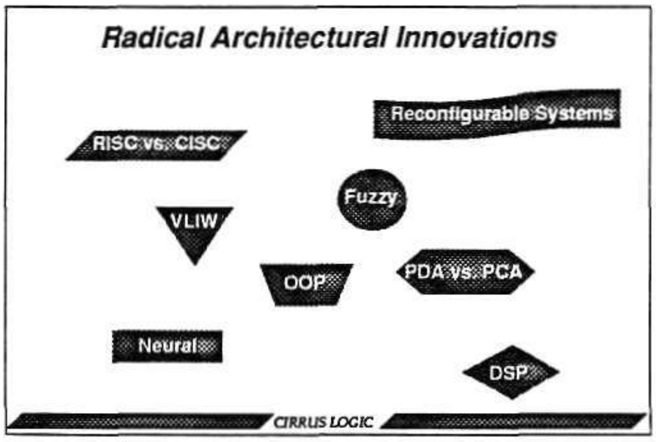


Figure 22

If I look at the options for radical architectural evolution or innovation, they are all over the map. You've got fuzzy logic, neural networks, something called OOPs, and I'm not even sure what that one is myself, reconfigurable systems, your very long instruction word computers, in addition to the well-touted RISC versus CISC battle. My personal opinion is that you will see some of these technologies start to integrate into the PC as we know it today. We are already seeing that with DSPs, as DSPs now look like they are going to become a standard part of the machine and will in fact complement the CPU to perform specialized functions for which those architectures are better suited.

We see possible applications for fuzzy logic in some of the communications and mass storage problems, more dedicated use of these architectures to serve a specific piece of the problem in building higher performance or lower power, or more intelligent computers going forward.

My basic take though is, that as long as what I'll call it the x86 consortium, (the seven firms that were mentioned earlier) continues to provide the evolutionary enhancements in performance and lower power the market is looking for, I would anticipate that the mainstream of the PC market as we know it today will remain in the x86 camp.

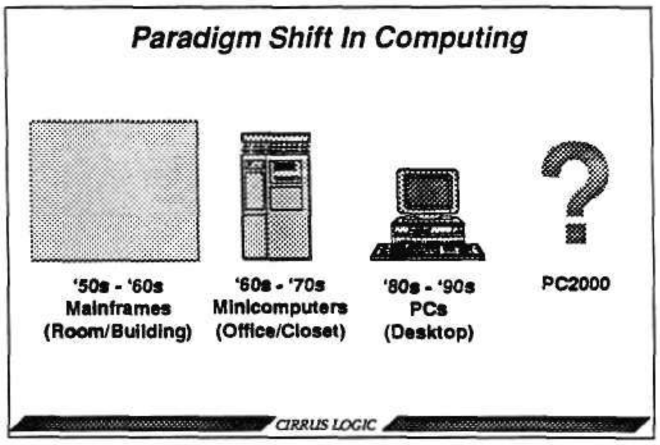


Figure 23

The shift in the paradigm, though, I think is one that we need to spend more time thinking about because that's one which can have a much more dramatic impact, not as a replacement for the PC as we know it today, but potentially more of a displacement. I can imagine a Dataquest meeting, (I assume Dataquest was in existence then back in '74) when the minicomputer guys were talking about where their market was going to be in the year 1980 or 1984 and not necessarily anticipating the shift in the paradigm from minicomputer to the PC. If you are looking back in history, you've had the era of the mainframes, the era of the minis and we're now well into the era of the PC as we know it today and the question mark is, is there another paradigm out there that we need to be anticipating that will not, as I said, replace the PC but become the high-volume driver of the semiconductor industry, and what are the technologies and the architectures that are going to drive that. This is an area where I think there is fertile ground for any new architecture whether it's the PowerPC or fuzzy logic. If there is a new paradigm that evolves, there can be new architecture opportunities, new software architecture and development opportunities to exploit and enable that market and gain share.

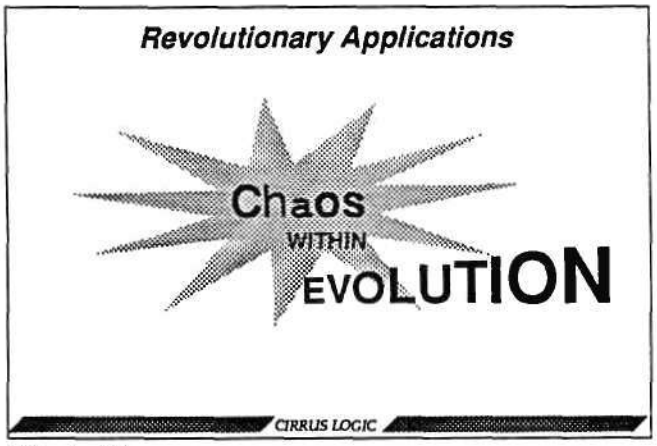


Figure 24

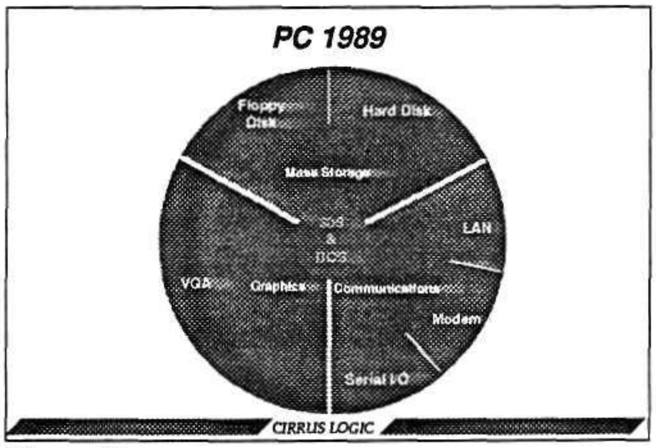


Figure 25

I talked a little bit about chaos within the evolution and this shows the enhancements and evolution of the PC as we know it today, which has been discussed quite a bit today. But if I just go back and look at the PC of 1989 you can see it was a DOS machine with a hard disk and a floppy disk and a graphics controller and maybe a LAN and maybe a modem, but definitely serial and parallel I/O, and that was about the extent of the machine.

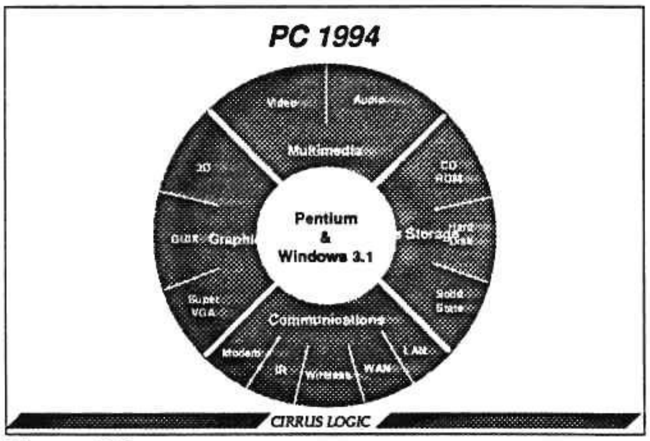


Figure 26

If I look at the PC today, units are being shipped with a much broader variety of technologies. Now in the mass storage side it includes CD-ROM, as was mentioned before, as an enabler for multimedia, as well as things like Flash memory cards to assist in the small form factor portable computer. We now have the entire element of multimedia that has come into play bringing audio and video to the PC plus new forms of compression /decompression for both the audio and the video.

Graphics has gone from simple VGA to graphical user accelerators and we now see 3-D. Not only do we see 3-D but we see multiple types of 3-D targeted at different segments and needs of the market on a cost performance basis. There is your standard high-end GL based 3-D, targeted more at the workstation markets, and there are new types of 3-D that are becoming irrelevant to the lower-end PCs that are more targeted at the games market.

So we're seeing a vast expansion in the technologies and the capabilities of the PC. If you look at communications, that's an even broader portfolio. You now have wide area networking, and ISDN. ATM is now coming on the screen with people coming out with $1,500-to-$2,000 ATM add-in cards to bring higher performance networks to the PC, as well as all the wireless communications.

These are all areas I believe fall under "chaos" because there are a variety of standards that have to settle down before the industry can focus in and bring these to the high-volume price conscious and price-sensitive points that are going to be needed to make them ubiquitous. So there is going to be a period of chaos, a period of bleeding edge to some of these technologies as they evolve and become standardized to satisfy the marketplace.

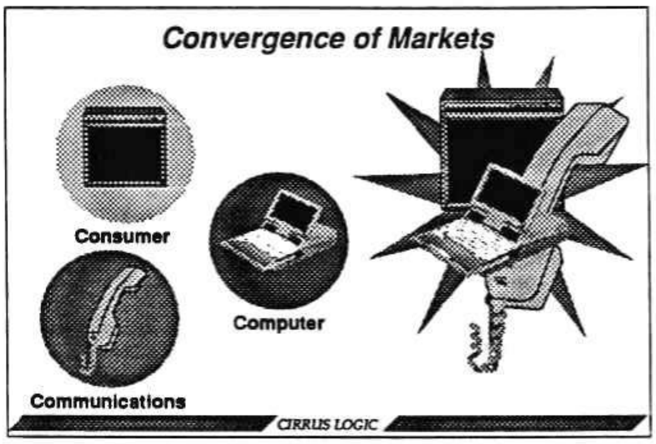


Figure 27

The last one I'll talk about is the convergence of technology. Here we want to talk about the use of the PC architecture to address the consumer and communications markets. One of the things we've seen at Cirrus with our focus on the PC market, is that we spend a lot of time bringing digital and mixed-signal technologies together to address the needs of the PC. We saw the need for wireless communications to address portable computers. We saw the need for digital and mixed-signal electronics to address multimedia. Those technologies are very applicable in all the next generations of wireless communications, both digital and voice, as well as in next generation consumer electronics products.

It was mentioned here today that set-top converters are an example of that. These new markets are going to have their own needs and their own requirements and they're going to start to backfill on trying to apply the PC architecture in leveraging the volume price points of the PC market into these. So we see people talking about the different needs of the set-top converter on the architecture that would have normally been a PC. We see different needs for communication devices.

So these are opening up opportunities, not just for new architectures, but radical changes to the architecture to the PC as we know it today.

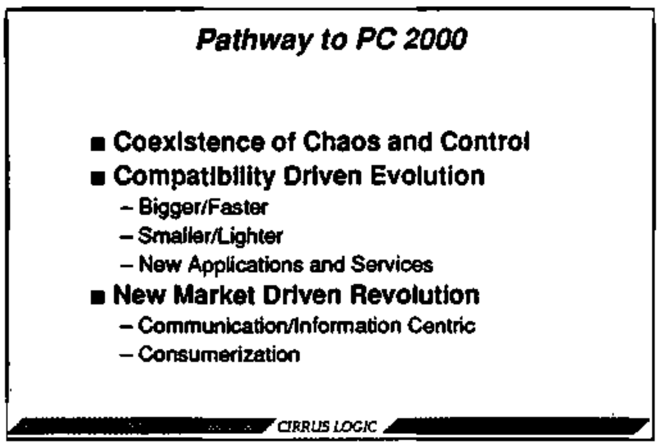


Figure 28

So in summary, the points that I would make about where we see the PC going for the year 2000: it's the coexistence of the chaos and control. The controlled evolution with a strong overlay of chaos in there, which is the growth factor of the industry. We see compatibility-driven evolution, bigger/faster, smaller/lighter, lower power/higher power, all the normal evolution that will put demands on process technology and architecture and system design: power management techniques, higher performance graphics, higher performance buses. But then we have to overlay on top of that the new market-driven requirements and revolution that is on top of the controlled evolution. Thanks.

Mr. Banks: Thank you George. Now wrapping up the panel presentations is Lorie Strong. Lorie is the vice president of Portable and Software Marketing in the Portable PC division for Compaq. She has been with the company for ten years and has a very wide range of responsibilities within Compaq, including responsibility for Compaq's portable product lines from concept to their life cycles, which are getting shorter all the time I guess, which makes your job more intense. Her role includes product definition and strategies for pricing, distribution, support, training and promotion, and it doesn't stop there. She is also responsible for software. With such a broad range—is there anything you don't do?—of experience as the current number one shipping PC company in the world we can truly value Lorie's view of the PC by the year 2000. Lorie Strong.

Ms. Strong: I do feel I have the renegade position here, coming in with my own PC. I have some things that you'll see a little later on that I wanted to use it for. I have more of a marketing orientation rather than being from the engineering community, so I fear that many of you may look at me more as the enemy in a lot of your organizations. Also, I'm actually, only the second woman speaker here today, in a room decidedly dominated by men. Although I found that a clear benefit—there's been no waiting in the ladies' room.

So, I will take somewhat more of a marketing perspective here today and clearly a mobile perspective as that is my current area of responsibility. What I would like to discuss are just some of the changes that are currently going on in the near term with notebooks. I also see a very high priority on communications and I'll talk about some of the things happening there and about what multimedia means in the mobile environment. A little bit on handhelds and then come back to our question about what is going to be here in the year 2000.

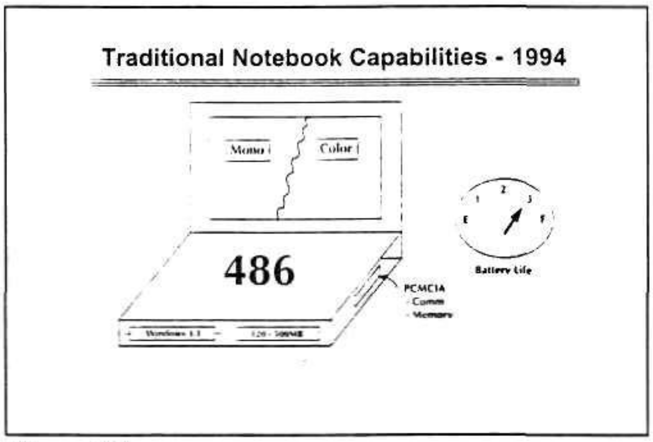


Figure 29

Looking at what we're delivering to our customers today, the 486 is clearly the dominant microprocessor; we've got a mix of color and mono displays that we're shipping to customers, both in passive and active. Drive sizes are ranging from 120 up to 500 or so megabytes. Windows 3.1 is the dominant operating system and PCMCIA, which I believe is probably the industry's worst name that we've ever come up with, is delivering compatibility about at the level of 1983 and has a little ways to come before it meets customers' expectations. Battery life for mobile products is ranging from about two to four hours, at least from anybody who is telling you the truth.

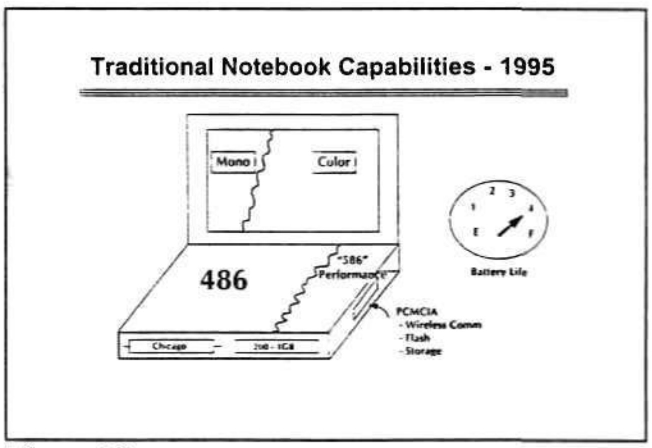


Figure 30

Next year we should see some improvements. We will see Pentium-level performance coming into the mobile marketplace. Storage, believe it or not, should be up around the gigabit level. The availability and the cost decreases of panels should move us almost entirely to color displays. Microsoft should deliver Windows 95. PCMCIA should get better and have some good compatibility improvements, and yes, battery life will get longer. One of the things that is likely to contribute to that is a growing utilization of lithium ion.

One of the things I've noticed today is we're talking the price points in the industry and what the customer expectations are. I think, actually, we've got people pretty well-trained to expect to spend the same amount of money year to year, and right now that is about a $2,000 price point, or even if it's a commercial customer who may be more at a $3,000 or $4,000 price point, and what we've trained them to expect is to spend that money, but get a greater and greater degree of performance and functionality and capability each year.

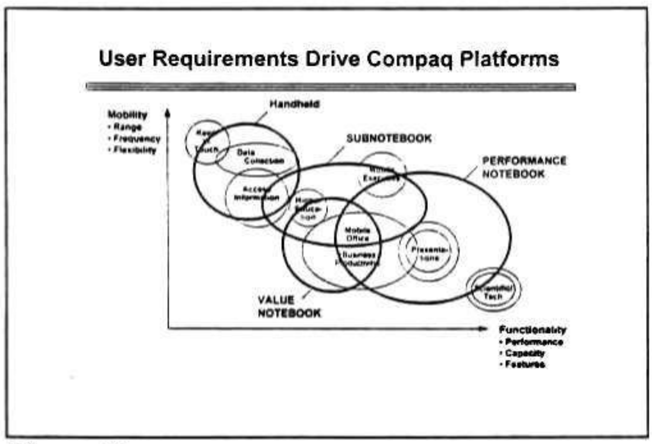


Figure 31

Now this is a real simple chart, but somehow the word chaos comes to mind. Let me walk you through it. If you look at the X-axis, that is increasing functionality, if you look at the Y-axis, that is better mobility as you go up. Then what I've done is indicated some of the key uses of mobile products, such as making presentations, business productivity, accessing information, and overlaid on that are the form factors that we have available in the mobile market today.

So things like high performance notebooks are handling presentations like we're doing here today. You are also at the high end of the word processing, spreadsheet, and database kind of applications. Value notebooks are addressing our customer requirements for more baseline needs, and then we have the ultra-portables or subnotebooks, which are being utilized by students and people with other high mobility requirements.

Lastly, we've got handhelds that are doing things like data collection and information access. One of the things I might note is that most of these applications for mobile devices are still in the commercial arena although we talked a lot today about the growing consumer market. So far, that has been primarily focused on the desktop products.

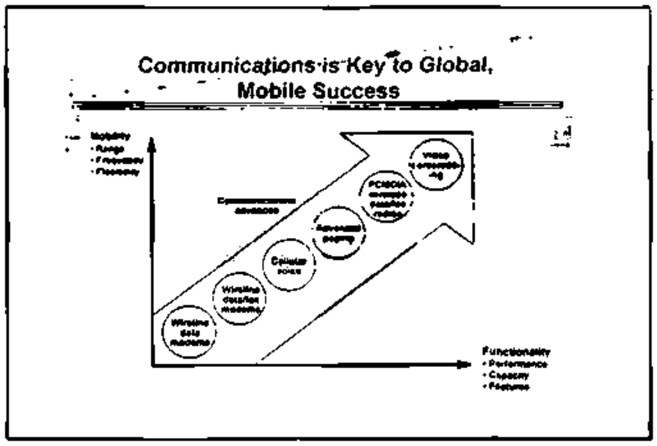


Figure 32

Communications is likely to be one of the key enablers that determines whether or not mobility is under control or chaotic out in the year 2000. In reality today, we're only delivering on a widely usable and cost-effective basis, wireline data and fax capabilities. But as the infrastructure builds, we should have more wireless data transmissions, wireless local area networks, more useful paging, and eventually things like video conferencing for mobile devices. Broadening standards, such as the GSM standard developing for Europe and other parts of the word, will contribute to our successful transition to untethered communication.

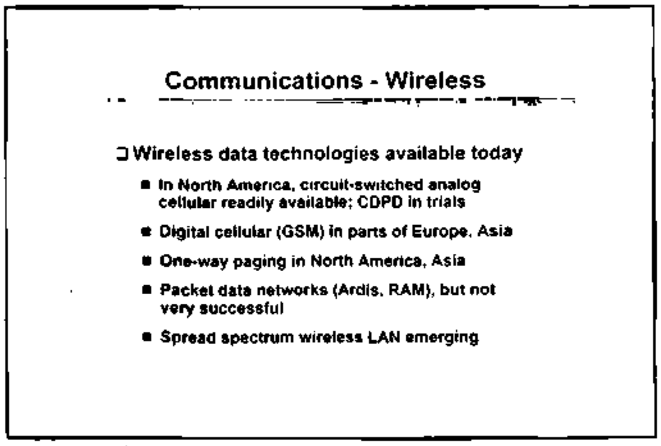


Figure 33

Just quickly, looking a little bit more at the wireless state of technology today in North America, we have analog cellular and then we have CDPD under trial. As I mentioned, the GSM standards are coming together nicely for Europe. We have one-way paging and hopefully one of these days two-way. Packet data radio is available and spread-spectrum wireless LANs are emerging.

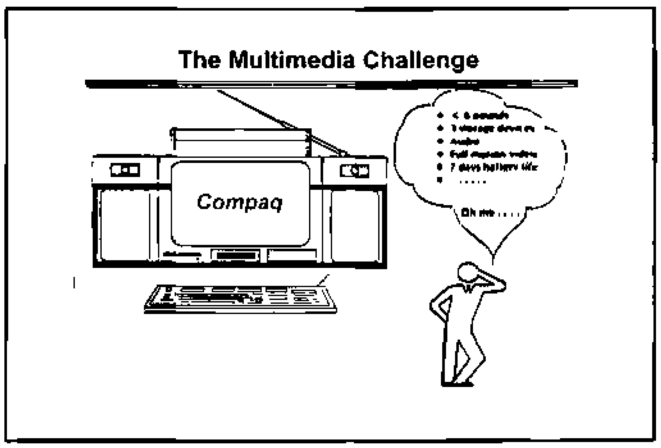


Figure 34

Multimedia today is being delivered primarily on desktop PCs. Our dilemma in portables is trying to cram all that stuff into a six pound product, run it on a flat panel and deliver any kind of battery life at all to you. Hopefully, and I'm going to show you a little demo here in a moment, it's coming to mobile products, we'll be integrating more things like audio, full motion video, and CDs will be externally connectable and I'm sure before long easily internally used. That is going to support requirements for things like training and presentations and other applications for us.

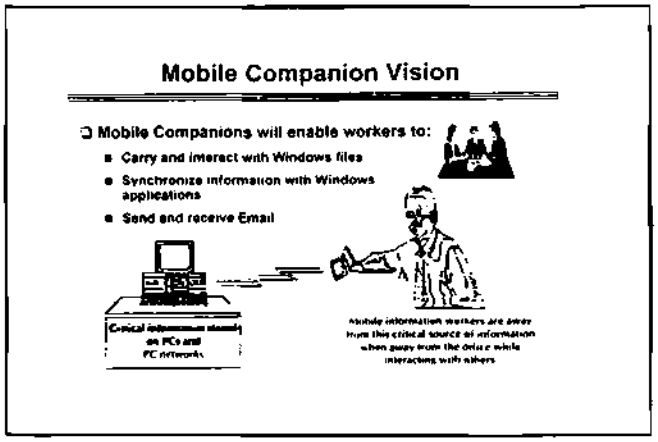


Figure 36

Mobile Companion Challenges

- ❑ Provide right set of features that give users better access to information from their desktop PCs, portable PCs and corporate networks
- ❑ ISHV development of applications and hardware that address real customer needs
- ❑ Education of users to apply new technology in a manner which may modify the way they currently work
- ❑ Ability to disassociate the pen from handwriting recognition

Figure 35

Well, we've been through PDAs and then we did PICs, well our term is MCs. We've called our handheld products that we've had under development "mobile companions". The vision that we've had has always addressed the commercial market. We believe that people do want to carry information with them in a mobile device and be able to interact with their Windows files. We think they want to synchronize between that device and what they have either on their desktop or on their network, and we think that people want to be able to send and receive e-mail while they are away from their office.

Today there are a lot of challenges in delivering that capability. We have on our hands something of a disconnect between what our customers expect and what we can deliver to them. It is in the size of the unit the people want to use, it is in the function that is in there, and it is clearly in the price that we can deliver those units at today.

There are also issues with the availability of enough applications support to make those products useful, and in the meantime we're saying, okay, don't worry about all that, we want you to change the way you work. We want you to give up your paper-based calendar, we want you to quit carrying that information around that you get on paper and figure out how to get it digitized and in this device. It is really a very difficult thing to do and then it's like, how do you interact with this thing? We delivered chicklet keyboards, we've confirmed that we all have illegible handwriting, and we've confirmed that there is no way you could look at these things in this room because you need much more lighting. So we have some real challenges here.

On the other hand, as Gary said this morning, I think the creativity of our industry will help us to overcome these things over time and make it so that one day we all do have our handheld products with us instead of our typical notebooks full of paper.

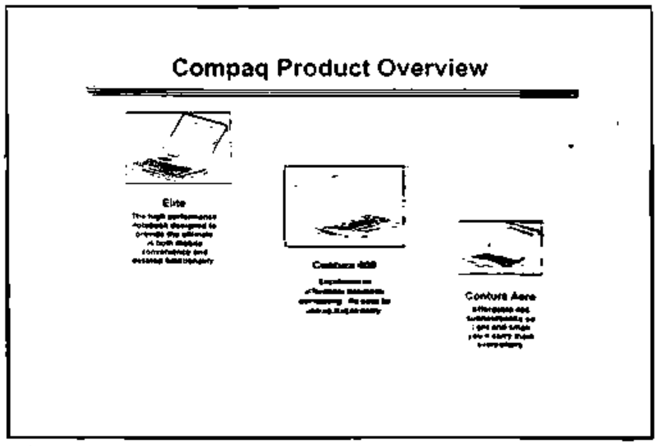


Figure 37

Just real quickly something on what we're shipping today. The Compaq LTE Elites are what we at the mobile division at Compaq are trying to take over the desktop world with. Our most recent announcement was the Compaq Contura 400 that is aimed at our more value-conscious customers, and lastly the Contura Aero that hopefully is starring in a traffic jam on your favorite sports event and it's a small and light product.

But what are we going to have in the year 2000? Will it be chaos? (Sound effects.) Will the Compaq/Intel feud be resolved? Will communications costs come down so that wireless capabilities are available to the masses? Can Microsoft, Intel and IBM find a way to kiss and make up? Well, okay, maybe just interact. Actually, I think so. (Sound effects.) I think our collective end customers will demand that we do and have a compatible environment. I think the creativity that this industry has will provide it and I think the dream of computing at your time and place of choosing will be here by the year 2000. Thank you.

Mr. Banks: Thank you Lorie, for the sound effects as well. Thank you panelists for your comments. Well folks, this is a panel and that means interaction. It is interaction between the audience and the panelists, and with the array of panelists we have here today this is not the time to sit back, be shy and then kick yourself later for not asking a question. We have the dominant software company in the world, Microsoft; the current 1994 leader in PC shipments, Compaq; last year's number one shipper of personal computers and a key member of the formidable PowerPC alliance, IBM; the reigning world heavyweight champion of microprocessors, Intel; and last but not least the largest vendor of chipsets to the PC industry in Cirrus Logic.

These are people with opinions and people with very heavy-weight opinions. I could spend all day asking questions, but I'm not going to do that. I'm going to let the audience dictate the questions in the direction of the panel. As an old college professor of mine used to say, the only dumb question is the one I didn't ask — well I don't want to have any dumb people in the audience. We have microphones in all three aisles. Let's not be shy. Remember, if your question doesn't get answered and you didn't ask it, you only have one person to blame. So we're open for questions.

Question: Craig, I have a question for you. What happens to the lousy PCMCIA cards when your CardBus comes out?

Mr. Kinnie: Well, hopefully CardBus doesn't start off on the same grounds, but first you get downward compatibility with those lousy cards, so if you happen to have them you can still use them. But I think CardBus has been worked heavily within the PCMCIA committee and it has learned from the mistakes of the past and I think a lot of the issues like having a software stack available when the standard is announced and that kind stuff has been addressed by the committee.

Question (John Bryan, Admiral Corporation): My question is for Mr. Stork. You commented on a $500 retail price for a PC, I assume that would include software? My question is how does the software business model have to change to evolve to that kind of consumer product?

Mr. Stork: There is a wide variety of software price points today. I work in the systems software part of Microsoft where we develop our operating systems and we sell the majority of our operating systems directly to the PC makers who include the operating systems with the computer. It's a very small percentage of the total system cost. In terms of applications that people buy, there is obviously a wide variety of price points available today, ranging from entertainment and game packages that sell anywhere from $25 to $50 or $75, encyclopedias, which seem to be around $100, and there are home packages that are fully functional in the $100 kind of range.

I think a lot of it will probably depend on what the distribution medium becomes for these products over time. Today, a typical package that you go to Egghead to buy has significant costs of materials. As hard as you may find it to believe, I think that the gross margin on x86 CPUs is substantially higher than the gross margin on the software products that are sold to retail stores. The cost of the manuals and the disks is actually a greater percentage of the end-user price. If alternative distribution media becomes common, such as downloading software from services or CD-ROM distribution, obviously there is an opportunity for the prices to get lower in that form as well.

Question (Goldstar Electronics): I have a question for Craig Kinnie that pertains to two issues he talked about; one would be native signal processing, the second was Serial Bus. How do those two break down the cost barriers, and could you also define those two standards again for us?

Mr. Kinnie: Okay. Native Signal Processing is an environment that's installed in Windows that allows you to do the processing of comm and media signals on the main processor itself. It works in the same way in Windows as it does for a DSP subsystem. Microsoft has defined an interface called RMI that allows apps to talk to DSP boards and it works with a number of operating systems for DSPs. We have put one of the popular operating systems SPOX from Spectron Inc. in a driver under Windows and called it IASPOX and it too runs under the RMI interface. So anything that you could run on a DSP subsystem you can run on this subsystem for most things at least.

But anyway, Serial Bus is simply a serial interconnect that extends plug-and-play on a serial connection outside the box versus plug-and-play now, which is centered inside the box on things like PCI and ISA that plug-and-play. Serial Bus will target about 5 megabits/sec and we'll shoot for a very low cost-per-connection interconnect so that you can afford to connect things as inexpensive as mice and keyboards or all the way up to speakers and a lot of communications links.

The way the two work together to reduce cost is that all you need to have on the end of the wire that you want to connect to the communications link is an adapter or A/D or D/A and send the digital signals back to the processor where all the processing is done. You no longer have to have a DSP-based modem card or adapter card or anything else. You simply need to convert it to digital and send it back to the CPU. The combination of that low-cost connection point and the fact that you don't need a separate processing subsystem makes it much simpler and makes it less costly.

Question: This is for the whole panel. What kind of sets do you see, respectively, that are going to take the PIC, PDA, MC market up from where it is now. What is going to make that the growing market of the future.

Mr. Banks: I would like to steer that one, at least the first in response, to Lorie Strong from Compaq.

Ms. Strong: Where we think that customers' interests are right now is in a product that's in a one-poundish kind of range but that has a good size display and essentially one of the characteristics that it needs is instant on and instant information. So that's really a performance issue in how do you get enough processing power and RAM in a very small device so that you can get that instantaneous response. Then the price point that we're seeing interest in is probably under $500. So it's, again, how do you get something that small, good battery life, back-lit display, crammed into something that's instantly acceptable and all for $500. We'll do it, but we can't do it yet.

Question: When?

Ms. Strong: When? Two to three years.

Mr. Banks: Okay, George Alexy, Cirrus Logic would like to comment on that.

Mr. Alexy: I would like to comment on that. I think the primary thing that has been missing for these devices is the wireless communications. If you look at the Newton, I think the mistake was the emphasis put on handwriting recognition. That really wasn't the fundamental requirement.

I saw a demonstration just a week ago of the Simon phone that was developed by IBM and I think they now have a major player bringing it to market, one of the carriers. That is a very interesting machine in the paradigm of communications, two-way digital data messaging, ability to fax, providing a number of features that you would find on what you would call your organizer on steroids. Plus, extremely good communications capability. And that is a very interesting device. Whether it is going to be successful or not will depend on the market acceptance. It may be a little bit bigger or maybe a little bit heavier than the market would like to see right now, but I think it is the first product I've seen that really addresses the communications issue.

Question: My name is Doug Fink, I'm from SMC. I would just like the panel's opinion as to whether it is still possible for the small start-up company to make it big in the PC business as it was ten years ago.

Mr. Janick: I certainly hope so. We view PowerPC as just a small start-up company trying to make it big in the PC industry. I believe that there is the potential with some of these PC companies — that just a few years ago were small start-ups — that are now in a mode where supporting some of these emerging marketplaces is either not part of their core business, is not something that they want to invest in, or it is not something they can afford to invest in. So I think there is a lot of potential in this marketplace for start-up companies and for, again, those individuals that are willing to take risks, willing to go for a focus, to market a solution.

Mr. Kinnie: I would also like to take a shot at that. If you mean starting from scratch and building an alternative machine I think that is difficult. But, although a lot of people seem to think that the open standard's-based computing industry stifles innovation, I think it is just the opposite. I think that one thing our industry has shown over and over and over again, if there is a clear target to shoot at, and if you know that there are millions of units on the other end of hitting that target, that the amount of innovation and the amount of R&D that goes in and hits those points is amazing. I think the open computer industry does the best job of harvesting innovation and growing innovation.

I think the thing that is important is that we have clear standards in the right places in the computer hierarchy for people to target. You don't have to be a large company to target them. So it's pick a target and if it turns out to be the right one, which we hope we do the right ones, there is lots of room for innovation for small companies. In fact, I think that is the success of the market.

Question: I'm Larry Jordan with Integrated Device Technology and I want to address this to the panel. Looking at the year 2000, and the home, if you take the set-top box versus the home PC, are they separate or do they merge, and I would like it looked at from hardware and software operating systems.

Mr. Banks: Well, there may be more than one person that wants to address this one. Okay, who's first? Okay George.

Mr. Alexy: The primary comment I would make about that is that we see already a distinct move toward fragmentation in the PC market in the specs and requirements of systems in the business versus the home environment. I mean we have people who want totally different capabilities for display in the home versus the office environment, totally different specs in their audio between the two, in the video between the two.

So I think you are going to see more, and more fragmentation of the market to hit price points. This is becoming true consumerism. You can't have just one automobile, you've got to have ten automobiles that you offer to the public and we see that in the PC market already and I think we are going to see more of it before we see less of it. So I think you are going to see PCs that have cable TV connection capability, but I think you are going to see set-top boxes that handle that directly at a different price point to address a different segment of the market.

Ms. Strong: I think there is an aspect here, though, that you also have to consider. One is that interacting with the PC is kind of an 18-inch experience and interacting with a television is kind of an 8- to 16-foot experience, and it looks to us like those are going to drive some different kinds of utilization. So maybe something that you want to do up close, shopping, I can't see doing word processing from a keyboard looking at a TV 15 feet away, there is kind of a disconnect with that.

On the other hand video demand is much more likely to come together in that 15-foot environment. So we've been kind of thinking through what's the split of those and that is not to say that there are not some gray areas in the middle, but that they are probably going to diverge and have some of the things come together on the PC and then a set of different functionality in more the TV and set-top box environment.

Mr. Banks: I believe you wanted a software look at that also. Carl would you answer that?

Mr. Stork: I'm not sure that anybody really knows how this will evolve. In the long run people are going to want to have some form of high bandwidth communications and that high bandwidth communications might at times be used to deliver video-on-demand, but at other times it might be used to send a video tape to your parents or to download something off a database or whatever.

The sort of architecture that seems to me to be most appropriate is that somewhere one of your PCs in your home is hooked up to this high-speed information highway and is essentially a communication server for the other PCs that are around your home, one of which might be a PC at 10 or 12 feet, which you use for watching movies and playing video games, and a different one that might be the PC that you use at your desk, where you do your work and send e-mail and file your tax returns and that kind of thing.

I think all these devices could be PCs that have very, very different characteristics. The economics of set-top boxes today — where the cable systems buy them from one or two vendors and keep them completely proprietary and don't let anybody write software for them and essentially give them to the users for free, but charge monthly rentals — that is not likely to lead to very high function set-top boxes and it is not likely that there will be a vibrant software industry for that. One piece of good news for the PC industry is that most people have at least two different companies that run wires to their homes, the phone companies and the cable companies, and conceivably more, so that there will be options for how to get access to high bandwidth communications and they won't be necessarily captive of the cable TV companies.

Mr. Banks: It was interesting to hear this morning that the PowerPC architecture had replaced the 68K as the number two RISC. When Intel did that, within the X86 architecture it was accused of eating its own children. My question is directed towards you, Mr.Janek. How can you build momentum and critical mass behind the PowerPC when there is already an expectation that:

a) there are too many implementations that are made of one architecture, and
b) there seems to be a major disconnect between Apple and IBM as to common designs in the future?

Mr. Janick: There are two questions. One was a concern about Apple and IBM's working relationship and another concern regarding architecture, because there are so many implementations that it does not look like one architecture.

Let me describe how we are going after the PowerPC market. We believe that companies like Intel, who have a very solid base of processors out there, have the ability to do a design like Pentium and over time move that design point down from very high-end machines down into the desktop and into the portable market place. That is not a luxury that the PowerPC has today. When we designed PowerPC we focused on three marketplaces: portable, where the focus is sub-three watts; best performance, where the focus is sub-three watts; and the desktop, where the focus is price/performance. It is a tough design point. It is a balanced price/performance design point and for the desktop it was the 601 second generation going to 604.

We also recognize that servers have a unique set of requirements, a very high data band with transaction processing kinds of requirements and so we have a high-end 620 part. All of those parts are totally 100% software-compatible. They may be different design points, but to the software they look exactly the same. That is what is critical within an architecture.

With respect to Apple and IBM, that is a difficult one to answer. That goes back to people's expectations, some of which we probably are guilty of setting. We continue to work with Apple towards a more common reference platform, we are not there today. We do not view that as one of the things that is totally critical to the success of PowerPC. We continue to work in that direction.

Mr. Banks: In case I misspoke this morning on the PowerPC becoming the number two architecture in terms of revenue, that is our projection for 1995.

Question: I am Dave Boswick from AMD. We have all been to presentations where an executive will get up and open up a bag and show us a vast array of cables, devices, batteries, and battery chargers that are required for mobile professionals today. I would like to open this to the panel. What will the mobile executive be carrying in the year 2000? What will it finally boil down to?

Ms. Strong: That is a great question. As we were rambling down our mobile communications path, as mobile executives, we looked around and we were carrying a notebook, pagers on our belt, and cellular phones. We said, "How many devices are people going to carry?" What we are seeing is a desire to consolidate devices. You use a pager that has a PCMCIA card that you can put in the slot. That eliminates that device. You use the notebook with audio that is also voice-capable, maybe even has speaker phone capabilities and that becomes a single device. I think one of the things that the industry needs to do is work towards consolidating all those multiple pieces into a single device that does our computing and communication.

Question: Do you have a Microsoft supplier that can supply some of the software? Do you have a vision of what people will carry with them?

Mr. Stork: I think a lot of it depends on the type of profile of the individual that you are. I certainly carry more devices now and more weight now than I care to. I have found it to be very useful to have a single machine that I can take home or take to meetings around the campus. I can take it with me when I travel, or I can use it to project presentations, review presentations, produce spreadsheets, do e-mail, create documents, and so on.

I personally favor a PC that is not exactly the highest performance, as I would buy for desktop. I am willing to trade off some of the performance that I could get in a desktop in order to have my main work environment available to me in the hotel room and on the airplane. I think that there probably is another set of target customers that do not need that, but are walking around their campus or traveling to client sites, and perhaps travel less regularly, that would want a lower weight, smaller form factor device that lets them still be in communications, touch, receive messages and e-mail and answer e-mail, that sort of thing.

We do have a feeling that the device would need to be a very good companion to a base PC. Maybe it would have that person's schedule on it and things like that. Being able to share the standard PC environment is quite important. The challenge with that device is it will clearly have less functionality, and I think in order to be successful, it needs to be very portable and fairly inexpensive. Ms. Strong mentioned the $500 price point. I think that is what has made it very hard for them to succeed so far. The price points have not been that low and the usability, the value that it has created, has not been high enough. I think that there is still some work to be done and some time to pass before they become successful.

Dan: Would you share with us how you do the field trials both inside of Compaq and with outside groups when you are designing the Elite or Contura or follow-on product lines. With today's rapidly changing product cycles, how do you have time to do all of this? Please share with us how you do the prioritization of the various systems parameters as you try to design a new product?

Ms. Strong: One of the nice things about Compaq is we have always looked at the user requirements up front, as well as the available technologies. When we get to the concept stage on a project we do a lot of research at that stage to make sure that we are on the right path, because in our business, if you get down to design and you have worked six, eight, or twelve months, and then you find out that you have the wrong product, you have missed the cycle. You are too late.

Part of what we do is a lot of customer research upfront. We do that through direct customer visits. We do a lot of focus groups, and then we have some quantitative studies that we do with current customers. The testing that we do is also concurrent with the development cycle. There are different design phases that we do internally. We do not do a lot of external beta testing. Most of it is in-house. We have a group called Wide Area Test who set up a full environment with multiple operating systems, all of the different networking capabilities, and all of the known expansion boards and applications. We do most of the testing internally.

Question: I am Dale Ford from Dataquest. I would like to ask you how you believe chip set vendors will battle the trend toward more of the key PC functionality being pulled into the MPU software complex?

Mr. Alexy: This is a bit of a mixed blessing. If you look at the market, it is highly desirable to have software-based solutions for practically every peripheral device you have in the system to some level. It basically becomes a freeway to enable the market to adopt that technology. We see that to be particularly important in multimedia. We think some of the things we see going on in video conferencing may be very important. There is actually a balance of having software-based solutions that bring a level of capability at a very low price point. It then opens the door and helps establish the standards for us in the silicon business to come out with higher performance, higher quality solutions, where we leverage the performance capabilities of the silicon to address that. That is the side for software-based solutions.

As far as the CPUs trying to integrate the functions that we do today into their CPU, that has been tried a couple of times. I am not sure that makes a lot of sense. I think the CPU people are better off taking their silicon budget based on the reticule size and putting it into more MIPs, because the life cycles for the peripherals have a very high rate of change. There is a dramatic amount of diversity. We are seeing more and more of that in the industry.

This fragmentation of the people doing home-based computers want to have a device that drives the TV directly, not a CRT. The person doing the desktop wants very high-performance graphic user interface acceleration. The person doing home computers wants games-orientated 3-D, and the person doing work stations wants other types of 3-D for the workstation. There is enough fragmentation, that I don't think it makes a lot sense to try to integrate the functional blocks, but in terms of having the MIPs that can be bundled with software to enable the capability, I think it is fundamental to the industry.

Mr. Kinnie: I agree with everything that George said, that if you take a look at blocks that exist in a base platform today and say, "Why don't I sweep some of that on to the CPU? It would simplify the board". Take low-cost silicon and sweep in some very expensive silicon. The economics don't work. I don't think things like memory controllers and bus controllers and the basic functions are at risk of being swept into the CPU anytime soon. I was referring to the new capabilities; I think George was to. They are coming, like media or communications, or other things.

If you look historically, this is not a new thing. The first really good graphics controllers were fairly complex add-in cards. Where we are today, there has been a split that has evolved, some function stays in the hardware and some went to the processor. The same thing happened with LAN cards. All we are suggesting is that for media and higher-end communication cards, the same thing will happen. We are going to try and accelerate it a little bit, but there will be some natural partitioning, some left in hardware and what processing will be done will be done most effectively on the host processor. There is always a natural partitioning that evolves. George's point about it is that it starts as a relatively expensive add-in thing and over time migrates. As it gets into software we can actually cause the acceptance and the ease of use of things to be better and the solutions are much more scalable.

Question: I am Pete Bonny from Eastman Kodak. I don't think anybody in this room would dispute the facts that have been thrown out by many people today. A $1,500-to-$2,000 investment will buy you a good PC, and that $1,500-to-$2,000 price has remained pretty constant over the past few years and it probably will over the next several. The emphasis of your companies, both hardware and software, will be to put more integration, more functions, more performance into the same box for the same price. However, I hear comments like Carl Stork saying that more and more schools are asking,"Does every student in this class have access to a PC?" Carl also made the point that we could sell a lot more PCs in the industry if the price were $500 instead of $1,500. Something I have wondered about, I live in a neighborhood of about 60 homes, about 8 to 10 of those have families with children and I am the only one in that neighborhood that has a PC. What I would like to ask the panel is:

1. What do you think it is going to take to bring a PC down to the $500 level to expand it to many more families and homes across the country?
2. Do you think it will come from some of the mainline companies, such as IBM or Compaq, which are concentrating on higher-end products, or is it going to come from a completely different market and a completely different set of suppliers?

Ms. Strong: We would love to get the product down to $500. Now I need to talk from a desktop perspective rather than notebook. Especially in notebooks, the flat panels remain so expensive that it is very difficult. We are waiting on the cost of the components or else for the requirements to stabilize so that things can come down so we can deliver that kind of product. On the second part of your question, it is something that we have in our goals and would like to be the manufacturer that delivers and not see Taiwan manufacturing or someone come in and be able to deliver those kinds of products. The volumes would be great at those prices. We'd love to get there.

Mr. Kinnie: I have to disagree with your assertion of what it will take to get it into all of those homes, for all of those kids to have PCs at the lower price point. We have to be able to make functions of the PC more useful and learnable by everyone in order to get them into more homes. If you want a $500 PC, just look in the ad section of the paper and buy a two-year old PC. If that was the case you wouldn't have any trouble getting rid of your old one. It is not just any function that needs to be down at $500. It is a function that serves the purpose of the student. Today if you tried to do that you would miss the target, just like a two-year old PC misses the target.

Question: Follow-up on that question. After you spend that $500 and get something that is useful, do you expect them to come back two years later and spend another $500?

Mr. Kinnie: For most of the things that people want to do today I don't think $500 will buy the functionality that you need. I think as we pour more function into the $2,000 price point, we expand the market greatly and we bring functionality to people that find it useful. I think that is why the price point has been fairly stable. We keep growing the market at that price point versus dropping the price of the machine. There are machines that are $1,000 or less, but typically people are reaching for the functionality that comes at the $2,000 price point because it does more of what they want to do.

Mr. Stork: Today you probably need to spend between $1,200 and $1,500 dollars to get what I would consider to be the minimal reasonable machine for somebody to put in their home, which probably has a 486 of some sort in it, CD-ROM drive and audio, and a moderate hard disk. It was that machine last Christmas that started the wave of serious use of PC in people's homes. I think CD-ROM and sound are absolutely required. I think the leading machine for a high end consumer who is not price-sensitive will probably continue to be in the $1,500-to-$2,000 price range because they will always get more power. I think if you take that machine that sold last Christmas for between $1,500 and $1,900, it will probably sell this Christmas for between $1,200 and $1,500. Machines with that level of capability will get cheaper over the next couple of years. Every single year you will be able to save more money or get a substantially higher performance machine for the same price as the year before. In two years you might decide that the new functions are worth enough to get the new model. It is similar to cellular phones. Every two years the cellular phones have gotten better. The old phone became obsolete.

Mr. Kinnie: I remembered a point I wanted to make. The gentleman asked a question about the people on his block not having computers, connecting that to the point this morning about education. I think most parents would pay the $2,000 price to give their child an edge up in education if they simply were assured that that would be true. I think one of the issues is that a lot of the schools are very computer-poor; therefore, the teachers don't make assignments that are appropriate or they don't necessarily train students on how to use a computer. I think if a parent were convinced that a student would make good use of it for improving his education, they would pay the $2,000. I think the gap is not that the computer wouldn't help, it is the training and the utility within the schools. I have spent a lot of time in schools addressing that issue and that is a big problem.

Mr. Banks: Are we approaching an era of software consolidation that we will only have a few major architecture-independent operating systems and few enough central applications of the type of microprocessor used, for example, X86, PowerPC, etc., becomes a purely price performance decision. If so what time frame? What is the driving force? What impact will this have on the semiconductor companies?

Mr. Janick: Certainly we would like to see the day when the main operating systems are much more portable than they are today and that transition is certainly in flight. When it occurs, I believe that we will get to the point where the kind of processor you have in your machine is going to be much less based on the amount of software that is available and much more based on just pure price performance and capability. Certainly that is a point you would expect out of someone pushing PowerPC. When it is going to happen is now. When it is going to be complete is sometime in the future. I think that there is some potential that even the king of architecture today, X86, is going to find that some time in the future it is going to have to move off of its current instruction set. We may be thanking the PowerPC for helping to move the industry to a more portable set of operating systems.

Mr. Stork: I don't think that there has been a consolidation of software companies, certainly not at the application and home title categories. We run very active software developer programs. Every year there are more and more software companies, more new software companies, and those software companies are growing. I don't think you will ever get to the point where there are people developing new software.

