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CONFERENCE

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SEMICONDUCT
OCTOBER 14–1
MONTEREY

Monterey Confe
Monterey
California

SEMICONDUCTORS & APPLICATIONS

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CONFERENCE

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SEMICONDUCTOR
INDUSTRY CONFERENCE
OCTOBER 14-15
MONTEREY

Monterey Conference Center
Monterey
California

Semiconductors & Applications

Dataquest

Published by Dataquest Incorporated

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PROGRAM

Agenda

SEMICONDUCTOR INDUSTRY CONFERENCE
Semiconductors & Applications
October 14-15, 1991
Monterey Conference Center
Monterey, California

Sunday, October 13

5:00 - 8:00 p.m.	**Registration**	Monterey Marriott Hotel North Foyer
7:00 p.m.	**Welcoming Cocktail Reception**	San Carlos Ballroom Monterey Marriott Hotel

Monday, October 14

7:30 a.m.	**Continental Breakfast**	San Carlos Ballroom
7:30 a.m	**Registration**	Steinbeck Lobby Monterey Conference Center
8:30 a.m.	**Conference Begins**	Steinbeck Forum
	Welcome and Introductory Remarks John Jackson *Dataquest Incorporated*	

Electronics Industry Overview

9:00 a.m.	Electronics Industry Issues Gene Norrett *Dataquest Incorporated*	

Differentiating Your Product Through Customer Satisfaction

9:45 a.m.	The Road to Becoming a World-Class Semiconductor Supplier Geno Ori *Senior Vice President and Director* *Customer Relations* *Motorola Semiconductor Products Sector* *Motorola Incorporated*	
10:15 a.m.	**Break**	Steinbeck Lobby
11:00 a.m.	Evaluating Semiconductor Suppliers' Performance: A Buyer's Perspective Gene Richter *Executive Director* *Corporate Procurement* *Hewlett-Packard Company*	Steinbeck Forum

Semiconductor Technology Update

11:30 a.m.	The U.S. Semiconductor Industry and SEMATECH in the 1990s Dr. William Spencer *President and CEO* *SEMATECH*	
12:00 p.m.	**Lunch**	San Carlos Ballroom Monterey Marriott Hotel

Semiconductor Industry Trends and Issues

1:30 p.m.	Dataquest's Semiconductor Industry Forecast Jerry Banks *Dataquest Incorporated*	Steinbeck Forum Monterey Conference Center
2:15 p.m.	Executive Market Session: *Products, Manufacturing, and Pricing*	Monterey Conference Center

Following the presentation of Dataquest's Semiconductor Industry Forecast in the Steinbeck Forum, the conference will split into *four (4) concurrent smaller seminars*. During each breakout seminar, Dataquest analysts will explore in more detail the general semiconductor forecast as it applies to the topic being discussed. Seminars will be repeated after the break, allowing each attendee to participate in two seminars.

Seminar A: DRAM Device and Manufacturing Trends
- Sam Young — Memories
- Dr. Peggy Marie Wood — Manufacturing Trends

Seminar B: ASICs, Tools, and Foundry
- Ron Collett — ASICs, EDA
- Howard Bogert — Foundry

Seminar C: Semiconductor Pricing and Procurement Trends
- Mark Giudici — Procurement Trends
- Ron Bohn — Pricing

Seminar D: Semiconductor Manufacturing Trends
- Jeff Seerley — Manufacturing
- Mark FitzGerald — Materials
- Krishna Shankar — Equipment

3:15	**Break**	Steinbeck Lobby
3:30	Repeat Executive Market Session	Monterey Conference Center

Following the break, we will repeat each of the four presentations. *You may choose a second seminar to attend.*

4:45 p.m.	**Conference Adjourns**	
6:30 p.m.	**Cocktail Reception and Dinner**	San Carlos Ballroom Monterey Marriott Hotel

Agenda

Tuesday, October 15

7:30 a.m. — **Continental Breakfast** — San Carlos Ballroom, Monterey Marriott Hotel

8:30 a.m. — Opening Remarks
Joe Grenier
Dataquest Incorporated
— Steinbeck Forum, Monterey Conference Center

Emerging Semiconductor Applications: What's Driving the Future?

8:45 a.m. — A New Way of Looking at the Electronics Industry—Networking for Competitive Advantage
Stan Bruederle
Vice President and Director
Dataquest Incorporated

9:15 a.m. — Multimedia: What Is It? Where Is It Going?
Dr. David C. Nagel
Vice President
Advanced Technology Group
Apple Computer Inc.

9:45 a.m. — Telecommunications Trends in the '90s
Today's Desktop Need is Tomorrow's Communications Market
Stagg Newman
Assistant Vice President, Technology
Pacific Telesis Group

10:15 a.m. — **Break** — Steinbeck Lobby

10:45 a.m. — Directions of Strategic Semiconductors: Will They Match User Needs? — Steinbeck Forum

Moderator:
John Jackson
Dataquest Incorporated

Panelists:

Gordon Campbell
Chairman and CEO
Chips & Technologies Inc.

H. Egawa
Senior Vice President and Director
Toshiba Corporation

Craig Barrett
Executive Vice President
Intel Corporation

Wilf Corrigan
Chairman and CEO
LSI Logic Corporation

12:00 p.m. — **Lunch** — San Carlos Ballroom, Monterey Marriott Hotel
Industry Shifts in Value Added: An Investor's Perspective
Tom Thornhill
Semiconductor Analyst
Montgomery Securities

Agenda

Semiconductor Application Markets Trends and Issues

1:30 p.m.	**Dataquest's Semiconductor Application Markets Forecast** Greg Sheppard *Dataquest Incorporated*	Steinbeck Forum Monterey Conference Center
2:15 p.m.	**Executive Market Session:** *Application Markets*	Monterey Conference Center

Following the presentation of Dataquest's Semiconductor Application Markets Forecast in the Steinbeck Forum, the conference will split into *four (4) concurrent smaller seminars.* During each breakout seminar, Dataquest analysts willexplore in more detail the general semiconductor forecast as it applies to the topic being discussed. Seminars will be repeated after the break, allowing each attendee to participate in two seminars.

Seminar A:	**Personal and Wireless Communications**		
	Dr. Steve Sazegari Communications	Dr. Jonathan Drazin Applications	Gary Grandbois Semiconductors
Seminar B:	**PCs and Personal Workstations**		
	Andrew Seybold Portable PCs	Kenneth Lowe Microcomponents	
Seminar C:	**Mass Storage**		
	Phil Devin Disk Drives	Nick Samaras Applications	
Seminar D:	**Flat Panel Displays**		
	Joe Grenier Technology	Katherine Bull Market Issues	

3:15 p.m.	**Break**	Steinbeck Lobby
3:30 p.m.	**Repeat Executive Market Session**	Monterey Conference Center

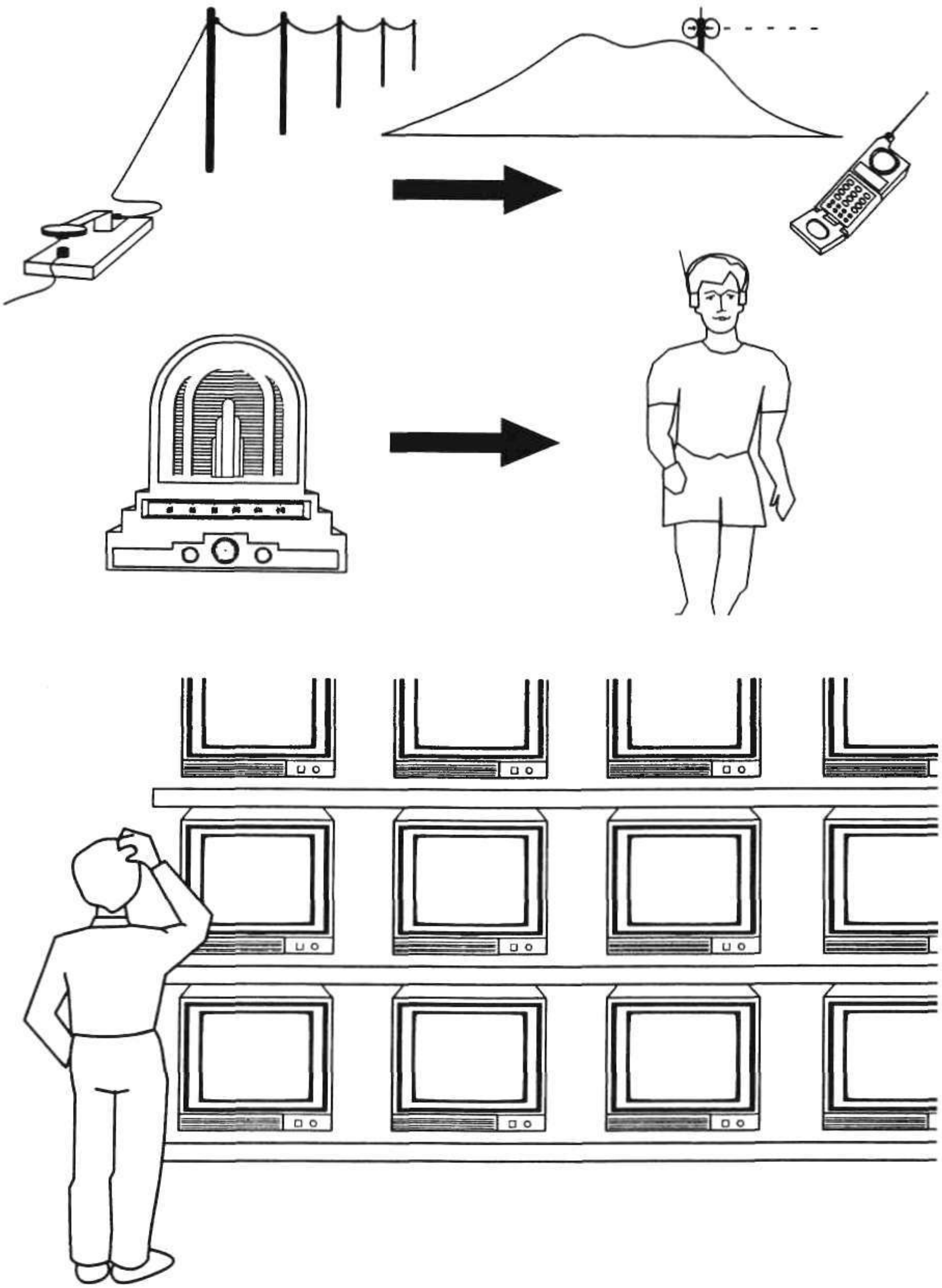
Following the break, we will repeat each of the four presentations. *You may choose a second seminar to attend.*