In the case of operating systems, I don't think there have ever been a lot of operating systems and there are not a lot of operating systems today. The question you might ask is, "Will the implementation of the various operating systems on different architectures become more consistent?" Our goal is to make one operating system implementation available on different processors. That isn't enough. You need to get a broad application base. So far, we have not seen an architecture neutral distribution format or an emulation technology that makes it acceptable to run one binary on multiple architectures. It is always best to have native software.

Mr. Kinnie: The name of the game is compatibility, not technology. That has been the strength of the Intel architecture PC market for several years. The whole goal is how do we maintain the installed base of applications, data, and the users, and move that forward to new capabilities. That is really what it is all about. Intel has been deploying RISC technology to achieve that goal and its compatible processors for the last several years. RISC is a technology, not an architecture. We can use it for compatibility. Intel will always move forward in a way that moves its users and applications forward. That defines their business.

Mr. Banks: I am now going to let the panelist make a few closing comments. We are going to start in reverse order and we will have Ms. Strong comment.

Ms. Strong: I wanted to tell a little story. I have two small children, a four-year-old and a seven-year-old. As you might guess, I do have a computer at home. I set the computer up so that it comes up in Kid Desk and most of their DOS games are in Kid Desk and the Windows games are over there in Windows. My four-year-old can take the computer, get out of Kid Desk, go to DOS to the C prompt, type WIN, get over to Windows and even when it comes up wrong, like it didn't come up with all of the different things, she knows how to look in the corner and get the program manager to come back up right. There are certainly a lot of improvements to be made, but I think we are likely to be growing a generation of kids that are going to really benefit from all of this technology. They will just have the thrill of the educational advantages they can get through their computers. It is also an opportunity for some enrichment in their lives. I think we are creating a great base for our children and look forward to participating with it.

Mr. Alexy: The only comments that I want to make in closing is that this gets back into moving from chaos into control. Many of the places where we see the opportunities for significant growth in the use of the PC and the utility of the PC are in areas where the standards are at least well defined. The one I am most concerned with is the wireless communications. I am watching Japan focus on a standard communications protocol for digital cellular. Korea is taking Epson. Europe has gone GSM and the United States has at least two standards and some people are talking about GSM. They have TDMA, CDMA, and even GSM is floating around in corners.

We are going the wrong way toward a standard. The activities in the PCS area for the new frequencies are being allocated. That could be a bigger disaster. We have to be very careful or we will make it very difficult to move forward and apply these new opportunities and develop the technologies in a consistent fashion to get the volume up and the ubiquity up of these new capabilities. It is a watch word to our industry because we are the folks that have to build this stuff in the semiconductor industry at the right price point so that folks like Compaq can apply it in systems that people can ultimately use. We have to be very careful how we deal with that and it is a standardization issue in moving from the chaos to the control, and from the bleeding edge to the leading edge.

Mr. Kinnie: In my final comments, I would like to pick up on a term that George mentioned in his talk. I hope it is not copyrighted because I would like to use it. It is called "compatibility-driven evolution" and I think that is exactly what the PC market is up to. That is what my group is trying to make happen in the industry. It is to evolve the PC forward to next-generation applications and capabilities in ways that maintain compatibility. The notion that that stifles innovation or opportunity is what I would like to counter. When the open computer industry is at its best and the growth is at its best is when there is a clear obvious standard for people to target so that people can build on one side and people can build on the other side, and it all works together. To the extent that we have clarity of direction, clarity of standards, the opportunity for growth in the industry is better. That is what we have in the Intel architecture PC.

Mr. Janick: I think you have heard a lot of interesting opinions. Probably the thing that I noted the most is that those of us up here who represent companies or architectures that are in control want to see control continue and want to see things evolve in an evolutionary manner. Those of us who represent more of a start-up kind of group that would tend to have a different opinion and would tend to prefer a little more chaotic transition and believe that that allows for more start-ups, more innovation, more creativity, and ultimately a better set of products for customers. In closing, I would like to say that we would like to see PowerPC add some chaos to the current controlled situation.

Mr. Stork: The world has changed a lot when IBM is arguing for the absence of control. The biggest challenge for us in the PC industry over the last six to eight years has been the fact that there is not one company in control, for example, in getting plug-and-play established. There is no one company that can dictate to any part of this industry. If you don't like what one company is doing, you innovate around it. In a certain sense the PC industry and the Macintosh show these opposite approaches.

The Macintosh is an example of complete control for one company. It designs the hardware, designs the peripherals, the operating system, designs the drivers, etc. They have created a well-integrated, nice looking easy-to-use product. It is a market where there is less innovation and certainly much less independent innovation and less price competition.

In the PC market we have had the opposite approach, lots of independent innovation and there are many companies that have succeeded. It has been by good execution and I think it remains by good execution. The moment that any one of us stumbles there are competitors who are ready to take our position away from us and we all know that. That motivates us a lot. I do see lots of future evolution and growth in the PC market.

Mr. Banks: I would like to thank the audience. I asked only one question and I forced that one in so I hope that is a good sign of things to come for the panels tomorrow. Panel members, thank you very much. It has been very entertaining and enlightening.

Overview of Day Two

Joseph Grenier
Vice President
Semiconductor Manufacturing, Applications, and Procurement Group
Dataquest Incorporated

Mr. Grenier: This is the screen of the Printrak 2000 fingerprint identification system that uses sophisticated digital imaging and processing technology to capture and process fingerprint data. With this system, fingerprint matching and identification can be done in minutes, instead of hours or days that were previously required.

Fingerprint analysis is very complicated, requiring 3 billion operations per fingerprint. The image processor of Printrak's previous system required 28 circuit boards containing 7,000 ICs, and 4 Motorola 68000 microprocessors. The image processor of the new Model 2000 replaces those 28 boards with a single board using TI's new MVP DSP chip that can do 2 billion operations per second.

Printrak's Fingerprint Identification Systems are used by law enforcement agencies around the world, including the FBI and Scotland Yard, to aid in the rapid apprehension of criminals. Other applications for fingerprint identification systems include welfare antifraud and DMV records. We may also see systems in use at local banks, where ATM machines will use your fingerprint instead of your personal identification number.

Digital imaging is also the core technology for other biometric identification systems, such as retinal scanning, hand geometry, signature verification, and voice verification. So maybe the retinal scanners we've seen in Arnold Schwarznegger movies may become a reality after all.

I would also like to point out that the striping pattern of zebras, like fingerprints, is also unique to the individual.

Digital X-ray System. Another example of digital imaging technology is the new AcuRay x-ray system used by dentists. The system uses a CCD sensor that is inserted into the patient's mouth to capture the x-ray image. The image is transferred from the sensor to the console via a cable and displayed instantly on the color monitor. There is no film, no film processing, and no waiting for results. A 1.2 gigabyte hard drive can store up to 24,000 compressed images, and a printer provides a hard copy of your x-ray.

The AcuRay brochure urges dentists to jump on the technology bandwagon. Somehow, this distresses me — will I now get calls from the dental office cancelling my appointment because, "the doctor's computer is down?"

Card Readers for Pachinko Machines. This is a picture of a Japanese pachinko machine. The pachinko business is often associated with gangsters, and pachinko parlor owners have not always been honest taxpayers. In order to prevent such abuse, regulatory agencies in Japan are encouraging the owners to replace their old machines with new machines that use card readers instead of cash. Cashless machines, it is hoped, will help keep everybody honest. However, the problem is that the new machines cost three to four times more than the old machines. Understandably, there is some reluctance on the part of the owners to pay more for the new machines that will keep them honest.

Another problem is that the soaring demand for semiconductors has caused a shortage of the logic ICs used in the card readers. Under current regulation, it is not easy to get the old pachinko machines without card readers approved, so the logic shortage is becoming a serious matter for everybody associated with the pachinko business, including the regulatory agency, owners, fans, and gangsters.

In addition, the new digital pachinko machines contain a Read Only Memory (ROM), and it is unlawful to change the ROM after approval of the machine. Apparently, there are underground professional ROM rewriters who alter the code, presumably for the benefit of the owner. However, new IC technology is being introduced to make ROM rewriting more difficult.

In the past, as I walked the streets of Tokyo, I thought that pachinko parlors were low-tech, harmless diversions. Little did I know that a raging war was going on inside, between the regulators, owners, and gangsters, and that IC technology was very much involved in the outcome of the war.

Radar Watchdog. Now you can protect your home and family with a huge, snarling German Shepherd guard dog. A dog that growls and barks so ferociously it stops trespassers in their tracks, and makes startled prowlers turn and flee.

Better than a live dog, the Radar Watchdog, available from Sharper Image, guards your property 24 hours a day, requires no food or daily exercise, never sleeps, and will not chase the neighbor's cat.

Radar Watchdog senses motion through the walls, doors, and windows with its built-in-radar. It responds like a trained guard dog, barking fiercely until the intruder has left the area. Should the intruder come closer, the barking intensifies, becoming fiercer and more frequent. Who wants to tangle with a 150 pound dog? The intimidating sounds are so realistic because actual dog barks are digitized on a chip.

Personally, I think the encroachment of electronics in our lives is simply going too far when we have to replace man's best friend with a chip. Perhaps, their next product will be a Radar Bird Dog. Lookout hunters, they are going to replace your favorite pointer with a chip!

BeeperKid $150. BeeperKid is designed to help parents keep track of their 1 to 5 year old toddlers with unequaled reliability. BeeperKid gives parents added reassurance in crowded public environments that their child is nearby. The unit worn by the child sets off an alarm on the parents' unit when the child moves beyond 15 feet. When the child returns to within 15 feet, the alarm stops. The parents' unit has a mute button in case you want to let them wander.

The system, the result of an innovative defense conversion project, uses technology previously used only in defense applications. The BeeperKid project management team includes past members of NASA's deep space and other military projects.

BeeperKid technology is essentially an advanced wireless modem, and uses a proprietary non-RF proximity detection system that works through walls, obstructions, and even metal objects. Each unit has a double-sided circuit board with 130 surface-mounted components with an ASIC mounted chip-on-board.

BeeperKid uses very advanced technology. Time magazine recognized BeeperKid as one of the ten outstanding designs of the year. Also, BeeperKid was recently part of America's touring exhibit in Japan entitled *Industrial Design: America's Competitive Edge.*

I think they ought to introduce another new product called BeeperDog which would allow leashless walking of your dog. Then they could bundle BeeperDog with Radar Watchdog, although probably the two products would negate each other.

Snore Control $60. Minutes after we hit the pillow, it starts, that nerve-racking snoring! Incredibly, it seems to go on all night, while the sands of sleep slip through the hourglass, lost forever. And what a sound! Tests have shown that some people produce noise as loud as a jack hammer or a jet aircraft on take-off.

Snore Control is designed to interrupt snoring. Whenever snoring is detected, you feel a pulsing vibration on the surface of your skin. This momentary disturbance interrupts snoring and prompts the snorer to shift to a new position in which snoring does not occur. Unlike a swift kick from your sleep partner, the pulses are designed to be felt unconsciously, not to wake your conscious mind.

Available from Sharper Image, it comes with a book entitled *Some Facts About Snoring*.

The promotional literature I read clearly left one to believe that males are responsible for snoring. Also, notice that it's a male's wrist in the photo. However, I am sure there are many of us who would agree that it is not only the males of the species that snore! I think I'll write Sharper Image a letter of protest.

Sonicare $150. Research studies show that Sonicare removes three times more plaque than conventional brushing. Also, university studies reveal it's also remarkably effective in controlling stains. After brushing with Sonicare for four weeks, test subjects achieved an 80 percent reduction in tough coffee, tea, and tobacco stains.

Sonicare uses a microcontroller to control brush head vibration at 31,000 strokes per minute. This rapid oscillating motion produces fast-moving, micro-size bubbles that travel rapidly through the toothpaste foam, penetrating nooks, fissures, cracks, pits, and gaps — all the places where plaque-causing bacteria grow. Sonicare's foaming action feels pleasantly effervescent, and users report that their mouths have that "just polished" feeling.

Optional is the Quadpacer timing system that ensures the four quadrants of your mouth get equal brushing time. For instance, right-handed people may spend more brushing time on the left side, and the opposite may be true for left-handers.

I would have shown you the traditional before-brushing and after-brushing teeth pictures, but I figured we had enough teeth shots for one conference.

Virtual Reality Bike $7,500. The Virtual Reality Bike, made by Tectrix, is the industry's first, fully interactive aerobic fitness machine. It comes with a 20-inch color monitor and sophisticated virtual reality software. The rider has the freedom to go in an infinite number of directions through the virtual world. Pedal along a country path, climb a grassy hill, join a challenging race, discover a country town, or take off to forge your own trail.

The rider is able to move as one with the unit as he steers through the virtual reality world. The rider uses his weight to lean the unit to either side as he goes speeding around a corner. A cool breeze blows by his face, increasing in intensity as his speed increases. Pedaling resistance increases or decreases in response to the terrain he is exploring. Stereo speakers provide realistic background noise and sound effects.

One of the most amazing features is the ability to network groups of Virtual Reality Bikes so that riders can travel casually together through the virtual world, or compete against each other in a challenging virtual race.

Virtual reality worlds are stored on a CD, so changing workout worlds is as simple as changing a CD. Virtual Reality Bike has Intel inside.

I am going to suggest to the company that they offer an optional, very uncomfortable bicycle seat to make it even more realistic.

Talking Picture Frame $35. With a touch, this picture frame plays up to 16 seconds of a recorded message. Frame comes complete with a built-in microphone and a nonvolatile memory.

Another talking product is BirdGard ABC, an electronic bird repeller made by Weitech. Actual bird distress cries are recorded on a chip and played back through a speaker system to repel birds. Birds can't differentiate the recorded cries from the original cries.

However, since birds only respond to their own species cry, you need different units for different birds. Fortunately, the company has units for robins (what kind of person wants to repel robins?), starlings, thrushes, finches, sparrows, grackles, great blue herons (who needs to repel herons?), seagulls, and blackbirds.

I think the same person who designed BirdGard ABC is the same person who designed Radar Watchdog, and that person doesn't like animals.

Actually, we are being deluged with talking products. Here are a few more:

- Talking cat feeder
- Talking doormat — for instance, it could say, "Welcome to Dataquest!"
- Talking pinata — it says "You missed!" or "I'm over here!"
- Talking tombstone — but you gotta get to the person before he dies. This one has a lot of possibilities, doesn't it?

You know, a cemetry is one of the few quiet spots left in a city. Can you imagine going to a cemetry and having a bunch of tombstones talking away? Personally, I would rather be cremated than put up with that.

Also, I think you should know the company responsible, or should I say irresponsible, for the talking chips in these products is Information Storage Devices. If I were them, I would be very worried about getting a warning from the Environmental Protection Agency against environmental noise pollution.

Wireless Communications: The Second Revolution Unfolds

Moderator

Gregory L. Sheppard
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Semiconductor Group
Dataquest Incorporated

Panelists

Masood Garahi
Chief Technology Officer
Destineer Corporation

Michael J. Hames
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Worldwide DSP Manager
Texas Instruments

Robert S. Sellinger
Director, PCS
AT&T Network Wireless Systems

Daniel V. Romano
Vice President
Competence and System Development
Nokia Mobile Phones

Mr. Sheppard: Good morning. That's a tough act to follow, but we'll do our best here. I think we, at least in my opinion, have the best panel session in the universe here, but I'm just a little bit biased. I do have to say that Mr. Tooker yesterday stole a little bit of my thunder, but that's OK. The subject is, obviously, wireless communications, and that's a very broad topic. It includes everything from cellular telephones to cordless, to wireless connectivity with notebook computers. We've assembled a very nice panel here for you this morning, covering the entire food chain. We have included Masood Garahi who is with Destineer Corporation, Mike Hames with TI, Bob Sellinger with AT&T, and Dan Romano, who is with Nokia Mobile Phones.

The cellular telephone, once a symbol of mobile executives and drug lords, is now becoming one of the world's most ubiquitous technologies used by high school students, housewives, and even some Dataquest sales people when they're allowed to write it off on an expense report. What would the world be like today if when Boris Yeltsin was trapped inside that building in Moscow he didn't have a cellular phone to make a call to rally the troops to come bail him out? There could very well could be a bunch of hardliners still controlling what's still the Soviet Union today. Very dramatic the capability that this offers us. It's revolutionizing our lives, and for the first time, as we're rolling out mobile communications into areas like China, Eastern Europe, and the former Soviet Republics, people are able to place phone calls and, as Gary mentioned yesterday, estimates are as many as half of the world's population has never placed a phone call.

Mobile communications provides a very low cost way of providing phone service quickly in that it allows a way to get around the established public telephone company infrastructures, which are typically state owned in a lot of countries. Many of the mobile systems that are being put in place today are, in fact, entrepreneurial companies that are funded sometimes by outside capital or joint ventures with other companies. In six months time a phone system can be installed. We estimate that there are approximately 100 million users worldwide now of mobile communications systems, and that could grow easily to 300 million by the year 2000.

A primary attraction of installing mobile communications is the relative speed and cost savings, obviously, and, in particular, we note areas such as Poland and Hungary, as well as Southern China, Peru, and Brazil, that are pursuing aggressive plans in mobile communications. These also happen to be countries where the economies are growing the most rapidly. In effect there is double growth effect going on here. The developed countries of North America, Asia, and Japan are now turning to new digital and microcellular systems for advanced capability. In addition to the increased channel capacity and clarity of signal, these new services will be tailored to handle data and, in some cases, video information as well. So perhaps those AT&T commercials we've been seeing aren't so far off after all. I also should point out that these new digital systems allow for very small handsets which can preserve a lot of battery life, and I'm sure some of our panelists can get into some of the technological advantages.

Of these new systems, the GSM digital standard, which is out of Europe, is off to a particularly strong start, and we estimate that there are over four million phones expected to be produced this year. Besides GSM, new hardware opportunities exist in two-way pagers, cordless technology such as CT2. There's a system called the Personal Handy Phone in Japan. PCMCIA RF modems, these are card-type modems you slip into the notebook computer for wireless connectivity. In the U.S., we have a bit of a battle ongoing for what the future's going to look like. We have one standard known as IS-54, which is based on TDMA technology. It also can operate with the current analog system. There's another standard known as IS-94 that uses

CDMA technology, which is basically a spread spectrum technology that came out of military communications.

We also have CDPD for packetized data, and this can operate over the current analog system, as well. In Japan there is a standard there known as the Japanese Digital Cellular Standard. We can also add to the list Wireless Local Area Networks, which uses frequencies that are known as the ISM bands. For the most part, they can be unlicensed, meaning the FCC doesn't need to get involved. Wireless PBX—wouldn't every facilities manager just love to move phones and computers around without having to worry about stringing wire and connecting up things?

We also have personal communicators like Sony's PIC and Motorola's Envoy. These are taking advantage of General Magic's technology, which has some very interesting aspects to it. One is the Telescript capability, which employs a concept of an intelligent agent. Basically, it's a little software program that can go out in a network and book theater tickets for you and other remote tasks. The Motorola Envoy and the Sony PIC are examples of this new wave or second generation of PDA technology. I think we talked about that yesterday where, after two weeks, some declared it was a dead market—maybe yes, maybe no. But, clearly, these devices are becoming more communication-centric. It has become very clear to the developers of these things that value that they bring to the user is in the ability to connect, to read e-mail, conduct functions like that.

Of recent note in the U.S., the FCC for the first time is auctioning off bandwidth to support narrowband and broadband personal communication services (PCS). Mr. Garahi is fresh from those auctions, and he has some interesting stories to tell about how that went. As a side note, the auctions are part of the Clinton Administration's plan for reducing the deficit and there could be several billion dollars, if not tens of billions of dollars, generated there. We estimate that the semiconductor market for wireless applications — and this includes handsets and infrastructure — is approximately \$3 billion today, and that could easily top \$9 billion by the end of the decade.

So, in order to more fully explore these issues and others, I'd like at this time to introduce our first speaker, and his name is Masood Garahi, who is the chief technology officer for Destineer Corporation, a subsidiary of Mobile Telecommunications Technologies, or Mtel. He's responsible for developing all of Destineer's technology and services, and plays an active role in the strategic direction of Destineer. Maybe he can share with you a little bit about what went on at those auctions. So, without further ado, Masood.

Mr. Garahi: First of all, let me thank you for inviting me as a carrier, somewhat of an oddball in this industry, to talk to your industry. The carrier is going to play a major role and be a fundamental player in wireless communication's next generation. As Greg was pointing out, with devices like Sony and others coming out, the only way that that's going to be possible is through advances in the semiconductor industry.

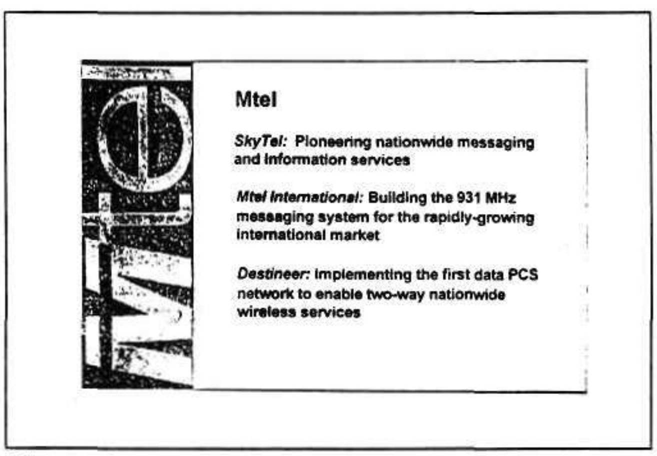

Figure 1

Before I start, I would like to give you a little briefing on Mtel and Destineer. Mtel has three major subsidiaries. One is Skytel, which is probably the most well known of the three. Skytel was responsible for our nationwide services throughout the United States with the Sky Pager, Sky Talk, and other products. Back in 1985, we decided that people eventually wore pagers and would like to travel and still be in touch, even though initially it was somewhat a laughing matter—who would want to take his pager and get on a plane and go to another city and be paged. Today, there are four major companies who offer this product and there are more and more coming.

On Mtel's international side, in 1987, we decided that since we were right about the people getting on a plane and going to other cities in the United States, they were definitely going to travel overseas as well. So we started expanding the Skytel's 931, 9375 frequency throughout the world. And we've been actively pursuing the governments and PTTs around the world to allocate that frequency to become an international standard frequency throughout the world, where you can take your pager and, without changing anything, without notifying anybody, just get on a plane and fly into Singapore, and when somebody pages you, that pager will alert you in Singapore. Many times I run into people from HP or Texas Instrument who would fly over there. I've seen some of them wearing those pagers and it's really a great tool. Currently, Mtel International has most of South America and Central America built, and products are offered and service is available in Hong Kong, Singapore, Malaysia, Indonesia, and others are coming.

On the Destineer side, this was a company we started initially as NWN, Nationwide Wireless Network, back in 1989—1990 when we went to the FCC and presented our pioneer preference application for a two-way data messaging system. Recently we changed the name to Destineer to handle all our narrowband PCS. During the last auctions, we received two additional frequencies, in addition to our pioneer preference; a 50-50 kilohertz, a 50 kilohertz forward channel, a 50 kilohertz reverse channel, and also a 50 forward and 12-1/2 reverse, in addition to our 150 kilohertz forward channel. That's a total of about 150 kilohertz forward channel and about 62.50 on a reverse channel for data services.

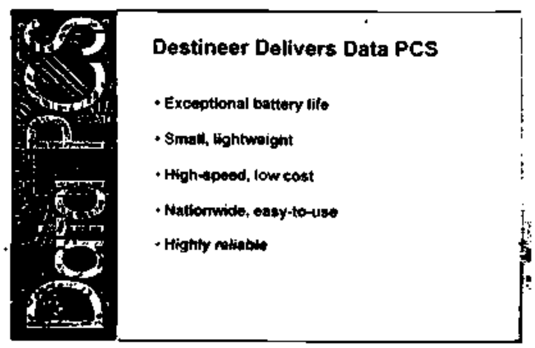

Figure 2

Back in 1989 when we thought about data services, we went around and talked to our application partners, AT&T, Easy Link, MCI Mail, and some other application developers; what we consistently heard was that they liked the paging technology because the devices are small, lightweight, and with long battery life. But they wanted higher capacity data and lower prices, especially on the nationwide side. And with that in mind, we started with a clean sheet of paper and came up with the idea for two-way messaging, Destineer, for our Pioneer Preference.

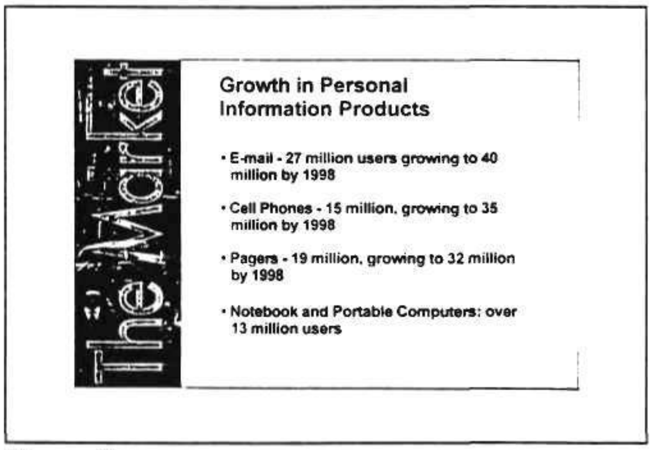

Figure 3

Looking at the market today, there are about 27 million e-mail users, and it's estimated to grow to about 40 million. The same with the cellular phone, about 15 million with a high growth. There are 19 million pagers today, and that's estimated to grow to about 32 million pagers by 1998. This is a great opportunity in terms of developing, not only for one-way, but two-way as well. And, of course, notebooks and portables have over 13 million users today.

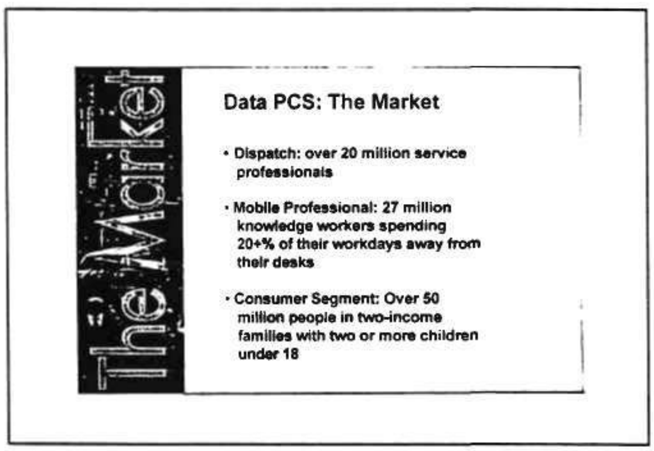

Figure 4

Looking at these technologies, we also wanted to look at the market segment itself. The way we divided it was into three different segments. In the dispatch market, doctors, plumbers, delivery dispatch guys. There are about 20 million service professionals that are using dispatch. Second, mobile professionals, of which there are probably about 1000 sitting here, these are people who are spending 20% or more of their time on the road. And then the consumer segment, where there are 50 million households, or 50 million people in two-income families, that are going to play a significant role in wireless and two-way messaging. And when I go over the applications, you'll see the way we divided the applications and the personal messaging.

Figure 5

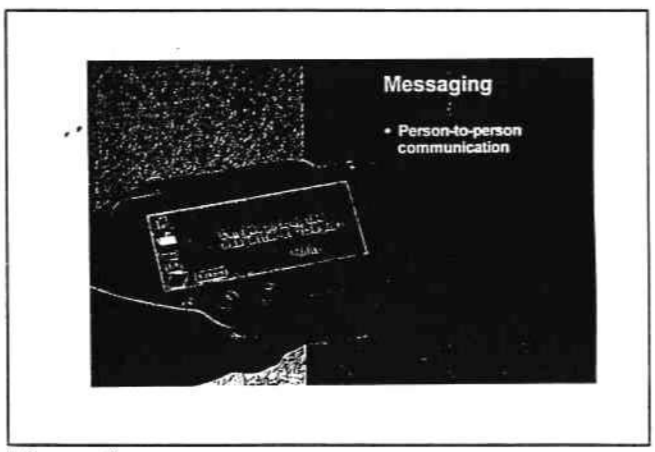

Figure 6

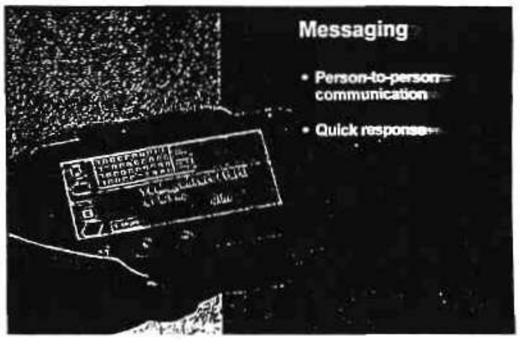

Figure 7

Peer-to-peer communications is a significant part of personal messaging, a kind of electronic post-it note. It's simple, you just jot down a little note on a little device the size of a small PDA. It could be as simple as this Motorola device which just flips open, and has a selection of canned messages you can pick from. That would be the first generation. Or, a device is fully screened and you can just write a little note on, or maybe even bigger size devices like the Sony Magic Link or Motorola's Envoy device. And those will mostly be used by any of the three segments for just electronic post-it alone; jot down a little note, can you meet me there? Answer "no" or "yes" and be done with it. No calls, no disruptions, nothing. Of course, mobile office professionals use e-mail and fax, which I'll talk about in a few minutes.

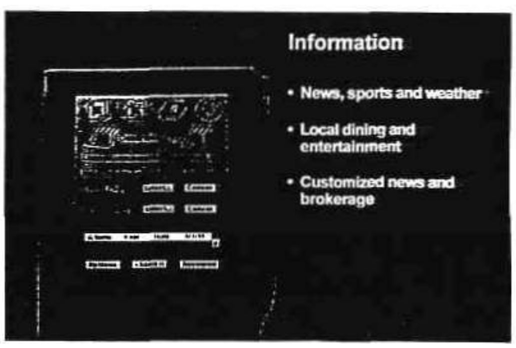

Figure 8

Information services is one of the areas of great opportunity for entrepreneurs to provide value-added information through wireless services; sending sports, news, or weather information, all going into a Magic Link-type device or a PDA-type device, ready for you whenever you need it. Transactions services are the next generation of products, which are probably slower coming than the other three, where you actually conduct transactions with those devices. I'm going to look at each one of them so you can get an idea about similar devices; very small, lightweight devices you can keep in your pocket or purse and even clip onto your belt.

Figure 9

On fax services, what we had in mind were small faxes. We didn't think that you would want to get a 200-page contract coming over the air for you to review. Even today, when you get a 200-page fax, the first thing you do, even if you get it on your laptop or your computer, is print it. Then you go through it and mark it up and then, even if you edit it on your screen, after you mark it up, you go ahead and edit it. So what we thought about faxes on the wireless side would be one-page, two-page, or three-page faxes, that a fax machine would send and you'd review it; or you'd draw information, or even a message that you want to send to somebody who doesn't have a PDA or other devices. There are millions of fax machines out there that you could simply fax it rather than having to be a member of a closed group, which currently is the case with the e-mails and some of the paging devices.

On information services, as I pointed out, you could get information that's generic. For example, the device could be programmed to automatically grab information about a city's weather as soon as you touch down in that city. So you would no longer have to buy a USA Today to see the national weather map. As soon as you landed, all the necessary information would be loaded because your PDA would be smart enough to know it's in a new city and get information automatically. And that could happen with anything — restaurants, sports events, and other things.

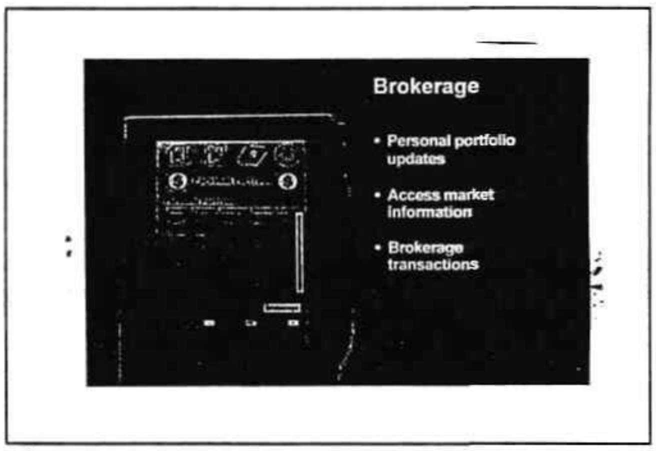

Figure 10

One example of transaction services would be getting updates on the commodities market, for example, and you could actually conduct transactions, buy and sell. For those of you who have seen the pits where they actually write a piece of paper and notes for themselves or exchange and conduct transactions, that could all go away and be conducted electronically, but not necessarily in the same pit. They could just be sitting there in their offices, or be on the road, conducting business with the transactions.

On the consumer side you could buy tickets, you could order flowers for your wife or your husband, and that could be even combined with the Hallmark cards that have one of those voice chips today that you can buy for about $11-$12, on which you record your own happy birthday song and send. Now you could actually record that on the system and every time you want to send somebody a card, simply purchase that card from Hallmark and that voice recording could be preprinted and sent out to the recipient. The recording mechanism could even go away, because it's no longer needed. So that kind of transaction could also happen on the system.

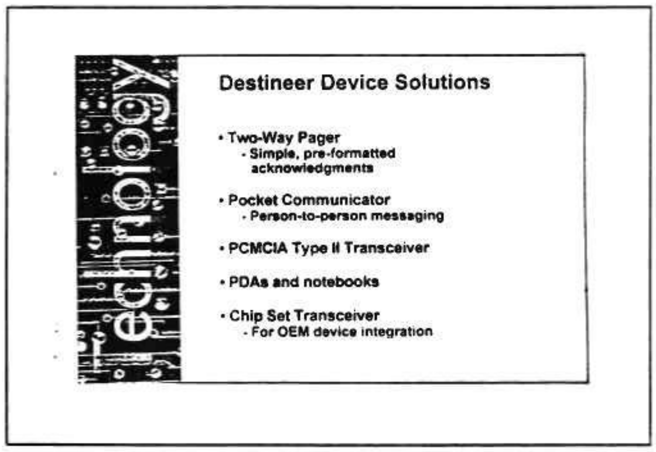

Figure 11

Now a little bit about the technology that we're going to use to do this. The first thing is, of course, the devices. As I pointed out, a two-way pager, a very simple device, unintimidating, a kind of device that you can give to plumbers, who are using a pager today; all you tell them is that they have an extra button, and every time you press that button, it just says, "Yes, I got the message," or another button that says, "yes" or "no." These would have multiple-choice questions coming to them. "Can you be at so-and-so's house at 5 o'clock, 3 o'clock, 2 o'clock — yes or no." And then all he has to do is just select one of the answers that came with the question and press the button, and that answer will go back to the dispatch operator, sender, or whomever.

The next devices would be the pocket communicators which are like a Sony Magic Link, Motorola Envoy, or PDA-type device, on which you actually can send and receive information. Of course, the PCMCIA card is a very significant part of this industry, or the wireless industry, because it's becoming a standard. Today I have a Magic Link in my briefcase that has a PCMCIA card from Wireless Access, which is a pager, essentially, an alphanumeric pager completely, and is available today. And we don't see any reason why we shouldn't make that a two-way device that you can actually use to answer or request information.

For the bigger size of PDAs and notebooks, we are hoping that that will be an integrated part of the devices. And that goes further than just getting consumers to receive information; you can even get updates, you can control devices, you can send and broadcast information to thousands of people at one time. Send one message and thousands of sales people across the country could pick up that sales information or pricing information simultaneously. So there are great opportunities for office automation. Of course, the most important are the chips transceivers. We want to reduce this technology in such a way that chip tranceivers would be embedded into the security systems, sprinkler systems, make meters where you can automatically read meters, or the sprinkler system could be activated or deactivated, remotely. Also, this service is so inexpensive.

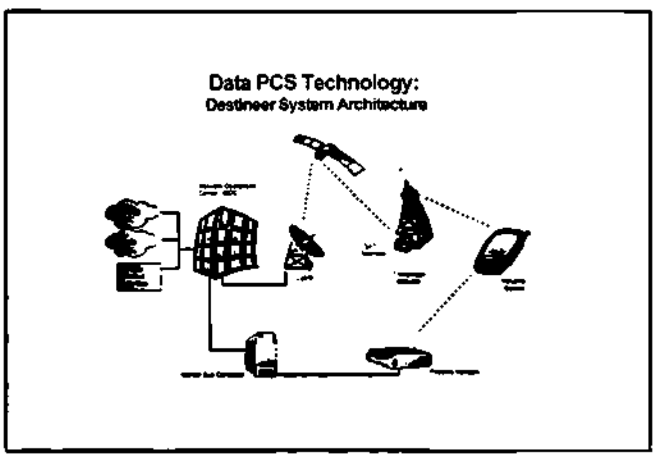

Figure 12

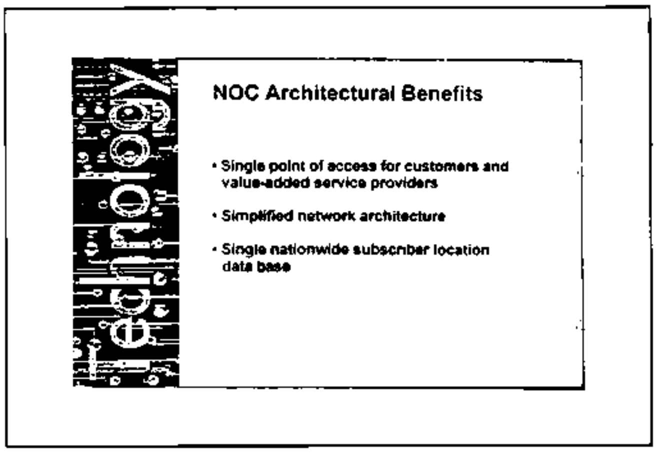

Figure 13

The design of Destineer's network; it has a single NOC, or Network Operations Center. It's a single point of contact for value-added application developers or any other software developers who want to contact or have communications to a single point. So if you have a solution that is available, it could be simply deployed anywhere in the United States without having to deal with the local operations. It has a single operation; however, it is dually redundant and has all that fancy stuff that we deploy for the reliability and availability of the system.

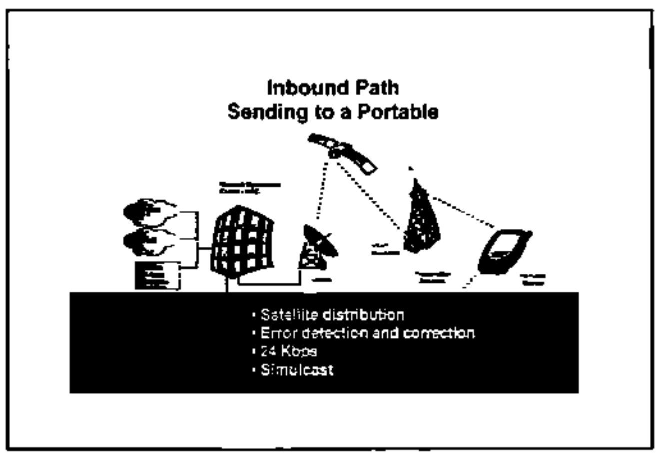

Figure 14

This is the front end of the system where it comes into the network operation. You can come in through the packet switch network or packet switch telephone network or any other mechanism to get into the network. And then, of course, the information is broadcasted and sent up to the satellite and down to every single transmitter site throughout the United States. However, the pertinent information would be sent to a PMU, a PDA, or a device for that particular city. And, of course, a message could get originated here, be sent to the receivers, and multiple or single receivers could pick it up, and then pass it on to the local controllers, which would pass it on to the NOC, and a response could then go back to the sender. The messages could get originated here or here, anywhere, it doesn't matter. It just makes the loop.

A little bit about the inbound or the broadcast portion of the network. It's running at 24 kilobits per second on only one 50-kilohertz channel. And we've got three of those. And this is the first generation technology. We're hoping to increase that to about 100 to 110 kbits per second on a 50-kilohertz channel.

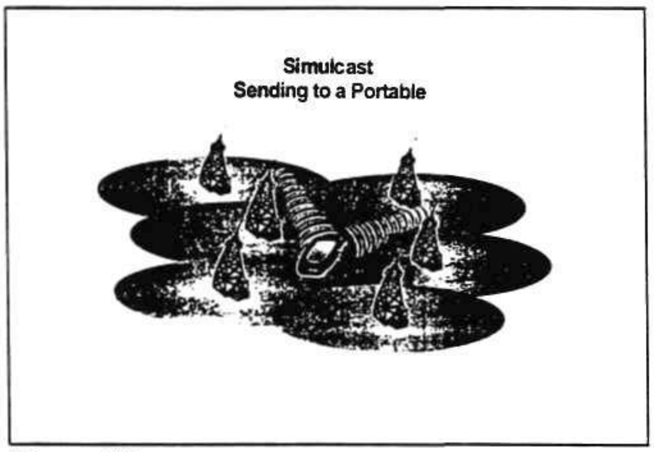

Figure 15

It uses simulcast technology where we have all the benefit of a simulcast paging system that you can penetrate buildings and increase reliability. Satellite distribution will allow us to add a transmitter site instantly, anywhere we want to, for any purposes.

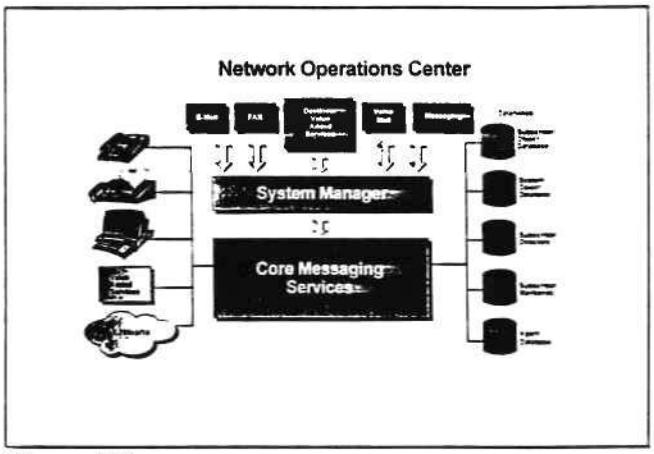

Figure 16

We talked about simulcast. We talked about the network operations center. To just give you a bit of an overview of what the operations center consists of, it's a core messaging service that actually conducts the commodity side of wireless, it actually delivers data. It doesn't matter where it comes from, it doesn't matter where it ends, there is a delivery of the data. There is a system manager that actually provides certain basic services to subscribers through a single mailbox, and those are e-mail, fax, voice, paging, and some transaction support.

However, these services are available to all the other application developers who want to add their own applications or even replace some of these. These are simply services available to application developers. The system would be able to handle a host of databases, in terms of object databases, as well as a subscriber's directory and subscriber database, and a gateway on the front end where you can come in through X.400, Internet, any kind of telephone, like a plane telephone, faxes, or computer modems.

Now, in terms of APIs, we are writing all the popular APIs for the system; however, we're taking the burden of writing anything that's necessary in order to allow other application developers to plug into this system, and that's a very important point.

Figure 17

My last slide is about our alliances. Microsoft was not only an investor, but also an applications developer, and they are working with us on some of the applications, not only for office automation, but also on the side of consumer products. Motorola is developing all the transmitters and receivers and the PMU devices, or as we call them, the small messaging devices. Wireless Access is also developing, as a second source, the PMU and PDA-type devices. Glenayre Electronics is working on our transmitters and receivers, again as a second source vendor. And, of course, Kleiner Perkins, who every time our treasury gets tight, we give them a call. So, essentially, this is my pitch for today. Thank you.

Mr. Sheppard: Thanks, Masood. We've just heard from a company involved in developing new services for wireless communications and we've heard some interesting concepts here. The next three speakers will be folks that are involved primarily with the hardware side of it, either the infrastructure, the terminal devices, or the handsets themselves, as well as the enabling chip technology going inside of them. And, first up, who is coming at it from the semiconductor perspective, is Mike Hames. He is VP of the DSP. Mike's been responsible for managing all of TI's digital signal processing business, including directing all the research and development efforts there. He was actually, according to his bio here, involved in the launch of the original 320 way back when. So, without further ado, Mike Hames.

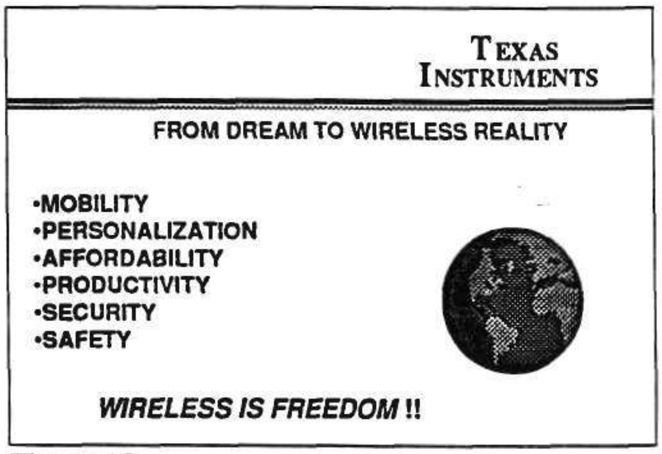

Figure 18

Mr. Hames: Thank you. As Greg talked about, I'm going to switch gears here and talk a little bit about the enabling technology that's really fueling all these exciting services. What we really see at TI is, just like personal computers in the '80s, wireless communications in the '90s is becoming affordable and forever changing the way we look at people-to-people and people-to-machine communications. The trend toward untethered voice, data, and video personal communications is now profound and irreversible.

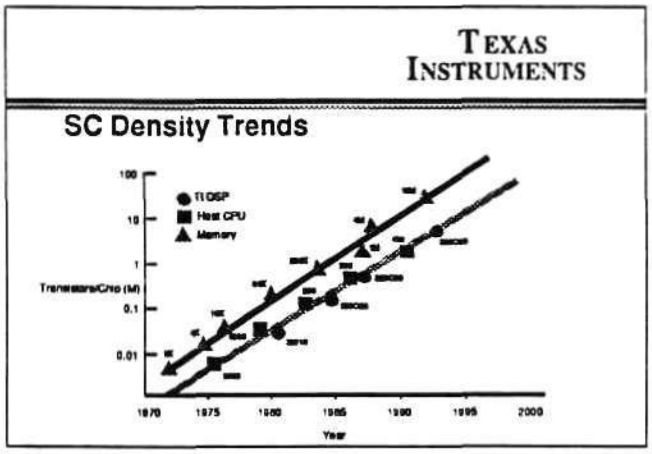

Figure 19

Microelectronics technology, in particular digital signal processing, is making all of this possible. As Wally Rhines talked about yesterday, the scaling of semiconductors is really facilitating this growth. Today you can integrate five to ten million transistors cost-effectively on a single piece of silicon. By the year 2000, we'll be able to cost-effectively manage 100 million transistors on a single piece of silicon. DSPs are following the same trend as these host microprocessors we talked about yesterday and the Pentium and Power PC. In fact, this morning we mentioned the C80, which is the latest generation of DSPs; that's roughly a five million transistor chip capable of two billion operations per second. That's opening up tremendous capabilities from a wireless communications perspective. This trend is really enabling all the core technologies that we're going to talk about moving forward.

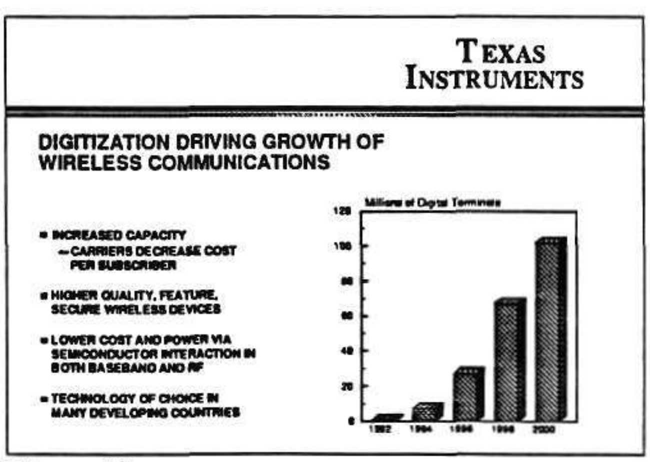

Figure 20

Digitization is really driving the growth. Why? Because digital communications can carry significantly more bandwidth than the preceding analog systems. For example, in a voice system like cellular, you're seeing a 3-10X increase in the capacity over the same bandwidth, or air channels. What that's doing is obviously giving us the opportunity to significantly lower cost per subscriber in the future, which is obviously just going to continue to fuel more demand. In addition, once you have it in the digital domain, you obviously have the capabilities to introduce significantly higher data rates and even combine multiple channels to provide LAN-like access into a remote site.