4:30 p.m. **Conference Ends**

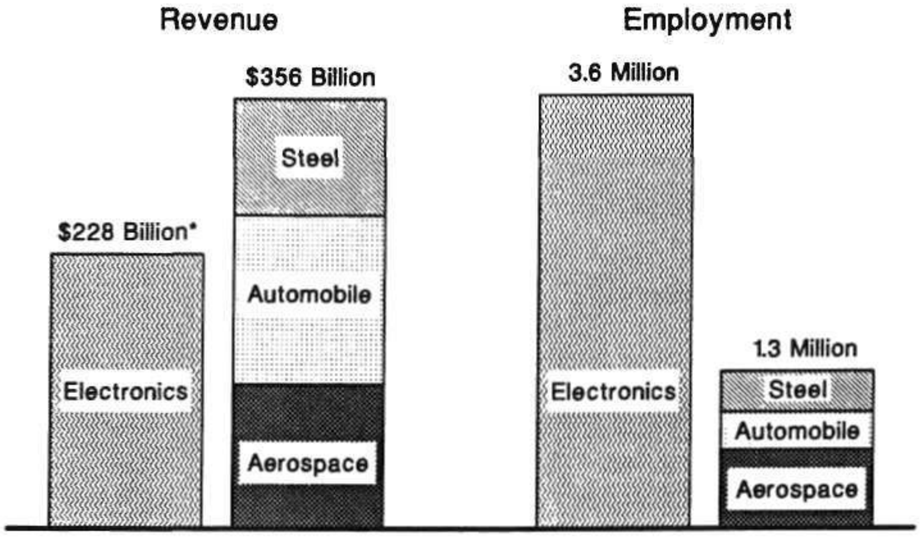
First Day

Electronics Industry Issues

Gene Norrett
Corporate Vice President
Dataquest Incorporated



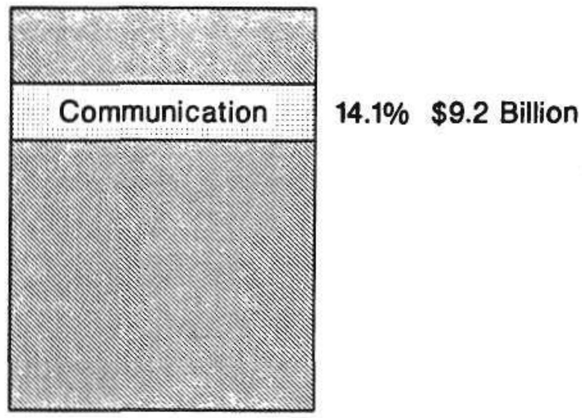
LARGEST U.S. INDUSTRIES



Source: American Electronics Association
*Dataquest

Notes:

WORLDWIDE SEMICONDUCTOR CONSUMPTION



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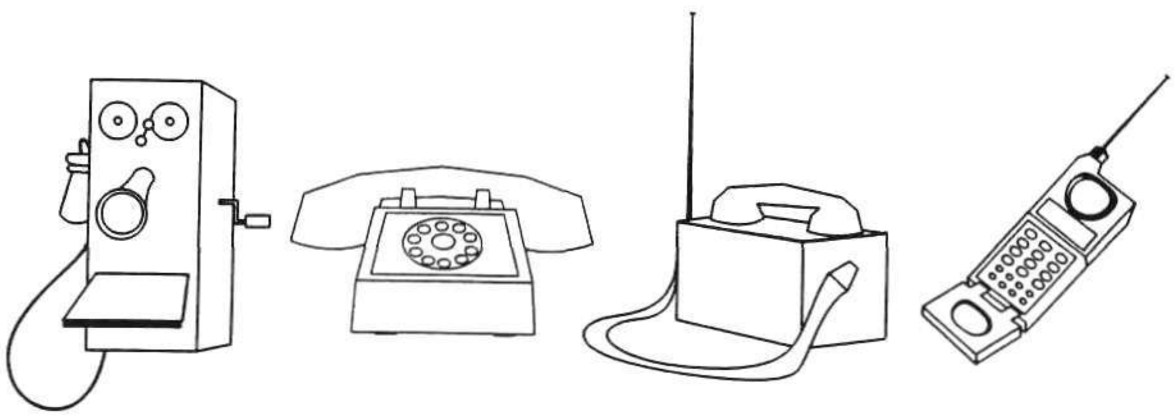
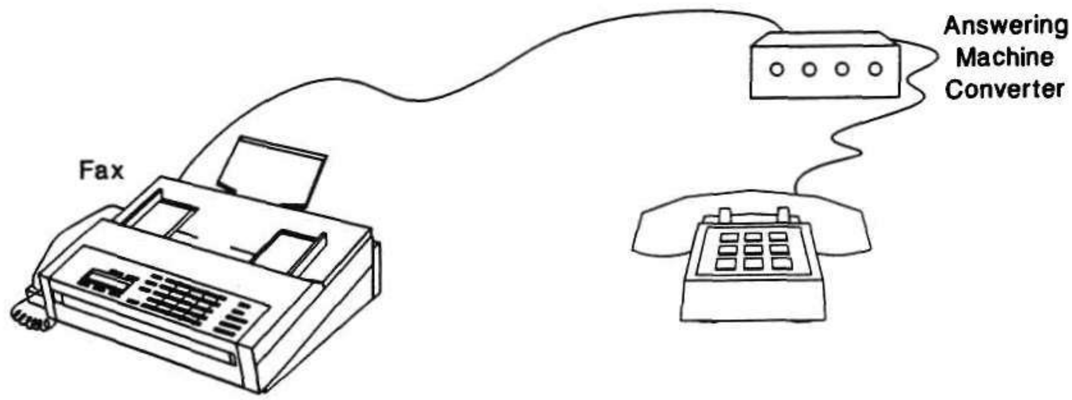


VOICE/HARD-COPY CONVERSION



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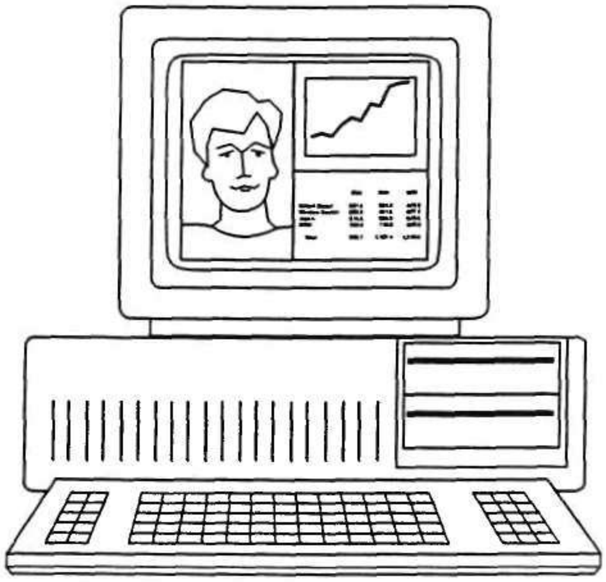
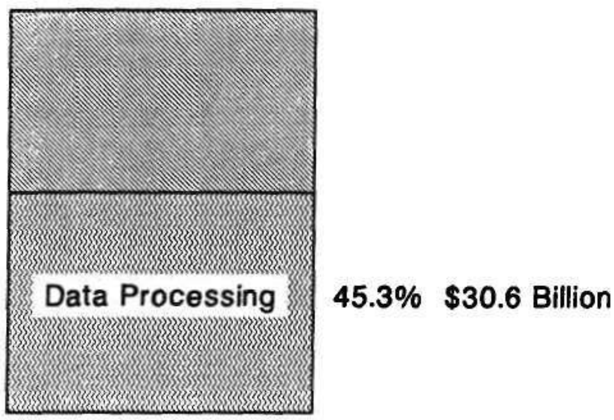
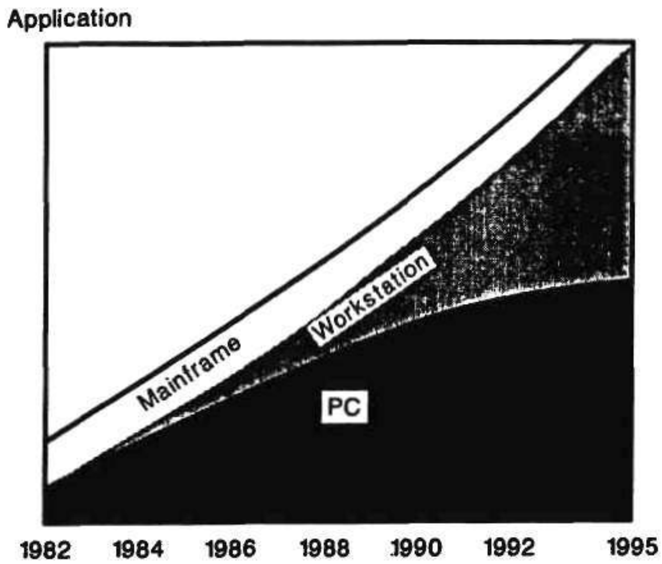


WORLDWIDE SEMICONDUCTOR CONSUMPTION



Source: Dataquest

APPLICATION COVERAGE



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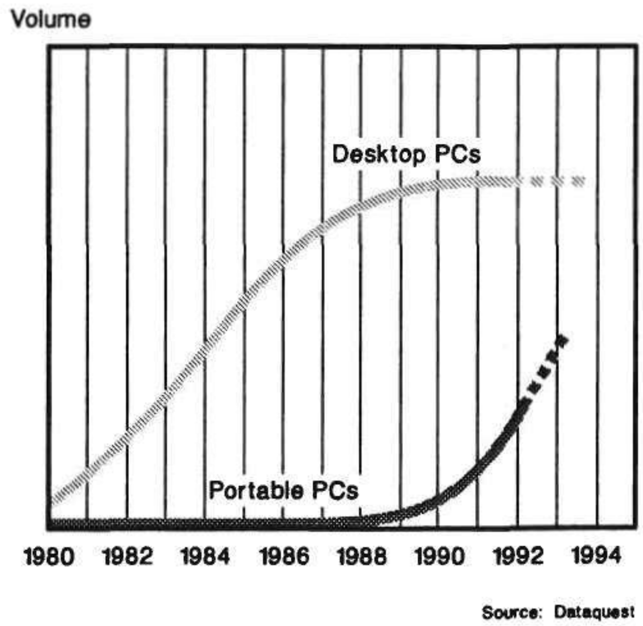
GROWTH PATTERN



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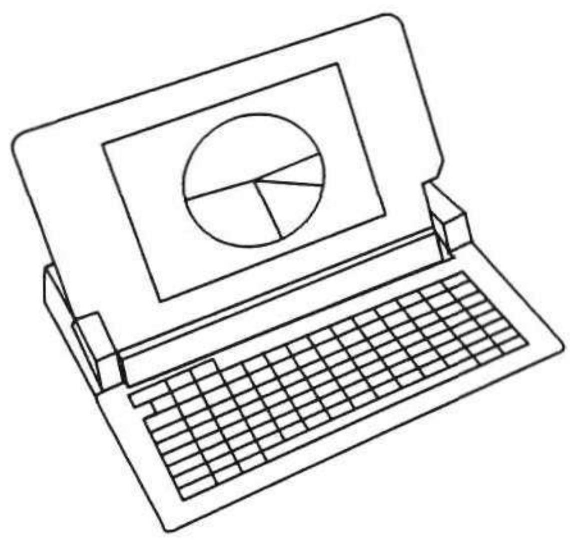
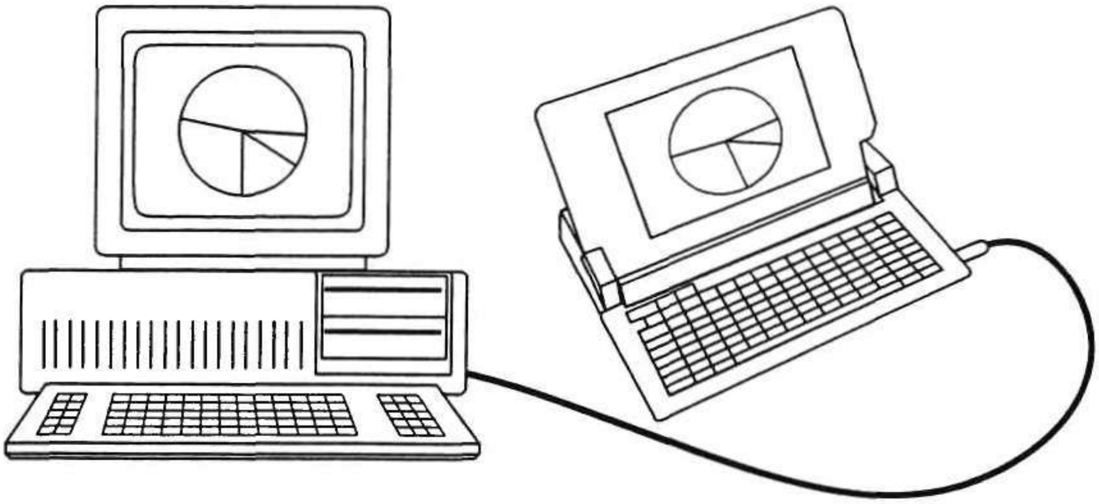


TRANSFERABILITY



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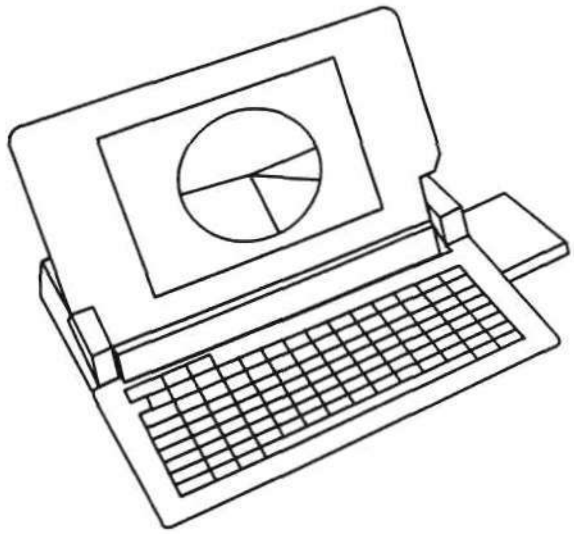
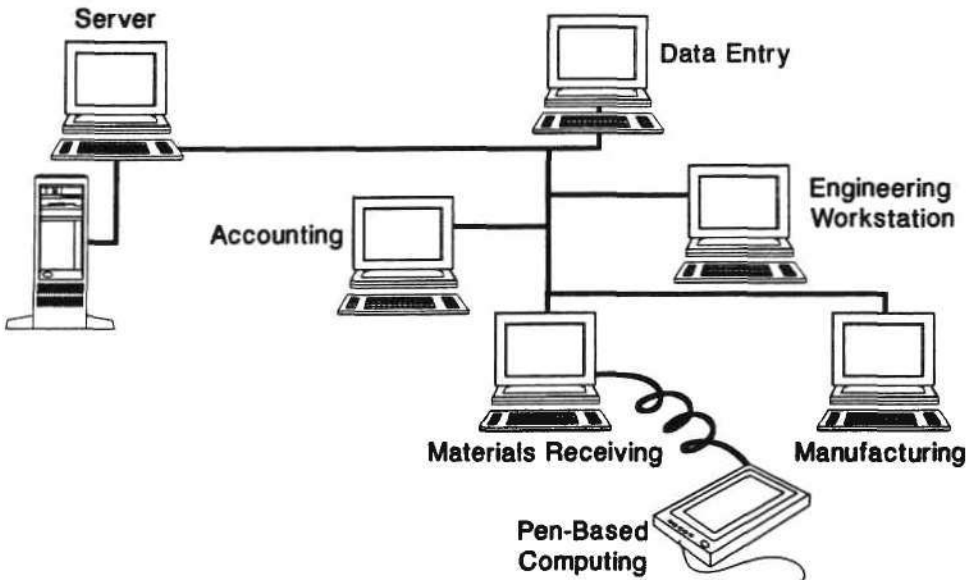
PC CARD VERSATILITY

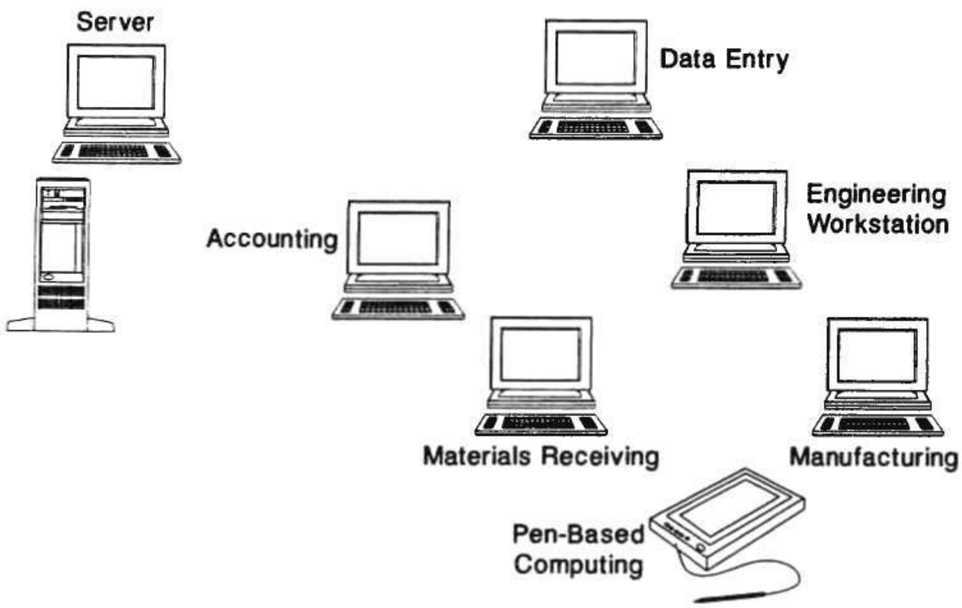


Data Storage
LAN Connection
Modem
Application-Specific
Extended Programs
Wireless Communication

DISTRIBUTED COMPUTING



WIRELESS DISTRIBUTED COMPUTING



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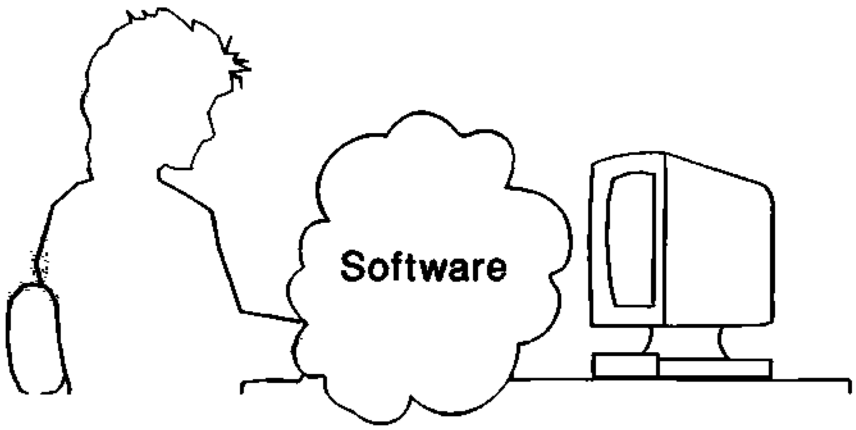
USER ACCESS

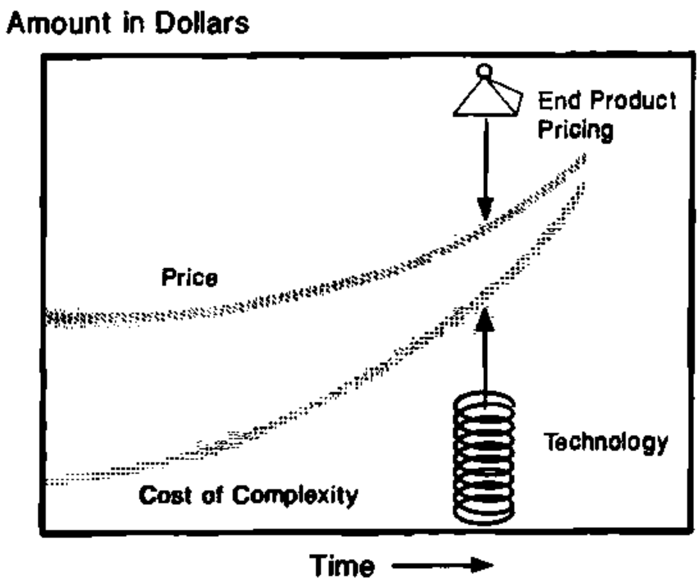


ADDITION OF FUNCTIONS

Disk Drive

Older Technology	Newer Technology
Read data Write data	Seek Position Read data Write data Error detect/correct Cache/buffer Interface (i.e., SCSI)

MARGIN SQUEEZE



Source: Dataquest

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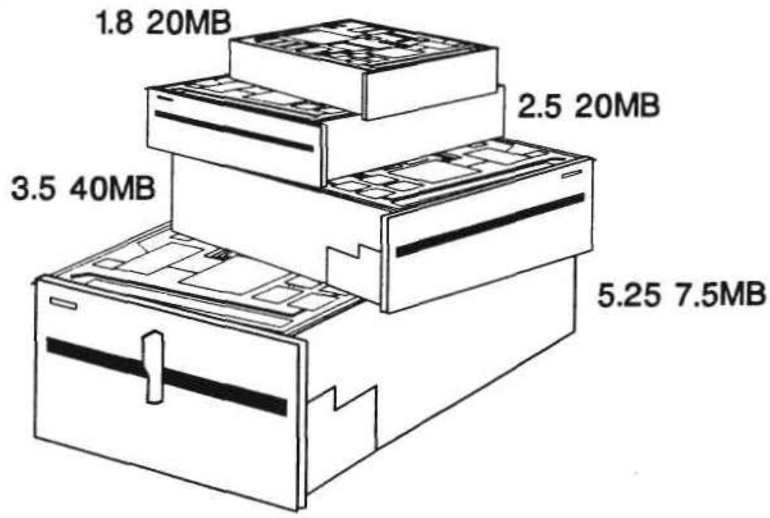
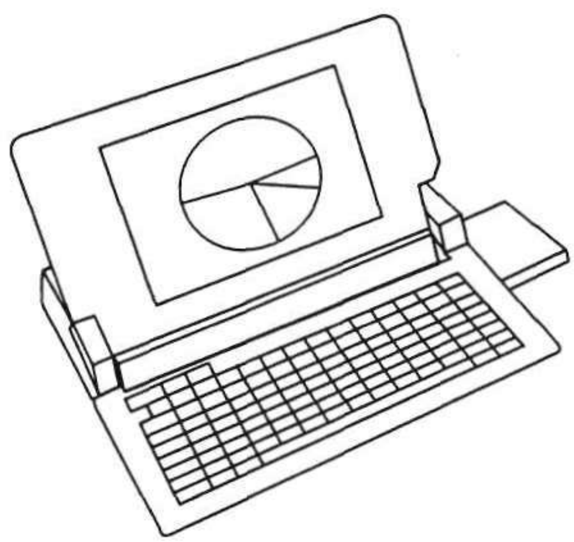
SHRINKING SIZES