Also, what you're finding is that voice quality today, which is at best at parity with analog, is going through a dramatic change. You're seeing the next generation of voice compression technology that's going to bring significant improvements in the wireless domain to provide significantly better quality and, ultimately, approach high-fidelity CD quality voice. In fact, with the rapid reduction in wireless communications cost, wireless infrastructure is replacing copper in many of the developing nations. As Greg talked about in his introduction, what you're actually finding is that it's cheaper in many cases, especially in the more mountainous and remote areas of the world, to put in wireless technology than it is copper, and very soon in the future what you'll see is in most of the developing nations wireless being the mainstream technology for the standard voice services. By the end of the decade, the market will meet, if not exceed, over 100 million digital terminals per year. I don't think anyone can even envision, given the capabilities that the gentlemen before and after me are going to talk about, how pervasive this wireless communications is going to be in our everyday lives.

Standards are the key to this growth, however, and picking through the alphabet soup of options between TDMA and CDMA, between cellular and PCS, and within cellular, between GSM, IS-54 B, C, IS-95, and PDC, and on an on, makes it more and more difficult to pick winners and losers. Each standard has its own tradeoff of availability, terminal cost, infrastructure cost, subscriber cost, and one can argue that if you look across all the different standards, there isn't a significant difference in the total cost to deploy the different technologies. The only question is where you pay for it. Whether it's in higher subscriber rates, whether it's an infrastructure cost, or whatever.

What I think you'll find is that one standard, or even a couple of standards, will not really emerge as the only standards, but what you're going to find is a fracturing. Just as in the PC where you're seeing many different PCs being talked about targeting the home, the office, the computing, whether a PC is in the set-top box, or whether you have five PCs in your home, you're seeing it get very diverse.

I think you're seeing the same in wireless communications where there's going to be a significant diversity. Different countries have different bandwidths that they allocate. They have different uses, they can afford different things. And what that's going to have is just a plethora of standards that will happen in the world. Whichever standards emerge, digital signal processing will be at the heart of the solution. DSP will allow the same terminal to support the multitude of standards, even switching from the mobility of a cellular on the same phone to the cost-effectiveness of the subscriber rate of a cordless phone, such as a DECT phone in Europe.

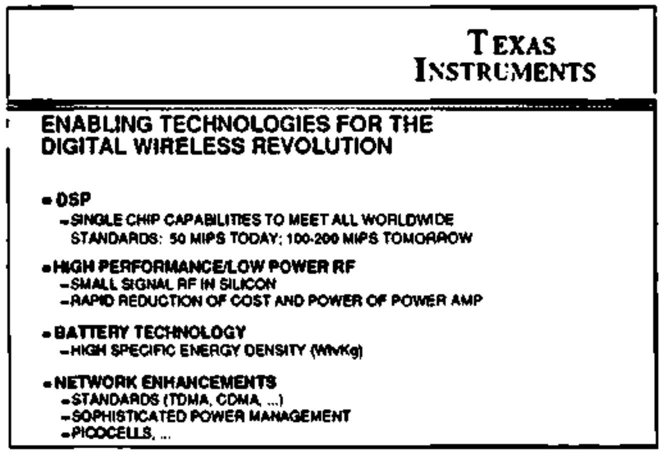

Figure 21

Increases in processing power will continue and revolutionize the man-machine interface, enabling such things as the true Dick Tracy watch phone or the Star Trek communicator. Regardless of the standards, all the terminals will see dramatic improvements in DSP. You're seeing DSPs go from 50 to 100 mips today. They're at very cost-effective rates to hundreds if not thousands of mips in the future.

You're also seeing significant improvements in the RF area where they're taking advantage of submicron CMOS and BiCMOS processes to move more and more of the RF into silicon, thus significantly reducing the cost. And you're also seeing just as in the PC, significant improvements in battery technology that will significantly extend the usefulness and the life of these products.

In addition, there's so much focus on the terminals, but what is happening is that the same type of advancements that are providing and fueling these low-cost terminals are also going to significantly reduce the cost of base stations and infrastructure, which will make the pervasion even faster. As the carriers understand more how to use their networks and squeeze more channels and more capabilities out of those networks, they will continue to reduce the cost of the systems.

TEXAS INSTRUMENTS

TDMA CELLULAR ARCHITECTURE EVOLUTION

	1992/93	1995/96	1998/99
BASEBAND	6or 7 ICs + memory chips	2 ICs + memory chips	1 Digital IC
RX/TX	> 150 discretes	3 ICs + discretes	1 AFE + transceiver IC
PA	Non-monolithic PA	Monolithic PA	Monolithic PA + power control
BATTERIES	5 cells	3 cells	2 cells

Figure 22

TEXAS INSTRUMENTS

SEMICONDUCTOR TECHNOLOGY IMPACT

1992	1994	1996	1998	2000
0.8 MICRON	0.5 MICRON	0.35 MICRON	0.25 MICRON	0.18 MICRON
4.5V-5.5V	3V-5.5V	2V-3.6V	1.5V-2.4V	1.5V-2.4V
18HRS STD-BY	36 HRS STD-BY	72HRS STD-BY	144 HRS STD-BY	>1 WEEK STD-BY
1HR30 TALK-TIME	3HRS TALK-TIME	6HRS TALK-TIME	12HRS TALK-TIME	> 1 DAY TALK-TIME

Figure 23

The whole phone, if you look at, for example, a TDMA cellular phone, is collapsing very quickly into a handful of chips. What used to be a very complex phone costing $400 to $500 is quickly driving down to a handful of chips where the total semiconductor content will be less than $50 and the whole phone will sell for less than $100. It's really independent of the standard — whether it's a cordless standard that doesn't require quite as much processing power, or whether it's a highly mobile cellular standard, everything's going to merge. The cost of the terminal is not going to make a significant difference due to the processing power inside the phone. And you're going to see a significant merging of all these technologies.

Not only are you going to see a significant reduction in the cost and size of these terminals, what you're able to do today in a high-end cellular phone, you'll be able to do in a pager tomorrow, but you're seeing a dramatic change in talk time, going from one to two hours today, which is barely acceptable today, will be days tomorrow, and standby time going from 18 to 24 hours to weeks, truly making them the practical devices that we need to drive the pervasion.

TEXAS INSTRUMENTS

SEMICONDUCTOR ADVANCES ENABLING THE WIRELESS REVOLUTION

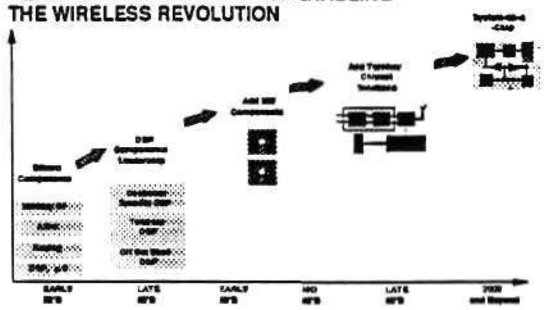

Figure 24

As standards evolve, they will be embedded into a single piece of silicon, facilitating high-volume, low-cost manufacturing. Customers will embed their differentiation onto this single chip, and the human interface will be a critical part of the system. SC vendors will work hand-in-hand with system houses to provide the product differentiation into all the different spaces. So, in conclusion, infrastructure costs, regulatory issues, and rate structures will ultimately determine which standards emerge. However, it's certain that wireless communications tomorrow will be as commonplace as the telephone today. Thank you.

Mr. Sellinger: Good morning. It's a pleasure to be with you this morning. What I'd like to do in my remarks is focus our attention on the upcoming spectrum that the FCC will auction starting early December. Briefly, this represents a significant opportunity, not only for AT&T's infrastructure business, which I represent, but, of course, this represents a potential entry of six new carriers in each of the major markets, particularly here in North America, for wireless services. So we expect to see an explosion in growth in terms of competition, the subscriber opportunities and, obviously, an opportunity to sell more cell sites and switches, the things I'm paid to do.

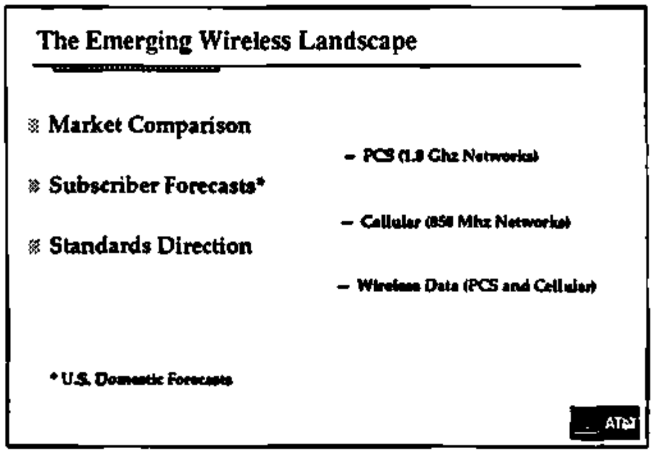

Figure 25

What I'd like to do this morning is to focus my remarks in three areas. I want to characterize this new market compared to cellular and wireline communications. Looking at what we believe from a functional as well as an economic perspective will differentiate PCS from both cellular and existing wireline services. Again, with the emphasis on the North American market as a starting point.

I'd then like to look at what the potential market is in terms of subscriber growth, both for voice services as well as data services and, finally, to take a stab at, where I think the standards are going to end up. I'm a bit more optimistic than Mike is as to how this standards debate will end up. We believe there are some significant advantages to certain technologies being proposed today for this new emerging marketplace for PCS, and we'll share those with you as we conclude our remarks.

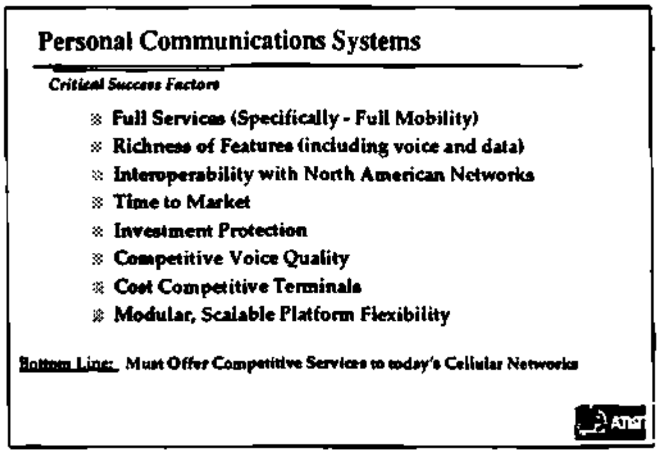

Figure 26

Let's start with what we believe the new PCS entrants — the new carriers — will need to offer to compete successfully in a market where wireless services have, in fact, been offered in certain markets for over ten years by two cellular incumbents. We believe those new carriers will need to provide a full range of services and, in particular, full mobility. The new phone, the PCS terminal, needs to work as well in the home as in the office, and certainly in the car and at full mobility —up to 100 kilometer per hour. Much the same way cellular networks are deployed.

We also believe, though, that both voice and data will characterize the new service, and that PCS will be more than just plain old telephone service. The major opportunity, we believe, for the new PCS carrier to differentiate itself from the cellular incumbent will be in the area of data. In particular, vertical applications that take advantage of existing cellular data standards.

To reuse the infrastructure of today's North American wireline and wireless networks, we believe it is mandatory that the new PCS carrier pick a standard, pick a technology that plugs-and-plays with the existing switches, transmission facilities, and intelligent networks that exist in today's North American network. So strong adherence to North American standards, we believe, are mandatory for that carrier's success.

We believe another major opportunity for PCS is differentiation through voice quality. Mike mentioned that as DSP technology evolves, as standards like CDMA, in particular, are introduced, there will be a significant opportunity for the new PCS carriers to distinguish themselves, relative to the voice quality of the basic telephone service. The cracks, snap, and pops of the past, the hard hand-offs — much of that, we believe, can be eliminated with the correct choice of digital technology.

And, of course, we believe anything that one chooses to do in 1995 or 1996 is bound to change, and picking a technology platform that evolves as the technology evolves is obviously mandatory for carrier success as well.

But the bottom line, we believe, is that the competition the new PCS carrier will face will, in large part, be set by the two cellular incumbants. Many of the same problems, the distribution problems, the business problems, the cost targets in the minds of the consumer have in large part been set by that cellular provider. That's the playing field, in effect, that the PCS carrier needs to be cognizant of and plan to compete upon. That's a backdrop.

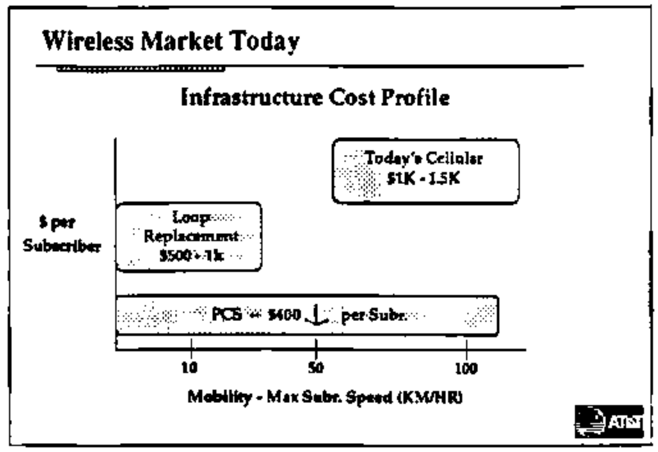

Figure 27

What I'd like to do is share with you our belief as to the cost profile of wireless services. The cost of the infrastructure. The cost of the cell sites, the switches, the access managers, the intelligent network access that new PCS carriers can take advantage of in defining their competitive strategies.

By and large, today's cellular networks are analog-based — becoming digital-ready, I think is a better way to portray it than digitally active — and typically represent anywhere from $1,000 to $1,500 per subscriber in infrastructure cost.

With PCS, we believe the right technologies for PCS (and as you'll see, that means North American digital standards, in particular, CDMA) can reduce that cost per subscriber significantly. It is not unrealistic to expect infrastructure cost to be $400 and declining over time with those first networks. And that compares with wireline access, which typically is in the $500 to $1000 range, fixed wireless systems, low-tier systems, which are also in that same price range. So, we believe from a cost point of view, the opportunity is there to provide the subscriber with added savings that go with the new PCS service, that distinguishes it from the current usage costs associated with cellular.

By the way, existing digital networks tend to be in the $800 to $1000 range. That's the typical subscriber cost for technologies like GSM, which have been deployed in Europe over the last few years. We believe, again, that the more contemporary technology like CDMA gives us an opportunity to reduce that significantly.

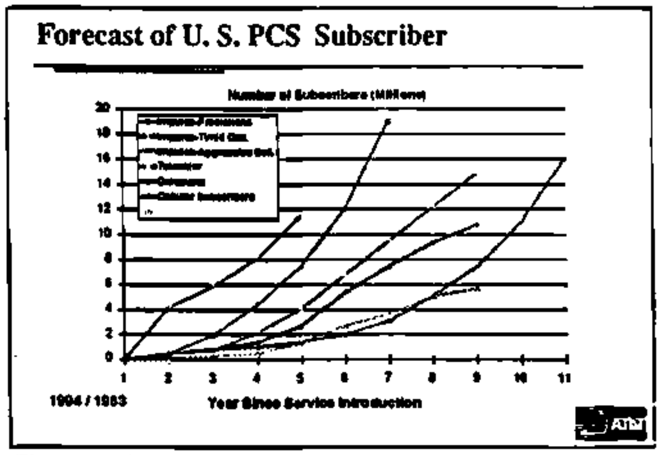

Figure 28

That is the cost backdrop. What I'd like to do is share with you some of the market forecasts for the number of subscribers predicted in the wireless markets. The important curve here, I believe, is the red curve, since that's a historical curve showing our historical experience in the cellular markets since they were first introduced in 1983. Cellular markets are growing today at a very healthy rate — 30+ percent compounded growth. As you can see, many of the forecasts for PCS tend to be a bit more aggressive in terms of the slope of the curve; nonetheless, they parallel the experience that we have seen over the last ten years with 850 MHz or cellular networks. This gives us, we believe, a great deal of confidence — that the promise of PCS is real as long as the cost targets can be met and there are competitive opportunities for the new PCS carriers to distinguish themselves from the existing cellular incumbents.

By the way, this is a voice forecast. I'll share with you in a moment where we think the data opportunities are. That would be additive to what we've shown here. We don't believe it is unrealistic to expect by the year 2000 wireless penetration that's over 20 percent in any of the major markets. That would be broken between four to five successful wireless carriers in any BTA or MTA. BTA and MTA, for those that aren't familiar with the rules the FCC has described for PCS, basically are the basic trading areas or major trading areas that will define the geographic footprint — how the spectrum will be auctioned.

We believe this is a healthy business for all, and we anticipate, as I mentioned, a significant growth in the wireless markets.

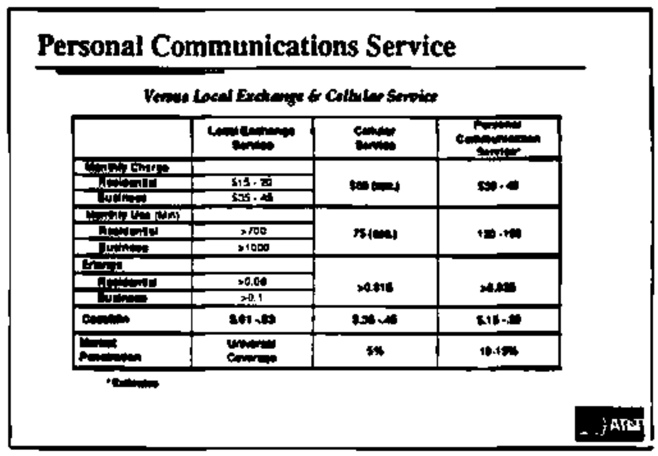

Figure 29

Regarding subscriber cost — the cost of the service to the subscriber — we believe PCS will fit between cellular and existing wireline rates. As you can see from this chart, as the cost goes down, as the cost of the airtime decreases, obviously usage goes up. The business models we've run indicate that a very profitable business can be created with monthly usage rates that are shown here. That, we believe, will represent close to a doubling of the usage of the network. By the way, the cellular service column here, that's more or less what we see today — it's an aggregate of what we see today in some of the best cellular networks domestically. We see airtime more or less doubling the usage of the network. About 0.01 erlangs up to 0.02, 0.03, and the cost per minute of airtime that will fuel that additional usage coming down. We don't see within five years PCS offering the same cost profile as a subscriber with existing wireline services. The crystal ball is a little bit cloudy as you look out beyond five years, admittedly. But it's not unrealistic, we think, to expect a convergence as this column evolves to converge to where we are today in terms of existing wireline service rates.

Be that as it may, this would fuel a healthy industry. But as I mentioned, as you look out 5 to 8 years, you'll see wireless penetration as you combine cellular with PCS in the 20 percent to 25 percent range.

Let's switch for a moment to data. As I mentioned earlier, we see data as a major opportunity for the PCS carriers to distinguish themselves, particularly in the area of vertical applications. One of the acronyms you've heard earlier was CDPD. CDPD has recently been introduced in cellular networks to provide a digital packet connection with data service. This will co-exist with existing voice services, be it digital, TDMA, or analog voice.

Wireless Data Market Assessment - Addressable Subscribers

(Thousands)

Market	Total	Packet	Circuit
Field Service	2,900	1,800	1,100
Field Sales	1,500	750	750
Transport	2,600	2,340	260
Insurance	250	225	25
Utilities	420	378	42
Railroads	23	18	5
Reporters	70	28	42
Food Service	48	43	5
Professionals (Doctors, Lawyers)	2,400	720	1,680
Public Service (Police, EMS)	835	665	170
Fixed Telemetry	5,000+	5,000+	?
TOTAL	15,500+	12,000+	~3,500
		(~75%)	(~25%)

AT&T

Figure 30

Most of the current cellular data networks are circuit-based and are targeted at the two markets shown here that are most applicably served by circuit — field service/field sales, that's become a healthy business, as well as the professional market. People like us who carry laptop computers, who need access to the wireless network through a modem and laptop computer.

We think there are large opportunities elsewhere, particularly for the PCS carrier — very graceful ways for them to distinguish themselves, particularly in the areas of fixed telemetry. Vertical applications — portable point-of-sale devices, environmental monitoring, burglar alarms, security devices — with the CDPD subscriber cost coming down under a hundred dollars per subscriber unit, these are very natural markets for that PCS carrier to consider exploiting. One of the virtues we see in CDPD is it's a very open standard, and it's built upon existing computing standards. So it's quite easy for existing wireline-based data networking applications to put wireless CDPD end points on that wireline network. It's very easy to interface to the Internet, to existing TCP/IP-based networks as well as even more of the defecto networks, like SNA networks. It's not hard at all to put wireless CDPD end points on those networks and not change the application software on the server or on the mainframe.

We see very compelling arguments that make CDPD very attractive as a connectionless packet data service, both for cellular carriers as well as for the emerging PCS market. The bottom line of this chart is, we believe, that roughly two-thirds to three-quarters of the wireless data market is best served with packet technology. Circuit technology will remain, but we believe that the untapped opportunity by and large is with packet.

Now we shift to the third topic as I promised, and that is standards. How do we expect the alphabet soup to sort itself out and what do we think are some of the advantages of the various proposed digital standards?

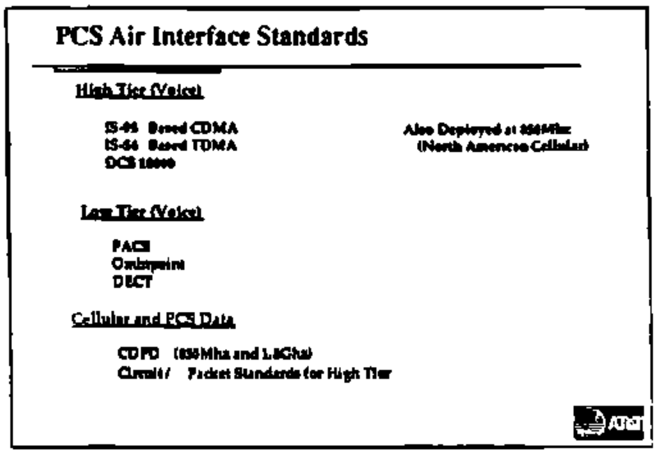

Figure 31

The wireless industry is debating today a variety of standards for PCS. The proposed standards more or less fall into two categories for voice. One is high-tier that is more or less derived from existing digital cellular standards, and another that is termed low-tier or pedestrian services that more or less are extensions of cordless telephony. As I mentioned earlier, it is our firm belief that high-tier services will be mandatory for PCS carrier success. We believe the right answer for PCS is somewhere in the top of that chart, between the proposed digital standards for North American wireless, IS-54 or TDMA, IS-95 or CDMA, or the evolving European standard GSM or, in this case, DCS1800, all in various phases of deployment in existing wireless networks around the world. As I mentioned, particularly in North America where people drive more than they walk, we believe it is mandatory to pick a standard that supports full mobility.

For data, we believe as I mentioned, CDPD has much to offer. We believe it is equally attractive at 2 gigahertz as it is at 850 megahertz. To help us sort through what's the right answer in terms of the bet that I had to place, as to the technologies that AT&T would sponsor for PCS, we looked quite closely at the financial benefits of each of the three options, looking at things like the coverage characteristics, the link budgets, the cost to build networks, and the opportunity for improved voice quality, as well as looking at what worked best in the North American market. As I mentioned, we firmly belief in the PCS carriers that can take advantage of the existing facilities — existing intelligent networks — because they've chosen a technology that conforms with North American standards, has a significant advantage.

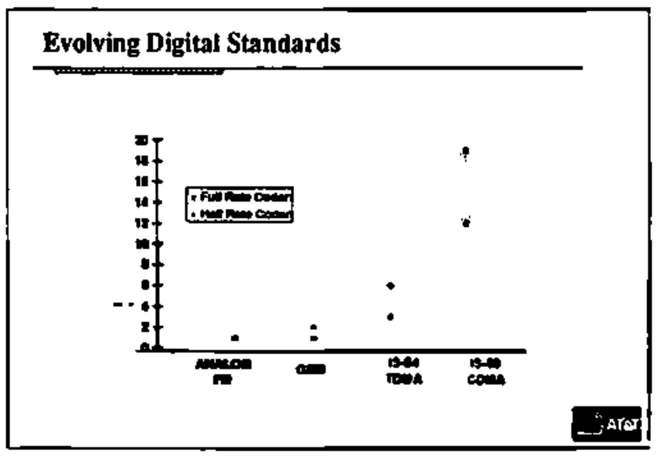

Figure 32

This is kind of a sparse chart but I hope it is telling. When you look at the spectral efficiency and the capacity opportunities of the high-tier choices I described, GSM, TDMA, (by the way, GSM and TDMA are more or less close cousins — they're both time division types of technologies, the time slots are different, the power level is different, but they more or less have common origins), versus IS-95 CDMA, we see some significant spectral efficiencies, link budget gains that CDMA represents. In fact, for the purist, there's about an 8DB difference between the link budgets that CDMA represents versus what is possible with the DCS1800 system. That 8DB difference translates to roughly half the number or less of cell sites required to cover a new market, as opposed to DCS1800. Given the scenario of new PCS carriers trying to build new networks, trying to find cell sites, trying to cover an area so they can serve their first subscriber, if you can do it with significantly fewer cell sites than your competitor, we believe you will enjoy a significant advantage.

The cost numbers I gave you earlier in the chart are based upon what we expect for the cost parameters for CDMA networks over the next 6 to 12 months. So we're quite optimistic that there are some realistic gains to be enjoyed by the new PCS carrier and that as CDMA quickly matures, it will be the right technology for many of the new networks that we'll see built with PCS.

We also expect, of course, that IS-54 TDMA, as shown here, enjoys not the 8DB difference with CDMA but it does enjoy about a 3DB difference. It also has some coverage benefits over GSM.

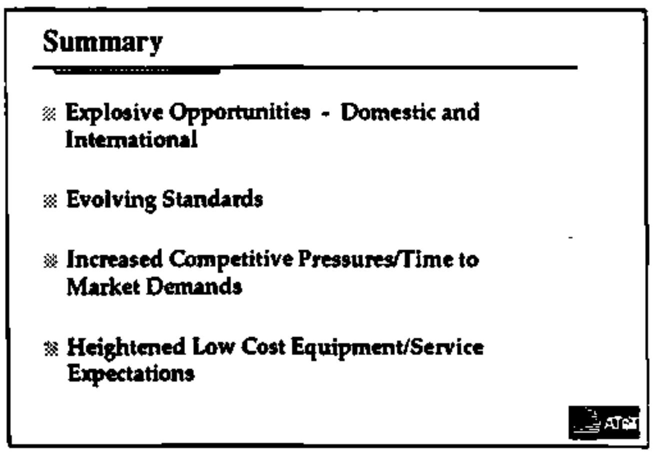

Figure 33

To sum up, with new spectrum to be awarded, we see in the next few years significant opportunities for the wireless industry. Explosive growth for infrastructure providers, explosive growth for carriers, good opportunities for all, and increasing competition, as markets will now have up to nine wireless providers providing wireless service. And, not quite the pessimism that others have expressed as to how standards will sort themselves out. Thank you.

Mr. Sheppard: Thanks Bob. Our next speaker is Dan Romano, who is Vice President of Research and Development with Nokia Mobile Phones. He is based in San Diego, and his job includes basically coordinating North American R&D efforts. Nokia is a worldwide company, and we wanted to give a worldwide flavor to this panel, plus Nokia does indeed bump heads with Motorola as one of the largest suppliers worldwide of this technology. At this time I'd like to invite Dan Romano.

Mr. Romano: Thank you. Good morning. Mobile phones. Who would have believed ten years ago that mobile phones would be used today? That they would be used not only by businessmen but by housewives, students, farmers, in fact, by people in all walks of life. Who would have imagined they would be so small? So cheap. So easily used. In the light of what we have seen happen over the last decade, short-range market predictions are very difficult. The history of the industry has shown us that the combined effect of many different factors make it very difficult to estimate the market. Technology, marketing, and regulatory legislation are impossible to forecast.

Nevertheless, by the year 2000, we will no longer think about telecommunication as fixed or mobile, because there will be few communication networks that do not have elements of both. It will soon be difficult to understand why a telephone should be attached to a cord. In a century, some people may wonder why a wireless is needed at all. But we are not there yet. There are many changes that have to take place before mobile communication can assume such a dominant role.

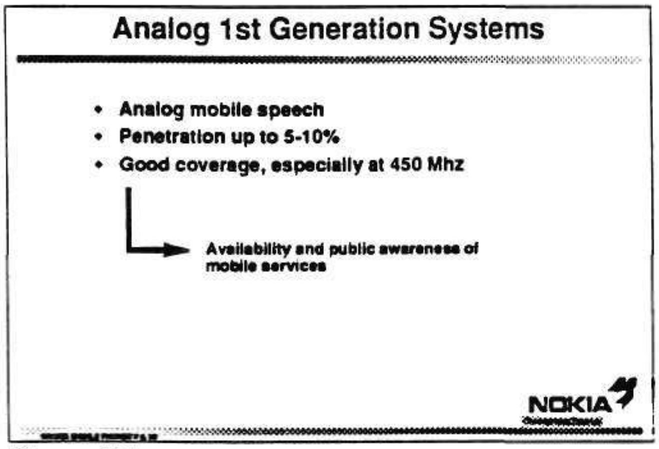

Figure 34

Mobile communication began in the '80s with the emergence of cellular technology. Coverage has achieved penetration levels of five percent to ten percent in the most favorable cases. The terminals are light, small, easy to use, and there is a general awareness of mobile services. What we still need in this environment is sufficient capacity for densely populated areas, improved speech, quality and security. Services providers who have analyzed the critical success factors quote the first three as coverage, coverage, and coverage.

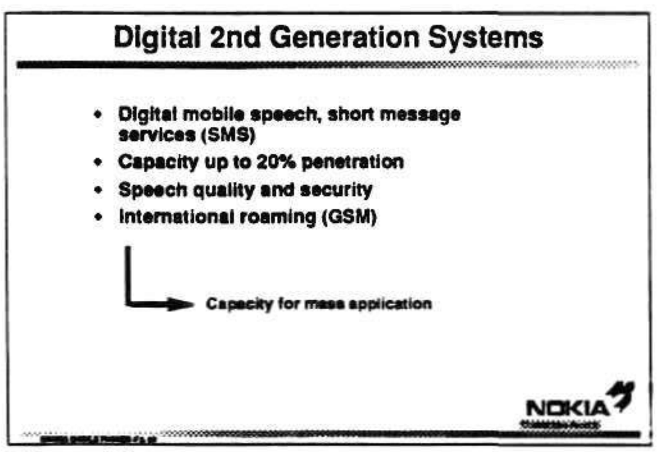

Figure 35

We have recently entered a new phase of development in second generation digital systems. Capacity provides both. A potential of up to 20 percent penetration. Digital features clearly exceed the levels of the previous generation. We see the terminal size race — it'll soon be over. There will be instead many different kind of phones tailored to the user's taste. There will be full-featured business phones, general purpose phones for general use, and fashion phones available in a multitude of colors. Although mobile communication is used mainly for voice communication, the newly introduced standards, PCMCIA, and short message services, have made data transmission over cellular networks easy and efficient. Big capacity and coverage still have a problem.

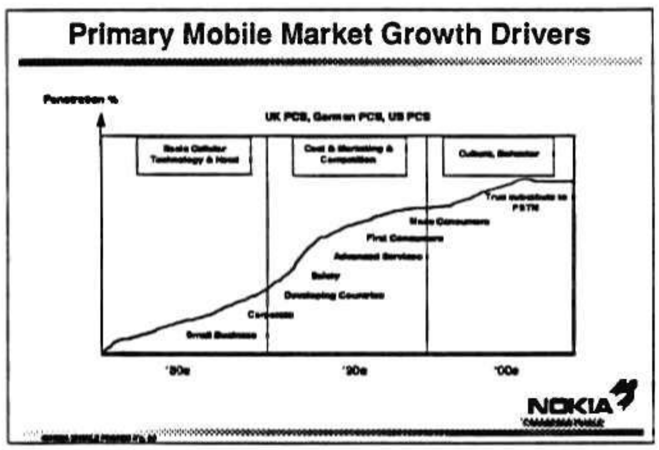

Figure 36

Analog technology satisfied the early basic need for mobility. The large corporation was slow in adopting this mobile communications, and the first to benefit really was small business. After the introduction of second-generation digital technology, new drivers have started to broaden the marketbase. Cost, competition, and new marketing concepts are responsible. Safety phones are already on the market. Advanced services are in use and cellular networks have expanded to over 100 countries. The first true consumers have been merged in the mobile phone market.

With this fact in mind, we see no reason why mobile communication should not provide a substitute for the traditional wireline service in terms of cost and added value within a decade. In this primary market group, however, there is a certain element which may play an increasing role in facilitating further penetration, especially around the year 2000, and that's human behavior. In other words, the sophisticated society developing today, based on mobility, will become a major factor.

At present, there are almost 20 million sets of subscribers around the globe. They are almost all from a single market, the typical business user. To split the use of cellular services into new groups, we need to think about new ways to push the consumer. We'll have to offer the business user more. The single most important factor for growth is segmentation. Future growth and market segmentation will go hand in hand.

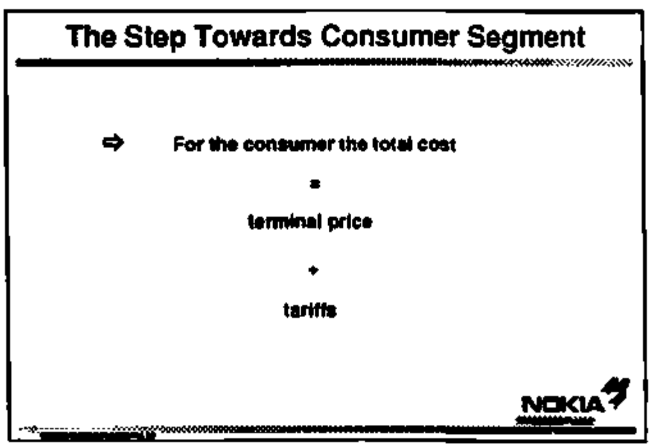

Figure 37

For the consumer, the true cost of ownership, including terminal and tariff, set the threshold for subscribing to a mobile service. Terminals have already become a real consumer product in terms of size, weight, and features. Advances in microelectronics and mass production has resulted in an enormous drop in the price of a mobile phone. The tariff reductions in most countries, however, over the last five years have been far less radical. We've taken as an example an average consumer, assuming he needs voice communication services for 60 minutes a month, wants his own telephone, pays for the service himself, and places half his calls during peak hours.

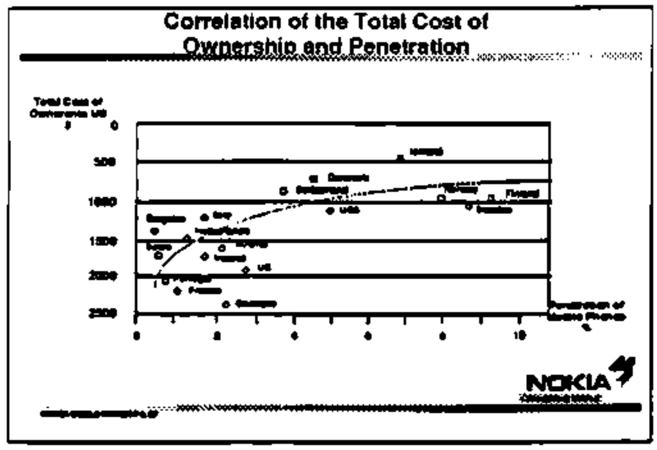

Figure 38

The total cost of ownership shows a surprisingly strong correlation with penetration levels. Scandinavian countries not only lead in penetration, but also in the total cost of ownership, closely followed by the United States. In England, the cellular tariffs differentiate between high and low usage customers. New PCM services there are making great inroads by providing lower cost of ownership. There is indication of a large growth potential in Germany, as has been demonstrated by the flourishing GSM market there. But in Japan and France, mobile communication is not yet in reach of the masses.

So while coverage is a critical success factor for service providers, for manufacturers, and our vendors, the critical success factors are cost, cost, and cost. I can't say that the reason Finland has the highest penetration rate is because Nokia is a Finnish company. We're a global company. We're Europe's largest manufacturer of cellular phones. We're the world's second largest manufacturer, and we're holding the number two position in the United States. Nokia's focus has been on cost, technology, and quality, and I'm pleased to say that in the world today, there are four personal communication systems and, of these four systems, three are Nokia's.

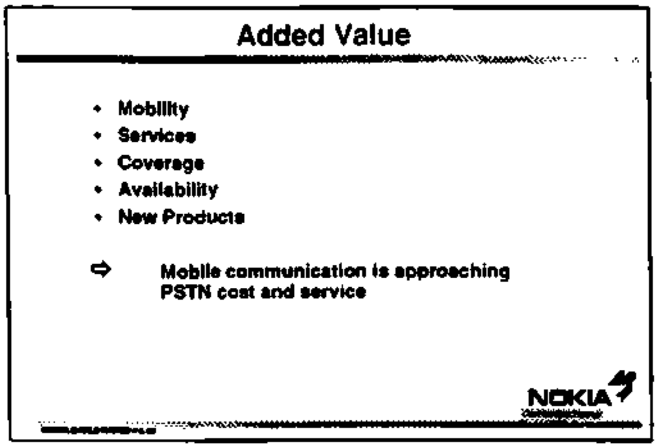

Figure 39

Mobility has been the added value that has driven the industry so far. The first to benefit has been the small business entrepreneurs. Mobility has brought upon an increase in their effectiveness.

Digital networks are adding even more value to mobility with new international roaming and new services, such as digital messaging, voice messaging, fax, data transmissions, and fully featured functions for personal digital assistants and organizers.

With lower cost and greater services, mobile communication is approaching the wireline, in terms of cost and service, and, as it does so, with the added value of mobility, it will overtake it.

As we approach the year 2000, new services will become part of our lives. This also means segmentation with new applications, such as wireless video and image transmission, which themselves will have to be supported by new terminals. To obtain higher dimensions and market expansion and to find the users of the new segments, two basic requirements have to be fulfilled. First, we have to have access to the technology. It must be affordable. Second and most important, we will have to orchestrate changes in human behavior and culture.

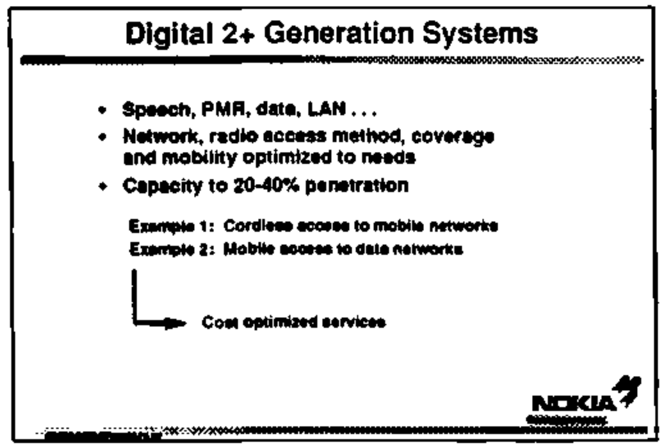

Figure 40

Innovation will drive the area of mobile communication in the late 90s. We call this the Two Plus Generation, where multiple services will exist, and there will be a platform for large-scale cost optimization. Digital cordless equipment will be introduced throughout the world at this time. PCS in the States, DECT in Europe, PHP in Japan. They will offer fragmented solutions with high total volumes but with somewhat limited mobility. A combination of cellular and cordless technology, either within a single terminal or at a system level, will provide a powerful base for further innovation in personal communication services. During this time, some areas might reach 40 percent penetration. But the key is going to remain — customized services.

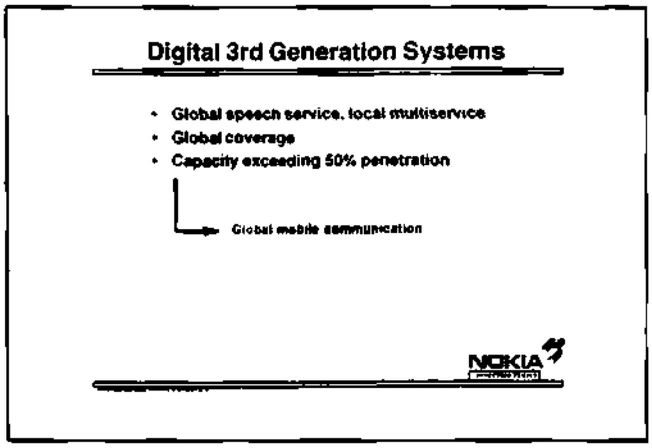

Figure 41

What about the third generation? During that stage, digital systems will provide global services for voice communication and a wide variety of local services. The capacity of the systems will allow deep penetration, which may reach 50 percent of the population in some cases. The most important single factor will be the propensity to lower the overall infrastructural cost. This will mean providers will be able to lower their tariffs while maintaining their required profitability levels.

Mobile communication has already changed the way many business people communicate. Now they call people. Not places. Location has become incidental. Consumers will be doing the same. The fixed telephone has made distance irrelevant. The mobile phone will remove the constraints of time and place. Effortless people-to-people voice communication will bring about changes in human behavior.

In summary, there are four major characteristics of the market as we see it in the year 2000. First, a growing market that will be built on a number of emerging segments. This will happen through segmentation based on cost and added value. Second, complexity will increase as a result of new technologies, new end-user segments, new applications, new services. This will lead to a fragmentation of the market and will be a major challenge and, perhaps, even a headache for us terminal manufacturers and for everyone else in the business as well.

Third, there will be technical solutions to most existing problems — we will have to pay special attention to human behavior and cultural issues when thinking about new services and the applications. Finally, the personal communication market in the year 2000 will be dominated by the wireless solution. At that time, we will no longer talk about mobile communications or mobile phones, only about communications and phones.

Thank you.

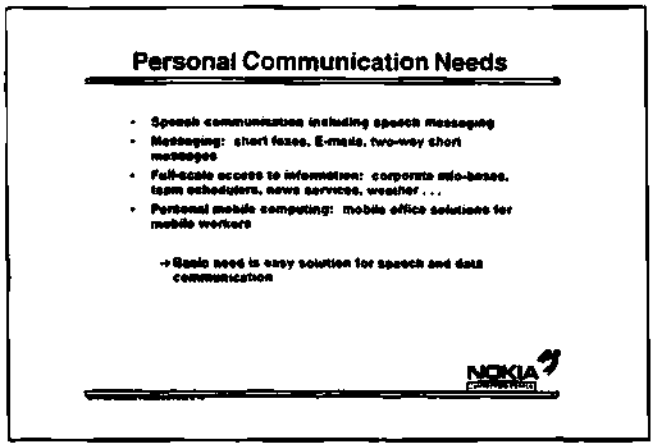

Figure 42

Mr. Sheppard: Thanks Dan. At this point, I would like to get into the question and answer part of the session today. I'll start by throwing out a few questions to our panelists. I really invite you, as you have a thought, to jot it down and grab somebody with a microphone. I'll get it started with a couple of questions. I've also invited these gentlemen to ask questions of each other as well.

I'd like to start with one kind of very basic question. I think those of us in the audience that are probably basic consumers of all these types of wireless services are probably a little overwhelmed by the different acronyms and the different sorts of services being proposed. On one hand, we have the traditional analog cellular phone and that's evolving towards a digital version. We have the cordless phone in the home, which is also evolving into a digital version and also the ability to put it in your pocket and take it with you. We add to this the era of personal communication services. I thought maybe I'd throw these kinds of sticky questions out to kick things off to see what is the difference between all of these, and who is going to buy it. Maybe just to be fair, I'll direct this question to the other gentlemen as well, since they're smiling. But I think these are real fundamental questions. There are a lot of these new things coming up, and I hope you can help sort them out for us.

Mr. Garahi: Actually, personal communication services is divided into narrowband PCS and broadband PCS. The narrowband PCS mostly focuses on paging-like or small messaging devices with much lower bandwidth, mainly 50-kilohertz pieces. The broadband, which is at the higher end of the spectrum, also is mainly geared toward voice. I personally see all of these converging sometime in the future to broaden broadband PCS — that's voice and data. The narrowband PCS also does voice and data. As you know, some of the companies are talking about actually using their narrowband PCS to provide small answering service or answering machine-type devices on their belt, which would deliver voice to your belt. Of course, the broadband PCS would definitely do data. How they would differentiate is actually on the narrowband PCS where the frequencies are open nationwide. They would be more of a nationwide service, where the service is available everywhere from a single carrier anywhere in the United States versus the broadband services, where more MTA-type services have their roaming opportunities, of course.

Mr. Sheppard: Great. Mike, would you like to take a stab?

Mr. Hames: I'll give you my interpretation which may not be anyone else's interpretation on the panel, but the way I look at it, I see a couple of different spaces. Cordless to me is primarily the low-cost phone that you have in your home. The mobility, in most cases, is in terms of tens or hundreds of feet away from the base station and, typically, in a cordless environment today at least, the way that you communicate back to the base station can be proprietary because then you go into the plain old phone system and get into the network. The only issue is that the base station terminal be able to talk.

Now as you move in to PCS, what you add on to cordless technology is more mobility, and you force interoperability in my mind. You want to be able to take the phone that you have in your home and place a phone call within a certain reasonable number of feet. Maybe it's now thousands of feet as opposed to hundreds of feet from a remote base station. Whether it be at a train station in Europe or Japan or in an airport in the U.S., not having to look around for a traditional dial-up phone.

And then as you move to cellular, the big differentiator is the high-speed hand-off. The ability to, while you're driving at 100 km per hour, be able to roam across cell sites, whether it be from Chicago to California, or whether it be from Germany into Sweden, and still have the full interoperability and transparent conversation. What gets to be really confusing is when you start in the U.S. When PCS says you have to have significant mobility, how do PCS and cellular technology differ? They basically are the same thing, and what you're really arguing now is just more the protocols and how you implement them. This is my view.

Mr. Sheppard: Anything to add Bob?

Mr. Sellinger: Yes, let me just take a stab at that. I by and large agree. I think cordless telephones can be used in an unlicensed spectrum, and they are more or less extensions of the wireline network. They tend to work around the house. People don't tend to take them with them. I think cellular today is a good glimpse at what PCS will offer. I think you'll see some of the cellular carriers begin to portray their services as PCS. As I mentioned, I think with the entrance of now up to six new PCS carriers in a major metropolitan area, they will be mandated to provide the same set of services as the cellular carrier offers today. We'll quickly see this high-tier, low-tier debate subside with most of the PCS carriers offering high level mobility networks.

Mr. Sheppard: Some thoughts Dan?

Mr. Romano: To make it very brief, the distinction between cellular and PCS will disappear and pretty soon we'll just think of cellular services as just frequency bands, whether it's 850 or 1,900 megahertz, it'll still be just cellular services.

Question: With the broadband auction coming up, is it perhaps something somebody could clarify for us? Maybe I'll direct this towards Bob. Are we going to see separate PCS companies from our traditional cellular companies or are they going to be one and the same? How is all that going to work?

Mr. Sellinger: I think the FCC has set some fairly specific rules that are good indications of how which companies will win the upcoming auctions. As I mentioned, there are six major channels to be auctioned. They are anywhere from 10 to 30-megahertz wide. They fall into basically three categories. There are two 30-megahertz MTA sets of channels; that's where the auction starts, December 5th. There are rules as to who can bid for that spectrum and who cannot. By and large, existing cellular companies cannot bid for that spectrum if it overlaps their existing service area. They are not constrained if the 30-megahertz MTA spectrum is outside of their service area. So I think you'll see the traditional wireless companies look to extend their cellular networks with 30-megahertz MTA awards outside their existing service area.

There is a second set of spectrum that is set aside. It's set aside for companies that meet certain criteria for designated entities; often called swimmers, small women, minority, real telephone companies. And there are some very specific rules as to who can contend for that spectrum. There'll be a 30-megahertz channel awarded as well as a 10-megahertz channel awarded on a BTA basis, a smaller basic trading area basis. That, we believe, will be the second round of the auctions, probably in the April/May time frame next year.