SOLID-STATE



Data Storage
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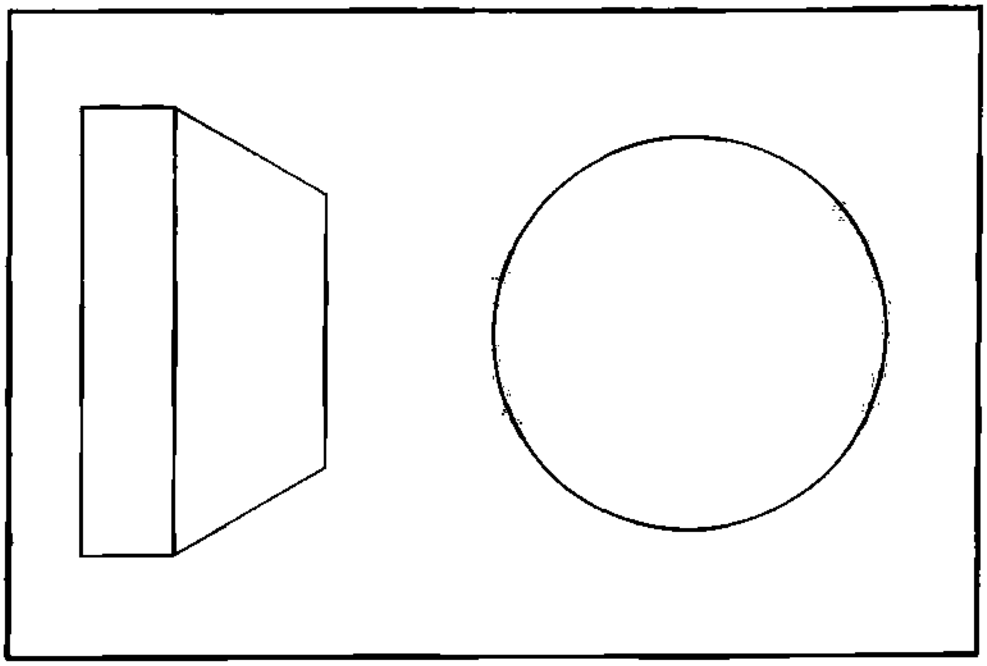

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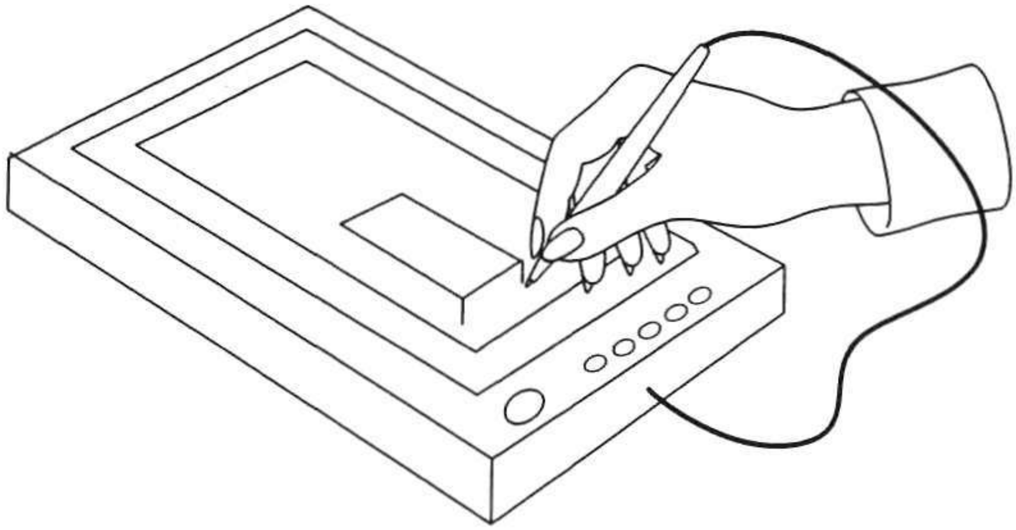
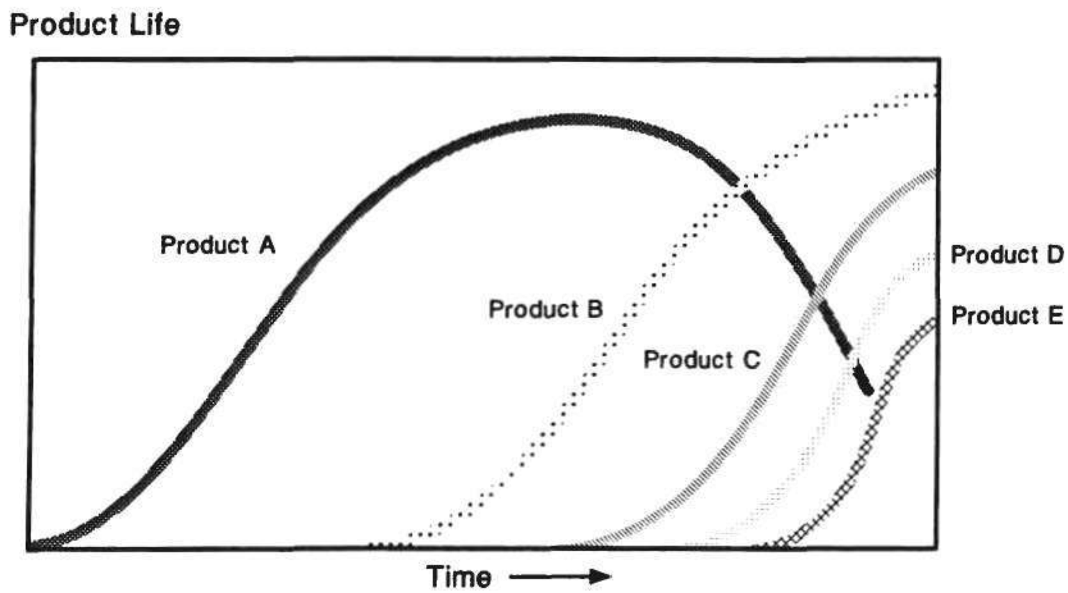
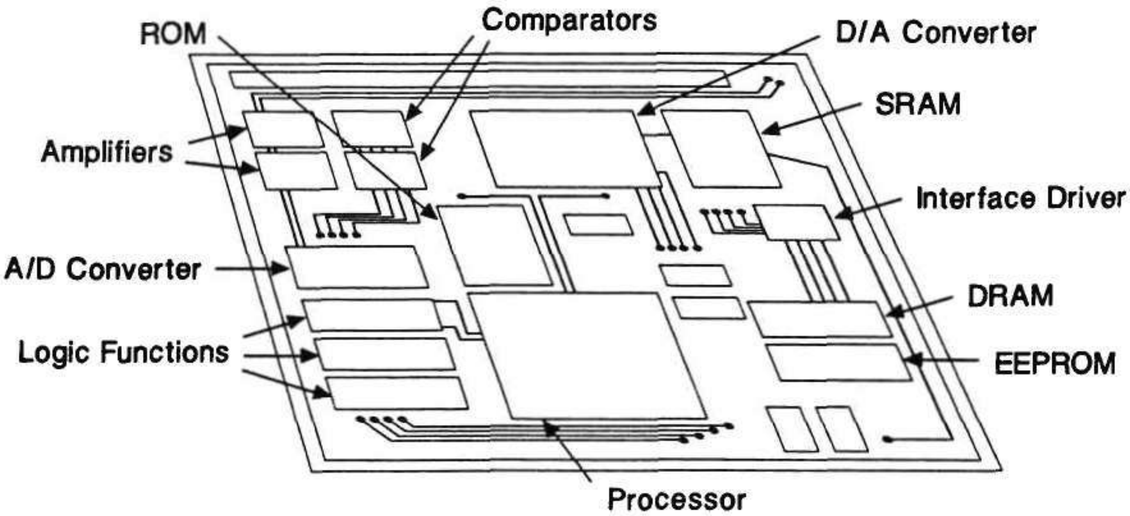


DEVELOPMENT CYCLES



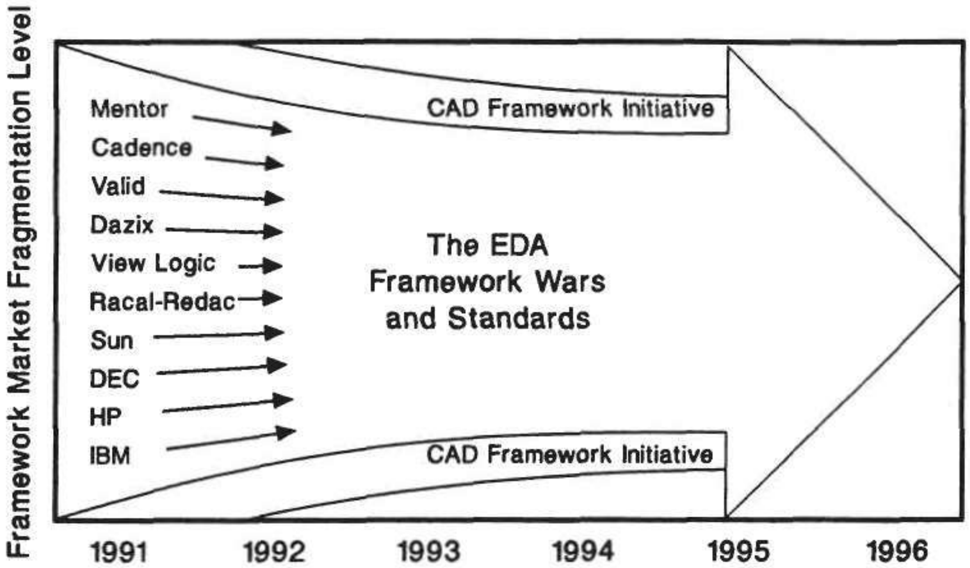
Source: Dataquest

HIGHER ON-CHIP INTEGRATION
MIXED ANALOG/DIGITAL



Notes:

FRAMEWORK FRAGMENTATION



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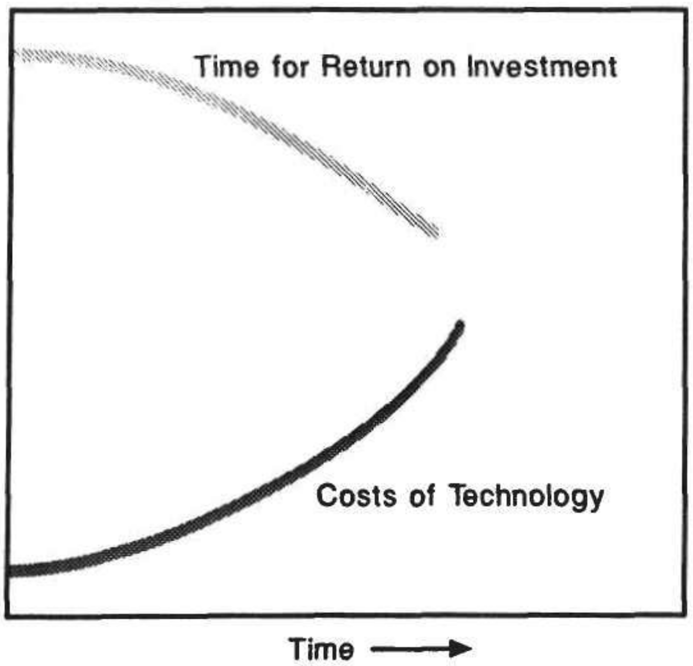
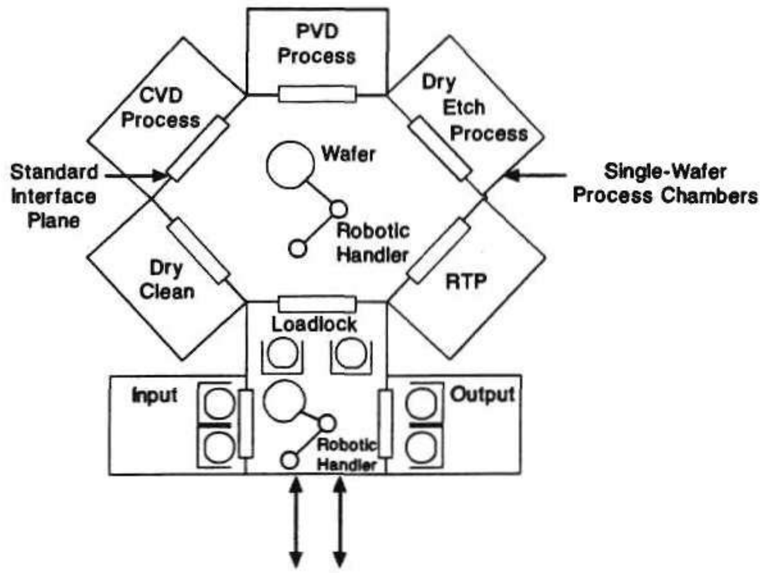