Finally, there'll be the last two channels awarded. Those are 10 megahertz wide on a BTA basis, and there the existing cellular companies can indeed bid for that spectrum without concern if it overlaps their existing service area. This is kind of a longwinded response, but I think it's important to understand the FCC's intent. I believe that will dictate which companies or which groups of companies you'll see emerge as the winners of this auction.

Mr. Sheppard: Hope everybody's working on their questions. I'll ask a couple more.

We have IS-54 and IS-95 in the U.S., and one of the questions that I'm asked a lot is do we see these merging into the handset and will the infrastructure be able to deal with both in different service areas. Do you agree that this will happen, and what time frame do you think that will happen. If I could direct this towards Dan to start out.

Mr. Romano: The fact that there are a number of different standards makes our live complicated because now we will have to have more terminals, or we lose a little bit of our ability to provide lower cost for higher common volumes. In terms of multiple capable handsets, the format is a combination of TDMA and analog handset. We'll see the same kind of handsets. CDMA and analog. I do not believe you will see CDMA and TDMA. So what we'll see is analog being a backbone where you go outside the CDMA coverage, you'll phone back in analog. Analog is not going to disappear. It's going to stay there as a kind of a support. We do not predict a winner between CDMA, TDMA, DCS1900; they all have advantages and disadvantages and, as a matter of fact, what we'll see is this segmentation for purposes of differentiations, different people will use the different standard to differentiate. For instance, in the L.A. area, the two cellular carriers are getting set up, one to be a TDMA and the other to be a CDMA. It will not be easy to switch carriers there.

Mr. Sheppard: I'd like to switch a little bit to the data communications area. I think Gary Tooker said yesterday that the wireless data communication market was zero and/or probably near zero and at least people were struggling with it. I think there's a lot of vertical use going on, but your average business consumer is probably still trying to figure out what service do they buy and what hardware do they buy? Perhaps I can direct this one toward Masood. How do you see that shaking out? We have the proprietary networks, such as RAM and Ardis, and we a have more open approach in CDPD. How do you guys view that shaking out, where's the market going to go?

Mr. Garahi: OK. To set the stage, there is currently RAM and Ardis that have their own proprietary technologies. The paging industry uses POCSAG, which is a European protocol, adopted in the United States and around the world as a paging standard that enables delivery of data in a limited form. Currently, a lot of companies are adopting a new protocol from Motorola called Flex, which is a higher speed protocol, but it also allows for the delivery of data on the paging networks. On the PCS side, even though there is no standard established yet, Motorola has one on the table called ReFlex, which is a two-way version of Flex.

There are certain advantages to this protocol. One, it would be a standard if it's adopted by the industry. Another, it would be compatible with the lower-tier, one-way devices in terms of some of the infrastructures and devices that could actually interoperate between a one-way paging system and a two-way paging system. You could allow roaming to countries where two-way is not available; you could still receive information, but wouldn't be able to acknowledge it through the existing paging infrastructure. Also CDPD, which is used as the current cellular infrastructure.

Each one of them has its own advantages and disadvantages. In the case of, for example, Ardis, where it establishes connections, it's actually a circuit that exchanges information, essentially ties up one of the circuits. It's geared more toward value-added applications and connection to a host device versus some of the packet switch datas; whereas in ReFlex and others, a piece of data comes in a packet form and then you receive the acknowledgments or the information goes back in a store and forward mode. Only ReFlex or Flex sit on a data site, and there are advantages in terms of doing broadcasting and also ubiquity in terms of having a nationwide, roaming capability. Practicularly with ReFlex, roaming would be nonexistent. Even though you have local services throughout the country, you don't have to roam anywhere. It's practical, it's what we call unconscious roaming. It's that you don't even know that you are roaming. And in case of, for example, CDPD, you have to do that similarly. Obviously, this would be addressed in the future, but essentially it's designed for local operations.

Another one is about broadcasting; with Flex or ReFlex, you can broadcast data, and a single copy could be picked up by everybody who has a Flex or ReFlex pager so programmed. Most companies today program their pagers with a single CAP code, so they could send broadcast data to their entire customer base.

Mr. Sheppard: Anybody else like to add to that? Where we see wireless data going and more mainstream, what will it take?

Mr. Sellinger: I think I'd like to take a stab at that. I think the lessons of the computing industry will extend to wireless, and open networks will prevail. And I think the open standards that take advantage of the standards that are already widely used in computing networks will be advantaged. So, standards like CDPD, which were based upon TCP/IP, the internet, many of the same networking protocols that have become widespread on simple wireline networks, now have more or less wireless extensions that CDPD has defined, which makes it a very attractive way for existing wireline networks to simply be extended now with wireless endpoints. You don't have to change the software, you don't have to rearchitect your network, what's on the server, what's on the mainframe. And, in fact, what the subscriber sees in terms of interacting with that network is the same. The latency may be a little bit different because the wireless networks have different delay characteristics than a wireline network. But from a functional point of view, it's identical. So, I think you'll see more and more of the lessons learned on the wireline extended into the wireless arena, and I think that just is good for all. That leads to an open environment that allows the PC industry, as well as this growing communications industry, to converge.

Question: Let me ask a more generic question. And that is, given all of the standards — and there's a lot of confusion, at least there seems to be, and the fact that they're so rapidly changing — how do you deal with the potential perception on the end user's part that equipment may soon be obsolete? In other words, end users may balk at buying equipment because they may think that what they get now won't really be applicable a year from now. And the other way to ask that is how do all of you deal with rapidly changing standards in terms of both the equipment and the semiconductor technology?

Mr. Sellinger: Yes, I'll take a stab at that. I think a key arbiter in this whole standards distillation process will be the carrier. None of us represents the wireless service provider, and I believe because they are between us, in effect, the consumer doesn't care whether it's TDMA, CDMA, XYZ — they don't care. What they do care about is cost of the service and the ubiquity in terms of the service area. Carriers are struggling with this issue, and it's kind of a religious debate with some others looking at it in more of a dollars and cents financial analysis. And it's a moving target, which doesn't make it any easier for the carrier to sort this out. But I do think you'll see even standards like CDMA are well-defined.

IS-95 has been a standard now for over a year, and it will be offered both at 850 and at 1.8 gigahertz for both cellular and PCS networks. The terminals are being produced, it's mature to the point where you'll begin to see it in the mass market fairly quickly. I believe the carrier, though, will force the vendors to help in this process, because they do not want to be in the situation of having to deploy a multitude of digital standards. They look forward to the world where things have consolidated, converged, and we can all, more or less, place our bets and invest in not the smorgasbord of standards that tend to exist today, but in the one or two that we believe will survive.

Mr. Hames: I think from a silicon perspective, it's a little bit easier than from an equipment perspective. If you look at all the different standards, they fundamentally have the same architecture. There is a base band block that must process signals at a very high rate. The different standards require different mip rates, but they all have a fanatical need to continue to increase performance, to make better voice quality, add feature, and, although CDMA might be the most mips-consuming and GSM on the lower side, the basis, what they require from a silicon manufacturer, is pretty constant. So we know what we're shooting at and the challenge is to just keep it flexible enough because, in most cases, our customers cannot predict right now which one of these standards are really going to take off at any given point in time, and it's important that they have the flexibility to take their development, run it across a platform to support different standards, and then be able to quickly ramp on the ones that the market chooses in the end run.

I think from a standardization standpoint, from a global perspective, there are going to be a lot of different standards. Within one country, it'll probably settle out. So I think most of the differences, when we talk about this view of the alphabet soup of different standards, is really when you take a global view and you try to figure out between Europe, Asia, North America, and the developing countries, what's all going to happen; it's a mess. Within a country, I think there's a lot more stability, with North America probably being just the most confusing at this point in time.

Mr. Sheppard: So thank goodness for silicon compiler technology, huh? Any other questions out there?

Mr. Giudici: This is Mark Giudici, Dataquest. I've got a question on the graph you showed, you know, the chips integration going down to one chip in the year 2000. What are the levels of integration on the base stations, or what would you see going on besides the DSPE side of that cellular wirehouse?

Mr. Hames: From an integration standpoint, you can very quickly see the integration of the base band into one chip. You can put 40 to 80 mips of processing power, the equivalent of 50 to 100K gates of logic. You can integrate a microcontroller for the user interface. And that can all be done in today's half-micron type of technology. The next challenge you get into to get to the true single-chip phone is the RF, which is significantly more challenging. And I think you're seeing piece by piece as you move from the base band to the RF.

As we keep on shrinking the technology, and as switching rates go up, you can implant more in a CMOS or BiCMOS technology, and you can creep that integration toward the antenna. Whether it really makes sense to have something as complex as all the RF and the base band on a single piece of silicon or whether two or three, I think once you get to a couple of pieces of silicon, really all the cost, space, power issues pretty much go away. And, certainly you can foresee in the future that it is all capable of doing that.

Mr. Sheppard: If I can slip in here redirecting that type of question towards Dan. What do you need out of a good chip supplier? What sort of services and technologies do they need to have to do a good job for you guys as you're trying to play the standards watch here?

Mr. Romano: Well, one of the big differences we have to keep in mind between terminals and the base stations are the infrastructures because terminals are battery-powered, so the power consumption is critical. And while we can have very powerful chips available in base station and terminals, the power conservation is a big, big, big game that we have to play constantly. In terms of integration, what we're looking for here really is bottom line, what's the cost of the phone? The size of the phone nowadays is such that we can afford to have two chips. The question isn't so much one chip set, but what's the cost? And so if it's cheaper to have a two-chip solution or three-chip solution, that's all right.

Question: Yes, I have a question. There were some comments made by Mike about silicon technology. What does the panel, and specifically Mike, think about gallium arsenide and silicon germanium, and what position they'll play in wireless?

Mr. Hames: Gallium arsenide in parts of the phone — the power amp and the RF side — I think what you're going to find it is as fast as silicon and CMOS. BiCMOS can eat away into the RF, they will be much more cost-effective and, depending on the different frequency bands you're talking about in the different standards, that'll happen either sooner or later. So, I think as soon as silicon can meet the performance CMOS and BiCMOS in the RF arena, it will displace gallium arsenide for simple cost reasons.

Question: I have one and it concerns the famous intellectual property. There are intellectual property claims to both CDMA and TDMA. How do you see this affecting deployment of either of these standards? And who wants to tackle that on? Directed towards maybe Dan to start?

Mr. Romano: In the process of developing standards, intellectual property rights is a big game, positioning. But after all is said and done, the only way the owners of patents are going to be making any money is if they see that technology widely used. And that technology being widely used implies that the royalty rates that they will get are very low. So, just having a patent is not enough. You have to be willing to have that patent widely used and expect a very low royalty rate, and not think they're going to make big scores on these patents. Companies who charge high for the property rights, are going to find us going elsewhere for our technology.

Mr. Sheppard: How about Masood, if I could follow up on that? You are looking at these different technologies. You have to; to some degree, you're underwriting, you're buying down the cost of the terminal. They get it out there. How do you view this intellectual property issue?

Mr. Garahi: It's a significant issue for us because it slows progress, but it also prevents some people from entering. Obviously, in terms of Flex and ReFlex, both are owned by Motorola, and they have to be licensed to the OEMs and others who are going to develop these products. We obviously have every incentive to make that easier to do. However, that doesn't mean that the industry may not come up with the POCSAG-like protocol that actually is open and available, with no intellectual property claim on it. And we feel that eventually will happen, not only with this but with voice and others, as well. I don't think the market can bear feeding too many mouths in between. And it will probably sort itself out.

Question: Compared to communication through wire, it's relatively easy to listen to a wireless communication. Do you hear complaints from your users about this feature. If so, what are you planning to do about it?

Mr. Garahi: I gather the question is in the area of security? Digital standards will all address that issue, regardless of the choice. And there's a very sophisticated encryption, authentication, set of algorithms in any of the standards we've talked about which remove the concern of the analog voice systems today which are not secure.

Question: Yeah, Mike, I was curious. Do you believe that from your comment that BiCMOS and CMOS are going to displace gallium arsenide in the future?

Mr. Hames: I don't think totally, but I think they're going to eat away into the gallium arsenide part of the phone for pure cost reasons.

Question: Can you give us a time frame? Three years, four years, five years?

Mr. Hames: I think over the next couple of years in the cordless and PCS arena, you will see a significant pervasion of cellular (in probably five to ten years). You've gotta believe that the advances that are being made in silicon are going to keep pressure on gallium arsenide, unless there's some dramatic breakthrough in the cost of manufacturing of gallium arsenide technology. But, to date, that's been tough.

Mr. Sheppard: I have another question targeted at Mike. We kept hearing cost, cost, cost, and then yesterday, battery life as being the most important features. What do you see, and you showed that a little bit in one of your slides, as the key challenges to preserving, both in standby and talk time, and getting these batteries to last longer? Because that's still just a tough issue, you know. People are afraid to leave their phones on because they're running down, and that's just one of the key things that takes away from the utility of that device. What do you see the chip industry doing about it?

Mr. Hames: Well, if you look at it from a semiconductor perspective, there are obviously a couple knobs that you have to turn. One is a rapid reduction down the voltage curve. Lowering the voltage significantly improves the power dissipation. And in half-micron and below processes, you actually get more performance at lower voltages than you do at higher voltages. That's the easiest part of the equation. Obviously, in this whole wireless world, you tend to have to use leading edge, wafer-fab technology to make the area as small as possible. You drive less capacitance and, thus, less power. So they will always be utilizing more leading edge capacity for power reasons if nothing else.

Third, you're seeing a significant rethinking of circuit technology techniques. You have to be very conscious, especially in the cores that you develop, to use the right type of low power circuit techniques; turning off all the logic, minimizing the amount of switching that's happening, and containing it only to the active components.

New tools are required to give more sophistication, both to the custom designers of core CPUs, as well as the system designers, to really understand where the power is being dissipated in their systems. That's really the activity that's really putting more focus right now on improved circuit and system design techniques and different clocking mechanisms in order to significantly reduce the power. Cost is obviously something that we're used to in the semiconductor industry. Obviously, aggressively driving it down the learning curve and really focusing in on what are the common blocks across these wireless applications, and how can we invest into very custom layout mechanisms in order to pack the transistors as tightly as possible for those blocks that are going to get reused over and over, but still allow them to be integrated in an environment so the customer can add his particular differentiation into that hand set. So it's a never-ending journey, and you just keep on pushing on it as aggressively as you possibly can.

Mr. Sheppard: Just a final question I had. When we move into the broadband PCS services, there's going to be a "personal communicator" involved. Perhaps I'll throw this out to all of you. What's that going to look like? And, for our audience here, if you could comment on what it means from a semiconductor or silicon standpoint, what are some of the key requirements that are going to come out of that? Maybe I'll start with Masood and work our way down.

Mr. Garahi: Well, as a carrier, what we have heard from our customers is that they wanted a small device, light weight, with a very high battery life. Ours won't cut it. We're talking weeks, even months. So that is the device that the customers want. As far as the inside is concerned, we see more and more people buying into this agent technology where you have a small demon, a little genie, inside your personal communicator that does things on your behalf, who knows things that you usually like. It remembers things for you. It kind of understands your behavior and your profile, and it understands your likes and dislikes to some extent, and it actually works on your behalf to gather information that it knows you like and also to discard or file the information that annoys you to even see. For example, nasty memos from the boss asking for things could be filed in the back while the nice, sweet notes from the wife pop right up.

Or, for example, screening the calls for you the same way your secretary does. If so-and-so calls and wants to talk to Mr. Garahi, it's obviously a call that can be screened and investigated for what it is that they want, versus if they want to talk to Masood. So it could be as simple as that. Essentially, diverting people to the voice mail, inside the personal communicator, which is a semiconductor chip in itself and nothing more, that stores that voice for you, which could have been a PCS broadband phone call or just an ordinary analog or digital phone call coming into that personal communicator, or it could just divert them into a messaging center, to an operator set, or just simply forward the call, or actually allow them to send messages or faxes. Essentially, that's the personal communicator, the way we see it.

Mr. Hames: From a semiconductor perspective, to get to the phone on your watch or phone in your pen, where obviously the size is a premium, what you're going to have is technology that's capable of running on a one volt-type of battery. And, obviously, you're not going to have room for keypads and easy ways to interact with that, so a really good voice recognition that allows you to use voice input to get to that information, I think, is going to be critical. All those things are actually, if you just extrapolate where we are, within the realm of possibilities. The question, I think, you're going to get into is who's going to be the company that figures out what's the right time and how to package it. Just as we've had a lot of interest in the PDA market with a lot of confusion as to exactly what is the right product to sell, I think you're going to have the same dilemma there as far as exactly what is it, who buys it, and what is the right form factor and capability that it's going to supply.

Mr. Sellinger: From an infrastructure vendor's point of view, I agree with much of what's been characterized for this personal communicator, although I don't think there'll be one icon. There'll be one device that's applicable for all markets or for all applications. I think you'll see standards emerge in the network and that will be out through the air interface, but that will allow a plethora of actual subscriber units that can be tailored to what the subscriber wants to do and how the subscriber is willing to pay for that device.

I think important characteristics, though, are low power. Low power gives you, I think, two very important characteristics. One, it extends the battery life, the talk time is higher, and it also means it doesn't interfere. I think there are some technologies that have some interference characteristics that make them a more difficult technology to foster in certain markets than those that are the lowest possible power. So, low power, we believe, is a strong virtue and the lower the better. Obviously, the technology has to allow this flexibility.

I mentioned we don't see this one icon that everybody carries as the answer to everyone's personal communication needs. We see a number of differing devices that will all be built, perhaps, upon the same chip set, the same underlying set of standards, but that are flexible enough to be tailored to the needs of the individual subscriber. Low cost, we believe, is very important. An interesting statistic in the cellular industry is that, while there are 18 to 19 million subscribers today who have subscribed monthly to cellular service in the United States over the last ten years, there have been close to 28 million cellular phones actually sold, and that translates to roughly a two and a half year average lifetime for the typical cellular phone. So we've seen churn, we've seen the market accept new technologies, and I don't believe it's an unrealistic expectation to see, as these digital technologies evolve and mature, that the market can go through a fairly rapid maturation and, as long as the cost is low enough to allow the churn to continue, I think we'll see the same types of lifetimes exist for most mobile devices.

And, finally, we believe strongly that the technology must support both voice and data. It must be based upon what the subscriber desires, but it can't be only voice or can't be only data. It must be able to do both.

Mr. Romano: I'll also support what's been said so far. And the potential for all kinds of new gadgets is tremendous out there, and the question is going to be, does your phone have an organizer or does your organizer have a phone? The thing to keep in mind when we talk about data services is who is going to provide the basic service you are trying to connect to? And that's an industry of itself. Plenty of opportunity for a lot of people.

Mr. Sheppard: OK. I think we have one more question out there.

Question: Just one question to tie some of this technology back into the consumer that should be buying it. Some people have become a bit pessimistic about how quickly some of this will take off. We've seen the obvious benefits of the digital technologies for the service providers and talked about the costs and being able to pass those on to the consumer. But some people have been a little skeptical about the ability to convey the real benefits to the consumer of these devices, particularly if it's just somebody using their current cellular, switching from an analog technology to a digital technology. All they see is a telephone. How are you going to persuade these consumers to switch over where cost savings might not be there in the near term?

Mr. Sellinger: Let me take a stab at that. I think that the functionality, in large part, will be very similar, that offered with analog versus digital. But there'll be two significant differences that will encourage a migration. I believe digital services will be priced lower, significantly lower, and the charts I showed on the PCS market in comparison to cellular, I believe, will stimulate usage of the digital technology, as well as the quality of the service will be better. And with things like 13 kilabit vocoders being available for some of the technology, you can approximate land line voice quality with wireless services, and I believe that, combined with the lower monthly cost for the service, will stimulate that churn fairly quickly. And, even in certain European markets where GSM has been accepted, one of the keys to its acceptance has been that the carrier has raised the price of analog service while they've lowered the price of digital service and that's gotten the desired result.

Mr. Sheppard: Well, that's, unfortunately, all the time we have this morning. It's 10:30 sharp, according to my watch. I'd like to take this time to thank my panelists for coming today.

Future Manufacturing Strategies: Make or Buy?

Moderator

Clark J. Fuhs
Senior Industry Analyst
Semiconductor Equipment, Manufacturing, and Materials Service
Semiconductor Group
Dataquest Incorporated

Panelists

Vinod Mahendroo
Managing Director of Corporate Marketing
Applied Materials Inc.

John T. Dickson
Vice President
Integrated Circuits
AT&T Microelectronics

Koichi Nishimura, Ph.D.
President and CEO
Solectron Corporation

Donald W. Brooks
President
TSMC

Bernard V. Vonderschmitt
President and Co-Founder
Xilinx Inc.

Introduction: This panel will be moderated by Clark Fuhs, who's in charge of our semiconductor manufacturing research at Dataquest. Clark and his panel will discuss where contract manufacturing stands in the semiconductor industry, and he'll explore the relationships between the chip designer, the fabless company, the foundry, and the equipment company, and how this relationship is going to evolve over the next few years.

Mr. Fuhs: I'd like to take just a few moments to introduce the subject to the panel and give a brief overview, and then we'll get into the panelists making their presentations.

We've assembled a diverse set of panelists to discuss trends in semiconductor contract manufacturing. As many know, fabless companies emerged in the 1980s, taking advantage of excess capacity in the market and foundries began to emerge. Today, this has evolved into a bonafide manufacturing strategy with the concept of the dedicated foundry taking hold very recently.

Dataquest believes that semiconductor contract manufacturing is a permanent trend and is evolving, and this panel will discuss the current trends and visions for that contract manufacturing strategy, concentrating on the relationships required among the players.

Considering the value-added chain in contract manufacturing, the normal manufacturing sequence is from the chip design and concept, through prototyping, the manufacturing, final test assembly, distribution, and sales.

Contract manufacturing in any industry typically evolves along the lines of R&D centers. In the standard chain, design is one R&D center and manufacturing engineering would be another one. In the semiconductor industry, we actually have three major R&D centers, the third being the process design, with the equipment and material suppliers taking an increasing role.

We've shown by color code where each R&D center may fit. The yellow, being the fabless company, taking chip and design through prototype, and then taking some of the responsibility in the final assembly and distribution and aftersales. The green areas here are where the material and equipment suppliers would participate into the area, and the magenta oval is the manufacturing of the product wafers, the foundry. The foundry would also be responsible for providing manufacturer requirements to each of the different participants, so it's more of an integrator kind of role in the semiconductor manufacturing. I'd like to point out that the border basically contains elements of both the designer and the supplier, which are required in a relationship to make a seamless manufacturing process.

Each R&D center provides expertise to the overall equation: chip designers providing value-added solutions to systems; wafer fabs providing manufacturing knowledge and concentration of capital; equipment suppliers and material suppliers providing processing expertise, service, and automation systems; and we will explore how these roles will change and evolve over time, and the infrastructure that needs to be developed for the industry.

We have a number of panelists from various perspectives. I'd like to introduce each of them briefly right now in the order in which they will present, so that a minimum amount of time can be taken in between speakers.

First of all, we have Koichi Nishimura, the President and CEO of Solectron. Solectron is a key world-wide contract manufacturer for the systems business. He will share some thoughts on his industry and make suggestions for the semiconductor industry as it evolves into its contract manufacturing strategy.

We have Bernie Vonderschmitt, the President and Co-founder of Xilinx, a leading fabless company selling PLDs and other logic devices. He will offer the customer's view of why they are a fabless company.

Donald Brooks is the President of TSMC, the leading dedicated foundry in semiconductors. He will describe issues they face moving forward, and suggest ways they could add value to the relationships.

John Dickson, from AT&T Microelectronics, is the Vice President of Integrated Circuits. AT&T is an integrated circuit manufacturer, which buys and sells foundry capacity. He will review and discuss the decision-making process he goes through and also discuss some trends that he sees for his business moving forward.

Vinod Mahendroo, the Managing Director of Global Corporate Marketing from Applied Materials, will also speak. Applied is the largest semiconductor equipment manufacturer. He'll discuss how the equipment manufacturer's role has changed over the years, and how they view their role evolving with the manufacturer going forward.

The format will be that each speaker will get up and make a 10 minute presentation, and then we will open up the panel for questions from the audience.

Dr. Nishimura: Good morning. How many of you know what your CEO's job is? Can you tell me in 25 words or less? What do you think it is? How can you support him then? Let me tell you what I tell my people. I think it's pretty close to your CEOs, whether it's Bob Allen, Bernie here, or whoever it is. I think our job is to consistently and systematically grow the value of the enterprise. Pretty simple. We're talking about creating wealth. Wealth creates good jobs, so keep that in mind as I go through my pitch.

We're in a time-based competition. It's time to market, time to volume. I think you're all involved in that. You've got to be out there first with the most so you can get the highest margin. The second guy comes in, the margins drop, right? You've got competition. So we're really talking about how do you focus and do the things you need to do the best. You're talking about core competency. You could talk about, "We could do it as cheaply as somebody else." That's the typical argument I get from my OEMs. Our operations could do it as cheaply as we can, but that's not the issue.

SOLECTRON

Corporate Resources

- Cash (Expenses)
- Capital (Investments)
- Human (Time & Attention)

Figure 1

SOLECTRON

Resources are Limited Due to...

- Declining Margins
- Shorter Opportunity Cycles on Invested Capital
- Limited Expertise to Ensure Maximum Returns
- Dilution of Expected Returns on Used Resources

Figure 2

The issue is, is that where you want to focus your resources, your money, your capital, your human resources? Because time does not wait. You've got to figure out how to conserve time and make the most of it.

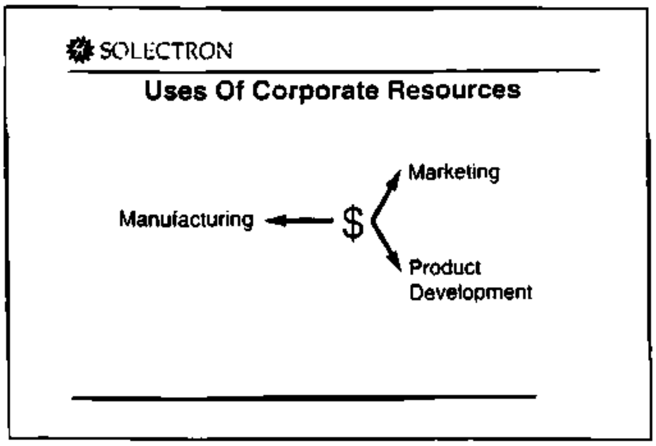

Figure 3

That's what you're trying to do when you outsource. You've got three parts: you've got innovative products, you've got a market you want to sell into, and you've got manufacturing. Most companies don't do all three of them well. So where do you want to spend your resources.

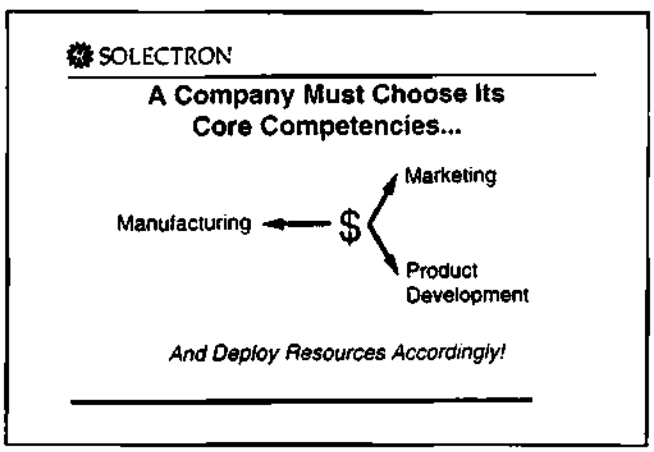

Figure 4

In the past, it may have been right to do it that way, but I don't see too many guys riding on horses and buggies today and getting their mail through Pony Express. You have to change with the times so you have to leverage your resources. You must deploy your resources accordingly. That means all of the people in this room, whether they work as a supplier, whether they work as an OEM, whether they're in the distribution channel or supplier of equipment.

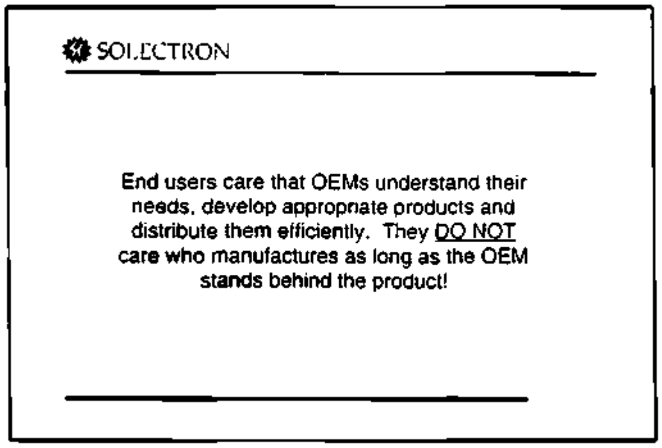

Figure 5

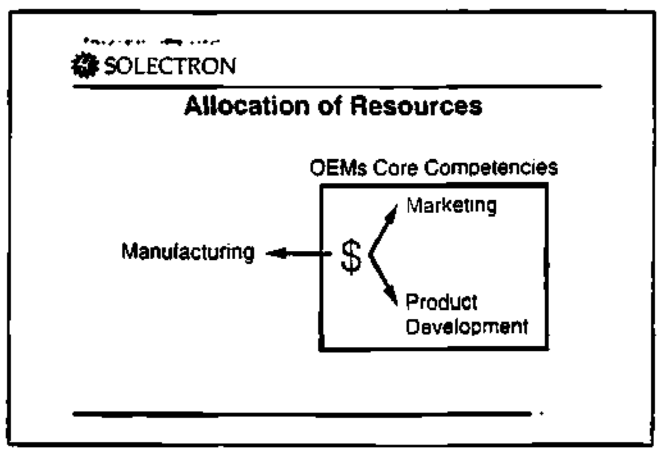

Figure 6

The basic premise is, the end users care that OEMs understand their needs. develop appropriate products, and distribute them efficiently. They don't care who makes them as long as the product works like it's supposed to, or you provide the service you're supposed to, and the OEM stands behind the product. In other words, the customer wants it cheaper, better, faster, when he or she wants it, where they want it, and so on.

So that's where we're at, especially people in the PC business know that. If your product is not on the shelf, they're going to buy the next person's product. We're the customer in that case. We drive this market personally. You talk about wireless. Who's the customer? The customer sits in this room also. You're the supplier and the customer in this case, so we're driving the marketplace.

In our case, and the semiconductor business seems parallel to this, many of the OEMs decided to spend their core competency and concentrate on marketing innovative product development, and decided to outsource some part or all of their manufacturing. Vinod, I believe we do work for you people, and you outsource all your printed circuit board assembly to us.

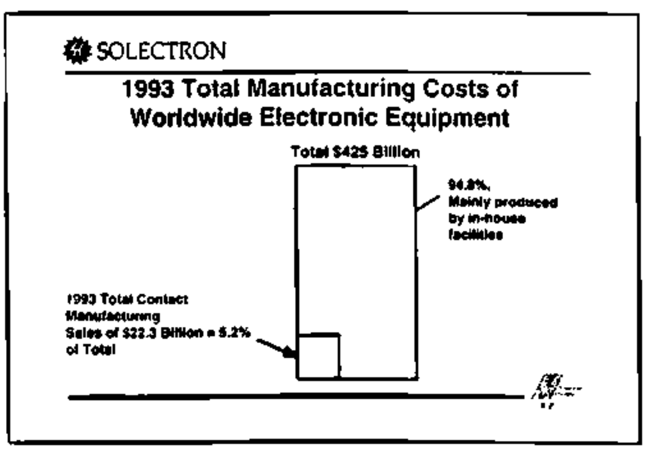

Figure 7

This chart differs from what Dataquest's number is. I believe in 1993 it's a little over $600 billion is the marketplace. That's the revenue. However, if you look at the hardware piece of this, it's about 60 to 70 percent, and when you look at that total, last year, 1993, over $300 billion was spent on hardware by everybody around the world in order to build their product.

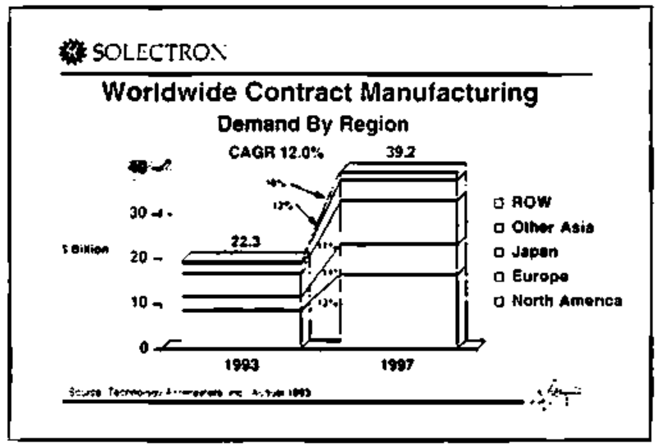

Figure 8

You can see that the contract business has about five percent of that total, and it's growing fairly rapidly. If you look at the next chart, even though the electronics business is growing at a rate worldwide between five and six percent, you can see the compounded growth rate of the contract business is growing much faster. This is only the board business; it doesn't include the box or any other afterservice they're talking about.

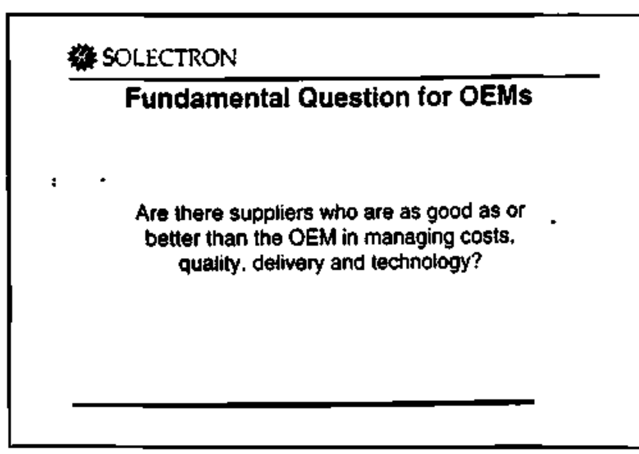

Figure 9

The fundamental questions: Are there suppliers who are as good as, or better than, the OEMs in managing cost, quality, delivery, and technology. How many of you guys are Baldrige winners? We could make quality products. We could make them cheaper, better, and faster probably than you can, because we don't have a product. If we're not good at what we make, we're out of business. That's what we do best.

We need to continue to be a dependable supplier of parts, try to get the best prices to build them, get them out to people. In the case of Applied, we build their boards, and they have what they in Austin, Texas call a bus route. We've even masked their boards for them because they really don't know what the configuration of their systems is going to be until the last minute. They need boards available so they can mix and match and customize their system. It's not whether you're going to outsource or not. I believe for every company, it's what is it that you're going to outsource, I think, that is what you have to go back and think about, because I can't sit here and make that decision for you, because you know your business better than I do.

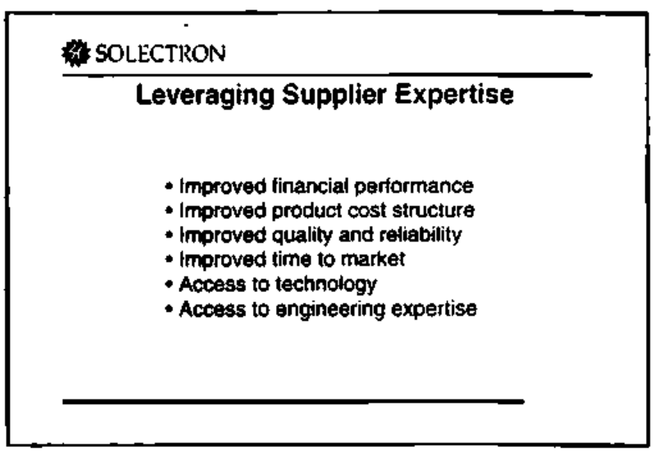

Figure 10

How you could leverage your suppliers or your partners are in the following areas. You could improve your financial performance. If your supplier builds your hardware, and he orders the part turnkey, he's going to be carrying your assets until he ships them to you. Therefore, your return on asset, as an example, will be much better.

Improve product cost structure. We talked about if we could do it cheaper, then we're not talking about price. You should think in terms of ownership. That's sort of like womb to tomb. The more sophisticated OEMs that use contract manufacturers think in terms of total cost of ownership rather than price, because price could get very expensive if you have to support them in the front end during the making of the product and aftermarket servicing. You can't improve reliability and quality because that's all we do.

Time-to-market. We have equipment. You don't have to have idle equipment. You just pay for the share you use, and you don't pay up front. You pay it as you use it. That's why we have to manage our own assets. You have access to technology. It's interesting in terms of some of the emerging technologies like BGA. Everybody does it a little bit differently, so we have developed our own technology to stay competitive, and we carry our own engineering expertise.

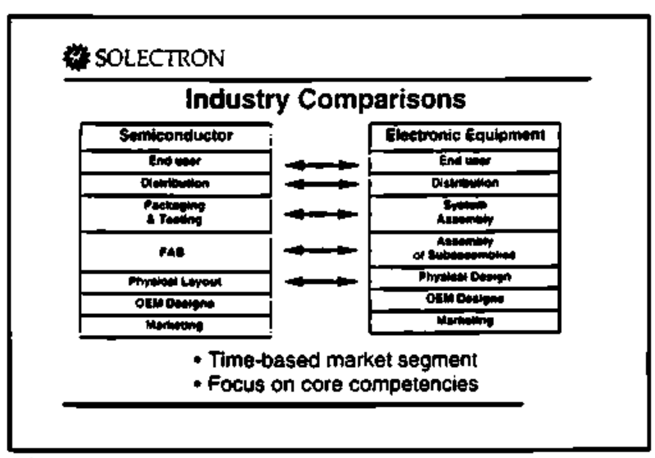

Figure 11

I tried to make a simple chart of how my industry, the systems-in-the-box industry, would be parallel to the semiconductor industry. We start providing services in the physical design. We'll lay out boards, do design for manufacturability, even qualify products for things like FCC qualification for our customers. Of course, we'll buy the parts and build the system that they like, and even ship them off to distributors, shrink wrap the stuff, even with the printed material, and if it requires floppies, we'll put them in there. We do a spectrum of services for our customers when they need it.

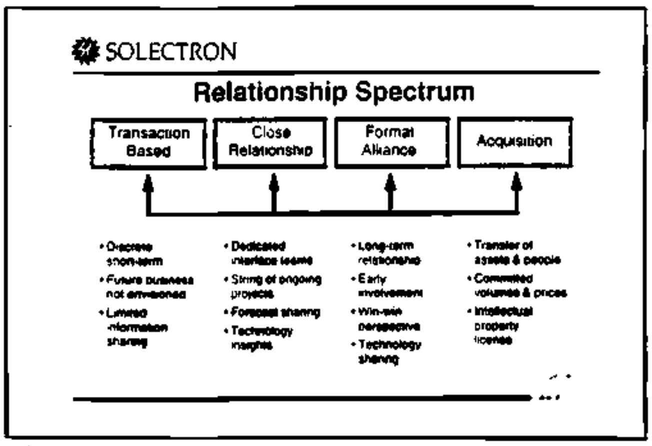

Figure 12

Now here is a wide spectrum of how you can operate with your partner. Typically in the past, it's been transaction-based. It's just the PO, that is what it is. Make me this, make me that. The other end is acquisition. Typically, we've done all four of these literally. Most of our relationship is in the close relationship, going on to formal alliances. You can see where we are with many of our customers because many of our customers have been with us 7 to 11 years. So it's really a win-win situation that we got into over a period of time. This is not the kind of relationship you build overnight. You have to start this and figure out what you want to do, and what you want them to do, because you can't do partnerships unless both sides bring something to the table. This is how we operate, and I hope this has been helpful. Thank you very much.

Mr. Vonderschmitt: We are here representing the users of foundries, and in the next 10 to 12 minutes, we'd like to talk a little bit about what that means. It gets probably more press coverage than it's worth, but that says that there are probably countless arguments about the merits of it.

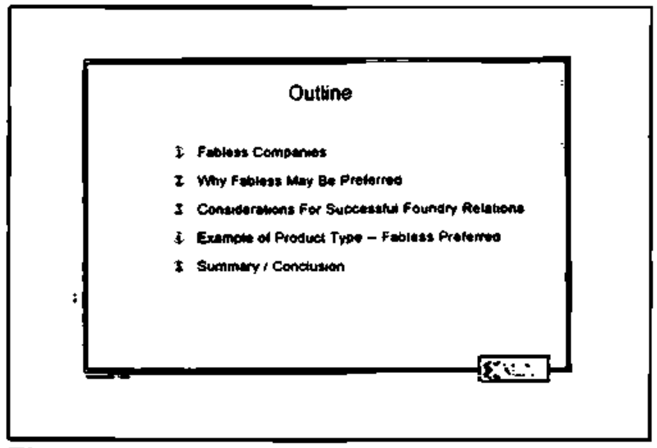

Figure 13

Brief outline: I'll touch on who the fabless companies are and how big a business is associated with that; why fabless companies may be preferred; some of the considerations for successful foundry relationships; an example of a product type, which we understand, that gives some of the background as to why this is the proper product to use for foundries. Then we'll conclude.

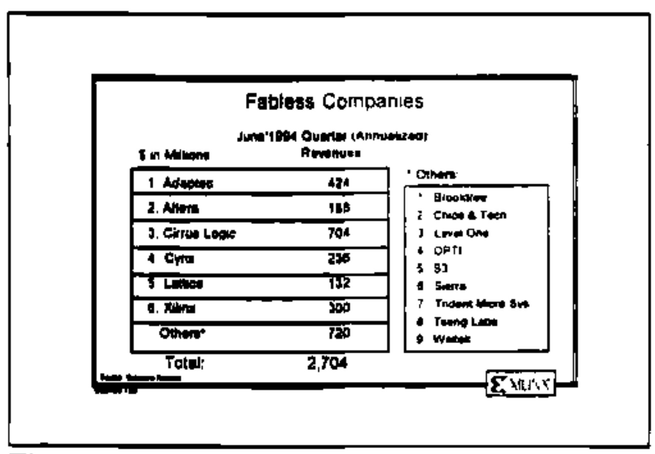

Figure 14

As you can see, here are the six largest users of foundries. Since this chart was made up, there's one listed here who now has risen above a certain threshold, namely Cirrus Logic, who has now decided that maybe they also need fab support from within. Maybe there's a magic number at the $500 million run rate or something like that, but perhaps we should put Cirrus Logic in the AT&T category. I just recently saw a report that quantified the foundry business for companies having no fabs at all to be a $3 billion revenue business at the sales level; that is, sales to end customers. There's a large amount of business where people who have their own fabs also use foundries, and of course, that's not recognized here. I'm sure that Don Brooks will tell us how big that total business is. So it's a $3 billion business (measured as revenue to customers) from the standpoint of people who have no fabs at all.

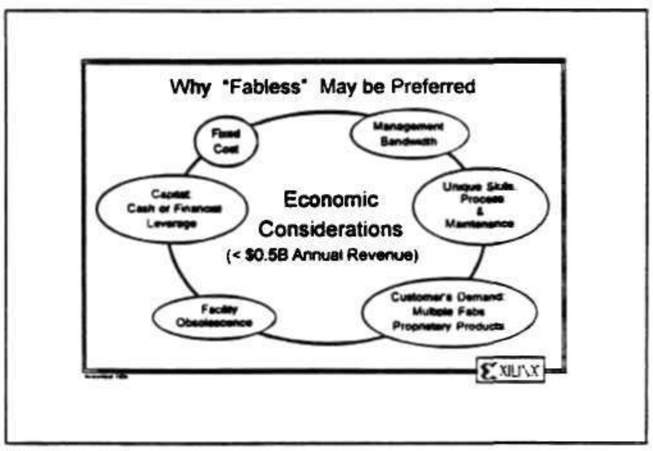

Figure 15

Why fabless may be preferred: This is a very complex subject, and if we look at this thing going clockwise, as Koichi just pointed out, we're running a business from concept all the way through manufacturing and sales, a very complex business. There are many things to do, so the management bandwidth, particularly for a small company, is really challenged. That's one of the reasons why it is not a bad idea to be fabless. Unique skills are required. That's part of the fundamentals, and it relates to the first item that we just addressed; namely, you need some very outstanding maintenance people. More than that, you need outstanding, committed process people to run the plants.

The equipment that Applied Materials sells is not worth very much unless it's utilized in a optimum way, and that's where the process engineers come in. The other reason is that if you have a proprietary product, customers, in many cases, require that you have multiple manufacturing locations. That is difficult for a modest size company. It means you have to have multilocation fabs — another good reason for fabless.

If you are on the leading edge, or if your product requires leading edge technology, what do you do with the fab that's three years old and no longer cost-effective? Larger companies, with a broad diversity of products, can use the older fab equipment to manufacture products that are less demanding in performance. What do you do with fab equipment that's three or four years old and is already obsolete? Of course, the item that attracts most attention is the capital required to build fabs, which, depending upon who's talking about it, can be anywhere from $250 million as a minimum to well over $1 billion. Small companies simply do not have the means of raising that kind of money. And of course when you have the fab, as many of you in the industry have experienced, there's that fixed-cost content, or a fixed-expense content if you will, that is a very significant part of the business, and makes for volatility of profits in a semiconductor company.

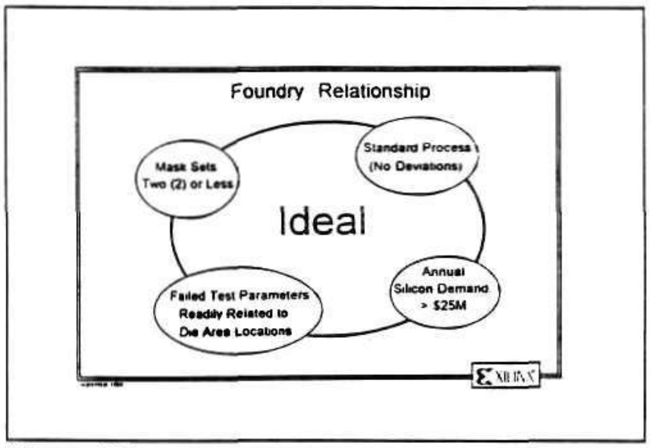

Figure 16

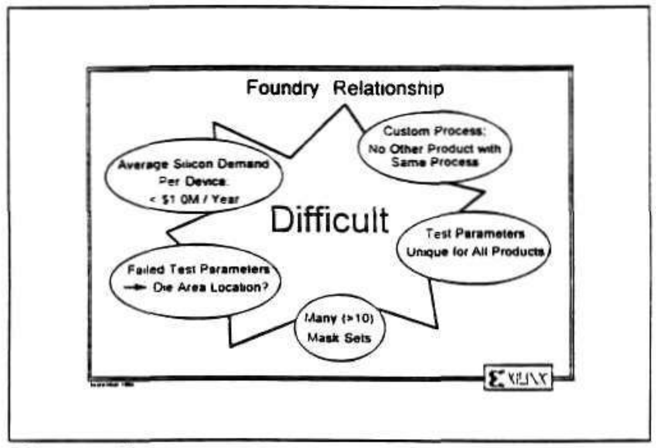

Figure 17

Now we'd like to describe two relationships, sort of an ideal relationship, and one less than ideal. In the ideal relationship between a design group and a manufacturing group, the normal relationships, the added value is in design and in selling. If you have no manufacturing, that's where the foundry and assemblers provide the complementary skills.

First of all, the ideal relationship should have a standard process; in other words, no deviations. The foundries are already making products using a standard process for other products. The annual silicon demand, in order to make it interesting, should preferably be more than $25 million, and that's not as revenue, but as silicon content. Further, a product that is easy to analyze from the standpoint of yield and yield improvement; that is, identification of poor yields with a minimum need to understand the IC to relate to the failure mechanism. Preferably, as noted here, two mask sets or less, so the "less" can only be one, and one set is the preferred number of mask sets.

Now on the flip side is a foundry relationship that is more difficult, and many of the items previously referred are inverted from what we just discussed; for example, a custom process. In other words, not a mainstream process. This leads to a difficult relationship. People like TSMC are not very happy about that unless you buy $100 million of silicon every year. Also, test parameters: analysis of the devices is unique or perhaps, you're having a dozen or so different parts fabricated, and there's no correlation for analysis, a very challenging problem for process engineers. Many mask sets are also undesirable (remember we said one was the ideal). And finally, the cruncher is less than $1 million of silicon revenue per mask set. That's what makes for tough relationships.