Source: Dataquest

FLEXIBLE CLUSTER TOOL



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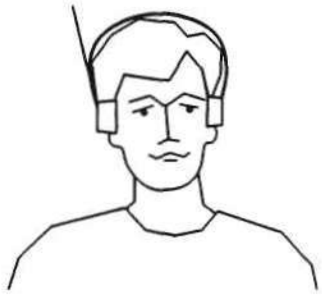

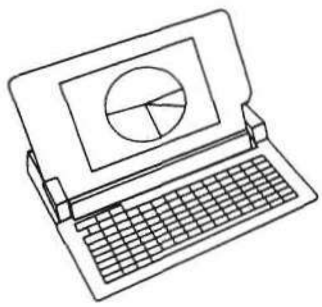

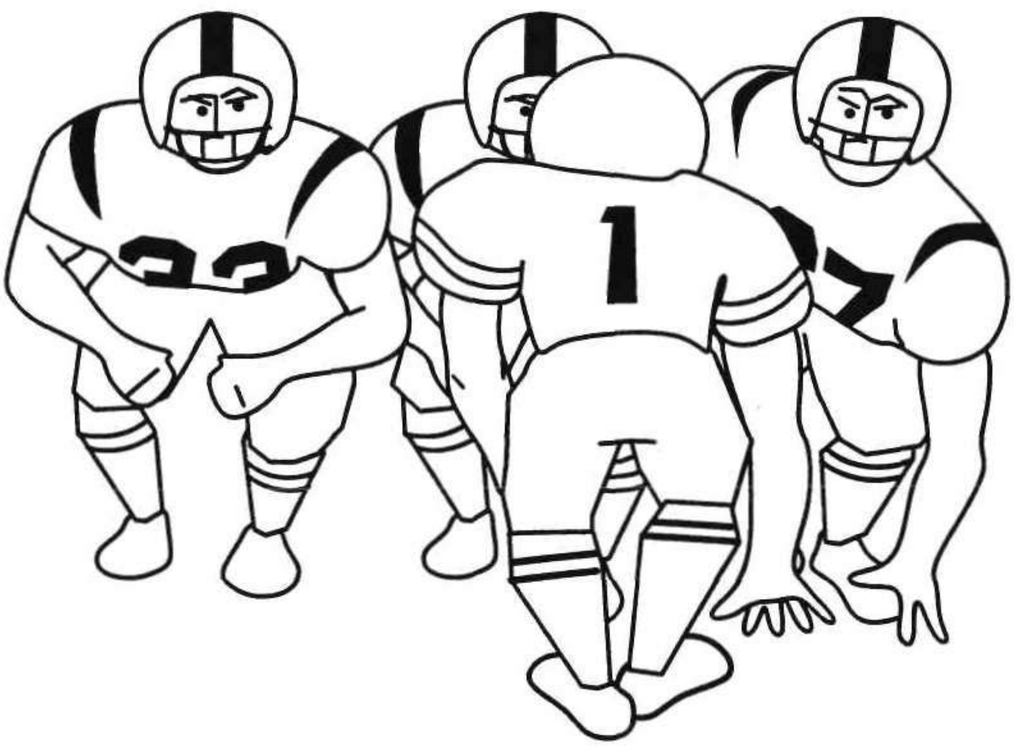

CUSTOMER ORIENTATION

- Understand customer
- Understand customer's customer
- Understand end user

Notes:

The Road to Becoming a World-Class Semiconductor Supplier

Geno Ori
Senior Vice President
and Director
Customer Relations
Motorola Semiconductor
Products Sector
Motorola Incorporated

THE ROAD TO BECOMING A WORLD CLASS SEMICONDUCTOR SUPPLIER

GOOD MORNING, LADIES AND GENTLEMEN,

WHILE THE MODERN BUSINESS WORLD HAS COME TO OBSERVE THE FACT THAT PRODUCT QUALITY IS A POWERFUL COMPETITIVE DIFFERIENTIATOR, AS I REFLECT BACK ON MY LIFE EXPERIENCES, IT SEEMS TO ME THAT THERE WERE NUMEROUS EXPERIENCES IN MY EARLY YEARS THAT MADE THAT FACT READILY EVIDENT. THE PROBLEM IS THAT WE IN THE U.S., AS A CULTURE, THEN CHOOSE TO IGNORE THE READILY APPARENT SIGNALS.

IN MY YOUNGER YEARS, I WAS INVOLVED IN THE WHOLESALE VEGETABLE BUSINESS. EACH DAY, WE HAD TO GO OUT AND BID ON LOTS OF VEGETABLES, WAREHOUSE THEM, AND THEN SELL THEM TO INDIVIDUAL RETAIL OUTLETS IN HEAD-TO-HEAD COMPETITION WITH OTHER SUPPLIERS.

WE QUICKLY OBSERVED THAT IF WE COULD PURCHASE CHOICER LOTS OF FRUITS AND VEGETABLES, OR IF WE TRIMMED AND DRESSED OURS SO THAT THEY HAD A SLIGHTLY BETTER PHYSICAL APPEARANCE, WE WOULD BE ALMOST ASSURED THAT THE GROCERS WOULD CHOOSE OUR PRODUCE OVER OTHER SUPPLIERS. WHILE THIS IS A VERY RUDIMENTARY ANALOGY OF THE QUALITY STORY, IT CARRIED MANY OF THE TRUISMS WE HAVE LEARNED THAT ARE AT WORK IN INDUSTRIAL AMERICA AND AT WORK IN THE SEMICONDUCTOR INDUSTRY.

ONE UNMISTAKABLE FACT RANG OUT LOUD AND CLEAR. THAT IS, QUALITY IS ALWAYS WHAT THE CUSTOMER SAYS IT IS!

AS MANY OF YOU ARE AWARE, MOTOROLA CORPORATION WAS THE FIRST LARGE COMPANY WINNER OF THE MALCOLM BALDRIGE NATIONAL QUALITY AWARD. ONE OF THE REASONS WE ARE AMONG THE FIRST WINNERS WAS THAT WE HAD BEEN DEDICATED TO QUALITY IMPROVEMENT FOR A NUMBER OF PRIOR YEARS AND THE PROGRAM THAT WE HAD IN PLACE ADDRESSED MOST OF THE KEY ISSUES IN THE BALDRIGE EXAM PORTFOLIO.

WHILE WE HAVE MADE DRAMATIC STRIDES IN TERMS OF QUALITY IMPROVEMENT, AND ARE CURRENTLY DELIVERING PRODUCT THAT IS 100 TIMES MORE PERFECT THAN JUST A FEW YEARS AGO, THERE ARE STILL HANDFULLS OF WAYS WE CAN AND SHOULD GET BETTER. OUR OWN ASSESSMENT OF OURSELVES IS THAT, ON A SCALE OF PERFECTION, WE HAVE A LONG WAY TO GO.

THE STORY OF HOW MOTOROLA GOT STARTED ON THE PATH TO HIGH EMPHASIS ON QUALITY HAS ALMOST BECOME FOLKLORE AMONG OUR EMPLOYEES. DURING A 1979 ANNUAL OFFICERS MEETINGS OF THE CORPORATION, THE LARGE ROOMFUL OF MANAGERS WAS MULLING OVER THE QUESTION OF HOW MOTOROLA COULD IMPROVE ACCEPTANCE BY ITS CUSTOMERS.

ONE MANAGER FROM OUR COMMUNICATIONS GROUP STOOD UP AND SAID, "OUR PRODUCT QUALITY STINKS!" THAT WAS THE SPARK THAT IGNITED THE QUALITY PROGRAM - AND ULTIMATELY REVOLUTIONIZED THE WHOLE COMPANY.

AFTER THAT MEETING IN 1979, BOB GALVIN, WHO THEN WAS CHAIRMAN AND CHIEF EXECUTIVE, MADE IT ABUNDANTLY CLEAR THAT HE HAD A PERSONAL AND EMOTIONAL COMMITMENT TO QUALITY. IT WAS NOT A PROBLEM THAT COULD BE DELEGATED TO A QUALITY ASSURANCE DEPARTMENT.

WHAT FOLLOWED OVER THE NEXT DECADE WAS THE EVOLUTION OF A TOTAL PROGRAM THAT ENCOMPASSED STRINGENT QUALITY REVIEWS AND A MORE FORMAL SYSTEM OF CUSTOMER VISITS BY SENIOR MANAGEMENT. THE VISITS WERE DESIGNED SIMPLY TO FIND OUT WHAT CUSTOMERS AT ALL LEVELS LIKED ABOUT US -- AND WHAT THEY DIDN'T LIKE. THE RESULTS DETERMINED OUR BASIC GOALS AND OBJECTIVES. BOB GALVIN BASICALLY PUT ALL THE ENERGY OF THE CORPORATION BEHIND IMPROVING OUR QUALITY.

I AM SURE EVERYONE IN THIS ROOM IS AWARE THAT PRODUCT QUALITY IS THE FUNDAMENTAL STEP TO BECOMING A WORLD CLASS SEMICONDUCTOR SUPPLIER. BUT HOW DO YOU GET AN ESTABLISHED CULTURE TO REORIENT ITSELF AND MAKE A POWERFUL COMMITMENT TO IMPROVING ITS QUALITY?

WHEN MOTOROLA FIRST SURVEYED ITS CUSTOMERS IN THE EARLY 80's TO DETERMINE THE MARKET'S PERCEPTION OF OUR QUALITY, REACTION AMONG THE MANAGERS CONDUCTING THESE INTERVIEWS RAN FROM CONCERN FOR SURVIVAL TO CHAGRIN FOR OPPORTUNITIES MISSED.

THE SURVEY WE CONDUCTED CONVINCED MANAGEMENT TO SET MUCH HIGHER EXPECTATIONS ON QUALITY MEASUREMENTS AND LATER ON, TO EVEN INCREASE THEM.

FORTUNATELY, MOTOROLA WAS ALREADY A PARTICIPATIVE MANAGEMENT COMPANY. MOST OF OUR EMPLOYEES READILY COMMITTED TO THE NEW GOALS. PLANS WERE DRAWN TO INVOLVE CUSTOMERS AND SUPPLIERS AS WELL. THE AIM: TO EVENTUALLY ACHIEVE TOTAL CUSTOMER SATISFACTION.

WE ALREADY KNEW WE COULD DO BETTER IN MANUFACTURING, EVEN USING EXISTING PROCESSES. WE SET INITIALLY HIGHER GOALS BASED ON A FAVORABLE RATE OF CHANGE FROM EACH DIVISION'S EXISTING PERFORMANCE.

WHILE THE GOALS CALLED FOR REDUCING THE LEVEL OF DEFECTS OF PRODUCTS, WE EXTENDED THE QUALITY IDEA TO ALL SYSTEMS -- PAPERWORK, PRODUCT DELIVERIES, CYCLE TIME -- TO 1/10TH THE EXISTING BASE-TIME LEVEL. FOR EXAMPLE, IF OUR BASE-TIME YIELD ON A TRANSISTOR WAS 5000 DEFECTS PER 1 MILLION DEVICES (NOT BAD WHEN YOU CONSIDER THAT IS 99.5% - GOOD, BUT NOT ACCEPTABLE BY THE CUSTOMER), WE SET OUR FIRST SIGHTS ON REDUCING DEFECTS TEN TIMES -- OR DOWN TO 500 PER MILLION, OVER THE NEXT SEVERAL QUARTERS.

THIS WAS ONLY A FRAGILE BEGINNING. TEAMS AND INDIVIDUAL CONTRIBUTORS VOLUNTEERED IDEAS FOR IMPROVEMENTS AND NEW CONCEPTS FOR CREATING AND CONTROLLING QUALITY. MANAGEMENT LISTENED. MANY OF THE IDEAS WERE ADOPTED.

WE EXAMINED EACH OF OUR INTERNAL FUNCTIONS AND BENCHMARKED THEM AGAINST THE BEST OF CLASS ORGANIZATION WE COULD FIND. WE LISTENED. WE APPLIED THE IDEAS OF OTHERS.

IN TIME, WE BEGAN A SERIES OF FUNDAMENTAL CHANGES. IMPORTANT AMONG THESE WERE THE ORGANIZATIONS' SYSTEMS AND STRUCTURES. PRODUCT QUALITY WAS THE FIRST ORDER OF ATTENTION AND, IN OUR STAFF MEETINGS, IT BECAME THE FIRST ORDER OF BUSINESS RATHER THAN ITS HISTORICAL LAST POSITION.

WE CLARIFIED RESPONSIBILITIES AND IDENTIFIED CHAMPIONS. WHERE APPROPRIATE, WE ORGANIZED TO A MORE MANAGEABLE SIZE. WE INTEGRATED RELEVANT FUNCTIONS. WE ESTABLISHED REGULAR QUALITY SYSTEMS REVIEWS.

IN A FEW BUSINESSES, WE SET ABOUT ON A TOTAL REVOLUTION IN THE WAY THOSE BUSINESSES WERE TO BE STRUCTURED AND FACILITATED. THIS INCLUDED CHANGING EVERY STANDARD, EXPECTATION, PROCESS AND SYSTEM, ALL THE WAY FROM HOW TO DESIGN, WHAT TO DESIGN, AND HOW TO PRODUCE. THOSE NEW, SUCCESSFUL BUSINESSES HAVE BECOME MODELS OF MORE TO COME.

SIMULTANEOUSLY, WE LAUNCHED A MASSIVE RETRAINING PROGRAM. WE TRAINED OURSELVES IN PROCESSES. WE BROUGHT IN THE BEST TEACHERS OF NEW IDEAS. WE TAUGHT OURSELVES HOW TO BETTER DESIGN FOR QUALITY. WE LAUNCHED A TRAINING PROGRAM ON HOW TO DESIGN FOR QUALITY. WE CREATED A CLASS ON DESIGN FOR MANUFACTURABILITY -- A PROGRAM STILL TAUGHT TODAY AT MOTOROLA UNIVERSITY WITH EVERY MANUFACTURING AND DESIGN MANAGER REQUIRED TO ATTEND. WE STUDIED THE LATEST TECHNIQUES IN CYCLE TIME MANAGEMENT. WE BORROWED FROM TECHNIQUES SUCH AS STATISTICAL PROCESS CONTROL TO ACCELERATE OUR QUALITY RESULTS.

FINALLY, THE CORPORATION ESTABLISHED A SIX-SIGMA GOAL FOR QUALITY BY 1992, WHICH ALLOWS FOR ONLY 3.4 DEFECTS IN 1 MILLION OPPORTUNITIES. SUCH A GOAL MAY APPEAR UNATTAINABLE, YET TODAY WE HAVE SOME INTERNAL PRODUCT OPERATIONS THAT ARE ACHIEVING SIX SIGMA RESULTS.

WE HAVE JUST RECENTLY BEEN RECOGNIZED BY ONE CUSTOMER, WHICH IS HEADQUARTERED IN THE BAY AREA, AS THEIR "SUPPLIER OF THE YEAR" FOR 1990, HAVING SHIPPED 100% OF OUR PRODUCTS ALL YEAR LONG WITHOUT A SINGLE DEFECT . . . AND WITH EVERY SHIPMENT ON TIME.

WE ARE ATTEMPTING TO APPLY THE CONCEPT OF SIX SIGMA TO EVERY ASPECT OF OUR BUSINESS. WE ARE LOOKING AT OUR FINANCIAL SYSTEMS, OUR INFORMATION SYSTEMS, OUR MARKETING SYSTEMS -- WE ARE LOOKING AT ALL OF THEM, TEARING THEM DOWN TO THEIR BASIC ELEMENTS AND BEGINNING TO MEASURE THEIR PERFORMANCE AGAINST A SIX SIGMA GOAL.

WHILE SIX SIGMA APPLICABILITY IT IS READILY APPARENT IN PRODUCT AND PROCESS OPERATIONS, IT IS NOT AS CLEAR IN ADMINISTRATIVE ACTIVITIES. IT TURNS OUT THAT WE ARE NOW OF THE OPINION THAT THE SIX SIGMA APPROACH APPLIES EQUALLY AS WELL TO ADMINISTRATIVE AS IT DOES TO MANUFACTURING.

WHEN ONE THINKS ABOUT HOW TO BECOME A WORLD CLASS SUPPLIER, I THINK THE FIRST THING ONE NEEDS TO DO IS DETERMINE EXACTLY HOW THEY PLAN ON GETTING THERE. WHATEVER THAT OBJECTIVE IS - SUPPORTED WITH GOALS - THEN IT BECOMES AN ISSUE OF WHAT STRATEGIES YOU PUT IN PLACE TO SUPPORT BECOMING THE WORLD CLASS SUPPLIER.

IN DEVELOPING A PLAN, IT IS EASY TO GO OUT AND CREATE A 2000-PAGE DOCUMENT. BUT YOU LOSE THE FOREST IN THE TREES. A CRISP, SHORT PLAN THAT CAN BE RETAINED NOT ONLY BY CUSTOMERS BUT BY EMPLOYEES IS CRITICAL.

A REASONABLE PLAN SHOULD CONSIST OF NO MORE THAN FIVE OR SIX PIVOTAL STRATEGIES. THESE STRATEGIES SHOULD BE SIMPLE; SHOULD BE WELL UNDERSTOOD BY THE EMPLOYEE BASE; AND THE TACTICAL ACTIONS DEVELOPED TO SUPPORT THAT PLAN SHOULD BE MEANINGFUL AND SIMPLE.
IT IS IN THE DEVELOPMENT OF TACTICAL ACTIONS THAT YOU ARE ABLE TO DEVELOP THE NUTS AND BOLTS.

ONCE YOUR PLAN IS ESTABLISHED, YOU MUST HAVE AN ORGANIZATIONAL STRUCTURE THAT WILL SUPPORT YOUR CUSTOMER STRATEGY, OR AT LEAST THE MARKETPLACE.

IF YOU DO NOT HAVE A FORMAL MARKET-ORIENTED STRUCTURE, THEN IT MUST BECOME AN INFORMAL STRUCTURE. BY INFORMAL STRUCTURE, I AM REFERRING TO NETWORKING -- THAT IS A VERY EFFECTIVE INFORMAL STRUCTURE. IN OTHER WORDS, YOU COULD HAVE A PRODUCT ORIENTED ORGANIZATION AS LONG AS INFORMALLY THEY ARE FOCUSED ON MARKETS AND CUSTOMERS.

IN MOTOROLA'S CASE, OUR MANUFACTURING ORGANIZATIONS ARE PRODUCT ORIENTED, WHILE OUR MARKETING FUNCTIONS ARE ORGANIZED INTO MARKET SEGMENTS. USING MANY CROSS-FUNCTIONAL TEAMS, WE ARE ABLE TO MELD THE TWO TO PROVIDE SOLID SUPPORT FOR EACH OF OUR CUSTOMERS.

YOU MUST MOBILIZE THE ORGANIZATION IN SUPPORT OF TOTAL CUSTOMER SATISFACTION. ONE WAY IS TO GO IN AND MOTIVATE BY REALIGNMENT OF YOUR MEASUREMENT AND REWARD SYSTEMS TO TOTAL CUSTOMER SATISFACTION. THE ABILITY TO ORIENT YOUR ENTIRE ORGANIZATION IN TOTAL SUPPORT OF THE CUSTOMER IS AN INCREDIBLE COMPETITIVE WEAPON.

THE KEY TO WORLD CLASS LEADERSHIP IN THE FUTURE WILL DEPEND ON THE ABILITY OF A COMPANY TO PLACE ITS SERVICES AND SUPPORT CLOSER TO THE CUSTOMER.

A SUBJECT WE ARE WRESTLING WITH AT MOTOROLA IS HOW TO GET OUR PEOPLE WHO ARE CLOSEST TO THE CUSTOMER TO HAVE GREATER EMPOWERMENT.

MEMBERS OF OUR SALES FORCE ARE SURROGATES FOR OUR CUSTOMERS. THEY HAVE TO BE ABLE TO REACH BACK INTO THE FACTORY SYSTEM AND PULL OUT TECHNOLOGISTS AND OTHER SUPPORT PEOPLE TO SOLVE PROBLEMS AND ANTICIPATE CUSTOMER NEEDS.

WE WANT TO PUT THE SALES PERSON AT THE TOP OF THE ORGANIZATION, RIGHT NEAR THE CUSTOMER. IF WE COULD GET THAT MENTALITY ENGRAINED THROUGHOUT, IN A NON-THREATENING WAY, WE WOULD MOVE A LONG WAY TOWARD THAT GOAL.

BUT THAT IS A GREAT THREAT TO THE TECHNOLOGIST! MANY TECHNOLOGISTS SHARE A CERTAIN ARROGANCE - THEY KNOW ALL THERE IS ABOUT TECHNOLOGY, AND TECHNOLOGY IS THE ONLY THING THAT MATTERS. HAVING HEADED OUR DISCRETE PRODUCT OPERATIONS FOR SEVERAL YEARS, I'VE BEEN THERE.

IT IS ALSO A THREAT TO THE EXISTING POWER STRUCTURE INSIDE TECHNOLOGY COMPANIES. SALES JUST DOESN'T HAVE THE SAME STATURE AS THE TECHNICAL SIDE. IT IS AN ISSUE OF HERITAGE. MOST COMPANIES BEGAN AS STARTUPS BY BRILLIANT TECHNOLOGISTS. SO THE ORGANIZATION EVOLVED REVERING THE ENGINEER AND SCIENTIST.