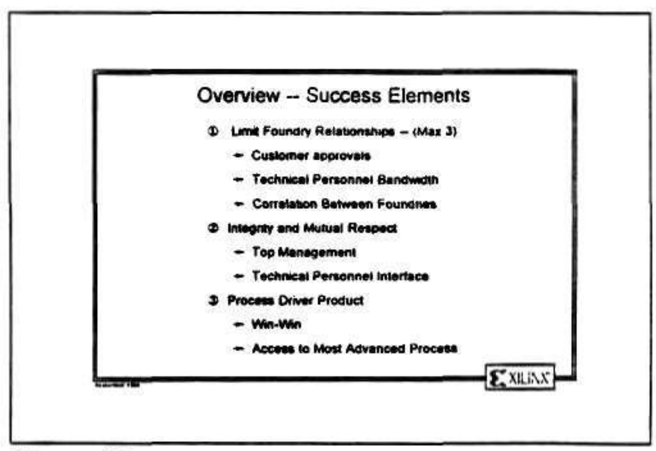

Figure 18

An overview from the standpoint of success elements: Unless you're a huge operation, it's very difficult to interface with many foundries. There have been cases of companies doing less than $300 million per year at the sales level, having as many as eight or nine foundries. We don't know how they can interface with that many suppliers. The logistics are a nightmare. We consider a minimum of suppliers a very important item for a successful relationship. Some customers require approval for every fab, so that poses a problem. Again, as we mentioned before, the technical personnel bandwidth that the company needs to interface with many foundries is very difficult. Also, to have correlation between foundries is very difficult, in other words, to meet the same specifications in the eyes of the customer.

Clearly, the foundry relationship you have is very important, that is, with whom are you dealing? There is a need for mutual respect, both at top management and at the technical interface level. It can be a great relationship if you have the type of product that the foundry can use as a process driver. In the past, DRAMs were the universal process driver. That no longer obtains, and now there are two different processes that you need: one for DRAM-type product, and one for logic-type product.

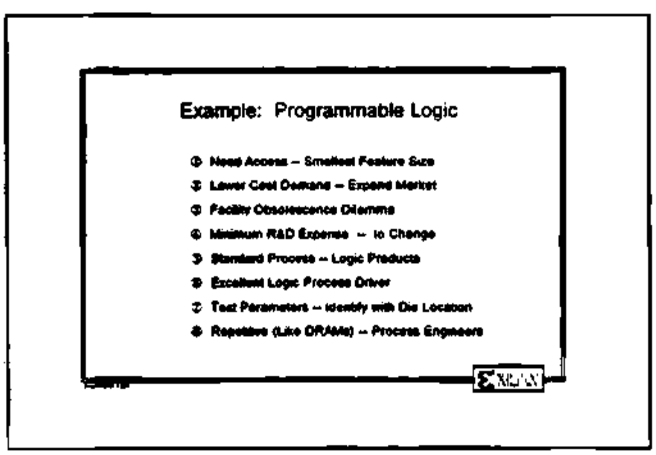

Figure 19

Let me briefly cover a product that is very amenable to using foundries. First of all, you need state-of-the-art for programmable logic, you need lower cost because you're trying to expand the market, because you need state-of-the-art you have to worry about facility obsolescence. You should have a product that is easily transferable to smaller feature size and further uses a standard process for logic-type products, test parameters that are easily identified from one product to all others, and a product that is very structured — like DRAMs. Repetitive circuit elements are ideal for process engineers to analyze failure modes and relate the failure modes to the process.

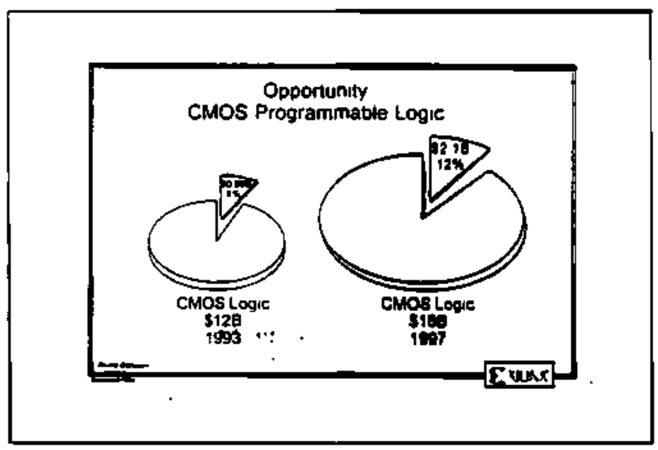

Figure 20

Courtesy of Dataquest, this shows the CMOS logic market was $12 billion in 1993; $950 million of that was for programmable logic. The CMOS logic is forecasted to be about $18 billion (1997), and the programmable portion is forecasted to be 12 percent of the CMOS logic market. The primary impediment to expand the programmable market relates to cost and price. We'd like to share with you very briefly how important state-of-the-art processes are.

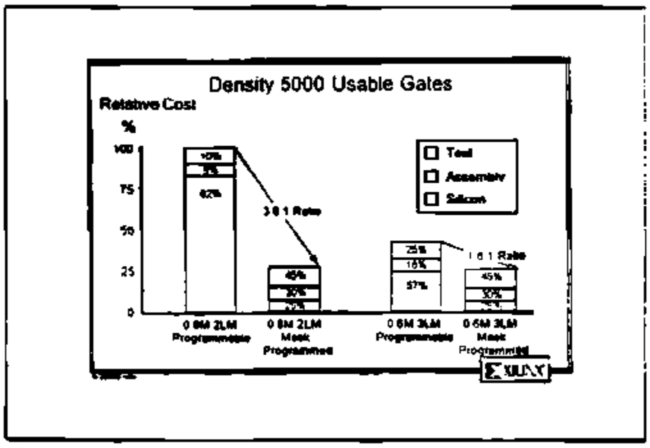

Figure 21

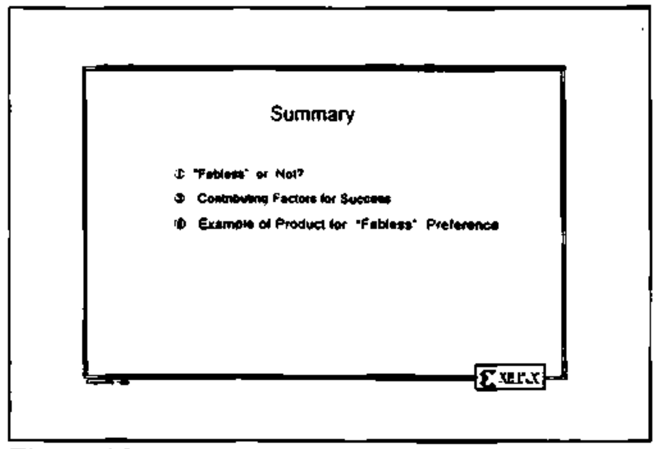

Figure 23

This shows you, for example, at a density of 5000 usable gates, the relative cost, and emphasis is on cost, between a programmable part at 0.8 micron feature size and two layers of metal between programmable devices and mask programmed devices. You can see that the large part of the cost is in silicon. If you compare the same density, but use 0.6 µ, 3 layer metal, it changes dramatically. For 0.8 micron the ratio was 3.8 to 1. For 0.6 µ TLM, the number is 1.6 to 1, about 2.4 times reduction on the total cost, with the major contributor being the silicon.

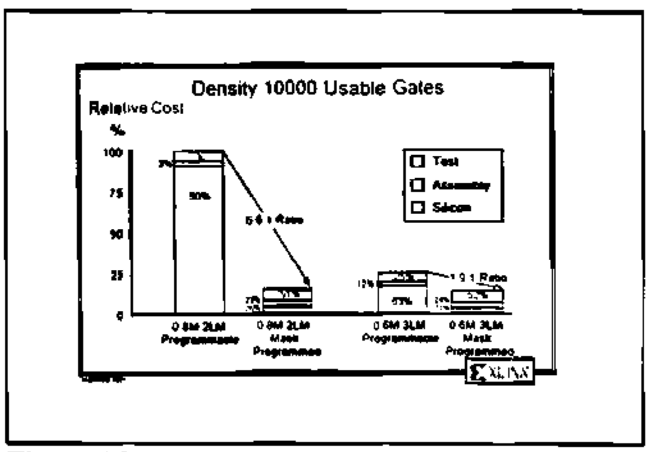

Figure 22

This is the same comparison, except for 10000 gates. 6.6 to 1.9, a 3.5 times reduction just from the process technology. The conclusion is that for high density programmable logic one needs to have access to state-of-the-art process technology.

Summary: Fabless or not? It depends. Contributing factors for success, we pointed out, depend on the relationship between the two companies, and it depends upon the type of product you have. And that product, we suggested in the slide we just went through, may be a good example Thank you.

Mr. Brooks: Good morning ladies and gentlemen. It's very interesting to find us centerpieced here a little bit having to do with foundry. I guess it's a sign of the times. When I first went to TSMC I spent a couple years trying to get rid of the word foundry. I always thought it looked a little unsophisticated, maybe a little dirty for the kind of business we're in. But I find it's so institutionalized now I don't think I have a chance to do that so I've fallen in line with that term.

What I want to talk about today is what I call a model of foundry, because I think so many of the businesses that you represent will be dependent on support from this area in the future that you might like the insight I have as to what I think is important. First, characteristics of a model foundry, I believe, is one of foundry only. I think there's too much conflict in the foundry business in the areas of intellectual properties of capacity at the time when there's not adequate capacity for the market. I think that cost structures or productivities can be optimized by focused, foundry-only companies. I mean this in contrast to companies who foundry as a second part of their business, and basically compete with their own customer base.

The second characteristic I think is important is one that provides high yielding, state-of-the-art generic processes. These processes should be managed such as they arrive at the time where the capacity comes on at the heart of the growth cycle. I mean that in contrast to foundries who transfer technology from larger corporations and are usually in the older technologies.

The third characteristic of a model foundry, I believe, is that it will differentiate itself in the long run with service. I think the test of that will be how much the foundry looks like one of your factories in the technical exchange of information, in the logistics, purchasing, loadings, etc., data that needs to be available, and the quality and reliability aspect. The model foundry will look like a plant to you in the future such that you don't lose anything in this interface by not having your factory.

Fourth, as in any business, is it self-funding? The model foundry will have self-funding because only if it is self-funding is it able to sustain itself and grow and let you grow with it. My point there has to do with the foundry not requiring its customers to put deposits, equity joint ventures, etc., to sustain its growth. I believe that utilization and yield will drive the profits ultimately for foundries, and that's pretty straightforward. But I believe then that the profits will determine the growth rate, i.e., how much capacity it can add year-in, year-out, because without those profits, and with the limitations of being self-funded, growth will be determined by profitability, and therefore the productivity of the fabs.

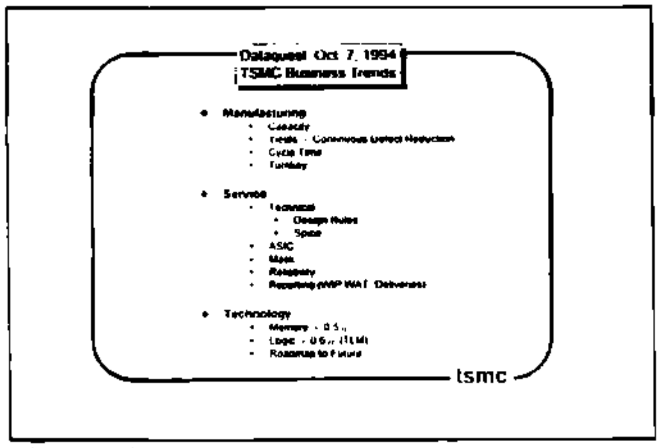

Figure 24

I've divided my discussion today up into three areas: first, manufacturing, second, service, and third is technology. Most relevant to most of you is capacities, so I will go quickly to it.

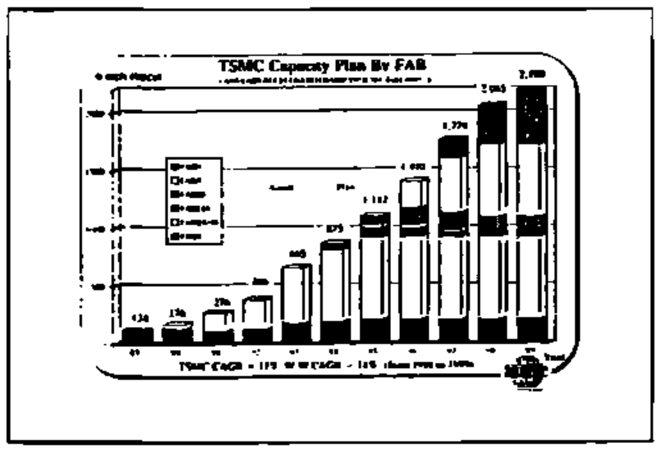

Figure 25

I show the TSMC capacity plan to make a couple of points. First is, we believe that we should add capacity in a linear fashion. To try to surge, to catch an up market, or try to delay our programs because of a down market, will ultimately not serve us. We'll probably be too late for an up, and we'll probably not have capacity when the market turns downward. Our plans here, we're passing through about 1 million wafers per year, 6-inch equivalents, is to add something in the order of 300,000 wafers a year for the next three or four years. This will cost us $400 to $500 million in annual capital expenditures, which we're prepared to make.

In 1997, if you look at the equipment capability in TSMC's fab, 90 percent of the capacity will be sub-micron, and 75 percent will be sub 0.5 or less micron. So we are truly investing in high technology because we believe in the phenomena that we've seen in the past few years in the value-added that's being brought by the semiconductor industry.

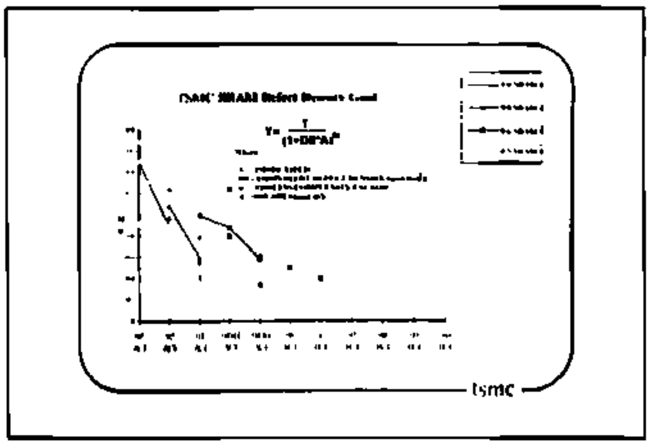

Figure 26

The next subject I would address is yields because yields is a single item that, in many cases, represents the value-added that the foundry actually contributes; it calls for continuous defect reduction. For those of you not too close to this industry, we'll talk in terms of defect densities, which is defects per unit area, which for every layer that we put on a wafer contributes to yield loss, and the lower the defect density, the higher the yields. It's very important, obviously, and this defect density allows us to compare one foundry versus the other, one fab versus the other, even one product versus the other within a fab, because it's somewhat of a common denominator. This is our history and forecast for defect density reduction for logic process, showing three processes, 1 μ, .8 μ and .6 μ, as you can see.

First is that a major change comes about every year and a half to two years. Second is that it is important to drive the defect density for foundry on each technology to set up the capability for the next technology. If you do not, your work doubles and soon it gets too large for you to compete. Much of this work is done in a model foundry by a product engineering activity of process engineers. They sit at the end of this line, they observe yield losses, they identify defects that occur, it goes back to process engineers, and you continue this cycle of improvement to drive this down. There are inherent weaknesses between related processes and there are related problems within equipment for a given process. It has to be identified and fixed to fix this problem.

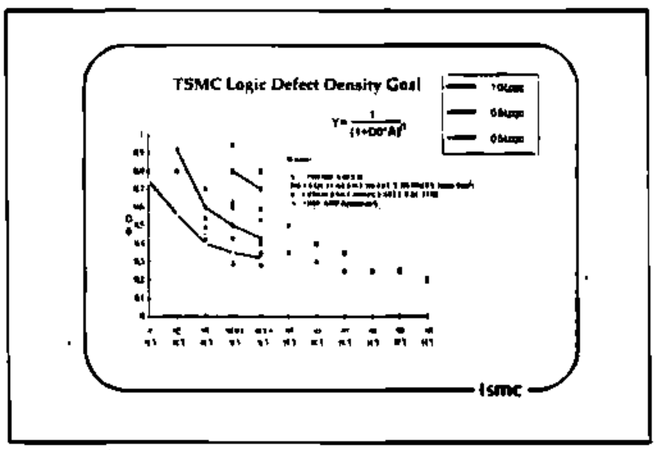

Figure 27

In the logic area — this is high-density for metalization — the primary task here is the metalization and the interconnect on the chip to identify these defects. In contrast, the SRAM, which is represented by this chart, is primarily the formation of the transistor and is usually the lead technology, at least that is the case at TSMC, usually the lead technology that we use to bring a process to production, and then we bring logic on some months later. Observations on the SRAM is it's a much shorter life cycle. We're not talking about as many designs, so as soon as it's cost-effective to move to the next technology, all designs are converted and converted very fast.

A couple of comments on some of the other items on this chart. The first is in the service area. As I mentioned, we feel it's important to drive the methodology of our industry to service the customer to the point that we look like one of your factories. We'll do so by supporting the technical data, in terms of design rules. We will offer ASIC net list conversion to cell libraries, and in the future we may even make those cells available to our customers, those libraries, those primitives, to motivate them to move to COT faster and more cost-effectively. Our reliability will be to give early assessment of the product reliability. We can see the day that it will actually be acceptable enough that customers can adopt that data for their products and move onto production earlier.

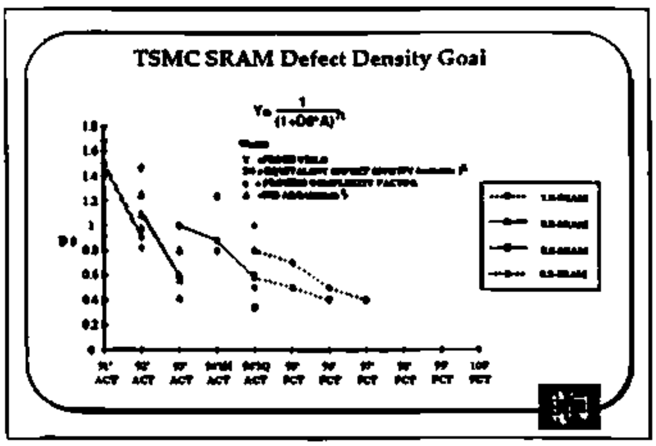

Figure 28

The next area is technology, which at TSMC is for memory is 0.5 μ and for logic is 0.6; triple-level metal is the state-of-the-art technology in production today. We interface with our customers with a very comprehensive chart of technology roadmaps so that they know where we're going and when we will be ready to bring up new processes. The code here is a little difficult but basically you're looking at the technologies. If you take the upper left-hand box, you're looking at 0.8 μ technology, 2 poly, 2 metal. You're looking at basically three process years of mixed-mode logic and SRAMs. But this carries through to 1998 so they have good visibility as to when new technologies will come. I thank you. I hope I gave you some insight to the foundry business and the future of foundry business.

Mr. Dickson: Good morning. My name is John Dickson, and I'm responsible for the Integrated Circuit business unit within AT&T Microelectronics. I think we were invited here today because we, in many ways, are an organization in a company in transition, and we actually, as of today, buy silicon from other semiconductor companies. We manufacturer our own silicon for shipment to our customers and we actually sell some of our silicon to other semiconductor companies, so we're the ultimate merger at this state of various strategies. Moving forward though, we are in transition, and I think the strategies of companies have as much to do with their history as they are to their future aspirations. I think it would be useful if I just spent a few minutes talking about the history of AT&T Microelectronics.

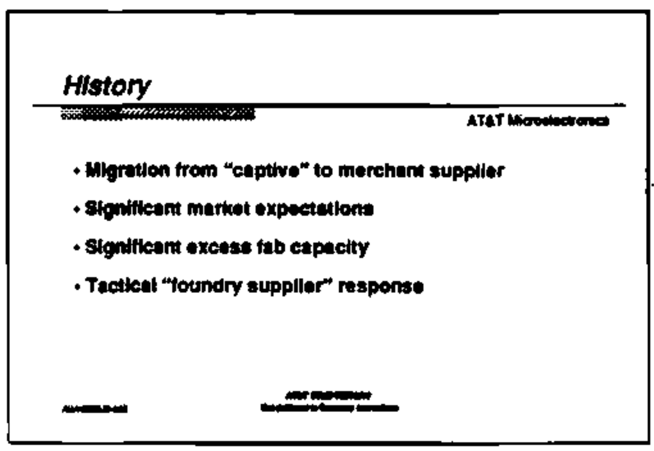

Figure 29

Prior to 1984, before AT&T went into the divestiture process, the semiconductor business within AT&T was essentially a cost center supplying silicon and silicon products to the various product groups within the AT&T organization. At the point of divestiture, it was decided within AT&T that the component manufacturing groups should actually go out and sell their wares and their technologies in the external marketplace. As some of you will probably remember, AT&T had a very, very well-held view, or the analysts looking at AT&T had a very well-held view, that once we entered the merchant marketplace we would quickly dominate, whether it was taking IBM out of business in the computer systems area or becoming a major semiconductor player. There was no doubt in a lot of people's minds, including people inside of AT&T, that we would be very, very successful. So at that time, we had very significant market expectations as to what would happen, and we all know what happens with significant market expectations.

The first thing that you do is to build lots of factories, lots of plants around the place, lots of assembly and test capacity, and that's what we did. Unfortunately, the people who were supposed to beat a path to our door didn't quite see it that way, and we had not much more than a trickle in the very early days of people coming to buy our products and take our products. So we were left with a significant excess fab capacity; fabs in all the continents, some full, some partially empty, some totally empty, and as you will probably remember, we withdrew from the microprocessor business and we aborted our attempt to be a major player in the MOS memory market.

So as a result of all of that, we were left with a significant amount of excess fabrication capacity, and hence we went into what we would call a tactical foundry supplier role. And we've done that from that point in time up until where we are today. We are still a supplier of foundry silicon in the marketplace. At its peak, our business as a foundry supplier was just a little bit short of $200 million per year, so we were a significant supplier in that period.

Having taken you through the disappointing part of the story, let me just say that in the latter half of the 1980s, we put our act together very significantly. We brought in people who understood marketing, who understood product technologies, product planning and customers, and certainly since 1989, the external business, the OEM business, of AT&T Microelectronics, including this year, has grown at a cumulative growth rate of 33 percent per year, which I think by any standards is a very impressive performance. In fact we'll close this year just a little bit short of being a $1.5 billion business, with well over two-thirds of our business being outside of AT&T, so a very significant change in how this business has managed itself and moved forward.

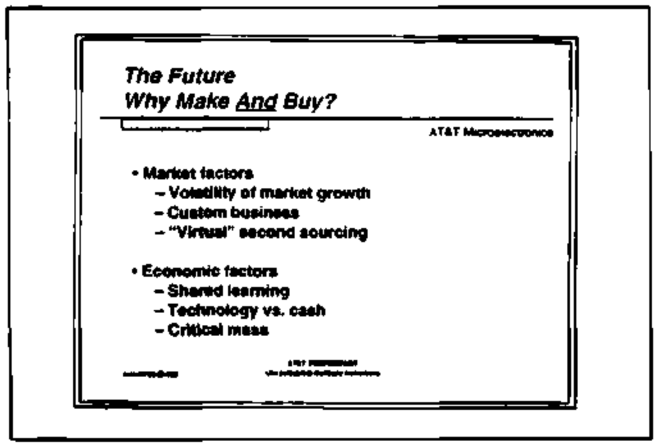

Figure 30

Now looking at the future, we're looking at continuing, and in fact increasing, our dependence on buying silicon as we phase out our participation in the foundry market. If you look at market factors first, we had just happened to participate in some of the most volatile markets that I think our industry has seen, whether it be the PC business, whether it be the cellular phone business, or whether it be the storage business. We're participating with customers who find it very difficult, for a very, very good reason, to understand what the magnitude of their demand will be at any point in time, and as such we need to find a way to respond to that demand. It's clear, given our size and given our financial structure, just like any other semiconductor company, that we could not sensibly, financially manage and retain enough capacity to satisfy our customers' requirements at all times as we go forward. So that's a key reason that we will be looking for partnerships with foundries to help us sustain those requirements.

The second factor is the very nature of the type of business that we have. Our engagements with our customers are almost 100 percent on a custom basis. If I look at the percent of our business that we could classify as a catalog business, it's probably less than two percent of our total portfolio. And there are, as you will know, many obligations associated with being a custom supplier to a customer, not least of which is his concern that one of these days you will have yield problems. You could have factories that burn down, he could have massive demand shifts, whatever, that stretch the resources of your organization, and could actually close his production facilities and cause him to lose customers.

So while we actually have three fabs still within our organization, one in Europe and two in North America, we feel it relevant that we should leverage our base capability by associating ourselves with other suppliers of silicon. We sold this concept very successfully, we believe, to our customers and describe this as virtual second sourcing. That is, we have a close relationship with a foundry supplier, or silicon supplier, essentially using our process so that we provide massive flexibility and upside capability in satisfaction of our customers' requirements.

On the economic factors several of the panelists have talked about this morning, even though we're a $1.5 billion corporation, we're still on the small side. It is clear that we have to focus in particular areas, and it seemed to us very sensible that we should have our major focus on both our product design and development, understanding our markets in relation to our customers, and really allowing someone else to bring the massive manufacturing capability to our particular party.

Part of our history says that we have Bell Labs within our organization and we happen to believe, and a lot of people tell us, that that's probably one of the greatest sources of technology and intellectual property that exists in the world today. Clearly a lot of the people who would like to work with us believe that also. It is a very attractive mechanism for protection against patent suits, for manufacturing capability, and advanced technology. So we believe we are perhaps unique in one sense that we have an opportunity to partner with people using our technological capability and in another sense trading that for the cash of our potential partners.

And last of course is critical mass and focus. As I said before, we believe it very important that, exactly as Solectron said, we look at where our strengths are and focus in those areas, and move on and let somebody else bring the expertise in areas we consider not to be totally strategic.

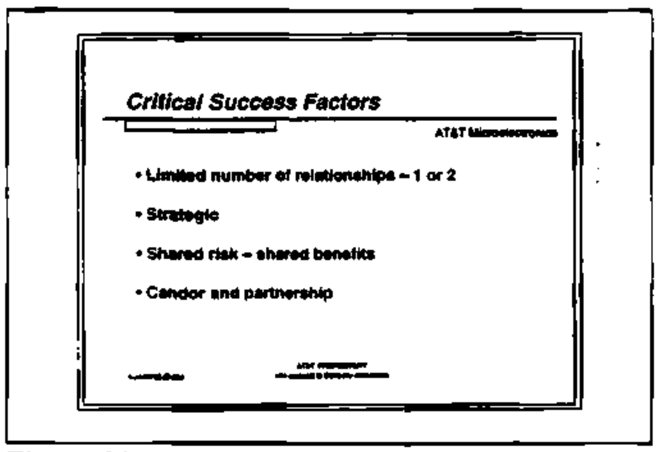

Figure 31

So what do we consider the critical factors to be? We are really looking for a very deep, very strategic relationship based upon experience that we've had. I think the amount of resource, the capital time management attention that is required to supply a key relationship in effect runs in a square law with the amount of relationships that exist. So we very strongly believe that we need an absolute maximum of two relationships and ideally just one.

We need to link ourselves very, very closely with a partner, such that we become very close and imbedded in the same business and the same business goals. We are looking for that relationship to be strategic. While we may continue to have a tactical relationship on a year-in and year-out basis, our main aim is to have an extended, long-term and deep relationship with one or two suppliers. For it to be successful, we really believe that it has to be shared risk and shared benefits. Those words are often used in a motherhood sense, but we really do believe that given the customers that we have, the opportunity that we have with them, we think that by sharing that opportunity with our partners we can both win, and our customers can win very, very significantly.

And last, and probably most importantly in any relationship, we truly would like this to be an open, a virtual single company where candor is the absolute requirement in that relationship. If we could have a situation where every situation, every problem that we have with our customers, is almost transparent to our foundry partner or semiconductor partner, then we believe we'd be very successful in moving this organization forward. Thank you.

Mr. Mahendroo: Good morning. I would like to go ahead and give you a perspective on how the semiconductor equipment in general, and how Applied Materials specifically, looks at this whole.

What I'd like to do first of all is amongst all the panelists — I'm in the somewhat unique position here in that almost all of you are either customers of mine, or people who are fundamentally driving customers of ours — I'd really like to thank you for making this road possible.

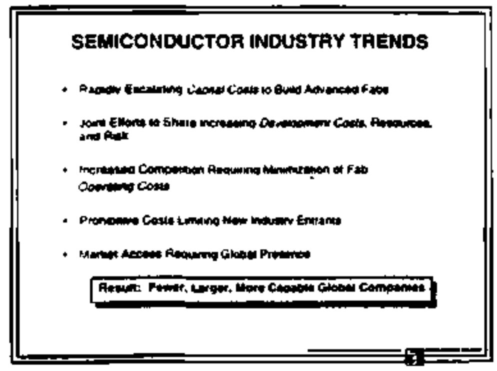

Figure 32

Moving very rapidly to the industry, when we take a look at semiconductor companies that have fabs and try to think about what are some of the key characteristics and the key drivers here, a great deal has been said in the past about the escalating capital cost to build advanced fabs, and certainly, while the numbers, as Bernie pointed, out are in a fairly wide range, there's no doubt at all that the numbers are large and they are escalating. Development costs keep going up also, and because of that we believe that we will continue to see more and more partnerships and alliances as companies try to find ways to do joint efforts and share risk. Clearly, from the perspective of an operating fab with the continued demands on the equipment industry to manage and reduce operating costs, and this happens in a couple of ways.

One of the issues here is an actual reduction of operating costs, and the other issue is to really extend the productive lifetime of the equipment in a fab. And in general, we're saying that the cost issues are really limiting the rate at which new semiconductor with fabs are being formed. In addition, we're finding that many of our customers feel that market access issues for them require substantial global presence, so we are seeing a more consolidated semiconductor industry from the perspective of people who have fabs and we certainly are seeing this industry as being increasingly demanding.

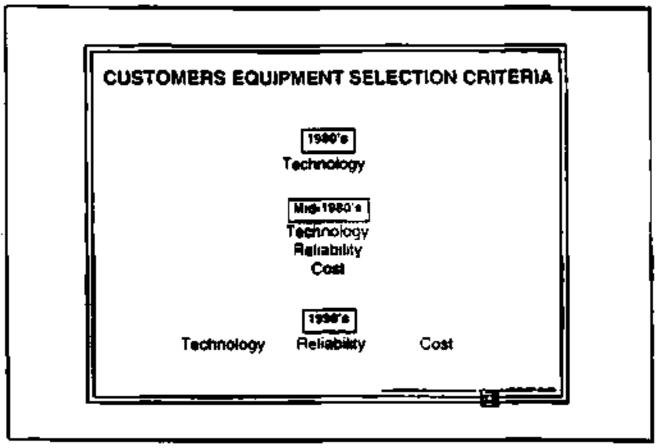

Figure 33

One of the unique perspectives we have is that 10 to 15 years ago, the major criteria that our customers had in selecting equipment was technology. The issue was, can you do 1 μ technology, 1.2 μ, whatever the demand at that particular point in time needed to be. In the early to mid-1980s, issues of reliability and cost of equipment became more important, but there was definitely still a hierarchy of needs. We now see all of these things as being very important. Our customers want technology that works, they want it to be reliable, and they want it to be really cost-effective today, and they want the lifetime of the equipment to be extended. In this regard we see absolutely no difference at all between the customers, such as Don and TSMC here who are foundries, and the customers, like an Intel, or a Motorola, or a Toshiba, who are more classically integrated semiconductor companies.

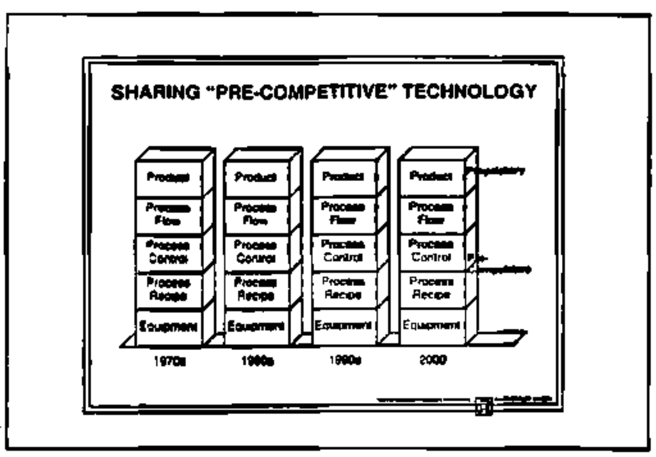

Figure 34

I think there's one other issue in which there's a substantial amount of change in the relationship between semiconductor equipment companies and our customers. Actually, if you go back to the left of this particular chart to the 1960s, a lot of the equipment development was done in house by the semiconductor suppliers. In the 1970s, though, it became more and more clear to many of the semiconductor companies that there was value in depending upon external equipment suppliers, but the relationship was very much more of an arms-length relationship where we provided equipment and our customers did everything else. In the 1980s, there was a greater requirement to start participating in, and contributing greatly, as far as process recipes are concerned.

And now in the early 1990s, in addition to that, there are demands and requirements from our customers. For the entire industry we are far more involved in the total process flow, and definitely the process control is a set of issues that we end up taking at least co-equal ownership of along with our customers. As far as this shot is concerned, there is no real measurable difference between the relationship that we have with a company like TSMC or other companies that are, again, more classically integrated.

I do however want to touch upon an area where there may be some differences, and this also brings me to the obligatory 30 second Applied Materials commercial. I'll try to keep it very short. But they'll revoke my travel privileges if I don't mention something about it.

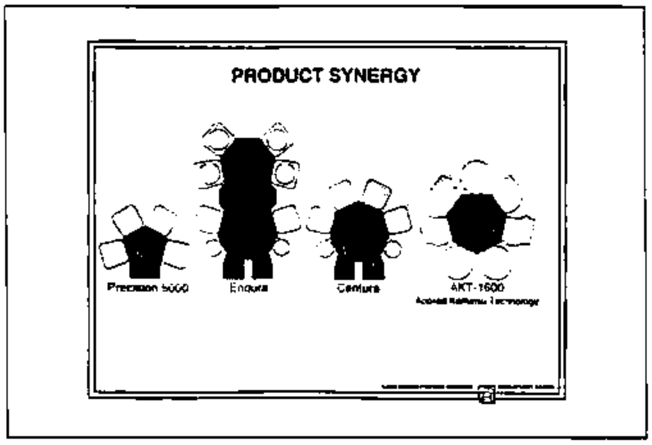

Figure 35

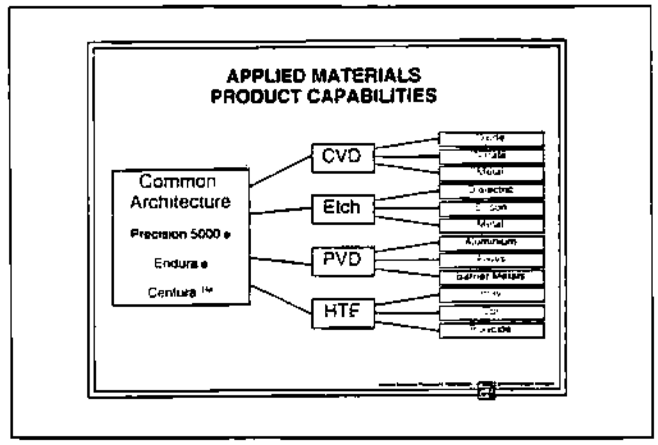

Figure 36

Fundamentally, our strategy as a company, is to provide equipment that meets the technology, the reliability, and the cost requirements on a variety of different mainframes. Three that are in high-volume production are shown here towards the left of your screen and they fundamentally meet different process integration and vacuum set requirements. The first one, the Precision 5000, we are on the verge of shipping our 2000 mainframe there, and the next two, the Endura and the Centura, are rapidly becoming the second and third most popular mainframes of all times.

On the extreme right is a new mainframe that we developed for a joint venture that Applied Materials formed with another company, Komatsu, Komatsu Technology, for the flat panel equipment manufacturing business. That is relevant in this discussion only because it essentially gives us the mainframe for the next wafer size processing.

Having said that, from a product perspective, the strategy then is to be able to offer a number of different applications on these mainframes. This is one regard in which Applied is unique as an equipment company in that we believe that the only successful multiproduct line company that's able to integrate on the same platforms, chemical vapor deposition, etch, sputtering or PVD, and high temperature processes. Essentially, this gives us a real capability of providing process integration on the same tool, where it really makes sense for our customer. This fundamentally means that there's greater leverage, and a closer working relationship between us and our customers, particularly in terms of being able to understand where processes are going in the long-term.

I'm pleased to say that as far as some of the best foundry companies are concerned, like TSMC, we find that they have the same kind of expertise that many of other customers do, and were able to work on similar applications and have similar discussions. But this is an area of long-term concern from our perspective, which is our ability to continue to innovate and provide the right equipment for the right processes at the right cost, and this will ultimately be one of the enabling technologies that will drive your ability to make magic happen with silicon. That is fundamentally going to be a function of our ability to be able to work closely with you and understand, at the process level, not only what you must have for the next two years, but what sort of a pallet you need to be able to create uniquely in the long-term.

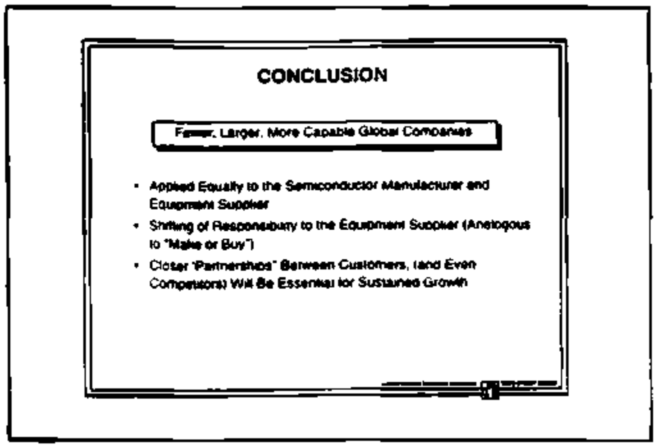

Figure 37

Now in conclusion, I think that this paradigm that I was mentioning earlier about a smaller number of larger, more capable, global semiconductor fab companies, applies not only to that industry but also to ours. We are seeing shifting of responsibility to the equipment supplier to us, so in a way the foundries are doing a little bit less. The foundries and the semiconductor fabs are, in terms of the totality of the core competencies of skills you need to have, doing a little bit less of what they used to do in order to be able to focus on really adding value where it's very crucial to them, and we feel that really close partnerships that are sustainable in the long haul are going to be critical to the entire food chain.

In conclusion, I'd like to quickly make three points. Our customers, whether they are foundries or whether they are fully integrated semiconductor suppliers, have very similar needs and they manage us very similarly. We do have a real opportunity in the long haul, through process integration and other creative means, to really help extend the capability of our customers. We are pleased that the higher-end foundry companies like a TSMC are able to work with us providing as much insight into their market as any of other customers do. If we can continue that, fundamentally, this issue becomes a transparent one, from the perspective of being able to provide the enabling, manufacturing technology. Thank you.

Mr. Fuhs: I'd like to open it up to the audience for asking questions to our illustrious panel of speakers. Do we have a question? We have one.

Question: We've heard a lot today about wealth creation and also focusing management's attention on what it does best and how it helps the situation? Yet over the last year, we've seen probably close to half a dozen times where some of the fabless companies, or those who rely heavily on foundries, have surprised Wall Street with earnings and revenues shortfalls, but they then point the finger at the foundries for being part of the problem. The result is that stocks tumble, corporations and their managers lose their credibility, shareholders file lawsuits, management time is spent in fighting those lawsuits, and the wealth creation begins to go away. Is the problem one of lack of communication between the foundries and the fabless design companies? Is it one of communication between the fabless companies and Wall Street, or what? What's the surprise? And how to we avoid this so that we can retain and keep management's attention where it belongs, on the business, instead of fighting lawsuits?

Mr. Brooks: First, this problem hasn't surfaced with TSMC customers. I'm thinking through the problems we've had that are described by loss of earnings and surprises and tumbling of stocks, and I don't remember any of them tied to the fabs, so maybe you can help me with a specific.

Question: I think there some situations, for example, when Cyrix or Catalyst and others who pointed fingers at Oki, for example, where not only did the companies have a problem, but even some of the institutions who supported them, were also dragged into lawsuits.

Mr. Brooks: I don't have any first-hand knowledge of those and I wouldn't speculate on them, maybe somebody else has.

Mr. Vonderschmitt: I think that the importance of having continuation of supply is very much a function of what the relationship is between the foundry and the user of the foundry. Sometimes people think that what you could do is just simply start discussions and you will have an instantaneous relationship that's very firm. I suggest that in order to guarantee continuing supply, it's very important that there be a long-term relationship and mutual respect and understanding. The difficulty we've had is, frankly, that we have too much inventory. Very seldom have we ever had, except through our own ineptness by ordering the wrong information, wrong product, very seldom have we had difficulty in getting any product. So I think it's very much a function of how good the communication is between the two parties.

Mr. Brooks: I have a comment to that. Our solution is to have longer-term agreements. They don't have to be such restrictive agreements, but they at least bring a meeting of the minds as to how much capacity out customers are going to need in time, and we make that commitment. It's a multi-year contract, and, of course, one of the benefits we have of being foundry only is that if we have a shortfall, it's 10 percent. Well, everybody shares 10 percent but it's not significant in that it competes with internal capacity. So we are able to make those long-term commitments and are willing to do so.

Question: Dick Joy, Unisys. I have a question for Dr. Nishimura. I think one of the most difficult parts of your business is controlling the inventories and I know you probably have a very fast cycle time, but in the majority of your relationship, who owns the inventory and who buys the inventory, the components, the board, etc., and how do you establish that relationship with your customer?

Dr. Nishimura: You're asking the question of who owns the inventory. If we do it on the turnkey basis, we're a very low-margin business. What we'll do is we'll buy to the forecast of the customer and, of course, we will be responsible for the inventory so we don't lose it or damage it. But in the end, the customer owns the inventory. We'll do everything to mitigate it if there are any excesses. We usually try to ameliorate the situation, so we work pretty hard at managing the assets of our customers, as if we own it.

Mr. Fuhs: Is that similar, Don, in the semiconductor foundry business?

Mr. Brooks: We build to contract, we overbuild only with increased yield, but we always have a firm order for what we manufacture. So we ship what's ordered.

Dr. Nishimura: By the way, if we have excesses that are outside of what the forecast was, we would have to do something with it also.

Mr. Fuhs: Actually, there is a structural difference, if I'm hearing correctly, because you're [Mr. Brooks] basically building to a forecast and you're [Dr. Nishimura] building to an order. Am I hearing that distinction correctly?

Mr. Brooks: We're building to order. If you look at our POs, our POs are typically four or five weeks. You can't buy semiconductors on a four or five week PO, so what happens is we get a long-range forecast so we can plan for it. That is also when we negotiate contracts, that's how we work it out. So I think it's really important to figure out how you want to operate and both sides must understand what the process is. I think the other thing is that you have to decide what metrics you want to use to measure how good that process is working. I'm talking about the business process, okay?

Question: I'm Mark Noor with World Semiconductor Trade Statistics. We recently read about the fabless semiconductor association. I think the reasons for the formation of this are fairly obvious. Can anyone on the panel comment on their near-term activities and plans?

Mr. Fuhs: Near-term activities and plans with regard to what specific issue?

Question: What kind of committees or what will they do or what are their objectives?

Mr. Fuhs: The interaction with the FSA?

Question: Among themselves. What are the activities?

Mr. Brooks: We're an associate member but I have to admit, I've been in Taiwan, I haven't been to a meeting. My understanding is that at this point in time, one of the primary objectives is to put together a demand/supply forecast: what is the anticipated supply of wafers from the foundries, what is the anticipated demand from the fabless semiconductor companies? So they get some perspective as the magnitude of the problem. That's about all I know at this juncture.

Mr. Vonderschmitt: We are not a member of that group, so we are ill-prepared to tell you what the activities are.

Question: Dan Klesken of Roberts and Stevens. This is mainly for Don and Bernie. I'm kind of expanding on your answer to the first question. I wonder if you might both tell us a little bit about the level of interface that goes on at the various management levels between companies like yourselves. And Bernie, what kind of visibility do you get from your foundries in terms of where a particular lot is and how often do you have face-to-face meetings between various levels within the organization and your foundry suppliers?

Mr. Vonderschmitt: Let me start from the minutia level. Actually, we communicate daily with our foundries, particularly the two major ones that we have, so we know precisely where the wafers are and how soon they're going to be delivered, and if there's any deviation from what the commitment is. From more of a longer-range standpoint, we have a policy that the top management meet at least twice a year and more likely three times a year to make sure that we're communicating.

More important than that, the technical interface is four times a year, and the purpose there is just simply to review the momentum, what the yields are, what the problems are, even though that's done, again in case of any deviation, on a weekly basis. The purpose is, however, at the quarterly meetings to get an idea of what each party needs from the standpoint of where the process technology is going out, one, two, three years. So there's a very good dialog to determine first of all what would the payoff be, particularly from the standpoint of feature size, additional layers of metal, and so on, which is really the crux of getting down to smaller feature size. There's a very, very close coupling, as close as it would be in those cases as it would be with our own fab. We think that's extremely important, by the way.

Mr. Fuhs: The follow on question was for Don, who has a foundry. How often you meet with your customers and is it pretty uniform across the customer base?

Mr. Brooks: I think it's pretty consistent with Bernie. I try to meet with the presidents or vice presidents of larger companies a couple of times a year. We support our customers with PhD-level engineers with five to seven years of processing experience on a technical level here in the U.S., so they don't have to interface with Taiwan, which is a time inconvenience. I really see three distinct channels: one's a quality qualification/reliability channel; one is the technical design rules, and the third is the logistics of where's the order, where's the whip, when are the different wafers going to be delivered. Each of those has its own routine interface. I would say obviously the order and logistics is the highest frequency, and next to that is the technical, and probably the reliability/quality is more, a few times a year basis. But I think through the organization, particularly with the fabless, is a very good lock at each level.

Question: I'm Ed Arnold from ICS. I have a couple of questions here with respect to Don. You commented on the foundry relationships and I agree it's very important, and as one of the speakers said earlier, you can only establish one or two of these, and preferably one. The first part of the question is really on the issue of the form of the long-term agreement that seems to work with us, the relationship which is basically defined by commitments on the semiconductor side to take a given quantity and/or buy it. And the second part, which I think is something I'd like your ideas on, and others also, with respect to other similar kinds of formulas that have been successful. And on the longer-range picture, the migration of technology which results in variations in your wafer costs. For example, if you're buying 0.8 µ material today, and we all know that you guys are moving to 0.6 µ very rapidly, if you do not have 0.6 µ technology, then there's sort of a problem because that 0.8 µ is going to get cost up to the 0.6 µ, and/or you'd better migrate your product to 0.6 µ. So how does the foundry of the semiconductor company deal with those kinds of issues?

Mr. Brooks: There are a lot of questions there. Let me say the motivation of the foundry to move from technology to technology is one of value-added. Let me give you an example. We're building FAB3 right now, which is an 8 inch 30,000-wafer-a-month alliance of $1 billion dollars. The capability is going to be 0.35; that's the equipment we're going to put in place. But the process technology is not available at this time, so we'll start on half micron, but as soon as 0.35 is there, the motivation for the foundry is going to move to 0.35 because the cost structure is such that it costs as much to build 0.35 as to build 0.5, because the equipment is the same, the appreciations are the same, the cost per level's the same. So we're going to want to push to that because that's the way we get the maximum value-added out of that investment, that's the way we turn around and invest again.

Now, there is no other way from the process obsolescence standpoint other than to communicate. We have it coming, we want to change, and we try to move as much as we can. Those customers who have long product life cycles, we'll move them to older facilities as they are made available, and qualify one of our other fabs so that we can extend the life of that technology. Sometimes, we just have some conflict over these when products run five, six, seven, eight years of product life. We just have to resolve it whatever way we can.

Mr. Fuhs: One of the questions I'd like to ask comes back to a comment that Bernie had and then we'll pick up another question. You had mentioned in your presentation that there might be a level at which the fabless goes into a fab state or a partial fab state, and that's about the $500 million level. Really it's anybody's guess. It's interesting that in the systems business, it's actually going the other way; integrated manufacturers are becoming fabless so to speak. I'd like to get John's opinion of where he thinks AT&T Microelectronics might be 10 years from now, whether or not they actually might evolve to be fabless.