BUT WE NEED NOT TURN OUR BACKS ON HERITAGE TO RECOGNIZE THE ROLE OF SALES AS A SURROGATE FOR CUSTOMERS. MOST ORGANIZATIONS DON'T DO THAT TODAY. IN FACT, TYPICALLY THERE IS AN ADVERSARIAL RELATIONSHIP BETWEEN SALES AND TECHNOLOGISTS.

WE DON'T KNOW PRECISELY HOW TO MAKE THIS CHANGE. WE'VE HAD DISCUSSIONS FOR A COUPLE OF YEARS AND OUR THINKING IS STILL EVOLVING. WE ALSO RISK TAKING SUCH A MOVE TO EXTREMES - WE DON'T WANT SALES PEOPLE MAKING COMPLEX TECHNOLOGY DECISIONS. BUT PERHAPS WE WILL HAVE TO ERR SLIGHTLY IN THAT DIRECTION IN ORDER TO FACILITATE A CHANGE.

WHEN WE TALK ABOUT INVOLVEMENT WITH THE CUSTOMER, NORMALLY WHAT WE DO IS LIMIT OURSELVES TO THINKING OF CUSTOMER SERVICE PEOPLE, OR PRODUCTION CONTROL PEOPLE, OR SALES AND MARKETING PEOPLE. THOSE ARE THE PEOPLE WHO WE GENERALLY WANT TO GET INVOLVED WITH THE CUSTOMER AS THE FRONT LINE INTERFACE.

WHY DON'T WE JUST GO BACK A COUPLE OF STEPS? WHY DON'T WE PROMOTE AN EXPANDED ORGANIZATIONAL INVOLVEMENT WITH SOME OF OUR CUSTOMERS? WHY ARE MIS ORGANIZATIONS OF THE CUSTOMER AND THE SUPPLIER NOT TALKING TO ONE ANOTHER? WHY ARE PERSONNEL ORGANIZATIONS NOT TALKING TO EACH OTHER?

IT TURNS OUT THAT IF ONE IS SUCCESSFUL, THEN BOTH PARTIES COULD SUCCEED. IT IS AMAZING HOW MUCH SYNERGY COULD BE GAINED.

FOR EXAMPLE, IF THE FINANCE ORGANIZATION IS ABLE TO CREATE A 2-DAY CLOSING PROCESS AT THE END OF THE MONTH, WHY CAN'T WE PASS THAT TECHNOLOGY ON TO OUR CUSTOMERS? EVERYONE HAS A RESOURCE ISSUE, SO WHY CAN'T WE GET OUR SUPPORT ORGANIZATIONS WORKING TOGETHER WITH CUSTOMERS SO THAT THEY CAN ADDRESS COMMON ISSUES AND SOLVE THEM? WE DON'T THINK THAT WAY AND IT IS VERY UNFORTUNATE.

WHEN WE TALK ABOUT MOBILIZING OUR EMPLOYEE BASE TOWARD TOTAL CUSTOMER SATISFACTION, IT WILL REQUIRE MORE OF THE ADMINISTRATIVE NON-FRONT LINE CONTACTS THAN WE HAVE EVER HAD BEFORE. SO THAT BECOMES THE ISSUE OF INVOLVEMENT. I USED EXAMPLES OF FINANCE, MIS AND PERSONNEL.

WE TALKED ABOUT MOVING OUR ORGANIZATION STRUCTURE OUT CLOSER TO THE CUSTOMER. WHAT WE WOULD LIKE TO DO IS REFER TO THAT AS RESHAPING OUR ORGANIZATIONAL STRUCTURE IN SUPPORT OF TOTAL CUSTOMER SATISFACTION. WE WOULD LIKE TO GET MORE OF OUR ORGANIZATIONAL STRUCTURE OUT TO THE CUSTOMER, - - IN SOME CASES AT THE CUSTOMER'S FACILITY. THAT PROMOTES BETTER SERVICE AND SPEED OF EXECUTION. IT MEANS THAT SOMEHOW WE HAVE LEARNED HOW TO WORK TOGETHER AND SHARE RESOURCES.

THIS SORT OF RELATIONSHIP LEADS INTO THE IDEA OF PARTNERING. AND AS OUR ASSISTANT GENERAL MANAGER, TOMMY GEORGE, HAS BEEN SO WIDELY QUOTED, "PARTNERING IS THE FUTURE".

IN YEARS TO COME, DEPENDING ON THE EXPECTATION LEVEL OF THE CUSTOMER, THE PEOPLE WHO WE ALLOW TO INTERFACE WITH THE CUSTOMER WILL BE THOSE ENDOWED WITH DECISION-MAKING RESPONSIBILITY -- A PERSON WHO HAS THE ABILITY AND AUTHORITY TO MAKE DECISIONS ON THE SPOT TO HELP THAT CUSTOMER.

TODAY, THERE ARE NUMEROUS EMPLOYEES WHO INTERFACE WITH CUSTOMERS WHO DO NOT HAVE THAT ABILITY. WE WANT TO GET MORE PEOPLE TO HAVE THE POWER TO MAKE DECISIONS FOR THE CUSTOMER, WHENEVER THAT DECISION IS REQUIRED.

SO, IT BECOMES AN ISSUE OF HOW WE DO THAT. DOES THAT MEAN THERE IS A RESTRUCTURING? DOES THAT MEAN WE GO IN AND SIGNIFICANTLY IMPROVE THE TYPE AND CALIBER OF PEOPLE WE USE TO INTERFACE WITH THE CUSTOMER?

THESE ARE ISSUES THAT WORLD CLASS ORGANIZATIONS SHOULD BE DELIBERATING TODAY.

ONE MAJOR ISSUE THAT WILL ALWAYS BE OF CONCERN IS HOW WE GET PRODUCT AND SERVICES TO THE CUSTOMER IN THE FASTEST, MOST COST-EFFICIENT MANNER. ON DAY ONE, WE STARTED SHIPPING PRODUCT. ON DAY TEN, WE SHIPPED MORE PRODUCT, BUT IN THE SAME FASHION. ON DAY 100, WE AGAIN SHIPPED MORE PRODUCT BUT WE SHIPPED IT IN THE SAME WAY. CAN THERE BE DIFFERENT WAYS? CAN THERE BE MORE EXPEDIENT, LESS COSTLY WAYS?

AS MY EARLIER "VEGETABLE SALES" ANALOGY POINTED OUT, WE MUST HAVE THE RIGHT PRODUCT TO THE CUSTOMER AT THE RIGHT TIME. WE HAVE TO MAKE SURE THAT ALL THE VEGETABLES ARE PROPERLY DISPLAYED AT THE COUNTER WHEN THE STORE OPENS. IF THE VEGETABLES ARE NOT THERE, THEN WHAT HAPPENS?

THERE WILL BE SUBSTITUTIONS THAT OCCUR. THIS COULD RESULT IN LOST BUSINESS, LOST SALES. THOSE LOST SALES MEAN MORE BUSINESS FOR A COMPETITOR UP THE STREET.

SO GETTING THIS RIGHT PRODUCT TO THE CUSTOMER ON TIME -- THAT IS WHAT REALLY ADDRESSES THE ISSUE OF LOGISTICS. I FEEL THE WHOLE ISSUE OF LOGISTICS NETWORKING NEEDS TO BE RE-EXAMINED. THE WAY WE SHIP PRODUCT TODAY IS NOT GOING TO BE SUFFICIENT IF WE WANT TO BE COMPETITIVE TEN YEARS FROM NOW.

ANOTHER WORLD CLASS PERFORMANCE ISSUE IS COMMUNICATIONS. WE FEEL THAT WE ARE NOT NEARLY AS EFFICIENT IN COMMUNICATIONS AS WE ARE GOING TO HAVE TO BE TO WIN THE WORLD SALES BATTLE - HOW WE COMMUNICATE INTERNALLY WITH OUR OWN EMPLOYEES AND SUPPORT GROUPS, AND HOW WE COMMUNICATE EXTERNALLY WITH OUR CUSTOMERS AND THE MARKETPLACE.

IN A GLOBAL COMPANY, PARTS ARE DESIGNED AND MANUFACTURED IN VARIOUS PARTS OF THE WORLD AND ARE SOLD ALL OVER THE GLOBE. WE MUST DEVELOP A COMMUNICATIONS SYSTEM THAT LETS US "BUILD ANYWHERE, SHIP ANYWHERE" WITHOUT UNNECESSARY EXCHANGES OF SHIPMENTS. TODAY, WE BUILD PARTS IN KOREA AND THERE A FREIGHT FORWARDING HOUSE PICKS THESE UP AND BRINGS THEM TO CUSTOMS.

ONCE PAST CUSTOMS, THE PRODUCT GOES TO THE AIRPORT AND IS SHIPPED TO LOS ANGELES. FROM LOS ANGELES, IT GOES TO A SERVICE FACILITY AND THEN IS DISPERSED TO VARIOUS PRODUCT OPERATIONS FOR FURTHER TESTING IF NECESSARY. THEN BACK TO THE SERVICE FACILITY WHERE IT IS PLACED ON AN AIRPLANE OR TRUCK AND SHIPPED TO THE CUSTOMERS.

NOW, IF YOU TAKE ALL THOSE STEPS, YOU ARE TALKING ABOUT A TREMENDOUS AMOUNT OF CYCLE TIME AND COST. LOGISTICS SYSTEMS LIKE THESE MUST BE SIMPLIFIED TO PROVIDE WORLD CLASS CYCLE TIME OF DELIVERY.

OVER THE YEARS, WE HAVE COME TO REALIZE THAT THE ELEMENT THAT SEEMS TO TIE THE WHOLE QUALITY PROGRAM TOGETHER IS TIME. WE HAVE STRESSED TOTAL CYCLE TIME REDUCTION. IN ONE DEFINITION, IT IS THE ELAPSED TIME FROM THE MOMENT A CUSTOMER EXPRESSES A NEED TO THE TIME THAT NEED IS FULFILLED. IN THE CASE OF THE NEW PRODUCT, IT IS FROM THE TIME WE CONCEIVE OF A NEW PRODUCT TO THE TIME IT IS SHIPPED TO THE MARKETPLACE.

WE ALL KNOW WHAT MAKES TIME SUCH A POWERFUL CONCEPT - WHEN CYCLE TIME GOES DOWN, COST GOES DOWN AND QUALITY GOES UP.

WE CAN DESCRIBE THESE RELATIONSHIPS BY USING THE TERM "CYCLES OF LEARNING". EACH TIME YOU GO THROUGH A CYCLE OF SERVING A CUSTOMER, YOU DISCOVER SOMETHING THAT ENABLES YOU TO DESIGN BETTER QUALITY BACK INTO THE PROCESS.

IF YOU BENCHMARK A VARIETY OF HUMAN ACTIVITIES, YOU GENERALLY COME OUT AT ABOUT THE FOUR-SIGMA LEVEL, OR 6000 DEFECTS PER MILLION. THAT APPLIES TO A MANUFACTURER WITH TECHNICAL PROCESSES, A DOCTOR WRITING A PRESCRIPTION, OR AIRLINE BAGGAGE HANDLING.