Mr. Dickson: I think 10 years out is quite a way given the sorts of decisions we made historically and missed on with a lot shorter horizon. But, certainly the push back that we get from customers would say that to be anything over $700-800 million as a fabless company is not particularly viable. Customers, for whatever reason, at least in our experience, believe very strongly that a semiconductor company supplier of that size has to have, to some extent, its own capability. As far as AT&T is concerned, we would probably see ourselves having somewhere between 60 and 70 percent of customer demand in our own fabs and acquiring the rest on a long-term basis from a foundry supplier.

Question: My name is Bob Felderama from VLSI Technology. What do you think the foundry supply base will look like in five years? In other words, will there be a few players like Chartered and TSMC remaining, or will some of the mainstream semiconductor manufacturers break of and do more foundry work?

Mr. Brooks: My customers talk to more foundries than I do, but I suspect that the foundries — with the kind of growth we've experienced and the expected profitability — will be emulated and there will be a number of people who will come to the foundry business. I think by 1997 there may well be an oversupply of foundry wafers and a glutted capacity based on the interest level that people now have in foundry and some of the installations that are going to place.

Going back to the question before, I'm amused sometimes that since I've had fabs for 30 years now, why people having fabs feel like they have flexibility. During the bad market they're not very flexible because all you do is pay the rent. And during the good market you run what you can out of them, but if you run it very efficiently, you run it 80 to 85 percent, maybe you get another 15 percent. I suggest that some of the companies that are fabless that have dealt with TSMC over the last three years have grown as well as they could have with their own fabs.

Question: Dick Joy from Unisys. I've seen a trend lately in these fabless companies investing into the foundries, and would the panel care to comment on what that will look like in the future?

Mr. Vonderschmitt: I think there are two types of things that have occurred. There's one instance of a fabless company that has actually had equity investments made. That's one set of conditions. There's another foundry company that has asked for advanced payments and no equity investment. I have opinions on both which probably time does not permit to discuss here. We ourselves did not invest, we made an advanced payment. The reason we did that is because of the fact that that deviates from what we had done before, and the reason we did it was because of the fact that it's going to be a unique process, so we needed to have guarantee of supply, and that's what the advanced payments guarantees us. As far as the equity investments are concerned, maybe somebody else here would like to comment.

Mr. Fuhs: Actually I'd like to get Koichi's view on this from another industry that's a little bit more established and a little bit more involved.

Dr. Nishimura: We buy our own equipment, because unless a customer insists on doing it, we have guaranteed a line for a customer, but if he doesn't use it we don't charge him. Basically it look like an insurance, and it seems like when you pay up you're sort of betting, it's a unique process. You're betting your fab that he can't fill the place. That's what it comes right down to.

Mr. Fuhs: So do you think it's good business?

Dr. Nishimura: I think if you're in the business you have a responsibility to use your assets. I'm not sure if you paid somebody or you took payment that you're not mentally geared to use that asset. You're sort of saying I'm scared to do this. If you're the best in the business you ought to be able to fill it.

Mr. Brooks: We've been surprised by people willing to do that. I understand Bernie's rationale because of the process uniqueness and sometimes there's unique equipment that needs to be paid. But I don't find that's a naturally relationship at all. It's like taking equity and putting your customer on your board, and I cannot understand why anybody would want to do that. Also, having a customer who you have taken money from to give him capacity, it just seems like we should sign an agreement that says you'll give him capacity and he'll give you the business, if that's what he wants. It just doesn't seem like a natural relationship to me. We've been surprised people are doing it. I don't think it will last. I think right now it's the flurry of concern for capacity.

Mr. Fuhs: That concludes this panel discussion. Thank you to our panelists.

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Luncheon and Featured Speaker

Funding Opportunities Along the Superhighway

William R. Hambrecht
Founding Partner, Chairman, and Co-CEO
Hambrecht & Quist Group

Mr. Grenier: As you know, we have Bill Hambrecht from Hambrecht and Quist here to give us our luncheon address. Bill is a founding partner and chairman of the Hambrecht and Quist group. H&Q is a banking firm specializing in emerging growth companies. Mr. Hambrecht cofounded H&Q in 1968 with the express purpose of providing investment banking service to small growing high-tech companies in Silicon Valley. This strategy has given H&Q national prominence as an investment banker and underwriter of emerging small companies and small companies with high growth stocks.

Bill developed H&Q's venture capital business, ultimately overseeing nearly half a billion dollars of placements in companies such as VLSI Technology, Xilinx, Evans & Sutherland, Adobe Systems, and Sybase, just to name a few. Today, Bill manages all of H&Q's venture capital activity and H&Q's Asia/Pacific offices, and he is involved in the firm's investment banking operations.

Besides his love of finding and building new businesses, Bill owns a winery in Healdsburg, loves gardening, and raises orchids as a hobby. There is an interesting parallel here; Bill loves to help business grow and flower, and he likes to help his garden grow and flower.

Today Bill will talk about funding opportunities along this information superhighway. Please welcome Bill Hambrecht.

Mr. Hambrecht: Thank you very much Joe. It is a real pleasure to be here. First of all, I feel very awed and humbled by the subject that I've been asked to speak on today because I know there are people much more qualified than I, in this room and elsewhere, to speak on some of the most challenging technical decisions and technical issues that this engineering community and the United States has ever had to make. So I thought I ought to start with a disclaimer that I am looking at it, and approaching it, from the point of view of a venture capitalist. I also mean this from the point of view of investing because there are lots of investment opportunities in publicly traded securities and in the larger companies; but today, I'm approaching it from a venture capital point of view.

So as such, I thought I would first of all open with just a few words about venture capital. I know a group like this knows all about venture capital; it has been intimately involved with the semiconductor business since Art Rock put up the money for Bob Noyce, and it has gone hand-in-glove with the great growth in the semiconductor business. But I think over the years, venture capital has evolved into something that is somewhat different than it was 25 or 30 years ago.

U.S. Venture Capital

1950s – 1960s		1970s – 1980s
Family Wealth	→	Institutionalized
SBICs		Professionally Managed
Small Partnerships		Focused on Technology-based Industries

Fueled by:

- Explosive growth in technology
  - integrated circuit/microprocessor/PCs
  - biotechnology
- Institutional framework
  - NASDAQ (1970s)
  - ERISA (1976)
  - Capital Gains Tax (1978)

Figure 1

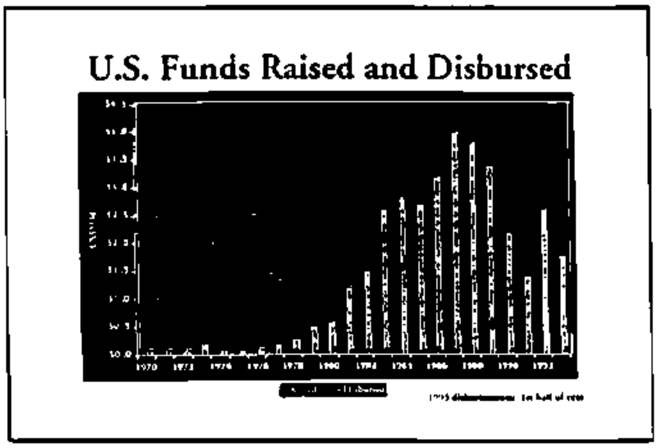

Figure 2

First of all, every time I talk about venture capital, I like to go back and emphasize that it has been a rather unique phenomenon based on a technology revolution that occurred within our economy. The integrated circuit, as you all well know, created a revolution that created a whole new industrial segment of our economy. You can get lots of different numbers; it can be 12, 14, 15 percent of the economy, or whatever. It is a new industry that was not here 50 years ago. The biotech industry was a new industry that was never here before. When you have technology revolution that creates new industry, you have very fertile ground for venture capital. This is what made, I think, venture capital so unique and profitable through various of its cycles. It also was aided and abetted, I think, by a rather institutionalized flow of money that really came about through some very farsighted legislation and farsighted people in the equity business.

First of all, NASDAQ, which has become a pretty unique American system that is now being exported, provided a marketplace for early-stage securities. It allowed venture capital to liquefy their holdings and, in effect, recirculate the money. It allowed the Intels of the world to go through equity markets that were equal to the major big companies and raise the kind of capital it needed. There was ERISA that allowed pension money to flow in, and there were capital gains taxes that were lowered. Lots of things created a big capital pool.

The offset to this, and the thing that has changed, I think, is that this great big venture capital pool is largely institutionalized; whereas, in the seventies, it was largely individuals and family funds. In the late seventies and eighties, there was a big flow of money that came into venture capital largely from pension funds or other institutional fiduciary-type managers. It provided almost a classical example of what is called the price theory of economics. This, incidentally, is the basis of the University of Chicago Business School. What it says is that whenever returns are abnormally high, it will attract money until the returns are driven down to normal and that is exactly what happened in venture capital.

During the seventies, people in venture capital earned huge returns; large amounts of money flowed in and ultimately drove these returns back to normal. I remember only too well, in the early eighties, rationalizing this away. We knew the money was coming in, and we knew that it would become more competitive, and we sort of said, if we keep our pricing discipline and if we have a pretty good position in the deal flow world, we should do pretty well. Well, in reality what happened was no matter how well you did or how good you were at it, there were too many companies formed in each niche.

It dawned on me very clearly with a company called Alliant Computer. I don't know if you all remember Alliant, but it was a classic VC model; our partners were Rockefeller and Tom Perkins. We raised plenty of money for them. They came out of DEC and Data General, they stayed right on schedule, they came out with a marvelous machine on spec, on schedule, and we brought the company public. I think two weeks later Convex came out with essentially the same machine, and it turned out there were seven others right behind them and ten others behind them. So instead of having that time when you could have a real run and get the profitability to establish yourself, all these companies were in a pricing dog fight almost from the beginning. So as a result, people started getting nervous; the money went down and returns have normalized.

I look at the market right now as somewhat in equilibrium, where returns are probably reasonably normal, or will be normal; the flow of funds is being absorbed without a lot of extra stimulation. So right now it looks pretty good, but it will be driven by rate of return. As long as it is driven by rate of return, I think you are going to have a marketplace and you are going to have people who practice venture capital in a different way than the Art Rocks of the world did.

They will be much more conscious of reporting responsibilities to fiduciaries; they will be much more conscious of having to get a rate of return quickly, and there will be less risk taking at first. Because in the institutional world, it is pretty hard to get up there and say, well remember that great deal I told you about six months ago, write it off. It is a hard thing to do. So most of this money, I think, is moving more toward backing things that have already started and that have good momentum.

"Others go where the puck is.
I go where the puck will be."

- Wayne Gretzky

Figure 3

What does this mean? Well, I think the really great venture capitalists, the Art Rocks, the Tom Perkins, Reid Dennis, had sort of an intuitive feel for where to go with the money. I know this quote I always loved. Somebody asked Wayne Gretzky one time, "why are you so much better than the other hockey players?" His answer was, "I go where the puck will be." I have a strong feeling that in the world we're in today, most of the institutional money tends to go where the puck is right now. The people who are willing to take the risk of failure, by going somewhere before the puck moves there, are fewer and fewer.

Information Superhighway

"Provide <u>easy</u> access for the <u>entire population</u> to the tremendous information bank civilization has developed."

Edgar A. Sack
Chairman & President
Zilog, Inc.

Figure 4

So we've had a rather difficult time figuring out how do we deal with this information superhighway? It is not a secret. You can say everybody knows where the hockey rink is; it is pretty obvious who the team players are; it is a little less obvious where the puck is going. So we sat back and said okay, how should we invest in this? First of all, in trying to define what the information superhighway is, you know you'll get lots and lots of interpretations. I mean it's multimedia, it's news media. It's interactivity, it's whatever. I thought Ed Sack came up with a very good definition that I saw recently in an article, a very good article, that he wrote on this subject. What he stressed were two things: the word <u>easy</u> and the <u>entire population</u>. I think this, in our minds, said what we're really looking at is a consumer marketplace.

You know, we've all grown up in a technology world where if it's smaller and faster and cheaper, someone will buy it and the business model will work. The consumer world is different. The people at Procter and Gamble don't necessarily come up with smaller, faster, better. They come up with perceived value. So it is a whole different marketplace. So as we sat back and said, okay, how are we going to deal with this consumer market? It occurred to us, of course, that this was a world that we had very little familiarity with.

Odyssey Survey:

- Enthusiasts
  - Cutting edge of technology
  - Watch less t.v.
- Hopefuls
  - Important to master new technologies
  - Lack economic and educational means of ENTHUSIASTS
- Faithfuls
  - Not eager to embrace new technologies, but not averse to it
- Old liners
  - Not really interested in learning to use new technologies
  - Heaviest t.v. watchers
- Independents
  - Demographically similar to enthusiasts
  - Lead lives in which t.v. and technology are not particularly important
- Surfers
  - Able to use and afford new technology, but are ambivalent to it

Figure 5

So one of the first things we did was to back a venture, a couple of people out of Yankalovich who wanted to form a company devoted to consumer sampling and consumer research for this new multimedia or information superhighway subject. They got started with a series of focus groups with over 4,000 people participating throughout the country, and what they found was that the typical demographic breakdowns that you usually use in studying a consumer market did not hold when it came to interactive TV, or information superhighway, or multimedia. Instead of categorizing people by income, by age, or by education, it made a lot more sense to categorize them by attitude, and these were the groups that they finally ended up with.

It costs a fair amount of money to get the survey to tell you how much is in each group, and I can't do that openly, but I think the interesting thing is that most of us, and when I say us, I assume most of us have some contact or relationship with Silicon Valley, most of us are in the enthusiasts; certainly if not there, then in the hopefuls or independents, whereas the rest of the United States has a lot of people out there who will not automatically adopt the newest, brightest technology.

Top Motivators

- Customization
- Price
- Service
- Privacy
- Programming

Choice - Control - Flexibility

Figure 6

Several things I think came up that were extraordinarily interesting. First of all, the top motivators from this group were significantly different than I think a lot of people thought. First of all, customization. One of the more interesting statistics that I saw when I was looking at this survey, was what had happened to the networks over the last 15 to 20 years. In 1978—1979 the three major networks in the United States had 91 percent of prime time viewing for the entire country. Last year in 1993—1994, these same three networks had 61 percent of prime time. Clearly there had been a big switch as people had the option to customize what they were going to look at as cable came in and expanded the opportunities.

The second thing, of course, was price. The price attitudes were again a little different than we had probably guessed. It wasn't so much absolute cost as relative value. There is a fair amount of anger out there about what happened with cable. I don't know about you, but you know, and this has also hit on service, the cable companies have a mixed reputation for service. A lot of the cable was sold to the original customer on the basis that you were eliminating advertising, and now advertising has crept in, so there is a feeling of having been had a little bit. So that is out there and has to be dealt with.

Privacy. Surprisingly important, from the point of view of putting your credit card number into a system or, not only that, getting on some marketer's list for telemarketing because he knows you look at certain kinds of TV programs. Finally, there are a lot of different attitudes about programming, but clearly people want more and are demanding a wider variety.

Executives Underestimate:

- The ability to customize what comes into the household through the television
- Concerns about violations of privacy
- The ability to obtain telephone and cable tv service from the same provider

Figure 7

Executives Overestimate:

- Home shopping
- Video game networks
- Lower absolute cost of television services -- compared to executives, consumers place less emphasis on absolute cost and more emphasis on value
- The basic desire for interactivity, per se

Figure 8

Conversely, when this firm did the same kind of focus group work on the executives that run the major companies that are in this business, there was a real dichotomy. What they found was that the executives underestimated the customization issue. They did not think it was as nearly as important as the consumer did. Privacy and the provider of the service, these were things that were more important to the customer, that at least was perceived by management. They overestimated the home shopping, the video games, and the absolute cost, but perhaps most important, overestimated the basic desire for interactivity. This is the buzz word that's driven everybody, and what has come back so far is that this isn't as important to the consumer as most people in the technology world thought it is or ought to be.

Now you can argue about this in a lot of different ways, and when I've talked to some of the executives who run these different companies, a good number of them will come back and use the example of color TV and they will say, "Look, when color TV first came out there were lots of consumer surveys and the consumer surveys said people didn't want it, and you know within a few years, it just swept over the whole consumer marketplace." So there is still a deep seated desire, I think, on the part of a lot of players in this business, to find what they call the killer app, the killer application, the one application that will sweep everybody towards a strong desire for interactivity or for any part of this multimedia.

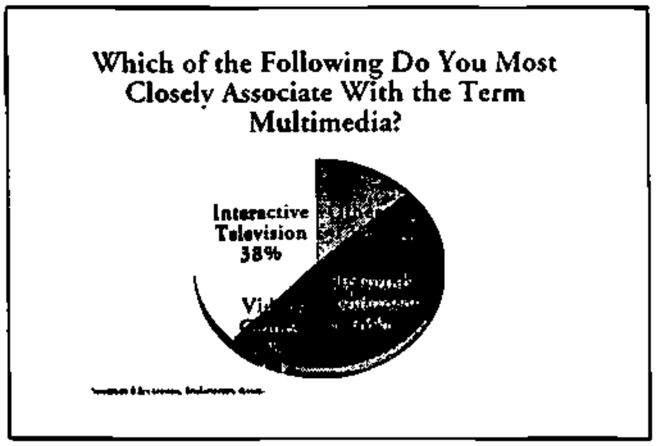

Figure 9

They may be right, who knows, it may happen, but our feeling was that the issues that were commanding so much attention within the technology world perhaps weren't as important to the consumer as we thought. For example, a great deal of energy is spent on trying to decide who is going to control the delivery pipeline. Is it going to be the PC? Is it going to be a set-top controller that allows your TV to be interactive? How are you going to get at it? I think what we found is that there are probably going to be a variety of ways.

From an investment point of view, we decided that the best way to approach this was almost to say, we don't care who wins. The stakes are huge to some of the companies that are vying for this position, but when you look at what we think is going to happen out there in the information superhighway, how it gets there is less important, I think, than what it is that you're delivering. So we looked at it and said, okay where are we going to go?

Key Investment Issues

- Consumer Market vs. Technology Market
- Evolutionary process
- Who will pay?
- Different skill sets
- Network

Figure 10

First of all, we came to the conclusion that it is a consumer market, not a technology market, and that says it is going to evolve much slower than the technology worlds that we're so use to, where suddenly you get a break-through product and it gets accepted almost overnight. We think like other consumer markets, this will evolve slowly over a period of time. It is interesting to look at the cable market; it has really been out there for 25 years and even today their market share is about 66 percent. So I think no matter what happens, this will move along in an evolutionary process.

There is a big issue of who will pay because, again, one of the basic things that came out in all these surveys was that people are very concerned about cost and want to really realize what real benefit they get if it is going to cost them more. Again, with our background in Silicon Valley and the life we lead, we have to remind ourselves occasionally that the average annual income in the U.S. is under $38,000 per household. When you get into some of the cost calculations that a superhighway is going to need to get up there, there is a lot of cost that is going to have to get absorbed by somebody and, at least at first blush, there is going to be real resistance to passing it directly on to the consumer.

There are going to be different skill sets that are needed. Marketing to consumers is a whole different ball game then selling computer programs. It is a different set of skills and it will take different kinds of people.

Then finally, what network will come out, will it be the current cable networks, will it be telecom, will it be modems on PCs? Lots of issues, but our feeling is that there are going to be a variety of ways of doing it, there is going to be no one simple clear answer. When we finally went through all this, we came back and said okay, what we want to invest in are companies that are developing niches and that are developing parts of the highway and are doing it in a way that they are not going to go bust if this thing doesn't happen overnight. It is going to be an incremental development and we want to be invested in companies that will participate incrementally. That also says don't put your big bets on the all-or-nothing super applications type of things, and that's essentially been our philosophy.

Enabling Technologies

- Servers
- Network telecommunications
- Compression
- Enabling software

Figure 11

We tried to break it up into some pieces that we thought would make some sense. First of all, we looked at what are the enabling technologies that are going to be needed to bring the superhighway and to bring multimedia available to everyone. This is a world that we're probably all much more familiar with and much more comfortable with. It is the classic venture capital PC model. It is the sort of thing where we all rely on increasing computer power. I think Gordon Moore's law will hopefully continue, and every 18 months we'll get a doubling in computer power, and it is going to allow the tools to attack some very difficult issues. Because, I don't mean to minimize them, I mean real time video takes up an awful lot of bandwidth, and there are going to have to be big technical steps and big breakthroughs. So we're assuming that with the basic drive in the semiconductor business, with the creativity that is probably sitting right here in this room, the answers will come technically.

We have ended up investing in this area and looking at this area very much the way we did the PC and computer business. Who's in front? Who's had the experience in developing these certain technologies? And, probably even more important, who's going to end up in a business that won't become a commodity where you'll have some price protection? So the investment patterns that we've had in this area, I think, are all pretty much based on this sort of principle that we've used in our venture activity in the past.

Distribution Companies

- Cable
- Telephone companies
- Satellite
- Wireless

Figure 12

The distribution companies are something different. Here you really have the big guys, and that is where it gets scary. We have billion dollar, five billion dollar, ten billion dollar mergers on and off as these people maneuver for position in terms of who is going to own the platform of the information superhighway. It is hard to imagine a role for venture capital in this. Maybe in some of the wireless areas there may be a way, but on balance, this is a world where you have big players with big balance sheets and big bankrolls and a willingness to take big risks to establish their positions, and it is hard to imagine where we are going to end up here.

Content Providers

- Applications
  - Banking
  - Publishing
  - Health care
  - Shopping
- Entertainment
  - Video games
  - Video on demand
- Educational

Figure 13

The content providers, though, are a different story because in my mind, to a great degree, this is a lot like the software opportunity of 10 and 15 years ago. What you have is a huge marketplace growing exponentially every year in users, reasonably low manufacturing costs — you know the wonderful 90 percent gross margins of software make it a very unique business, not a lot of capital needed usually to get your product up and out there — and a very attractive place to invest money if you can be successful. So we've broken it up into really three areas.

The first area is applications and here, I think, this part of the business is driven by an intuitive knowledge of the industry that you are serving. It is interesting when we look at the companies that are in there. The really successful ones in one form or another came out of the industry that they are serving. It is not as technology-driven as knowledge of what the customer needs and wants that's driving that business.

Entertainment is a little different. Again, if we're looking from a point of view of a venture capitalist, this is a new world to us. I was kidding our guys in our group and said, you know if we really get in here, we're going to have to change the cut of our suits and get new lawyers because there is a whole methodology and practice that has funded, for example, the film business. It is difficult to deal with if you are a venture capitalist who comes out of the technology world, but there is opportunity there. I think there the key is obvious again, it's this intuitive feel that someone is going to have for what consumers really want. These people are in great demand, obviously, in the entertainment business, but I think there are going to be slices of this business that are going to be interesting.

Finally, I think the educational world is going to have lots of opportunities. There I think it's going to be more perhaps revolutionary, because there I think you are going to be attacking or changing the basic way people are educated. So there is going to have to be some real innovative thought and it is going to have to come from people who really know how to teach and who question the product that we have today.

Investment Implications

- Enabling technologies
  - Usual v.c. Model
  - Software?
  - Adobe model
- Providers
  - Stakes are high
- Applications
  - Education
  - Financial services
  - Publishing
- Content providers
  - Different culture
  - Marketing

...

Figure 14

Multimedia Takes Many Forms

Year	Computing Platforms	Authoring Software	Video Products	Audio Products	Animation Software	Total Rev. Forecast
1990	85%	6%	1%	6%	2%	$3
1993	69%	8%	9%	10%	3%	$5
1996	58%	10%	19%	10%	4%	$14
2000	57%	11%	21%	6%	5%	$22

Figure 15

It is worth looking at because if you look at that last column, there are some big payoffs. We're talking about revenues in this multimedia definition moving to over 20 billion dollars. If you look carefully at those columns, you see what might have happened in the computer business 10 and 15 years ago, more and more money going into the software or creative side of the equation, and the computing platforms and the hardware platforms taking less of the dollars. So we think the opportunity is there, and it is worth working for and looking at.

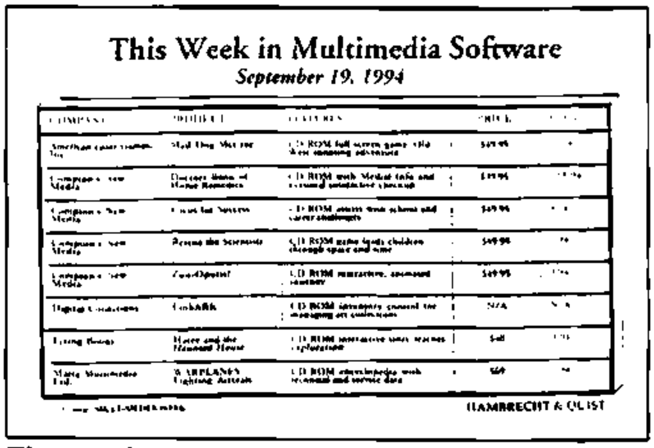

Figure 16

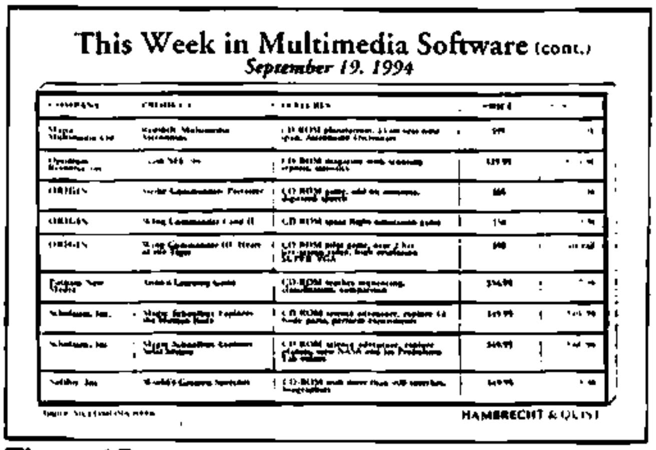

Figure 17

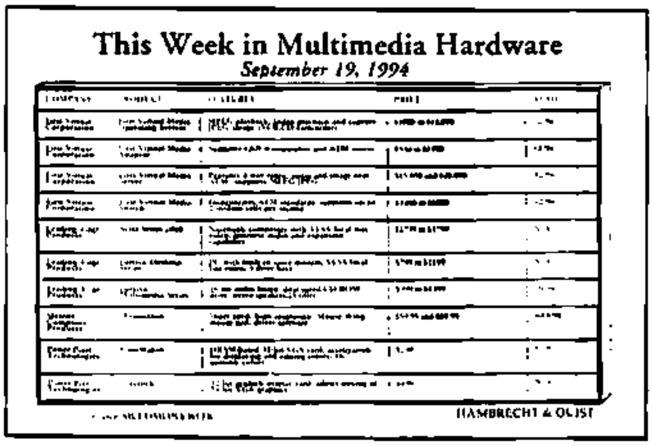

Figure 18

For example, when we look at what is multimedia today, the CD-ROM business is a business that is starting to grow and this is almost today's version, I think, of what multimedia will be eventually. If you look carefully at them, what you see, you see games, you see education, you see books, you see a very interesting collection of products, and the thing that is really interesting to me is that so many of them seem to be done by people who almost developed these programs in a vacuum, but these are not the major consumer companies manufacturing this product. These are technology-driven companies for the most part who are manufacturing this product. I think ultimately what you are going to find, when you get out to thousands and thousands of titles, is its going to be like the book business or the movie business. There are going to be some that work, some that don't, and there are going to be people that know how to make that selection. So we think this whole business is going to become more and more driven by people who understand consumer marketing.

New Media Investments

- On line services
  - America Online
- Network telecommunications
  - AFC
- Compression
  - C-cube
- Enabling software
  - Verity
  - Dataware technology
  - Saros corporation
  - Peerless
- Content
  - Axcis
  - Preview media
- Applications
  - Cascade systems
  - ESPS

Figure 19

Finally, one of the basic premises I've always used when we generalize is, okay, it is one thing to give an overview and a general investment philosophy, it is another to sit back and say, okay, are you doing what you say and are we following what we said we were going to follow? It has been an interesting pattern. First of all, when I first put this slide together, I didn't have America Online on it and my partner, Dan Case, who is now the president of H&Q, almost took my head off because, as he correctly reminded me, we were a startup investor in the company that has become America Online. We, unfortunately, didn't recognize it as perhaps the opportunity it was, so we weren't the largest investor or the most aggressive, but Dan keeps needling me because his brother is the president of America Online. So America Online is now on the list. Seriously, we have been lucky in a lot of our investments, ending up with some pioneers who led us into new areas, and we were very fortunate to have that early relationship with America Online.

In the network telecommunications area, one of the things we've done recently is a company called AFC (Advance Fibre Communications), and this is an example of what we really like to see or try to find. Again, we backed a man who had been one of the industry experts in digital loop technology for the telecom industry, and he came out and started a new company developing a digital loop technology for rural telephone areas, a market that the big guys had not pursued. We did it not because we had any insight into where it might go, but because we knew Don Green, and we had respect for him and our analyst said, hey this looks like a pretty good idea.

Well, what's happened is that Tellabs, one of the major telecom manufacturing guys, has come to AFC. They formed a joint venture, and they're manufacturing a product now that will give the cable companies the capability of delivering telephonic services to their users through their existing network. Again, I wish I could I tell you we saw it coming, but when you do bet on the technologies that are moving things ahead in certain niches, these are the niches that are being grabbed and where the opportunities are being taken in developing this whole information superhighway.

Again, we were very fortunate in that we have a very long and close association with Adobe, going back to its early founding. Adobe, about four or five years ago, made a big bet on a technology they now call Acrobat, which is essentially a technology to provide platform-independent, graphics-sensitive, interoperative ability. In other words, it allows you to transfer any digital document with graphics on any platform to anybody else's platform. It was a big step, and in doing that they had to adopt a lot of other technologies that were out there, so we went in and invested in a number of them, like Verity and Saros Corporation, who in effect now have developed part of the Acrobat system. I'll skip down to applications from that.

We ended up with a joint venture with Adobe where we invest money now, jointly with Adobe and companies that are either going to be part of that platform or are developing applications on Acrobat, and so, there are Cascade and ESPS, for example. Cascade is a pre-press software capability allowing people to develop a pre-press capability of editing newspaper on Acrobat, and ESPS is a group of people out of a drug company that are developing a system to allow the computerization of the entire FDA filing process, which is an enormous document-intensive job.

Then finally, we get to content, and this is going to be the hardest thing because this is where we're really out there in a world where it is very new and different from what we're used to. I won't go into all of them, but AXCIS is an interesting one in that it is sort of an electronic daily racing form that has developed a few algorithms that allow horseplayers to take all the data and come up with various strategies for betting, we'll see. Anyway, it is hard to decide how to go about that.

Where are we going in the future? Again, we're looking at lots of things in these various categories. We keep looking for unique approaches that are either developing very interesting content or perhaps have a different twist to it. For example, one idea, when you look at the cost question here of who is going to pay, it is clear that there is probably a big opportunity to develop equipment for the advertising industry, allowing them somehow or other to get their message into these new delivery systems in an economic way. So there are lots of opportunities, they are just a little different.

"Start with a growing market; Swim in a stream that becomes a river and ultimately an ocean; Be a leader in that market, not a follower; and Constantly build the best products possible."

- Robert Noyce, Founder of Intel and Fairchild Semiconductor

Figure 20

Finally, the reason we keep looking is that we are convinced that this is truly a growing market that is starting to become a river now or a stream and, ultimately, will be an ocean. Will we find an Intel that can navigate the whole way? I doubt it, that's probably once-in-a-lifetime. You are going to see something like that, but there are going to be an awful lot of other companies that will be swept along by this stream, and it opens up enormous opportunities to develop very good businesses that may ultimately become part of something else, or may ultimately develop into a big standalone business on their own because this is what a venture capitalist is supposed to do, I think. He should be the capital partner for business, to give them the capital and, hopefully, some help in becoming a standalone business that can grow and prosper in the future. Thank you very much.

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Can the Chip Market Live Without the PC?

Gregory L. Sheppard
Director and Principal Analyst
Semiconductor Application Markets Worldwide
Dataquest Incorporated

Dale L. Ford
Industry Analyst
Semiconductor Group
Dataquest Incorporated

Speaker: Our next speaker is Greg Sheppard, who you know from this morning, and Dale Ford. Dale is an analyst in the same service and works very closely with Greg Sheppard. In fact, they work so closely they couldn't decide who should give the speech, so they are both going to give it this afternoon. Dale and Greg's speech will be a forecast of the electronic equipment market with particular emphasis on the very hot areas that are driving the semiconductor industry.

Mr. Sheppard: Good afternoon, I'm glad to be back here again, and I would like to introduce Dale. Dale why don't you say something.

Mr. Ford: It is good to be with you today. Greg and I kicked around the title for this talk a little bit. It is always challenging to come up with something that might be entertaining, amusing, and make a point. In light of some of the information we received on investment in fabs in this conference, we wondered about a title along the lines of that movie with Kevin Costner, *Field of Dreams* or *Fab of Dreams, If You Build It, They Will Come.* However, we settled on something a little more mundane, *Can the Chip Market Live Without the PC?*

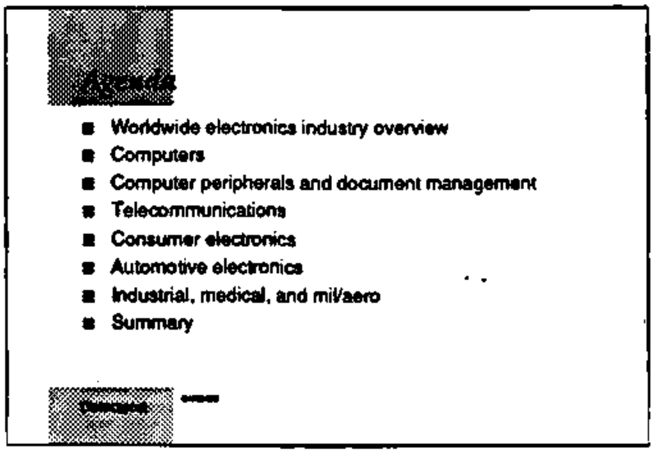

Figure 1

Mr. Sheppard: Our plan of attack is to start out by giving a general overview of where we see the worldwide electronic equipment market going; the overall macro envelope that's going to pull all these chips and drive profits and revenues. We are then going to take a walk, quickly, but hopefully in a strategically entertaining manner, through the various key uses of semiconductors, which are computers, computer peripherals, telecommunications equipment, consumer, automotive, and a quick look at industrial, medical, and military/aerospace, and then we'll wrap up with a few comments at the end.

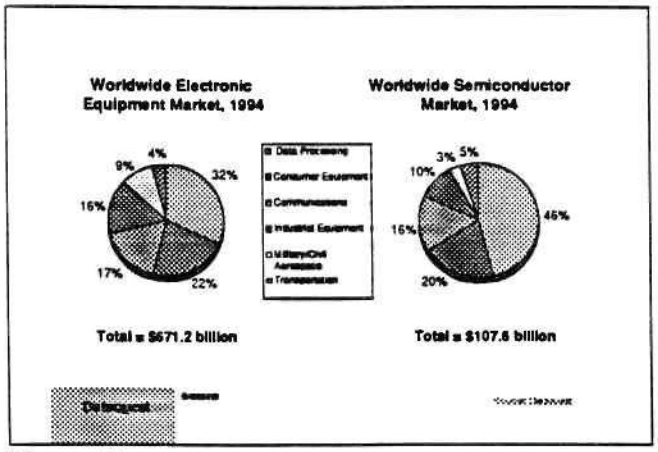

Figure 2

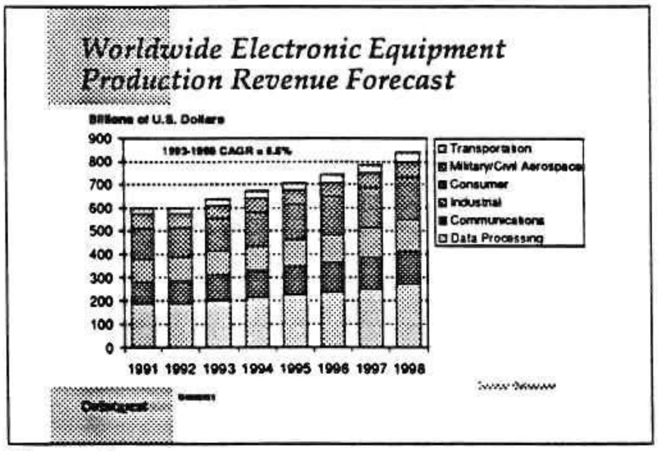

Figure 3

The worldwide electronic equipment production value for this year, we're estimating, is going to come out at $670 billion. If you look at it from a macroeconomics standpoint, what's produced in North America is 3 percent of the GNP; a similar number in Europe, and if you move over into the Asian countries, it's up in the 10 percent range depending on the country. Clearly the largest area in terms of electronic equipment is the computing area. In general it is permeating into a lot of the other areas as well. Computing, along with communications and consumer, comprise roughly two-thirds of the overall electronic equipment production area.

When we overlay on this the chip demand accounted for by these equipments, we note the semiconductor richness of computers. The data processing area does include storage systems; I/O systems like printers; and office automation, such as copying machines. These applications all together account for nearly half of the semiconductor market and then, along with communications and consumer, we have roughly three-fourths of the world semiconductor demand.

After struggling with a global recession in the 1992 time period, as far as the electronics business was concerned, we've seen steady growth kick in again. We are looking at a compound annual growth rate of 5.6 percent out through the 1998 time-period. A lot of people ask us the question, "Well how can the equipment area be growing at 5.6 percent and the chip growth be up in the high double digits?" Well, that basically has to do with the pervasion of chips into these markets, and all you have to do is just look at the chip content of your basic PC to get an idea of that. A more hidden use of chips is for something like a washing machine where chips are replacing what motors, gears, and pulleys used to do.

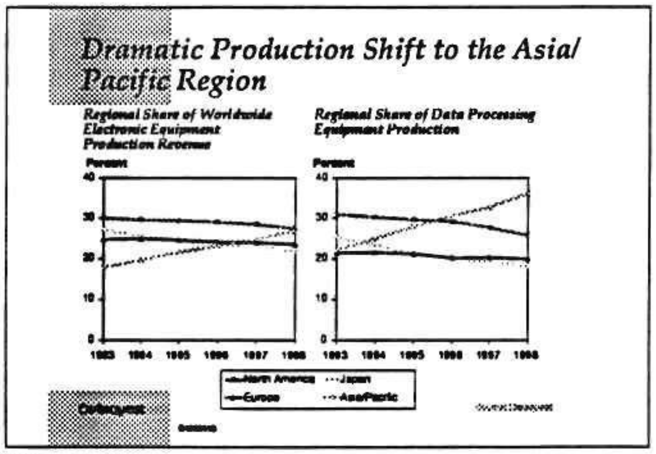

Figure 4

North America, we are predicting, will remain the predominant producing region for electronic equipment. We are not projecting a very dramatic impact of such trade agreements as NAFTA at this point in time. Europe will also stay in there, primarily producing locally in that region to serve the local markets. This seems to be the main thing we're seeing. Flexibility for local markets is typically what keeps electronic producers producing in a region and less so concerning such issues as labor content much to, I think, a lot of people's surprise.

This overlay shows the impact of Asia/Pacific. We are projecting that it will rival North America in production volume by 1998. In fact during 1996, it will become the largest data processing equipment producing region in the world. This is primarily due to two factors, which Dan Heyler outlined yesterday, and that has to do not only with being a contract manufacturer, if you will, to the rest of the world, particularly Japanese and American electronic OEMs, but, in fact, serving their own indigenous high-growth economies. That seems to be more and more of a predominant factor as time goes on.

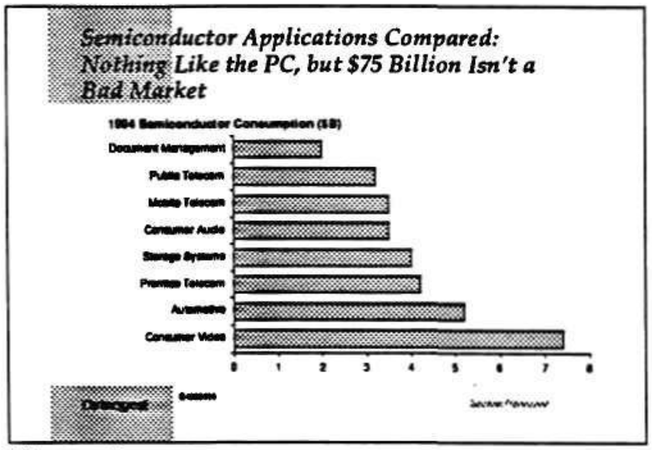

Figure 5

We spent a lot of time talking about the PC market, sometimes, in my view, maybe too much time. As it turns out, there is another $75 billion worth of chip consumption, using 1994 numbers, that is accounted for by non-PC applications. Here are a few of them: Consumer video; automotive; premise telecom, which are things like local area networks and modems and so forth; and storage systems lead a list of multibillion dollar chip opportunities. A 10 percent market share in any one of these will do just fine for just about any company out here. So I think it is really important to keep in mind the pervasiveness and the breadth of how chips are used. It makes Dale's and my job very difficult and very challenging to keep up with all this, but we are doing our best.

Mr. Ford: Well, while we may spend too much time talking about PCs, lets talk about them just a little bit longer. First of all, I would like to talk for a moment about some of the forces and opportunities we see driving this market to a 15 percent growth rate.

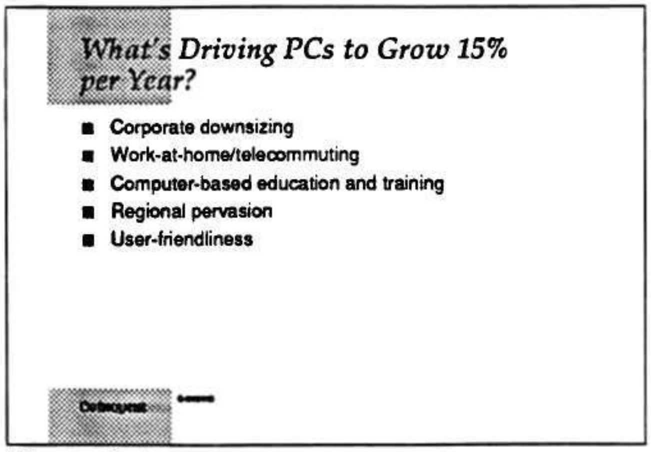

Figure 6

On top of that list, we would place corporate downsizing. Pick your favorite word, re-engineering, whatever, but companies are growing smaller. Working to make the most efficient use of their resources, large companies are now downsizing their work forces and investing less on the labor expense side of the sheet and more on the capital investment side of the sheet. Also, they are moving from mainframes to networked PCs to meet their computing needs.

At the same time, we see these work force adjustments taking place in corporations, we see increased entrepreneurial activity. More startup, small business opportunities driving the small office/home office type of environment is increasing also. All of these home offices are being equipped with a PC, a fax modem, a copier, cellular telephones, pagers, and so on. You could go on with that list, including equipment such as printers, and on and on. All of these home offices are benefiting from the new technologies that are being developed.

Companies are finding incentives from a number of areas to encourage employees to work at home. First of all, governments: They don't want us all on the roads, traveling back and forth, clogging the roads, creating problems for their infrastructure, and creating pollution. If they can encourage us to stay at home, they would love to do that. So we see a trend toward governments promoting telecommuting. Governments are beginning to provide some incentives to help companies in this area; perhaps they've provided more penalties at this stage, but we see various proposals now coming up to provide tax incentives.

Companies also see benefits to downsizing their physical plants. With the capacity they have to put in and the rents they pay for offices, companies see incentives to encourage employees to stay home. This helps companies to reduce and to make more efficient use of their resources.

Also, surveys that Dataquest and other organizations have done show that workers become more productive when they are given telecommuting opportunities. Workers are more willing to work longer hours and weekends if they don't have to spend extra time on the road commuting to work.

Computer-based education and training: This has been mentioned before in a number of presentations. We need to move beyond observing what is simply taking place in the corporations or even at the university level, and think about what can happen in the high school, middle school, and grade school level. In fact, the home will be a definite factor in computer-based education and training. Many, many parents are anxious to provide their children with the best education opportunities possible. The multimedia computer going into the home is filling education, entertainment, and information needs in the home. With PCs going into the home we have younger and younger children becoming PC literate. We have three-year-olds going into the computer room, getting up and running, and thanking their parents if they leave the room and not bother them while they work on the computer.

Moving on to regional pervasion. We're not just talking about PCs moving into the Asia/Pacific region. Now, we're looking at the opportunities in other countries: Eastern Europe, Latin America, and other regions where PCs are beginning to penetrate.

Finally, user friendliness: Perhaps the most concise way to put this would be "Windows" and what it has done for the PC and the PC boom. Every time a product is made more user-friendly, it stimulates the semiconductor market in two ways. First, we have new entrants to the market because we capture that all important consumer. So the market itself grows, but products require more powerful semiconductors to help make them more user-friendly. It would be a difficult thing to have "Windows" if you didn't have the 386 processor and the required amount of memory. So the semiconductor market receives a boost in two ways when more user-friendly products are developed.

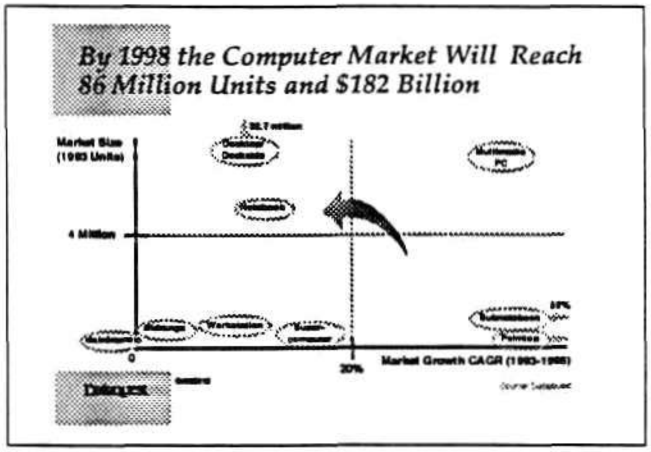

Figure 7

I would like to take just a moment here to give you the lay of the land on this chart. We have tried to provide a summary for a number of the markets we will discuss using this type of a chart. So I'll just take a moment to outline some of this for you, and as was done earlier, I will make a feeble attempt at the John Madden mode.

Along the Y-axis we've plotted the market size in 1993 units for various products. Along our X axis here, we've plotted the market growth that we're forecasting for the next five years, out in the '93-'98 timeframe. Then here, in some instances, they're just off the chart. If we look at the desktop/desk-side PCs, with 32.7 million shipments, we put an arrow at the top to indicate that we might go up a couple of stories to plot that. Subnotebooks and palmtops would be on the other side of the stage if we plotted those with their higher growth rates. The ideal situation would be where we're moving from the high growth areas up through the high volume areas where the profits and the revenues are generated for reinvestment back here into the next generation of products. So here we see the mobile impact with the subnotebooks and the palmtops as emerging products. And what was described most capably in the last presentation, the multimedia PC here in the sweet spot, still enjoying the high growth and the relatively high volumes in the market. You definitely do not want to fall back on this curve, toward the mainframe range. We are moving toward a market of 86 million PC shipments and $182 billion in revenue.

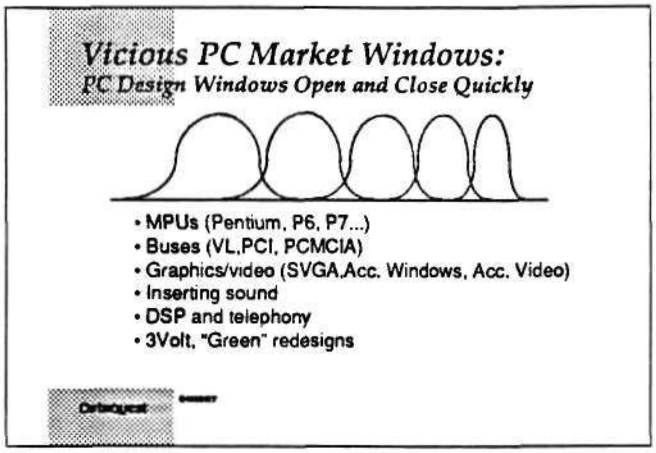

Figure 8

While this is an exciting market, it can be a vicious and challenging market as well. The product window opportunities are becoming more and more narrow all the time. Going from the two-to-three year window of opportunity to the six-to-nine month window of opportunity. Technology vectors coming from all directions are making these windows even smaller. Here we have put together a partial list of the various technologies that manufacturers and designers use in attempts to differentiate their product and to be successful in the market, but each one of these, as they are implemented on the next generation, creates a smaller market window.

Yesterday, just to take an example, we looked at microprocessors and Jerry Banks, our microcomponents analyst, explained the changes that are taking place simply with the Intel processor. We have moved from the seven year start-to-peak-production period for 286 processors, to a three-year span for the Pentium processor when it reaches peak production. And we can go down the line and see the other technologies that impact product windows, through the buses, with issues around standards that are employed in graphics, video, and sound, to the 3-volt designs with power consumption and mobile issues.

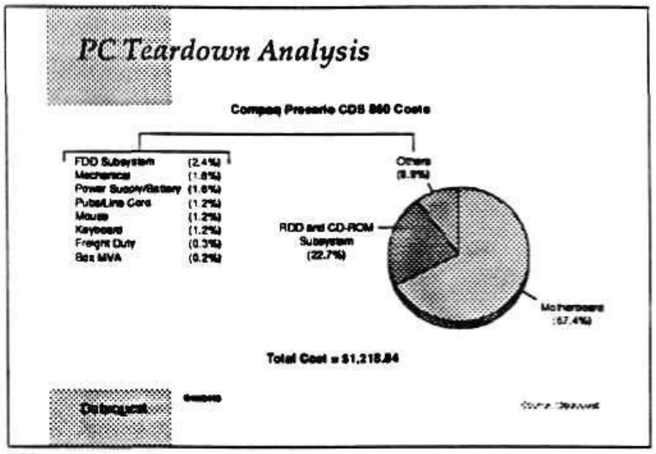

Figure 9

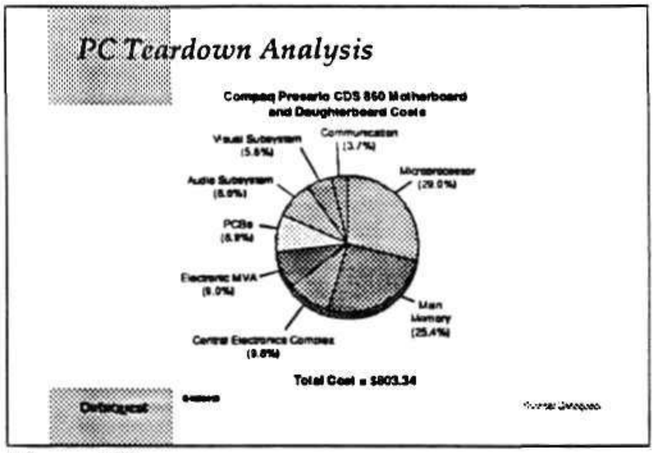

Figure 10

At Dataquest we have started an ambitious project where we are tearing down a large number of PCs. We are able to gain more accurate information by going inside the box and doing very detailed analyses of where the cost comes from to manufacture these PCs. The reports that are generated from this project have been mentioned earlier, and we have a table in the lobby where we invite you to look at some of these reports. Let's look at an example from one of these reports, the Compaq Presario CDS 860 from the multimedia line that was launched recently by Compaq.

Let's take a macroview of where the opportunities and costs are inside this PC. Here we look at the motherboard and see almost two-thirds of the cost going into the motherboard and the daughterboards in this system. Another 23 percent of the cost is from the storage for the rigid disk drive and the CD-ROM. All other costs in this system are less than 10 percent of the total cost to manufacture this PC.

Now, if we will break out this blue portion of the pie, the motherboard and daughterboards, and take a closer look at these costs. Not surprisingly, we see the microprocessor with almost 30 percent and the main memory with 25 percent of the cost. Over half of the cost here in the electronics portion is represented by the microprocessor and the main memory. However, to emphasize part of our presentation title, I would be very happy to take 5.6 percent or 8.6 percent for the visual subsystem and the audio subsystem opportunities in multimedia PCs.

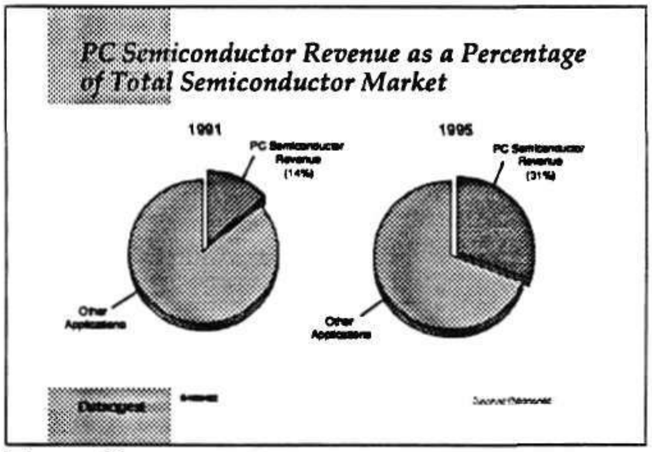

Figure 11

We want to highlight the impact of semiconductor revenues coming from the PC market on the total semiconductor market. We note that between 1993 and 1994, if you looked at the increase in the consumption of semiconductors going into PCs, this represents almost half the growth in the semiconductor market during that year. While I'm on that point, I'll point out another trend that shows the importance of the PC to the semiconductor market. We go to 1991 and we see roughly 14 percent of all semiconductor revenues were derived from PCs and applications in PCs. With the current trend, that's going to grow to almost one-third of all semiconductor market revenues by 1995.

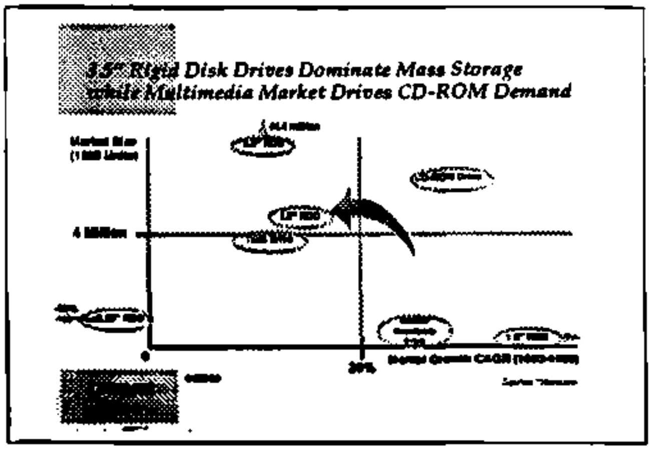

Figure 12

Turning for a moment now to the storage systems. We see, not surprisingly, that the 3.5-inch rigid disk drive is dominating this market with its 44.4 million unit shipments. Again, we see the CD-ROM here in the sweet spot of the curve, driven by the multimedia opportunities. Looking at the mobile opportunities, the 1.8-inch rigid disk drive represents the next generation.

Let's come back and visit the Small Office/Home Office again and the opportunities that are presented by that market. In the low-end printer market, we see the ink jet printer becoming the volume leader in the economical printer solutions, but we see also the page printers in an interesting position, perhaps setting up a dual existence. First, we have page printers with their increased capability of 1200 dots per inch, increased pages per minute, and networked to more powerful processing going into the high-end applications.

However, there is an interesting battle shaping up for the low-end printer market between the ink jet and the page printers. With the Pentium processor and the introduction of "Windows 95," we have an opportunity for host-based printing where more of the intelligence, the crunching power goes into the PC itself and rasterized data is sent out to the printer, enabling lower-cost printing solutions with lower amounts of memory and processing power going into page printers. Again, stimulated by multimedia, we see scanners and digital video boards with high-growth opportunities. There are also replacement factors impacting graphic boards and the sound boards as they go on to become an embedded application on the motherboard.

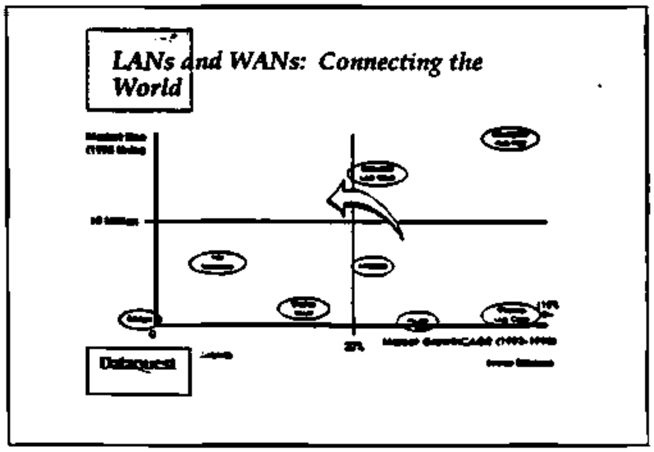

Figure 13

Mr. Sheppard: Well, I wish I could control the John Madden mode, Dale. Anyway, into the world of a few more acronyms, the world of communications. We could probably make a living out of just explaining acronyms to people. First of all, let's take a look at the world of LANs and WANs.

LAN of course is Local Area Network, WAN refers to Wide Area Network, and we generally broaden that to include just about anything you go out of the building to connect with and that would include things like modems. Once again, the high-growth areas are on the right side of the chart.

Starting with modems, we feel that that's a market area that has received rejuvenated life. It is really the true port that gets you onto the information superhighway at this point. I don't think people normally think of a modem in that way. Millions of units are getting shipped out through the retail sales channels and are being coupled with America Online and CompuServe software. It's just a booming business with astronomical growth. Also we note that we have the LAN cards, which continue to be a good business. We've seen connectivity of computers to networks approaching 100 percent in the U.S. market. Europe is somewhat behind that, but there is quite a bit of headroom in the Asian markets as many computers are not connected together yet over there.

Also, we have here intelligent hub ports, which are ports that are part of an intelligent hub. These hubs are systems to which you hook networks PCs these days and, then in turn, the hubs hook up to your server. Also on the growth front we have wireless LAN capability, which is starting to gel — we are starting to see some interesting offerings come out there. It is important to note that even though we have fax machines here in the lower left side quadrant, it is still a very good market.

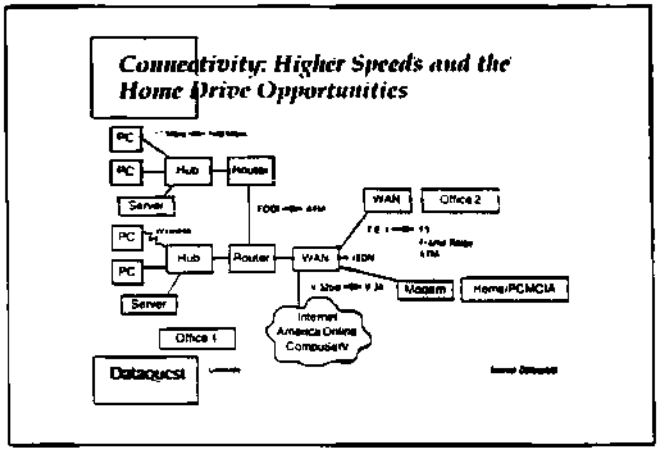

Figure 14

This next chart is an attempt to explain a little bit of where the opportunities are in the LAN and WAN area. First of all, you have the office, which has varieties of PCs being hooked up to a hub and then a server connected to that. That seems to be the configuration that we hook things together these days. In turn, different segments, as they are known, are hooked together through router-type devices. In the router area, there are three or four hot Wall Street companies just serving that market.

In general, these networks are being loaded with e-mail traffic. Another subtle trend is the movement towards groupware and products like Lotus Notes, where there is a lot of continual concurrent interaction amongst different users around the network. We're seeing this put tremendous loading, and the good old 10 megabit Ethernet or 16 megabit token ring networks aren't cutting it anymore. So we're seeing a variety of solutions being offered up by the networking community. Alternatives are starting out modestly in the 20 megabit area, with full duplex and switched capability being employed; the latter is where the hub is acting basically like a central office switch. On the three-to-four year horizon is the 100 megabit area. There are a variety of solutions being fought for at 100 Mb/s. One is known as AnyLAN which can also support token ring, and the other one is known as FAST Ethernet.

As we move to connecting the office out to the wide area networks so we can communicate to other offices and the home, we see opportunities there as well. In particular we're seeing speeds getting faster. Right now the predominant technology is known as T1 E1, which is 1.5 megabits per second. We're seeing activity starting to pick up as these high-speed pipelines between offices are falling under greater demand. We are also seeing a movement to a new technology called ATM (Asynchronous Transfer Mode) which, in fact, is a technology that overlays between the routers as shown here, but also can work its way out to the wide area network and, possibly, it will become the technology for the information superhighway to the home as time evolves.

In addition to ATM, we have some other new WAN technologies. One is known as T3, which is basically a faster version of T1, and frame relay. Modem connectivity to the home, as I mentioned earlier, is going through the roof as people need to connect through modems back to the office. Also, demand is booming for modems in a PCMCIA Type II card form that you slide into a notebook computer.

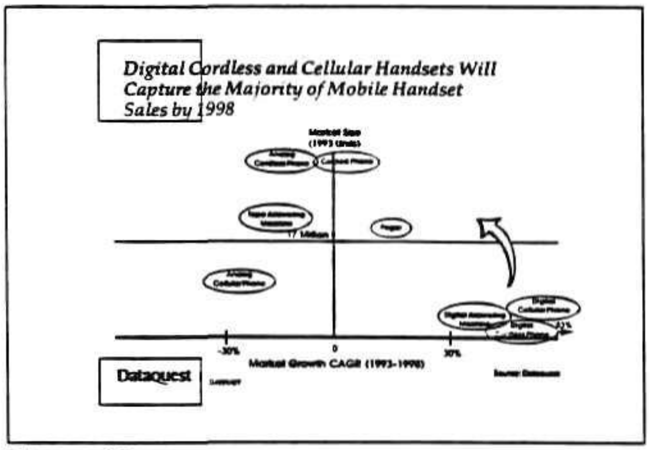

Figure 15

We went over a lot of this, of course, earlier this morning, but let's recap. In the cordless telephone and cellular area, basically everything is going digital. There are a lot of compelling reasons to do so, not all of them are from the consumer's point of view, by the way. A lot of them are for making services cheaper to provide, and in digital cellular's case, more channel capacity as well. In the pager's case, we're seeing a more advanced, two-way type of pager that is capable of handling data as well. I also put down here tape answering machines; we're rapidly seeing solid state, tapeless answering machines take over the marketplace which employ a compression type technology and also they use a form of DRAM as well.

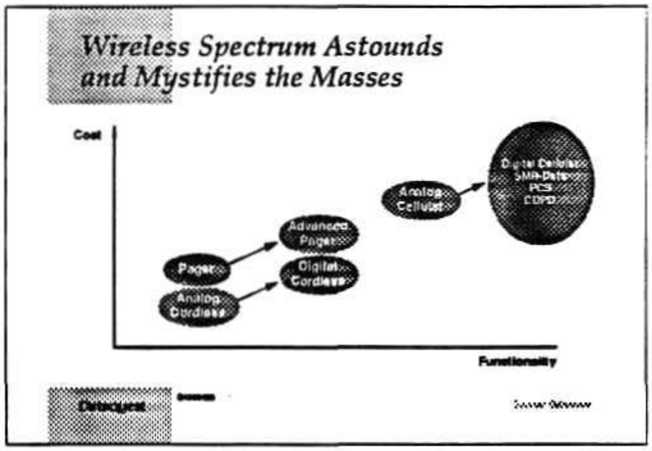

Figure 16

The general trends that we see going on is, once again, the analog cordless phone, the good old 48 megahertz phone that we have in our home, migrating up to a new digital capability and there are a variety of standards. In North America, there is what is known as 900 megahertz, and in Japan, personal handy phone, and so forth. Also, we are seeing analog cellular evolve into something else. I think one of the conclusions of the session this morning is that something else is still kind of a question mark, but in general, we know it is going to be digital, and it looks like the standards are going to be fairly fragmented; they'll be regionalized. One of the underlying themes on that, of course, is the movement towards wireless data. It looks like CDPD is certainly off to a strong start in that front.

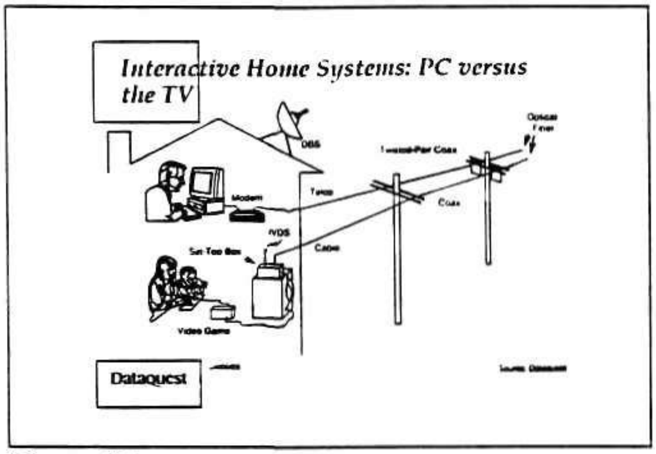

Figure 17

Now shifting to the home a little bit. We heard some somewhat negative words about consumers yesterday, but we're not quite as gloomy about that because once again there are the developed countries of the world that have bought VCRs and the second VCR, but there is a whole bunch of other folks out there around the world that haven't bought the first VCR yet. So we still are anticipating at least single digit growth in basic consumer video equipment, VCRs and color TVs, as we see pervasion into these other regions of the world. I think what we're seeing that kind of clouds our view, perhaps, is that the production of these is moving into areas that aren't the traditional countries people think of. A country like China, for example, is producing a lot of TVs and VCRs for its own internal use.

On the merging front, we have a new genre of video game, 32/64 bit, also CD-ROM based video games as the 16-bit video game market is starting to recede somewhat. That is also what is affecting the ROM market this year. We think there might be a bit of a gap, though, of two to three years before these new type of games emerge and become popular. The digital set-top box to support cable TV services as well as direct broadcast satellite services is a new application that will use a lot of chips.

One quick slide, just to quickly summarize. There are two portholes to the house today, and there is really a third which I'll talk about. One is the modem to the PC, and this is the "America Online market," and that is really hot right now. That is where a lot of action is and in my mind, it's the dark horse in all of this. There is also the developing set-top box connection to the cable world, which is basically in trials at this point, and then there is the satellite dish on top of the house that can pull in satellite signals. I think, in reference to Bill's comments about people being upset with the cable companies, we're seeing the Hughes Direct TV program being embraced by users as a way of getting around the cable guys.

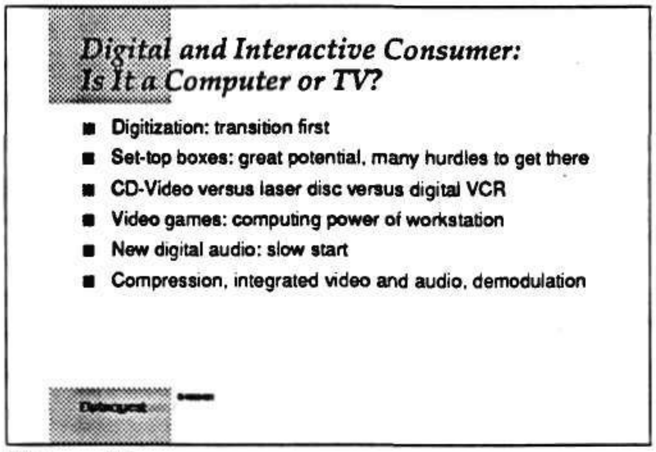

Figure 18

Just to conclude with some general observations in the consumer area. Digitization basically is the key word. We are seeing DSP-type techniques creeping into audio and video products and that is clearly the key trend. We talked about set-top boxes. There is a new standard emerging that is primarily being shipped into the Asian market known as CD video or video CD, depending on which way you call it, which is using CD-ROM technology. It is initially going after the karaoke market, but it has the potential of competing with the VCR market. Also, we're seeing the emergence of the digital VCR spec as well. We should see some interesting fireworks in that area, the recorded playback market in the home.

On the audio front, we've had a couple of new digital audio standards floated into the marketplace. So far acceptance has been slow, although what we're told by the key principals in that business is that it's not too far off of where acceptance of some of the technologies like the original CD, for example, was at this point in time, but so far sales have remained a little sluggish as consumers remain somewhat dubious on the value provided here. Key technologies: Of course we've talked about compression, integrated audio and video chip sets targeted at the CD video box, for example. Demodulation will require sophisticated DSP-type technology.

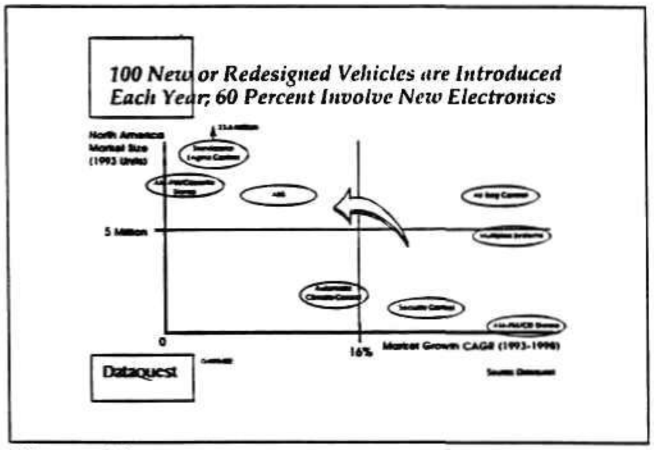

Figure 19

Mr. Ford: Let's take a moment to look at the automotive market. We see here an important opportunity with 100 new or redesigned vehicles introduced in the world each year. Over 60 percent of those have opportunities for new electronics modules. On this chart is a summary of the high volume opportunities. We see some of the high volume opportunities with standalone engine controls. New control systems opportunities are being driven by new regulations and standards on pollution and fuel efficiency. We also see the importance of safety and security, and the increasing role that plays with the antilock brake systems and the air bags.

Security systems: The need for these systems is highlighted by what is taking place in North American cities. Replacement mode dynamics are taking place here with the AM/FM cassette stereo and the AM/FM CD stereo.

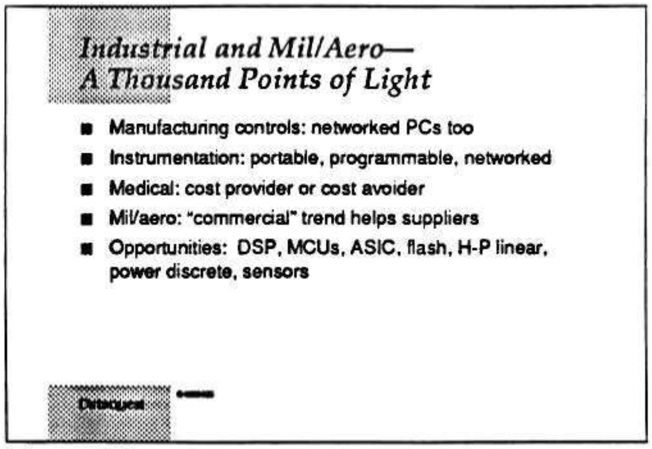

Figure 20

Finally, lets take a moment and look at the medical and industrial markets. We see manufacturing controls and opportunities there with networked PCs beginning to play a role also. Instrumentation with portability, programmability, networking capability is growing in importance. Last year the debate over medical issues and healthcare has moved to the front of everybody's mind the importance of cost controls related to medicine. Do you increase medical costs with the use of high technology in medicine or does it help us avoid costs by detecting illness earlier, enabling more effective treatments, and making it possible to provide treatment in the home rather than the hospital? So the debate will continue here over the role that electronics and technology play in medicine.

In the military aerospace arena, we note the commercial trends that are taking place in the semiconductor market, and how this is helping suppliers for this market. Finally, we list some opportunities for semiconductors in the industrial and military/aerospace markets.

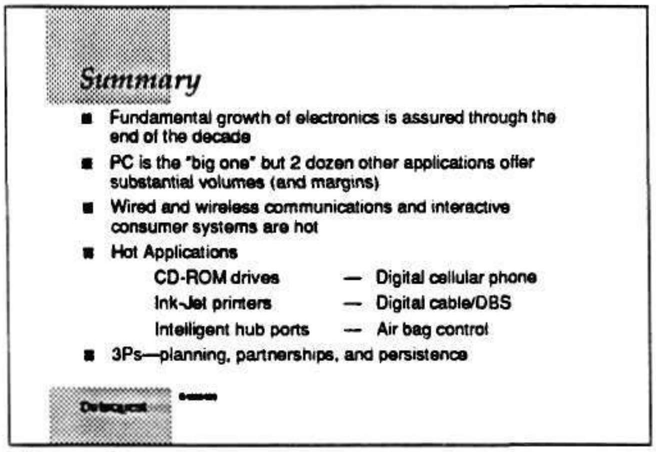

Figure 21

Mr. Sheppard: The bottom line is that the fundamental in equipment consumption of chips remains in great shape that we can see. Perhaps the developed countries might be slowing a bit, but Asia/Pacific, Latin America, and the rest of the world will pick up steam and keep the train rolling.

Mr. Ford: While we have reinforced the PC as the king perhaps in the semiconductor industry, we've also noted the high and exciting opportunities that are offered by over 2,000 different applications during this presentation.

Mr. Sheppard: I promised myself I wouldn't use the word hot again, but here it is in the slide, but clearly we're bullish on just about everything to do with high-speed communications and wireless communications as well as the interactive consumer market. Maybe it's not necessarily the set-top box, but there are a lot of interactive opportunities out there as well.

Mr. Ford: To leave you with just a few concrete ideas in your head, we show a representative sampling of some of the high growth opportunities that we've listed during this presentation. We go from CD-ROM drives to ink jet printers, to the intelligent hub ports, the digital cellular telephones, the digital cable and direct broadcast satellite boxes, and the air bag controls.

Mr. Sheppard: We couldn't leave you without a little McKenziisms, I guess. How to manage. I guess the watchwords are the three Ps, and we've been hearing them repeated by just about everybody today. We feel that growth opportunity lies in targeting particular application markets with intellectual property and value-added. This requires extensive planning up front. Application opportunities are also very fast moving, so you have to plan that into the equation as well.

Partnerships with OEMs, with other semiconductor companies, with contract manufacturers, with foundries are what is needed to be quick on your feet and to be able to target these areas with properly spec'd out intellectual property. Perhaps the most important one is persistence. You have to be able to be patient, you have to wait out some of these markets, you have to try it two or three times. I think the PDA is a good example of that, where you have to stick to it and eventually get it right. So with that, we are done. You can catch us later on if you have questions. Thank you.

PCs Versus TVs: Catering to the Couch Potato

Moderator

Jim Handy
Director/Principal Analyst
MOS Memories, Semiconductor Group
Dataquest Incorporated

Panelists

Doug Dunn
Chairman and CEO
Philips Semiconductors

Ichiro Fujitaka
Vice President
Systems Application Engineering and
General Manager
Microcomputer Semiconductor Business Unit
NEC Electronics Inc.

Robert Luff
Chief Technical Officer
Broadband Communications Group
Scientific-Atlanta Inc.

Theodore M. Hoff
Senior Vice President and General Manager
Fox Interactive

Mr. Handy: This is our panel. It's called *PCs versus TVs*, although we're going to be talking mostly about TV set-top boxes catering to the couch potato, because that's who we're after. Our panelists are: Doug Dunn, the first speaker who is Chairman and Chief Executive Officer of Philips Semiconductors; Ichiro Fujitaka from NEC, who's the Vice President responsible for applications in NEC America; Bob Luff, from Scientific-Atlanta, who is their Chief Technical Officer; and Ted Hoff, Vice President of Fox Interactive, a content provider. He's going to be talking with us about content.

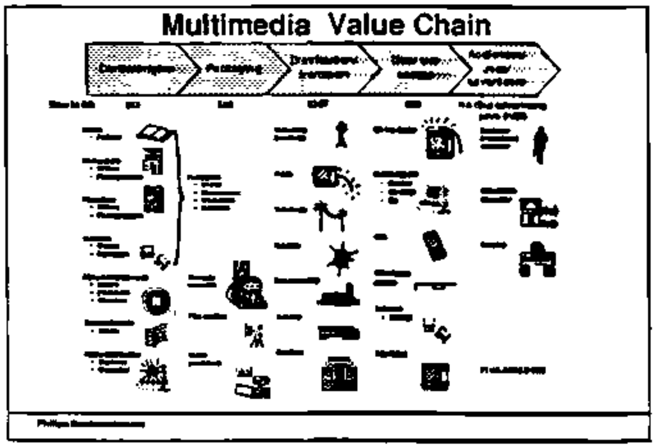

Figure 1

First I'll introduce Doug Dunn. He'll be presenting his views from a semiconductor and consumer electronics provider standpoint. Mr. Dunn is the Chairman and Chief Executive Officer of Philips Semiconductors where he's been since 1993. Before that he was Managing Director at Plessey Semiconductors, where he turned the company into a healthy business; today GEC Plessey is one of Europe's leading component companies, although they were struggling at the time that he joined the company. In 1992, Mr. Dunn was conferred with the Order of the British Empire by Her Majesty Queen Elizabeth II. So without further ado, I'm going to turn it over to Doug Dunn.

Mr. Dunn: After that introduction I can hardly wait to hear what I'm going to say. Good afternoon, by the way, couch potatoes. As you can tell from my accent, I'm not a native of California. I came in from Europe a few days ago, and this is a tribute to Dataquest, because they'll do anything to stop speakers from arriving here. The GI guy didn't make it. I was flying into San Francisco Tuesday evening on a small, no-frills aircraft called Southwest. Maybe no frills, but certainly big thrills because we were struck by lightning and I thought only Dataquest could organize this. They can't get a forecast right, but boy can they organize lightning strikes. Sorry Jim. You'll be glad to hear that the old proverb is true: Lightning never strikes in the same place twice. We made it down.

What I want to do in the next few minutes is just talk about the value-added chain of the multimedia market, and I guess what we're all after here finally is delivering information in some form or other to the consumer. What I've tried to do here on one very busy slide is to indicate how the value-added chain is composed. We start with the content end of it. By content I guess it's the things that we all recognize: the artists, musicians, vocalists, authors, journalists, writers, photographers, all those creative people who create the content. And that's been valued in 1993 around $52 billion. Not an insignificant market.

Feeding on from that is the packaging, those people who do the editing, formatting, integrating of advertising, and these are the publishers; the TV, cable, and satellite network operators; film studios; and the music publishers. That's been valued again at around $68 billion.

In the center you've got the distribution and transport people who seem to soak up the biggest dollars, $267 billion. This channel includes cable, telcos, satellite guys, movie theaters, retailers, and, feeding on from them, the actual user site access providers. I guess this is where the set-top box finally begins to fit into the value chain, and it's a pretty low total value at $30 billion. It's composed of set-top boxes, multimedia PC, CD-ROM, PDAs, the good old television, which is still the mainstay of this market, VCRs, more recently CD and CDI.

And finally, of course, you've got the audience and the guys who provide the advertising. There's no value assigned to the audience. The advertisers are summed at some $130 billion of input into this value chain. So that's how this value chain breaks down. Each of us is trying to carve out our own part of this market. I'd like to tell you just briefly where a European company called Philips fits into this.

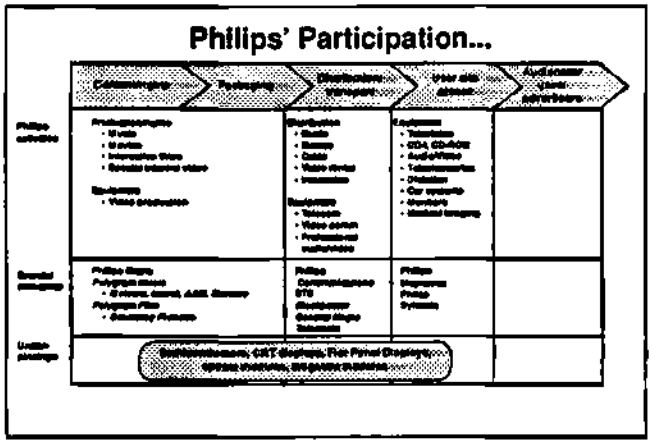

Figure 2

First of all, if you look at content and rights, we have within Philips, Polygram, more famous for music. They have the Motown label, amongst others, and I guess looking at the average age here, a lot of you people recognize Motown. We make interactive titles, or CDIs. We produce, in fact, equipment — video production equipment. And last, and by no means least, we finally have a blockbuster film to our name, Four Weddings and a Funeral, which is a Philips-produced movie. So Philips do value themselves in the content provider end of the multimedia spectrum. And the point I'm going to make through this is that it's the guys who can cover a significant part of that total spectrum that will emerge the winners by the end of this decade.

Distribution and transport, well, Philips own cable companies. From a user site point of view, we make TVs. No surprise to you. I'm pleased that every room in this hotel has a Philips television in there. And we make CDI. We developed and invented CD and CD-ROM. So many of the features of this total value chain will give benefit to companies like Philips, and there are many of us, who can show across-the-board access to this multimedia chain.

The question I ask myself as the CEO of the semiconductor part of Philips is, "What is in this for me?" Because the user access portion is only $30 billion. If you boil that down to set-top boxes, which is the subject of this panel, you get down to a very low number, maybe $1 billion, maybe $500 million. And the silicon content, of course, is quite small, perhaps 20 percent. The challenge I would put out is this: regarding the much-discussed topic of set-top boxes, what the hell is in it for the silicon manufacturer? Yes, we'll have our part of that. But right now, for the next few years, it's going to be a small part of our revenues. I think that challenge to the content providers, to the set-top box providers, is how they can go stimulate this market to give a bigger ramp-up than we can currently see. Having said that, I will now pass over to you the next speaker.

Mr. Handy: Thank you Mr. Dunn. Our next speaker is Ichiro Fujitaka. He's the Vice President of Systems Application Engineering and General Manager of the Microcomputer Semiconductor Business Unit in NEC Electronics. He's been with NEC for 25 years, and was appointed General Manager of the Microprocessor Products in 1990, and in 1992 established the Systems Applications Group within NEC Electronics in the United States. So now, Mr. Fujitaka.

Mr. Fujitaka: Thank you Jim. First of all, I would ask you to do a tiny exercise. Please participate. How many people in the audience come from semiconductor manufacturers? Wow, so huge! Today I want to try to create some controversy or some argument on how we can share our resources in consideration, to solve what's going on with the set-top box, the business structure, and the future. And first of all, maybe no one can understand what system application engineering means, which NEC has just introduced. So to make you understand easily, I want to explain just briefly our organization.

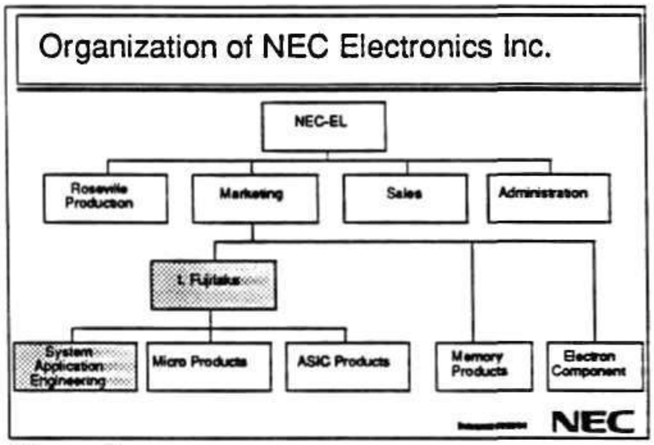

Figure 3

This is the NEC Electronics Organization in Mountain View, California, covering marketing, administration, sales and manufacturing functions. I am in charge of three groups. One is microproducts, another is the ASIC group, and one is a new organization, the so-called System Application Engineering Group. The purpose of this new organization is that we are now in the age where we need to provide some system solutions. We have migrated from being a simple supplier of silicon. Lots of customers in the United States want to know how they can share resources, how they can share some design, technology, and everything else with big semiconductor manufacturers. So in response to that, our big semiconductor company needs to establish a focused application team that clearly understands what the needs of the customer are. The customer in this case comprises all our customers, OEM and hardware manufacturers. To do that, I established the System Application Engineering group. So we are now handling a couple of emerging activities. Our company, NEC-EL, is relatively independent from our parent company, NEC. So we now handle not only marketing but also design and alliances and partnerships, solely in the United States, focusing on high-end technology in the emerging market.

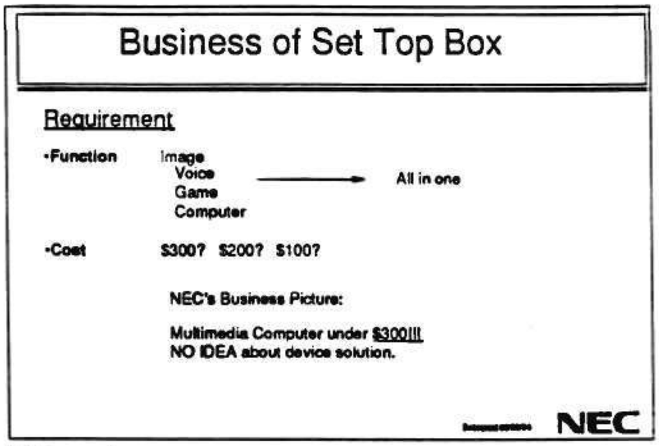

Figure 4

Today, I want to create an argument. I am very uncomfortable about the past history of market research. Part of it was our coordination with Dataquest. We are currently evaluating the set-top box business opportunity, and we found out that almost all of our customers, that means the hardware manufacturers and also some cable companies, want us, the silicon vendors, to integrate everything: image handling, voice handling, game manipulations and computer performance. When we ask the customer how much of a price you're willing to tack on, they usually say less than $300 per box, preferably less than $100 per box. How can we do that? We simply say it's impossible. At this moment, I want to say, you were born in the wrong time. Please come back decades later. At this moment, it's impossible to integrate anything even close to that total solution of a multimedia computer for under $100. So there's a big argument.

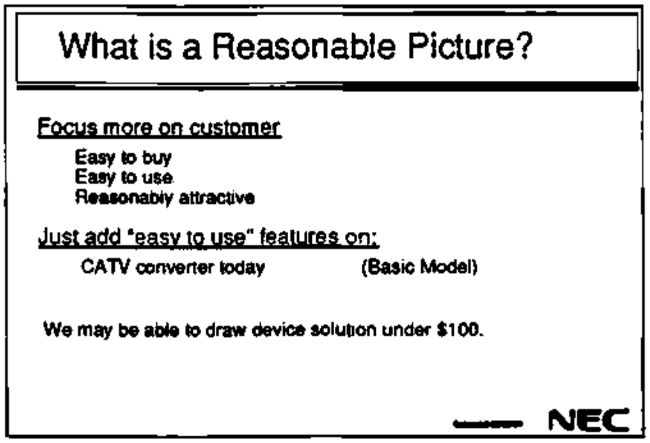

Figure 5

And I want to address the basic issue: where's this request coming from? You just heard a great speech by Mr. Hambrecht at lunch. He addressed lots of important issues that I want to address. Some engineers in this field right now are very excited about the set-top box, but they forget to focus on the customers' desires. In other words, we need to focus more and more carefully on a customer-driven business structure. Because of lots of excitement generated by the media — like the newspapers, and research data like Dataquest's — the emerging impression about the set-top box is that it's a great business in the future. But they are not responsible for making a profit. We are responsible, as a semiconductor manufacturer, and you are responsible, and also our customer, the hardware manufacturer, is totally responsible for how they can manage the business structure. So lots of press and lots of articles say the set-top box may include this function, this function, this function... Are these so attractive? I don't think so.

How many persons here, by yourself, can utilize the full function of the remote control unit on your home VCR? Would you raise your hand? I cannot do that; so many functions. That's a fact. It's not the business stage. It's a couch stage at the home. No one wants to learn such complicated functions. They don't want to spend more than $100 on useless functions. So that means the basic point is we need to change our minds and start from scratch. What the customer wants, the customer needs. I found out three other major issues concerning silicon providers.

One is content. I don't want to touch this issue, because there is a Fox person on the panel, so I want to listen very carefully to discussions about features. The content is a question. Still we don't have a clean picture of what's most attractive for the customer.

And the next issue I have already addressed: the cost of the set-top box. I don't believe the consumer in general ever wants to pay more than $500 for a set-top box. And the third one at least for the semiconductor manufacturer is one of the most important issues: how can we maintain and enjoy the continuity of our business supporting the set top box business? That means we need to evaluate our strategies very carefully. In the case of TV, because of the utilization of a big tube, there are some problems of color or resolution. So we tend to replace our home TVs every five years. Now how about a VCR? VCRs have lots of failure mechanisms, so we may replace it every three to five years.

But what happens with set-top boxes? I personally have a set-top box in my house. This is a very, very obsolete design, basically designed more than 10 years ago, consuming 40 to 50 watts. When you touch the top of the set-top box, you can feel it's very warm. It consumes almost the same level of power as the TV itself. What does that mean? Because there is no failure mechanism, no emerging evolution has happened. Once we distribute the set-top box to all the consumers, it's quite difficult to estimate demand for replacement parts. So we need to think about some strategic step how we can resolve that. The point is we need to focus on easy-to-buy and easy-to-use. This is essential. And the most important issue is that the set top box must be reasonably attractive, not so complex.

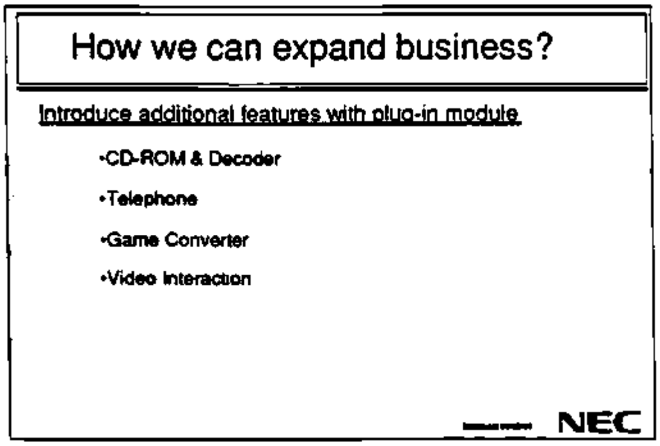

Figure 6

My suggestion is just to add one simple attractive function to the current CATV converter box. How can we support the customer in enjoying more and more functions in the future? This could be done with a module. We currently expect to see that kind of a solution from Scientific-Atlanta. Plug in some additional module providing one additional feature. With this kind of building block approach, train the consumer step by step and try to ask them to pay $100 per box per year, and when we can establish that kind of trend in the market, as a semiconductor manufacturer, I think we can also enjoy long-term business success in the set top box market. Thank you very much.

Mr. Handy: Thank you Mr. Fujitaka. Our next speaker is Robert Luff. He's the Chief Technical Officer of the Broadband Communications Group of Scientific-Atlanta, where he's involved in the strategic positioning of Scientific-Atlanta technology and products in the rapidly converging markets of video, voice, and data services. He's been with Scientific-Atlanta since 1991. Previously, Mr. Luff spent 12 years as a Chief Technical Officer for two of the top 10 cable TV system operators: United Artists Cable and, most recently, Jones Intercable. He's the President of the Society of Cable Television Engineers for two terms, and has served on its board for six years. In 1986 he received the cable industry's most prestigious award for outstanding engineering achievement. So with that I'd like to invite to the podium Bob Luff.

Mr. Luff: Thank you. You may not be familiar with Scientific-Atlanta, but convergence is bringing many different industries together and I was asked to spend just a few moments before the normal presentation to explain what Scientific-Atlanta is all about. We are the dominant broadband end-to-end network provider selling technology, and actually manufacturing that equipment, to the cable television industry and the RBOC industry, or the Regional Bell Operating Companies. We have about 70 percent of the head end. The head end is where signals are received, processed, put on the channels that you see on your home converter before they're launched to the system.

We have the world leadership marketplace in the actual optical electronics, the laser transmitters, and the optical node receivers that take those signals out of the head end and traverse them great distances within the franchise area, and market leader of the actual RF coax amplifier that takes that signal the last mile or so to the home. And then, of course, we are the second largest supplier of the actual set-tops, and if you break that down, we are the close second supplier of analog set-top boxes. We are the number one supplier of the brand new breed of advanced hybrid analog/digital set-tops, and it's too early to tell who's going to jump out of the chute as being number one in the digital-only set-tops. But we think we're well-positioned.

We were founded 43 years ago as a high-tech satellite microwave technology supplier to NASA and the government, and we've leveraged that into several other divisions, primarily the CATV and broadcast arena. We do other interesting things like provide the Stealth sonar technology for the U.S. nuclear attack submarine fleet.

Scientific-Atlanta is a nearly $1 billion per year revenue company and about one-third of our current revenues come from outside the U.S. We have facilities in 14 countries, and three manufacturing facilities around the world, including one in China and just slightly less than 4,000 employees.

If you know something about Scientific-Atlanta, you probably read that we were fortunate to have been selected as the technology supplier for the two most visible high-tech demonstrations of broadband multimedia full service network: first, by Time Warner in their Orlando, Florida trial, one of the major cable TV MSOs, and then also U.S. West, one of those RBOCs, Regional Bell Operating Companies, in Omaha. What's even more important, perhaps, is if you've read the papers, the press releases that went out from both of those companies — Time Warner hooked up their first two customers yesterday, which means that at least this company is no longer simply talking about the revolution of convergence and multimedia and high-tech set tops and end-to-end systems. We have actually progressed to the point where these are in modest levels of production through ISO 9000 plants, through FCC permission on signal leakage, chassis radiation, part 94, and have shipped product in quantities with manuals and warranties and trained service personnel, and these are in homes beginning to create revenue from customers.

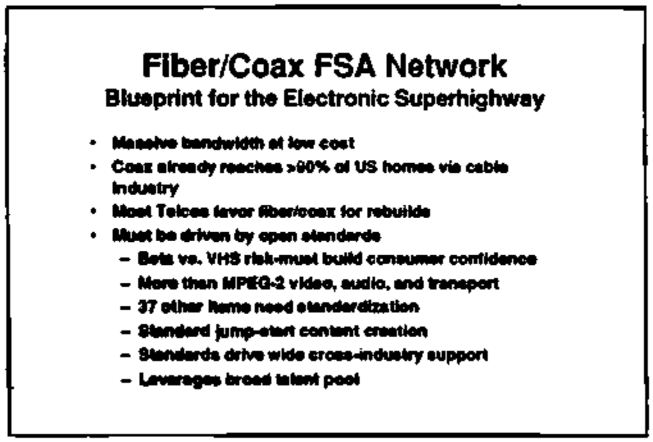

Figure 7

So with that as a backdrop, what I'm really here to present are three pretty important core fundamental drivers or truisms in the industry today. First, there's been a raging controversy for the last two years, which appears to have a de facto resolution as we stand here today: hybrid fiber/coax architectures appear to be the adopted platforms for those services which are going to be launched to the public. It has massive bandwidth at low cost; that is, a half gigahertz capacity in today's systems approximately, and easily upgraded to 750 Mhz, which is the new platform that systems are installing, both cable and telephony today, and also the ability to migrate to one gigahertz without redigging up the streets. These are upgrades that can be done by unscrewing the amplifiers and screwing in a higher tech amplifier or laser. So you have massive bandwidth.

A coax already runs in front of 90 percent of the U.S. homes and dwellings. That means that the current infrastructure has the ability to bring these services in today without digging up America. Most telcos and cable are certainly favoring this hybrid fiber/coax.

You've heard of other options: fiber to the home, fiber to the curb, ADSL. All of those are successful technologies. They work. There's isn't anything wrong with them except the cost point is roughly two to four times more expensive than hybrid fiber/coax and also, to some degree, they require a distributed intelligence in the network, which most network operators have critically analyzed as being very risk-burdened in a period of time when flexibility and shifts in technology are likely to occur at a rapid pace. Would you rather be a network that has a transparent network of enormous bandwidth, then as you change and add new services, you only have to install things in the head end and in individual homes? Or would you rather be the network operator that has to go out to every one of these optical fiber nodes and replace equipment each time you activate or deactivate a service? So really what has driven the hybrid fiber/coax is cost, but most importantly, is its ultimate transparency.

One of the major risks continues to be the issue of standards. It has happened so fast — the chip industry, the computer industry, the broadcast industry, the cable industry, the telco industry have been thrust upon each other with their own set of backgrounds and vocabularies and ways of doing things, and, indeed, even governmental regulations that have not caught up with this technological revolution that are being regulated very differently. So they're still inclined to do things very differently, even though from the public's standpoint, they sort of wish they had three or four carriers bringing these services into the home that they could freely flip a switch and go from one to the other, based on service, price, performance, channel availability, and such. But the reality is there are going to be standards. We all know we can't have interconnected systems carrying such things as telephony and file servers using different content providers and look like the Beta-versus-VHS dilemma. The last time that happened it caused the consumers to just sit down in the middle of the road and wait until things began to have less risk for them.

We thought things were in relative control when MPEG jumped out ahead to become the de facto standard for digital compression for video, audio, and the transport layer. But as it turns out, when you get ready to build these systems, there are at least 37 other items that I identified that also have to be interoperable or agreed upon in the industry, or when I hit "play", 70 percent of the file servers in America may not recognize that command. When our counterpart GI subscriber hits "play", file servers have to respond to that command and stop and start and fast forward and reverse. And content providers have jealously held their material until somebody has shown them $6 million for the right to put that on a satellite for 30 days and charge a subscription per view, and is able to audit those receipts from cable operators. Now people are knocking on the door and saying, "I'd like to take that data file called Sleepless in Seattle, I'd like to put it on a SONET ring, and ATM switching, and I'd like to distribute this to 20,000 file servers out there with no standards, and no accounting, and no way to audit, and trust me, the check's in the mail." It isn't going to work.

So the content providers are holding back on release of material in some of these new formats because they simply can't get in a pickup truck and drive and do audits at each of these file servers. So there have to be these business solutions before this is all going to happen. So we have these tremendous issues with standards that are necessary to jump-start the content creation, to drive wide cross-industry support so that the consumer isn't caught in the middle of a very confused issue, and this leverage of the broad talent pool.

All Digital vs. Hybrid Analog/ Digital

- All digital
  - Most channels-beyond diminishing returns
  - Lowest cost per channel-highest cost per channel used
  - Digital quality-public may not know/care
  - High-tech solution-technology risk
  - Digital end-to-end network-whole house clear
- Hybrid analog/digital
  - Supports most digital strength-reduces digital channels
  - Improves penetration 10% to 15%-channel management critical
  - Can be used without set-top box-restricts digital demos
  - Supports interactivity-but with restrictions

Figure 8

The second major point, and I call this, particularly to this group, the sword-through-the-heart slide. When I build this 750 megahertz transparent network, I can do analog signals, or digital signals, or some combination of both. The digital world has the most channels, it's the high-tech solution, it's end-to-end digital transparency. But you can read in the slide that there are other sides of this. It has diminishing returns, highest cost per channel, the public may not know or care how these signals got there, and it really has a very high technology risk deploying a lot of these things now when there are these standards issues afoot.

In the hybrid analog/digital solution, I take that 750 megahertz, maybe have 80 channels of analog. Those are ABC, NBC, CBS, and such. I continue to transmit those in plain old analog. Why would you ever do something like that? Because it's cheap, because it's friendly, because it gives whole-house service. Every TV set can enjoy the benefits of those signals. The digital signals need a digital set-top and those digital set-tops cost extra money, which drives the cost of the service up, and if the consumer is seeing the same services, one cost more than the other, and doesn't perceive any great benefit, you know which way they're going to go. We clearly believe, because of the 200 million TV sets and VCRs that are going to be around for the next turn of the century, that solutions have to embrace analog and digital. So the clear message to chip manufacturers and content manufacturers is, you can't just believe that this is a computer digital-only world to be successful or your product is likely not to be embraced.

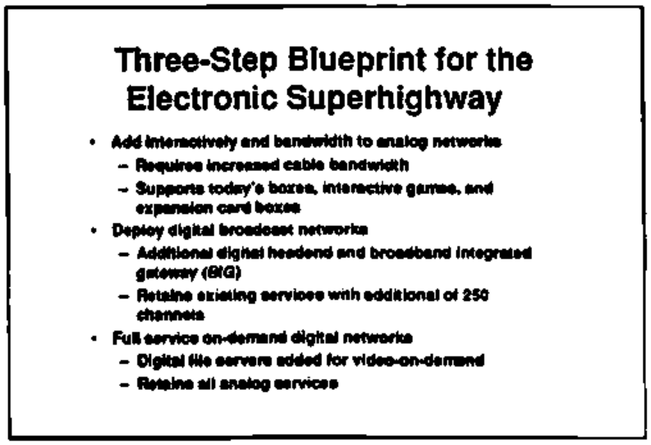

Figure 9

The last slide is what's really happening today. The networks, particularly cable, are adding bandwidth, they're increasing their bandwidth, they're supporting today's existing set-tops, they're adding these incremental advanced features and digital electronic program guides, and interactive offline Sega channels, and interfaces to Internet. The second phase is that they then deploy digital broadcast, not video-on-demand, not interactive. Put a file server and bring 40 or 50 movie titles with staggered starts. Very low cost. I need a digital set top box to do that but I don't need a lot of interactivity and extra memory, to do that, and the consumer grows with that.

The last stage is full service, full interactive demand, and we see that happening in the 1996-to-1997 time frame before we see reasonable deployment of full interactive. Much of that will depend, either accelerate or decelerate, based on the real-life experiences of Time Warner and U.S. West in their trials. Thank you.

Mr. Handy: Our next speaker is Ted Hoff. Although his name is the same name as the former Intel employee who was the inventor of the microprocessor, this is a different Ted Hoff. He's told me that since they both live in Los Altos they occasionally get each other's mail. They know each other. It's kind of interesting that, with that uncommon of a name, there'd be two people with the same name in the same neighborhood. Ted is the Senior Vice President and General Manager for Fox Interactive. He was just recently named Vice President. He's joined Fox Interactive after a four-year tenure of Senior Vice President of Marketing and Sales at Time Warner Interactive, the home entertainment software arm of Time Warner Incorporated. He's representing the content side of the equation here, so without further ado, Mr. Hoff.

Mr. Hoff: You can call me Ted. I'm not formal. I'm about to congratulate you because that enormous binder you have is like finishing college. You're now at the end of it. I'm not sure if this is an honor, or a privilege, or if it's a reflection of Gene's and my friendship or Jim's, but today's the last day of the conference and I'm on the last page of the book, and I'm sitting in the last seat at the table, and this is the last presentation of the conference. So I'm not sure exactly how to take that, but maybe we could chat a little later and you could let me know how I should interpret it, okay?

With that, as the last speaker, I will make a promise to you. I'm not going to show any charts. What I would like to share with you though, since we are the content provider, otherwise known as the entertainment portion of your program, I wanted to share with you for a few moments a little bit of the background of 20th Century Fox and its parent company, News Corporation. And the reason I wanted to do that is because we're very fortunate at 20th Century Fox, both in film and in television, and in books through Harper Collins and TV Guide and so on, that we, in fact, do have content that we now want to bring out to the consumer market. And your role in that is key to our success. I'm kind of like the dairy farmer in Wisconsin who has a huge herd and thousands of acres but without you I don't have any milk machines. There's no way I can get my content to market without the industry that's sitting in this room today. So what I'd like to do for just a moment is to share with you a little bit of what 20th Century Fox is all about.

[Video clips of Fox films and television shows over the past 50 years.]

Now that's entertainment. The reason I wanted to show you that is I think it's very important for all of us to understand that, as a few people have said previously in their comments, not only Bill Hambrecht today but others, it's not so much through all the efforts that you're making that we are in fact going to drive the industry technology, the fact is that we're in the consumer business and that content and that entertainment and information and needs of consumers and needs of businesses drive all of us. What the consumer is basically saying today is, "Don't give me anything revolutionary. Just give it to me a little bit easier, a little bit better, and with a higher quality than what I currently have." That's really what this is all about.

This isn't about reaching out so far that the consumer feels that they have to go buy something today. How many consumers are not going and buying VCRs today because it may be an antiquated technology? Gene said in his comments, "What's the best time to buy a computer? It's today." Because that's the best technology that exists today. And just as a point of caution, those of us that are in this room that are marketing our products to business, or marketing our products to the consumer, be very, very careful that we don't kill the golden goose before it's born. I'll give you a very good example of that.

The video game business, which started 20 years ago with Nolan Bushnell's invention of the game Pong in 1972, has transitioned very beautifully so that now it is, in fact, a standalone industry. There are hundreds of companies, thousands of companies throughout the world, and thousands of retailers, whose livelihood is dependent on the consistent delivery of software for video games. First it was Atari, then it was Nintendo, then it was Sega, and who is it next? Now the issue that is at hand is that each of those cycles has taken 3 to 5 years to mature. The 16-bit cycle is now mature. It's penetrated over 20 million households. Nintendo, with 8-bit, has penetrated almost 30 million households.

Yet what's happening in today's market is that we as publishers are saying, "Gee, the cost of goods on cartridges are so high I think I'm going to cut back on my deliveries. I've got a $25 unit sitting on the shelf in hard goods cost and distribution before the consumer even buys it." That's the publisher. If the publisher says that then he's not hiring the developer. Now the developer doesn't have the business to support him. Next thing that's happening is the retailer's saying, "I'm not going to go very deep. I'll order 60 or 70 percent of what I previously ordered, but I'm only going to order the top ten." That lets out about the other 390 titles that are going to be available this Christmas. There will be over 400 titles available this Christmas just on 16-bit platforms on Sega, Genesis, and Super NES.

There will be a bloodbath in this business in the first half of 1995. The reason is that there is no safety net. There is no taut bridge between 16-bit and the next delivery system. The reason is that the dedicated set-top companies, other than our friends at Philips, but the dedicated set-top companies that have, in fact, mastered the mass market for the last two generations of hardware aren't ready yet. Sony's Play Station may make its introduction. Nintendo's Ultra 64 — late 1995, maybe 1996. Sega's Saturn, big question mark. How do we sustain this industry in video game and in content delivery over the next few years until the set top box is decided upon and until those who market all the hardware — Sony, Sega, Nintendo, Philips, 3DO — settle on a standard? The only opportunity for us as publishers and for software developers today is the PC. And I am running full steam ahead in putting out every possible product that I can, from Diehard 3, to Alien 4, to Predator 3, to Bobbie's World, to Return of the Planet of the Apes, to Speed 2, on PC CD-ROM? And the reason I'm doing it is it's the only game in town. I can't go back in the cartridge business; cost of goods is too high, retailers don't want it. So I have to turn to the next generation of available hardware today, which is PC CD-ROM.

So I ask each of you in this room that has anything to do with developing or supporting the next levels of technology in set top box, please provide a transition in the marketplace so that we don't overwhelm the consumer, so that we don't try to revolutionize this business, but give me a hardware vehicle that is consumer-priced, that will play back CD-ROM products, and that will receive delivery, whether it's twisted pair, whether it's the telcos, whoever it might be. We've got a multibillion dollar opportunity to sustain a video game industry.

We, as a content provider, are deep, we're up to our knees in content. I need to deliver it to the consumer. I can't do it on Sega, I can't do it on Nintendo. I can't do it because the installed base isn't big enough on Philips CDI or 3DO, but the installed base that's happening today on PC CD-ROM is like a hockey stick. And I need to deliver my products to the consumer on that platform. But whatever you do, don't pull that platform out from underneath the consumer, so that if there is going to be a design, it will bring a set top box into the home, and deliver through the television set.

I'm ambivalent whether it's a television set or a PC when it comes online into the home. The reason is that once I get into online delivery, once I get into CD-ROM, I can lay film down to the consumer, so I can take my movies and give them either clips, or hopefully with the MPEG standard, I can give them full motion, full screen, 30 frame-per-second film.

Someone came into my office the other day and showed me something that I swore I wouldn't see for the next three years but told them I would never do. I sat and watched a movie on my Compaq. It's coming. But to ask you to support our industry with the ability to transition the consumer so that we don't drop the floor out from under them, is a very, very important point. So I want to leave you with that. It's great to open up a new interactive division at 20th Century Fox. We look forward to delivering to you the content you saw here on the screen, and I'll do it in whatever format you invent. Thank you very much.

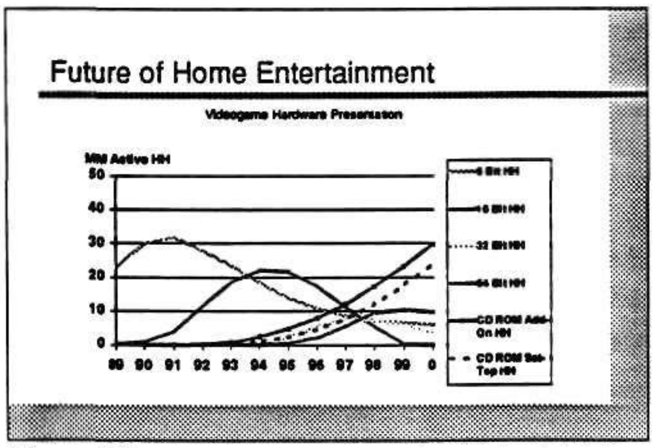

Figure 10

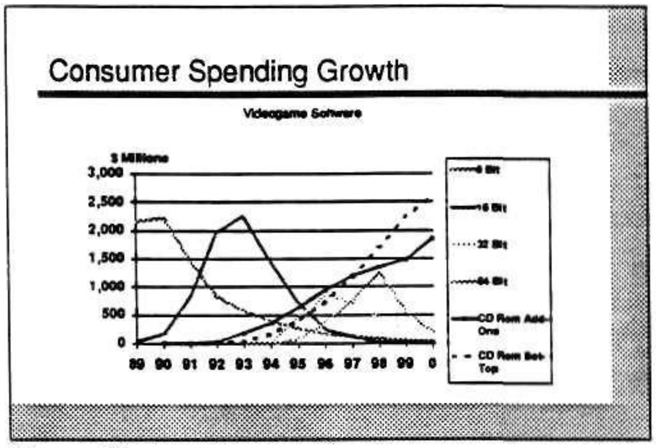

Figure 11

Mr. Handy: Thanks a lot Ted. We're going to do this in a little bit different format than the prior panels. We're going to interact just as a panel with questions and answers until about four o'clock, then open it up to the floor for any questions that you might have of your own. Something that we didn't really do with this is that it looks right now like a lot of very disconnected presentations, and why is that? Well, what we've got here is the whole food chain: we've got the content provider, we've got a major network hardware manufacturer, and then we've got integrated circuit manufacturers, one of whom also happens to be involved in the consumer end, the set top box end, of the industry. What I'm hoping to do with this is to tap into it in such a way that you can look at this industry, you can develop your own opinions about where it is headed, which is up in the air an awful lot right now, and maybe make up your own minds about what kinds of actions you need to take to be able to support this industry in the future, because as everything goes, it usually takes two years from the time you decide you're going to support an industry until you're actually able to do it.

What I'd like to do is, the first shall be last as it says in the Bible. Ted Hoff has been last several times and so I'm going to ask him a question that's based on something that Bob Luff from Scientific-Atlanta said. Basically Bob was assuming you knew how the future of set-top video was structured. That there are people who transmit things through satellites to servers, those servers go into networks, those networks go into the home. And there's a certain new thing that's going on with video-on-demand, where, at the satellite receiving stations, there will be storage for videos, so that instead of going out and getting your videos from the video rental store, you'll be able to order them from your home and look at them at your own convenience, and even pause them and back them up. That's going to require file servers in every neighborhood, and each one of those file servers will end up having a copy of the information that's on there. The content providers, according to Mr. Luff, are not going to be able to have an audit trail back to see who's been requesting their services. So I want to ask Mr. Hoff what he thinks about this.

Mr. Hoff: If there's no audit trail, there's going to be a real problem in either the collection of royalties or rental income that we currently see today. There are a couple of things that are beginning to educate the consumer into this right now. There's a company called New Leaf Entertainment, who, in conjunction with Blockbuster and Sega, have developed a system for basically downloading and burning EPROMs at individual Blockbuster stores. When that EPROM is burned and the consumer takes it home to play the game, a royalty piece of that goes back to the publisher. With regard to movies, and the downloading through a server at the head end, I don't know if the issue has been resolved as to what the relationship between the publisher and the sever is going to be. My guess would be that the server is going to be charged a fee by the publisher, by the studio, by the content provider, for full access to that property. But I can assure you that there won't be a property provided unless there's a financial remuneration provided back to the content provider.

Mr. Handy: Mr. Luff, do you want to comment on that?

Mr. Luff: Just in the way of amplification; not everybody may know this. Today when you go to a video tape store and rent a video, the way that business works is the video rental store prepurchases "x" number of titles. Ten titles of Sleepless in Seattle. The only money that exchanged hands between the store and the content owner is for the purchase of those ten titles and they can use those and rent those ad infinitum for some long period of time thereafter. So there hasn't been the need of a business model that says, when I come in and rent Sleepless in Seattle, two dollars or fifty cents out of that two dollars goes to somebody else. That all goes to the grocery store or whomever, to, hopefully, eventually pay back for those ten titles.

That's why there aren't very many titles when you go into the store and they're always all sold out, is that the guy running that business has really restricted the amount of up-front capital that they provide. In the new model where things are downloaded by a satellite to file servers, and then money exchanges hands on a per-usage basis, what the content owners would like to do is get a piece of that transaction, because there's more money in the recurring pieces in the model that says I'm just going to pre-sell ten copies. And that's really what has to be evolved.

Mr. Handy: Something that I might want to go back to is, what is the whole model? What are the parts of the cable system that are going to need to be changed in order to support broader bandwidth? You're talking about 750 megahertz on a system that used to only support 500 megahertz, and you're doing an awful lot to keep the cable that already exists intact. You talked about screwing in a little amplifier. We know that it's going to involve a change in the set top box. What kind of a change are we talking about in order to add interactivity and add more channels, video on demand, to a cable system?

Mr. Luff: When you build a cable system, the cost of the hole in the ground really cost more than what you're putting in the hole. To dig the trench is two dollars a foot, the coax or fiber that goes in it is a nickel a foot for fiber, or fifty cents a foot for the coax, so what you don't want to do is have to go back and dig up the streets any more often than you have to. Coax has a latent capacity of about a gigahertz and a half. It's been restricted in using that latent capacity because of limitations of amplifiers that occur every so often. That technology has risen to the point of about 750 megahertz as we said, so you literally do open up the case of the amplifiers, unplug the 500 megahertz amplifier module, and put in a 750, close it, and you have activated a portion of the plant to 750. I've taken some liberties, but that's roughly the issue.

In the set-top, the current model is to not replace all of the set-tops. You have to think of a world that has tiers. There are a significant number of subscribers in the cable industry, unfortunately, who don't take any pay services. They just take ABC, NBC, CBS, and some extended satellites, CNN, ABC. They pay whatever that is, $19, $24 a month. Even though you do something up here in the spectrum, you go from 500 megahertz to 750, and you put digital services and two-way interactive, a large portion of your subscriber base does not require any change out of set-tops if they're perfectly satisfied with those low-end cost leader types of services.

Only the subscribers who are ready, willing, and able to shove new dollars at you for those services get a new box. And that box that came out doesn't go in the trash; it allegedly goes back into the warehouse and gets redeployed. As your subscriber base continues to grow, there will be some number of people who, despite all of our best efforts, don't want those new interactive services. So there's just a five or ten percent incremental addition of new digital set-tops in even some of the most aggressive models of deployment of what we're all here talking about today.

Mr. Handy: But the cable provider will require the insertion of amplifiers on the whole network to support those five or ten percent.

Mr. Luff: Exactly. But in the trials, for example, some operators are just activating 750 megahertz on one leg of maybe 50 legs, and getting their feet wet and trying these services in a very restricted 200 home, 1,000 home, 4,000 home node, and not bothering with the other 100,000 subscribers until they get a better feeling as to what the purchase rates are. Because one of the most difficult things you can do, other than redigging up the earth, is keep coming into the living room and putting a new product in and taking the old product away. The consumers just really get uneasy about that.

And in a competitive market, the reality is this year, which is different than last year, there's a DBS (Direct Broadcast Satellite) satellite up there with 50 some odd channels of movies, very crisp, very clear, no outages, no repeaters, amplifiers just coming straight down from space, and they have a pretty good cost point. So the cable person is in an environment, and the new telco entry's coming in, where they have to be very careful how they handle the subscriber, because if they end up confusing the subscriber, they'll walk away from that provider and go to one whose message is a lot more clearly understood.

Mr. Handy: Okay, but still there's also some stuff at the driving end of the cable that needs to be changed, right?

Mr. Luff: You have to have file servers. In the past, the model of broadband was little islands unto themselves. One little cable system operated independent of all other little cable systems. The only thread of connectivity was the fact that they were all getting some of their signals like HBO from common satellites. But because there was no two-way, or interactivity, or telephony that had to interface with a telephony switch, every operator could enjoy the flexibility of picking their own hardware, software suppliers, billing systems, totally independent of the others.

Now the model is, with these file servers and two-way, a disproportionate amount of the programming is likely to be delivered by terrestrial means, and one of the drivers of that, to not get too far afield, is when you go up over the satellite and down, you have a quarter second delay. You can't do joy stick and eye hand coordination when you have a quarter of a second delay. So if you want to do true interactivity, you've got to have terrestrial links in order to keep the latency under control, and even then it's a challenge through ATM switches and other things, and also it incorporates some of this delay even when you've got the circuit connected, but the point is, the new technology will use more terrestrial circuits with SONET rings and such.

As an example, Jones Intercable has most of the systems around the southern crescent of Chicago. Why should they have eight different head ends and cost structures and reliability issues, when they can make one mega media center, and bring Fox's Entertainment on one huge file server, and run those fiber strands at a nickel a foot, $212 a mile, to connect the other head ends? And now, instead of each head end only having enough funding to do 50 or 100 titles, Jones can have one mega media center that can have a couple thousand titles, but connected by fiber. So not only does what you put in the head end change, but where you put it changes, and how you connect it all together changes, and where you're going with it and how you're deriving money changes.

Mr. Handy: So it's getting pretty expensive.

Mr. Luff: At a seminar I heard an estimate of about $7,500 storage cost alone per movie, and an ATM switch (and there's a raging controversy there), but if you choose ATM, perhaps another $500 on top of that just to get it out of the head end. Now you have a set-top, the plain Jane analog set-top is about a $67 price to the consumer with addressable features and such, so you can do HBO, pay movies, that's a $100 box.

The advanced analog/digital set tops, which is all analog video but has data carriers that you can get quick flash ups of weather and other information, stock market, club sports scores and such, is about a $150 box, but a digitally compressed, interactive set-top, because of the cost that was pointed out earlier of microprocessors and memory, starts today at around $400 a box. So you've got to be convinced that there's three times more revenue per household in the analog/digital world in order to justify a threefold increase or more in the technology cost. And that means all of you have to close your eyes for the moment and say, if you're grimacing at a $33 to $34 a month cable bill, how are you going to feel about a $78 or $80 a month cable bill. Because that's what it would take to support that in a competitive environment, long term.

Mr. Handy: All this sounds like it's leading up to the possibility that the cable providers are not going to be rushing to embrace this technology. Instead, they're going to be taking baby steps on the way there. And yet Mr. Fujitaka and Mr. Dunn are being asked to provide custom ICs to go inside that set top box. They have to work product plans around that. And if they don't see a market on the verge of explosion, they're probably going to find other places to put their engineers. I don't know. Maybe, Mr. Fujitaka, you could tell us whether NEC is happy to throw big resources at something, a market that looks like it's emerging somewhat slowly?

Mr. Fujitaka: Basically, we are really excited about the business opportunity of the set-top box in the future. But as Bob just mentioned, we have not gotten a clear answer on what a sweet spot in the price and the cost structure is and what kind of integration we need. Based on today's technology, we can do everything from the technology point of view. The big question is, as Bob spoke about the $400 box, is a $400 price tag for the total system the right price? If so, how much do you want to pay for the silicon?

Mr. Handy: I'll add a teaser in there. Right now DRAM is costing $25 a megabyte. The lowest amount of memory that's used in a digital MPEG decoder is a megabyte, so that's $25 just for the DRAM there, although some decoders use up to 8 megabytes of DRAM. That's basically $200 worth. You can run up the OEM costs inside of those a whole lot.

Mr. Fujitaka: I want to refer to what Ted said when talking about delivering some pictures and videos to the home. Currently, we can use the consumer's personal computer. That's the right answer. We can do that. Immediately. As long as the consumer is really familiar with operating the personal computer by themselves, they already have it. But what's the price they spent on the computer? Like Carl Stork said yesterday, there's no $500 fully functional personal computer today. So that means, fortunately, Ted could see some potential business based on lots of investment already there for other purposes.

But when we focus on the discussion of set top box itself, just as Ted said, we need to have the total configuration equivalent to what the current personal computer has, we should duplicate most of the functions that the personal computer has, and, as he said, the total box must sell for $400. If we can meet the $400 price, or as Carl Stork said yesterday — $500 a box — we can expect lots of demand. But currently, unfortunately, I do not have any answer for that.

Mr. Handy: How about Philips, Mr. Dunn? Is your company as strongly behind the idea that there's a price point that can't be violated?

Mr. Dunn: There's no such thing as a price point that can't be violated. But you've got some pretty fundamental laws here, if not rules, that tell us that we can't supply the complete functionality required by some of these guys inside the $400 margin. And I think we've got to go back again and say the technology's not the issue; it exists. We've all got mixed-mode ASIC technology, so we can do the digital center of the system. That isn't the problem. The problem here is how we take this and make a business out of it, a successful business for all the players in that value-added chain.

And I would repeat some of the things that are being said today. It's got to be evolutionary. You cannot take a radical change to the consumer market and expect instant lift-off. It confuses people. People stop spending. You see that in some products already. It's got to be simple to use. I cannot use my full function VCR. My kids can, but I can't. It's got to be low cost. The silicon guys have to make a profit too, and there's no way they can provide all that functionality and fit it inside a few-hundred-dollar box.

Are we interested in it as a company? Of course we are! Are we going to be there? Of course we are! But we've got to determine what the business model is, and we should forget the technology for a moment and find out what we're trying to do here, which is deliver information to consumers at a price they can afford, of the right quality, and with a system that they can use and they will know will not be replaced, outdated within a matter of weeks, or months, or even a year or two. And I think Ichi had a good point. Make it modular and incremental in capability. So you go in at the low end, you up-integrate, they get use to it, they understand it. I say "they," I mean "me" as well. And finally, by that technique, over a period of time, you achieve what Ted wanted, which is the evolution. You also train the consumer finally into a revolution, but a secret, slow one. So yes, we'll be there. But I think we have to carefully address what we can do to fit within the spending power of the average consumer, including myself.

Mr. Handy: Okay, so you and General Instruments we know, and Scientific-Atlanta are all talking about upgradable boxes that can be upgraded as technology becomes inexpensive, or whatever the reason, as the consumer decides to spend more money on the set top box, possibly incrementally rather than all at once. I guess the question then kind of goes in conflict with something that Bob Luff said was that cable users don't like having people come in their living room very often. Does that imply that people are going to run down to their video rental shop and buy a cartridge to plug into their box and then own the cartridge themselves, or how is that going to be handled?

Mr. Dunn: Even better than that and so there is no conflict. Customers have shared with us their concern about their appetite for robust, early deployment is directly proportional to their confidence that these boxes can be flexible and evolve in a marketplace-friendly way. And that drove us to three absolute key, fundamental, strategic positionings to really separate our company from most of the other companies out there.

Number one, it was important to wrap ourselves around national and international standards, not try to do a proprietary closed platform because you scare customers away, and you run the risk that in fact you are out there all by yourself with a platform that no one else is supporting. Number two, downloadable applications. And then we took it one step further, downloadable operating systems. One of the beauties of being selected, or one of the fallouts of being selected by two of the high-visibility, early market trials, was we simply didn't have time to develop two separate independent boxes, so we developed one box that had the ability of working into it an operating system by one company, or an operating system from another company and, therefore, became an early leader in this business of downloadable functionality improvements.

But you can only do so much with software, because the operators have to make this fundamental decision that Jim pointed out, that memory is so expensive. How much memory do you put on the motherboard? If you put too much, you burden the launch cost of all the services, and they fizzle because it's too expensive. If you put too little, you choke the eventual development of more aggressive applications.

So our third strategy was to create something we call a genius card, which is like a smart card, which is like PCMCIA, but PCMCIA doesn't handle analog very well. And so we needed a way to port in completely new chips, completely new memory banks. We also needed a way to port in very specialized applications. We're all talking about content video. Remember this network provider has got to compete against other network providers, and these networks have more than video and entertainment and games; they have telephony. They have load management from the local power company. They have possibly X10 inside the house home wiring control of air conditioners, heat systems, and such, and so this set top box is more than just this entertainment device. And none of those industries is really as well-developed as even the one we're talking about, and so you needed a way to do things including wireless PCS base stations in this set-top.

Since it's already a telephony node, how do you turn that into airwaves and get into a full phone or something you can walk around the room. Set-tops are going to be the node for that, so all of those purposes have to be envisioned and planned for, for a company to be able to successfully put in $5 billion networks over the next seven years. This is the solution that grows over time, not only in entertainment, but in telecommunications and other totally different applications.

Mr. Hoff: I think it's important for us to keep one or two things in mind. As we try and provide more information and entertainment and communications and reference education into the home, it's not going to be an either/or. It's not going to be, "Well, that's going to be in the set top box on the television set." Or, "This is for your computer only." I think what I see, if I look at the marketplace, I think each of us are all consumers at the end of the day. We all have jobs, and we all have careers, but at the end of the day we go home and we're in our home as a consumer. What do we do as a consumer?

We may bring work home. We may watch our children do their homework. We may teach our children reading and math skills. We may want to learn a new application. All those things are done on our computer. They're not done on a television set. I don't think the day comes when you sit back in your Barclay lounger with a 50-inch screen and surround sound that you're going to balance your checkbook in front of the television set. That's not the intention. The intention here is to be able to bring all different forms of communication, entertainment, and information into the home. The consumer will decide where they want it.

You go into a New York brownstone that's four stories high and the last thing you want to do is go online on America Online and get a scrolling thing of what TV Guide says is on television tonight and then run down four floors and say, "Wow, look at the data I just got off of my PC," and try and find that on your television set. We have to keep in mind that these are discrete markets. And the television set is primarily a passive entertainment vehicle. There will be interactive TV, there will be transaction TV, there will be all kinds of stuff, but I still don't think that you're going to do your taxes, or the work you bring home from the office, or your kid's homework on the television set. It's going to be done on the PC. If there's an opportunity to also enjoy some entertainment on the PC on a break, terrific! I think that's fine.

We, as News Corporation, are in the screen entertainment business. I could care which screen you watch it on as long as it's my product. So if I provide data, or if I provide information, or reference, or education, I think you're probably going to use your PC for that. If I provide Diehard 3, the interactive game, where you're Bruce Willis, and you want pyrotechnics, and explosions, and video clips, and you might want to sit there and watch the movie, I really think that's going to be on your television set. I think it's very important we recognize these are discrete markets.

There're different forms of data that the consumer wants in different formats, be it television or PC, and we have to drive and work both those markets. The eventual winner isn't, "Aha, I've got everything on the television set." What have we really done then? You can't watch multiple things on the television. You can't balance your checkbook and watch the movie at the same time on your television set. So let's not kill ourselves by displacing some other form of revenue by only having one screen in the home.

We want multiple screens to perform multiple tasks for multiple members of the family. And you tell me which one of you is going to allow your kid with your loaded PC, with all your data on it, to bring the coke, and the popcorn, and four kids into your den to play the latest video game. It isn't going to happen. But it will happen in the family room with the dog and the cat and the 50-inch screen and all the kids from the neighborhood and the ice cream slopping all over the place, where they can play the video game on the television set.

You know, you have a problem that's a lot like some of the semiconductor manufacturers, that you have to spend your R&D dollars on the place where you think you're going to get short-term revenues. Where I'm going to spend my dollar is, I'm a little bit like the guy who goes to the horse race today. I don't know who's going to win that race; I know one horse will win the race. So what am I going to do? I'm going to bet $2 on every horse and then yell and scream and be all happy when my horse wins. I may have lost $80 on the race, but one of those horses won.

I'm out today for one video game. I'll give you a perfect example. Diehard 3 is going to be a motion picture next summer. It's a terrorist movie. Takes place in New York. Bruce Willis. You're going to love it. Go see it. For me to develop a video game on that movie takes me almost a year longer than it takes 20th Century Fox to make the motion picture. So I can't get the game out on the same time on Memorial Day weekend, which is when you're all going to see Diehard 3. So what I'm going to do is tie it in with the video release.

Mr. Handy: The question is, with this stuff all creeping along very slowly, are you going to support set top boxes anytime soon? Which horse are you going to bet on?

Mr. Hoff: At the end, one of those horses is going to win. Today, for me to go out and hire a developer, whether it's in Europe, or whether it's in India, or whether it's in Seattle, costs me almost $2 million to develop a video game of Diehard 3. Why does it cost me that much? Because I have to develop it for seven platforms. Because I can't run the risk that Sega 32X is going to be the winner, or that PC CD-ROM is going to be the winner, or Sega Saturn, or Sony Play Station, or MPC, or MAC, or whatever it might be. Or cartridge, which is the trailing market. I can't walk away from a trailing market that has over 40 million in installed base. So I have to develop for all these platforms because I can't take the risk that the one horse I didn't bet $2 on wins. So content providers like myself are going to the horse race and we're having to bet on every horse, because we can't afford not to be on the winner, to be a jockey on the winner.

Mr. Handy: You didn't say what I thought you'd say. I thought you'd say that you were going to back off for awhile, in which case I was going to say that's going to further impede the progress of the standards. You can't back off.

Mr. Hoff: I can't develop for systems whose development systems aren't available yet. So what I have to do is develop for the systems that I can see are available for the consumer market. And there is no system available for the consumer mass market other than the PC and the trailing cartridge market for at least two years. I'm looking at mid-1996 before I can back any of those systems.

Mr. Handy: Is this horse race strategy a good one for the semiconductor manufacturers, Mr. Dunn?

Mr. Dunn: I field the horses sometimes. It is our strategy as well. There are multiple platforms around. Philips has platforms. We've had a lot mentioned today. Our strategy is going to be to bet on not all of these platforms, but sufficient numbers of these platforms that we try and cover the winner. And it's not our job either to dictate which platform will win, not as a semiconductor manufacturer. The Philips group has a different view; they think they have a platform that will win, and good luck to it.

So yes, we're spending good, solid R&D bucks on solutions for different platforms and that's how it's going to be for the next few years. And I don't think we'll see any emerging standard for a long time yet. So we have the onerous task of meeting the $100, $200, $300 set top box cost and multiple platform base. I keep asking myself the question, this is not a huge market for the silicon manufacturer. It's an important one, but not a huge one. At some point in time, we have to look at the business issues and say, "How much do we spend on these multiple platform solutions to move into a relatively small market in which the silicon content is forced down by the spending power of consumers?" It comes back again to Ichi's point — let's make it easy, simple, and modular.

Mr. Handy: I was going to ask Ichi to get on to it but I've just noticed that it's already 4:10, and I think it's probably a good time for us to open up for questions from the audience.

Question: Dick Joy from Unisys. I'd like to kind of reset the panel. First of all, I'm one who doesn't probably watch a lot of TV, and one of the things that Mr. Luff talked about was the fact that there are all these set-tops out there. I don't have a set top in my house, I won't pay for one, I won't lease one. I think it's an added expense. And I really wondered, maybe I think differently than everybody else, and obviously I guess I do. But I wonder what kind of market there is out there for a set-top, because if I'm going to pay $400, I'll go out and buy another TV set. I have a TV set that's cable-ready, and I have a PC that's got a modem on it. That's what I use today. And I don't want to pay those extra dollars for that, so am I off base or is there really a market out there for these things?

Mr. Luff: Let me tell you why I don't think you'll buy that TV set. If you turn the clock back 10 years, and we were having this panel and we were talking about maybe getting a remote control feature, channel up, channel down, volume, you might. But we've had a very controlling, overgovernment-regulated environment for the past 50 some odd years that has mandated NTSE, analog, one-way, and kept various services at wide stance from each other. Now that has all changed, or is in the process of changing. If you were going to take that otherwise perfectly good television set out to the curb and throw it away, and go to the store and buy a $600 or $700 set that had some other feature, let's say MPEG compression, but HDTV coming in three years, now how do you feel about that investment? We're going to go from 16-bit to 32-bit to 64-bit on some of these applications. Now how do you feel about that investment?

And we've already gone from simple stereo to surround sound to who knows what, and now how do you feel about that investment?

The consumer electronic folks have had their chance at providing and keeping up with the public's insatiable appetite in this video world. Some would argue very strenuously, they haven't done very well. When the public wanted more channels, where was the consumer electronics industry? They chose not to follow that demand because it started out kind of small, not too many standards, didn't know really where it was going to go, very competitive industry, didn't want to be the first one to drive their set cost up $2 over the $299 to $301, so they didn't do it. That would have paralyzed. None of us would be in here today having these conversations had it not been for the cable industry and the set-top. Not that the set-top folks were so genius, but it unlocked the part that was going to change the most in the shortest period of time; from the part like the picture tube, and the power supply, and the wood cabinet that isn't going to change very much.

So what's happening now is the network providers are stepping forward and saying, "Do I want to lock myself around a pace that changes every nine to twelve years?" That's how fast technology comes in the television environment, because of the huge cost and how much you have to prematurely obsolete to get that one incremental new feature that we're talking about. The public's probably not going to do that. Or, "Do I want to lock myself around a philosophy and a strategy that allows me to change and become more competitive than my neighbor network by taking a little more responsibility in that part that gives me a strategic advantage?" I could get more channels, better quality, more features with this kind of thing I have this love-hate relationship with over the years called a set-top. And if you look at the historical reference point of where we are, we're not at the end of technological upheaval, we've just begun to get on the cusp of what's going to happen, having had this thing frozen for 50 years, and now opened it up.

And so those of us in our world, and certainly the analysts in the investment world who look at these, one of the reasons Scientific-Atlanta stock hit all-time highs and split two for one last month is that people fundamentally believe that there is such change afoot, that those that are positioned for flexibility and who can do something that helps content get out to the industry faster are going to be those solutions that will be in demand and those that have the weight and sluggishness of more traditional approaches are not going to be in such demand.

Mr. Fujitaka: I partly agree and partly disagree with Bob's comment. And I almost agree with Mr. Joy of Unisys' questions. Beforehand, we discussed the amazing feature of the set-top box. I totally agree with the point that most people never require a set-top box in their home. More than that, as a semiconductor manufacturer, I know everything. Currently, we're enjoying a triple business on TV tuners in the United States. TV sets already have tuners inside and VCRs have tuners, and set top boxes have tuners. More than that, a more complicated situation is that most of you may already have so-called universal remotes. What does that mean? Once we install the set top box, the set top box requires the VCR and TV to be tuned to channel 3 only, for example. How can we utilize all the functionality of the TV and the VCR? It's so difficult! Currently the set top box cannot provide any weekly or monthly programmability. I totally agree with your point.

Beforehand, we discussed the digital set-top box. We had better focus on what the basic customers want. How difficult is it for the customer right now to use the set top box? I have a suggestion. Let's have a consortium between the VCR manufacturers and the cable providers and the TV manufacturers, arrange some standardized size of module, to be on the TV or VCR. Once you've bought the TV monitors, it has a module box, a plug-in box. If the consumer wants to try the cable TV special services, ask them to send some unit and install it on the side of the TV, providing all of the programmability it already has and some additional features. I think this might be the best solution. But that's my personal opinion.

Question: I'd like to get from the trenches to 30,000 feet. I have two questions for Mr. Hoff and Mr. Luff. The Hoff/Luff team here. First, Mr. Hoff. Can you give us some idea of how many dollars you think are going to be spent per month for a cable-received content? In other words, how many dollars do you think the average, or sweet spot, of the market is going to be per month to receive entertainment products? Second question, Mr. Luff. Why do you think that we can't pay for a set top box somewhere between $500 and $1000 that has 30 percent semiconductor content when we have paid in the past those kind of dollars for a single-function VCR?

Mr. Hoff: I think it really depends on the consumer. If you're my wife, anything over $24.95 a month is out. Let me respond to the question this way, which is basically, what's the point at which it begins really hurting the consumer? When's the squeeze on the consumer on how much per month they can afford to pay for subscription services? I've heard a lot of magic numbers, but those magic numbers depend on what's delivered today. And those magic numbers today, it really begins hurting at $49.95, and you've got an upper limit of $69.95. I don't know if other panelists would comment on that or not. But that's what we're learning and see to be the upper limits.

Part of it, as it evolves, is going to depend on what's taken away from the consumer. The more and more delivery-on-demand movies, the fewer trips there are going to be to the video rental stores. And the video rental stores today represent over 30,000 independent retailers. As those stores begin to disappear, and it becomes less convenient for the consumer to pick up a video on their way to or from the grocery store, or picking up the kids from school when most of that activity takes place, then more and more it will be, "I can't get it. The video store closed. What do I do now?"

Sega is currently testing the Sega channel, which basically downloads video games that are provided by Sega and their third parties. That is added to the monthly subscription rate for the consumer; I believe it's $14.95. They're testing three levels: $9.95, $12.95, and $14.95. That gives a young person unlimited game play on a choice of 50 games, plus it provides previews of 10 upcoming games, and you can play the whole game. That is cutting into, or will cut into, video game rentals. The caution is, will it cut into video game sales, because right now it's a one-way download system, and there's no way for the individual publisher to recoup on a per-play basis, royalty or revenue. If you participate in the plan, you get "x" amount back per month per subscriber. Like two cents. And out of those 50 games that they play 12 hours a day for 30 days, I don't get any more revenue than the guy who just threw his game on the system and nobody ever plays it. So there's an inequity there that won't work.

As more services are provided, I think again it's evolutionary. You can't take the consumer up to $129.95 overnight and say, "But look at all this stuff you get now." Because the consumer today doesn't know how they're going to absorb all that stuff, they don't know what to do with it. Just like they don't know what to do with all of the accessories that they have on their VCR that add a lot of cost to the VCR. Everybody thought, "Oh, everybody's going to record movies. That's what VCRs are going to be used for." Ha! We use them as playback machines. That's what a VCR is used for. So if you sold a consumer just a playback machine, it would probably be half to two-thirds of the price of a fully loaded VCR today. So I think we have to be very careful not to alienate the consumer and do something that's revolutionary and preemptive that turns them off and makes them turn away. "Here's your brand new service and it's $129.95." I think you'll get a real balk from the marketplace. We have to gradually take them up as incremental services are provided.

Mr. Luff: The question was, why won't consumers spend $500 or $1000 for a digital set-top when perhaps they had at least one time in their life bought one or more VCRs in that $500 price category? Two things have changed. First, competition. You've got network providers. The consumers aren't really buying these boxes. The network providers are buying these boxes. To network providers it costs roughly, I'm doing some real national averages here, certainly not downtown urban San Francisco cost, but also not rural America cost, but about $50,000 a mile to construct this network. At 100 homes per mile, that's $500 capital per passing for each of two networks in a community. So they've got to get back $500 per passing without even the set-top cost in the equation to break even. I know it's getting complicated, but stay with me.

If I had 100 percent of those who were willing to take these services, I can make a pretty good living out of that. But when that second network provider comes in, it might take half of my subscribers, even though my network cost stayed the same. The number of people who statistically are going to be paying money to me to pay for my network went down by half. So what if I do something in my service provisioning that pushes away more than half of the subscribers, and I only get 20 percent of the subscribers to sign on my network because of this thing that I've done. Now I still have the same $500 per passing but I only have 20 subscribers instead of 100 or 50 who are having to pay the bank and pay my note off. So their monthly rates have got to be even higher for me to make good on this, so I get into this upward spiral of business failure curve. So simply more stated is, "He who dies with the most penetration wins."

Now what are the kind of things that I could do to drive subscribers away from me to the other person? The reality is 70 percent of the viewing in the last 15 years in this nation has occurred on fewer than 10 channels. Not at any one time, but cumulatively, 10 channels, the networks, PBS, and a couple of independents. To get the next 10 percent, you'd need another 50 channels or so of cable TV, CNN, USA, Weather Channel, whatever. So with just 50 or 60 channels that can be transmitted in analog with no point or spigot by spigot by spigot conversion cost from digital to analog, I get 70 percent of my revenue with no set tops. That's network A.

Network B comes in town all hotshot, all excited about digital technology and new services and such, and his network model deploys this $500 set-top and drives his business such that it demands that $500 set-top and, therefore, his costs are such, and to the point just made, the consumers may not be quite ready to talk about $78 for all this service, so at the end of this month, somebody's got 80 percent of the penetration, somebody's got 20 percent, and at the end of the year, somebody's out of business. Because there's competition with two networks, forget them, you've got the satellite up there as well. You've got video rentals, and you've got all the other traditional ways, network providers now have to look at what is the common Joe subscriber likely to do when he comes home from work and there are two door hangers in the doorknob with different service options and costs and features like whole-house service to all the analog sets, or is it a $16 fee per every additional set-top because I've got to get back that $500 or $1000. You say, "Well what if the consumer just buys this box and we just get it over with?"

Certain cable companies tried that model, and they were marginally successful, and when two years later they decided to go from $330 to $550, the consumers came out with torches because they thought the cable company had perpetrated a hoax, got rid of their antiquated technology, got them to buy it, and then they changed the network and left them in a lurch, all greedy to get them to buy another set-top. And it cost them millions and millions of dollars in lost revenue and law suits. State laws were passed to see that you couldn't do that anymore. When you're dealing with consumers, you've got to have a rock solid, stable, position. You've got to have regulations or something you're in control over like standards, or this really backfires in your face.

Mr. Handy: We'll do one short question and one short answer. Can we do that and then call it a wrap?

Question: I think he answered my question whether it's a foregone conclusion that the consumer's going to end up buying this box or the network provider is going to buy it and then rent it out forever. Doesn't the network provider have the same concerns about the box needing to be replaced and upgraded as a consumer who would buy the box? Aren't those the same concerns?

Mr. Hoff: It's a little out of my ballpark, but I've heard a couple comments that I think apply to your question. The server will be the more likely purchaser, just as today we don't go to the retail store and buy a cable box per se. Our cable operator installs it. We as consumers wind up paying for it every month whether we know it or not. Over and over and over again. I think what you'll probably find is the service will buy the box and install it, probably have to amortize it over a shorter period of time knowing that something else is going to be coming. Whereas right now, I think, if you look at most cable box installations, I've never had mine replaced and it's been there 10 years. I think we're talking about a whole new ball game on the next go-around.

I don't see consumers going to a pay-per-view, and I don't see them just going to the satellite transmission. I asked somebody today about this. What's the new satellite thing from Hughes and RCA? Direct TV. He said, "Man, this is great. Seven hundred bucks and you get this little 18-inch dish and you put it on your house and you're golden." I said, "That's a good deal. How much do you pay per month?" "Oh it's very little; $19.95 or something." "That really sounds good." He said, "Well, there's only one drawback," and I said, "What's that?" He said, "You don't get any of the networks." I said, "So now you mean I need my regular cable?" He said, "Well, we didn't get regular cable. I went out and bought an antenna and put it back on my roof." I thought: "Now wait a minute. This whole thing is moving in the wrong direction."

So I think the next guy that comes in has got to provide you with the box that does everything, and you can't be bothered as a consumer to go out and buy boxes. What if the server changes, and so on. People don't want to own those boxes. Yes, if you move. Except today you take your telephone with you, right? So I don't know if that answers your question, but I think it's the server who's going to provide it. It's the consumer who is ultimately going to pay for it, and he's probably going to pay for it at a more accelerated rate.

Mr. Handy: Just briefly, do you agree with that Mr. Luff?

Mr. Luff: Yes, totally. Because of moving all those issues. The consumer's going to be a little timid about investing in a technology like this that's so hard to understand and comprehend. And the cable operator, or the network provider I guess I should say, is perhaps in a little bit better position to make value technology judgments. They, after all, also have a ready, willing, and able market for those repossessed devices into other homes who are not up to the full level of services we were explaining before. So they can still make other people happy or happier at lower cost because they're redeploying a technology slightly out of date, but there will be services wrapped around that just like some consumers just take HBO and don't take movie-on-demand services.

Mr. Handy: With that let's call it a wrap. I just did that so that Ted Hoff wouldn't be the last speaker, although he's the last one in the book. I hope you folks have gotten as much out of this as I have. I hope it's got your brains going as far as where you ought to be heading your own strategy to support the set-top box industry.

On behalf of Gene Norrett, I'd also like to thank all of you for coming to Dataquest's 20th Annual Semiconductor Conference. And I look forward to seeing you next year.