BUT, IF YOU DESIGN A SYSTEM WITH FEEDBACK AND LEARN FROM THE ERRORS, YOU REDUCE DEFECTS AND REACH A HIGHER SIGMA LEVEL EVERY TIME YOU GO THROUGH THE CYCLE. THE SHORTER THE CYCLE, THE FASTER YOU REACH SIX-SIGMA.

ONE OTHER MAJOR AREA OF CONCERN IN ATTEMPTING TO REACH WORLD CLASS CAPABILITY IS THE POWER AND STRENGTH OF YOUR LINE OF SUPPLIERS. IN RESPONSE TO GLOBAL COMPETITION, MANY LEADING EDGE COMPANIES HAVE DRAMATICALLY REDUCED THE NUMBER OF SUPPLIERS THEY BUY FROM; THIS ENABLES THEIR PURCHASING, ENGINEERING, PRODUCTION AND QUALITY PERSONNEL TO WORK MORE CLOSELY IN TRUE PARTNERING FASHION WITH KEY SUPPLIERS.

WE NOW USE A COMMON SYSTEM OF SUPPLIER EVALUATION THAT REFLECTS AN INDEX OF THE TOTAL COSTS OF DOING BUSINESS WITH A GIVEN SUPPLIER - NOT JUST THE PURCHASE PRICE.
BY BEING CONSISTENT, WE MAKE IT EASIER FOR THE BEST SUPPLIERS TO UNDERSTAND WHAT THEY NEED TO DO TO ACHIEVE A LARGER SHARE OF OUR BUSINESS. BECAUSE OF MOTOROLA'S EXPERIENCE IN APPLYING FOR THE MALCOLM BALDRIGE NATIONAL QUALITY AWARD, WE CAME TO UNDERSTAND THE VALUE OF WALKING A COMPANY THROUGH THE PROCESSES OF THE APPLICATION. IT PROVIDED AN INTERNAL SELF-EXAMINATION THAT GAVE US OUTSTANDING INSIGHT INTO POTENTIAL WEAK POINTS.

TODAY MOTOROLA REQUIRES ITS KEY SUPPLIERS TO HAVE APPLIED FOR THE MALCOLM BALDRIGE NATIONAL QUALITY AWARD TO MAKE SURE THEY HAVE EXAMINED THEIR PROCESSES TO MEET THE LEVEL OF DEMANDS WE ARE PLACING ON OURSELVES INTERNALLY.

TO KEEP THE BEST SUPPLIERS THAT WILL HELP ELEVATE US TO WORLD CLASS PERFORMANCE, MOTOROLA, EACH QUARTER, SENDS OUT QUESTIONNAIRES TO A SAMPLE OF OUR SUPPLIERS INVITING ANONYMOUS CRITIQUES. THESE CRITIQUES ARE REVIEWED PERSONALLY BY TOP MANAGEMENT OF THE CORPORATION. CONSIDERABLE TIME IS SPENT ANALYZING THESE RESPONSES SO THAT WE CAN IDENTIFY THE AREAS WHERE WE NEED TO IMPROVE AS A CUSTOMER.

WE ARE ALSO BRINGING SUPPLIERS IN AT EARLY STAGES OF PRODUCT DEVELOPMENT SO THAT THEY ARE ABLE TO MAKE A GREATER CONTRIBUTION TO THE WHOLE CONCEPT OF DESIGN FOR MANUFACTURABILITY AND QUALITY PERFORMANCE.

THE ROAD TO BECOMING A WORLD CLASS SEMICONDUCTOR SUPPLIER IS NOT YET FULLY PAVED. WE ARE STILL IN THE PROCESS OF GRINDING OUT ROUGH IDEAS OF WHERE THAT ROAD SHOULD GO.

BUT, CLEARLY, THE FOCUS IS ON SYSTEMS FUNCTIONS AND ESPECIALLY, PEOPLE OF EVERY DESCRIPTION THAT WILL HELP PROVIDE TOTAL SATISFACTION TO THE CUSTOMER. FINDING THE ANSWERS THAT BRING SUCH SATISFACTION WILL BE THE STRATEGY THAT WILL LEAD TOMORROW'S SEMICONDUCTOR MANUFACTURERS TO WORLD CLASS LEADERSHIP.

THANK YOU FOR INVITING ME HERE TODAY.

Evaluating Semiconductor Suppliers' Performance: A Buyer's Perspective

Gene Richter
Executive Director
Corporate Procurement
Hewlett-Packard Company

MB: 9/91
DATAQ1 GAL pk

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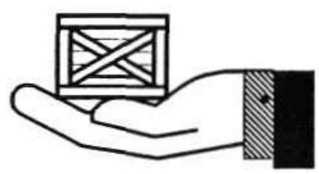
Some Suppliers' Strategy Seems To Be:

- Find A Technical Niche
- Fill It With A Unique Product
- Present It To The OEM's
- Accept The Flood Of Orders



- Fill The Orders When You Feel Like It.

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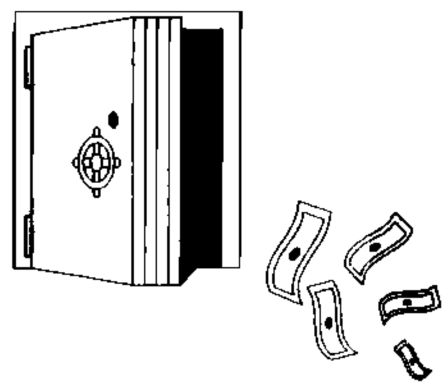
This strategy may maximize supplier profits in the short term, but we believe it to be devasting in the long term.



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Notes:

We believe it's the Buyers' job to help the Supplier keep a long term focus.

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One way Buyers can do this is by aggressive evaluation of Supplier performance.

These evaluations must be presented regularly to both the Suppliers' management

and to the Buyer's R&D people.

MB:9/91
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HP Supplier Performance Expectations
Quality

- Process Control
  - Meet or Exceed HP Specifications Requirements
  - Continuous Q/R Improvements thru SPC & TQC Techniques
  - Outgoing Quality Verification (Supplier Ownership)
- Demonstrate Product Reliability by Test / When Requested
- Documentation
  - Advance Notice of Major Process & Product Changes
- Responsive to Alerts and Corrective Action Requests

Corporate Procurement
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Notes:

At HP, we call our supplier evaluation criteria:

TQRDC

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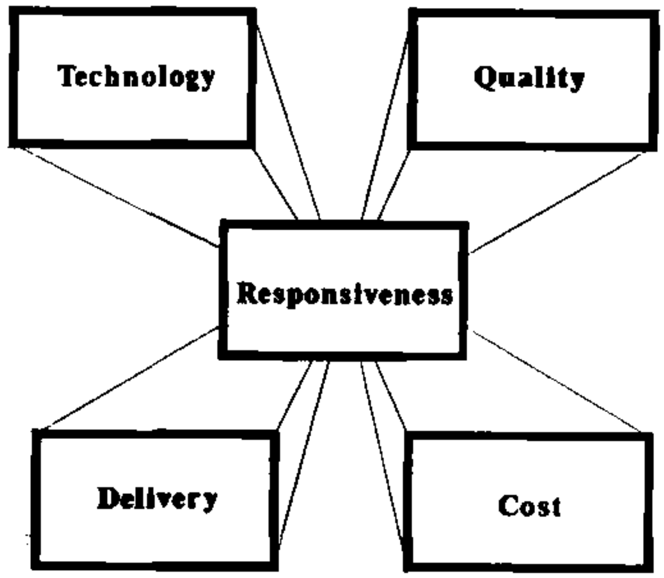
Notes:

Supplier Performance Criteria:



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HP Supplier Performance Expectations
Technology

- New Technology
  - Provide Leading Edge Technology
  - Timely New Product Introduction
- Mutual Engineering
  - Mutual Engineering & Technological Teamwork
  - Design & Application Assistance
- Strong Commitment to R&D

Corporate Procurement
Supexpt1 10/91 JK GAL10

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HP Supplier Performance Expectations Responsiveness

- High Level Management Commitment to HP
  - Responsive to Changing Needs
  - Initiate Communication on Potential Problems
  - Timely Response & Resolution to Inquiries
  - Support of Sole Sourced Parts
- Effective Worldwide Factory and Field Support for all HP Entities
- Long Term Product Support
- Flexibility to Changes

Corporate Procurement
Supexptr 9/91 jk gal10

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HP Supplier Performance Expectations Delivery

- On-Time Delivery
- Lead Time
  - Stable Lead Times / Decreasing Over Time
  - Progressively Shorter Manufacturing Cycle Times
  - Progressively Shorter Order Processing Times
  - Assurance of Material in Market Upturns
- Packaging
- Backup Shipment Strategy

Corporate Procurement
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HP Supplier Performance Expectations
Cost of Ownership

- Worldwide Price Leadership
- Cost Reductions
  - Continuous Price Reductions thru Process Improvements
  - Two-Way Feedback on Opportunities for Improvement
  - Leadership Toward Standard Parts & Processes

Corporate Procurement
Supexplc 9/91 jk gat10

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Notes:

HP Supplier Performance Expectations
Common Procurement Objective

Maintain a competitive advantage by providing materials of the highest quality and lowest cost, with the best delivery, responsiveness, and technology available by selecting fewer but better suppliers.

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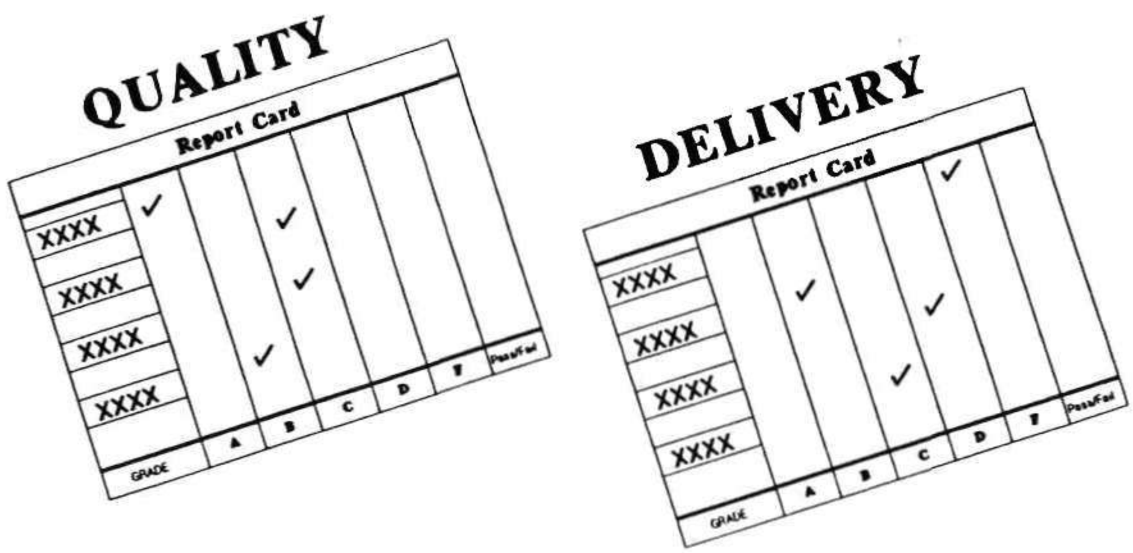

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HP Supplier Performance Expectations
Delivery

- On-Time Delivery
- Lead Time
  - Stable Lead Times / Decreasing Over Time
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  - Assurance of Material in Market Upturns
- Packaging
- Backup Shipment Strategy

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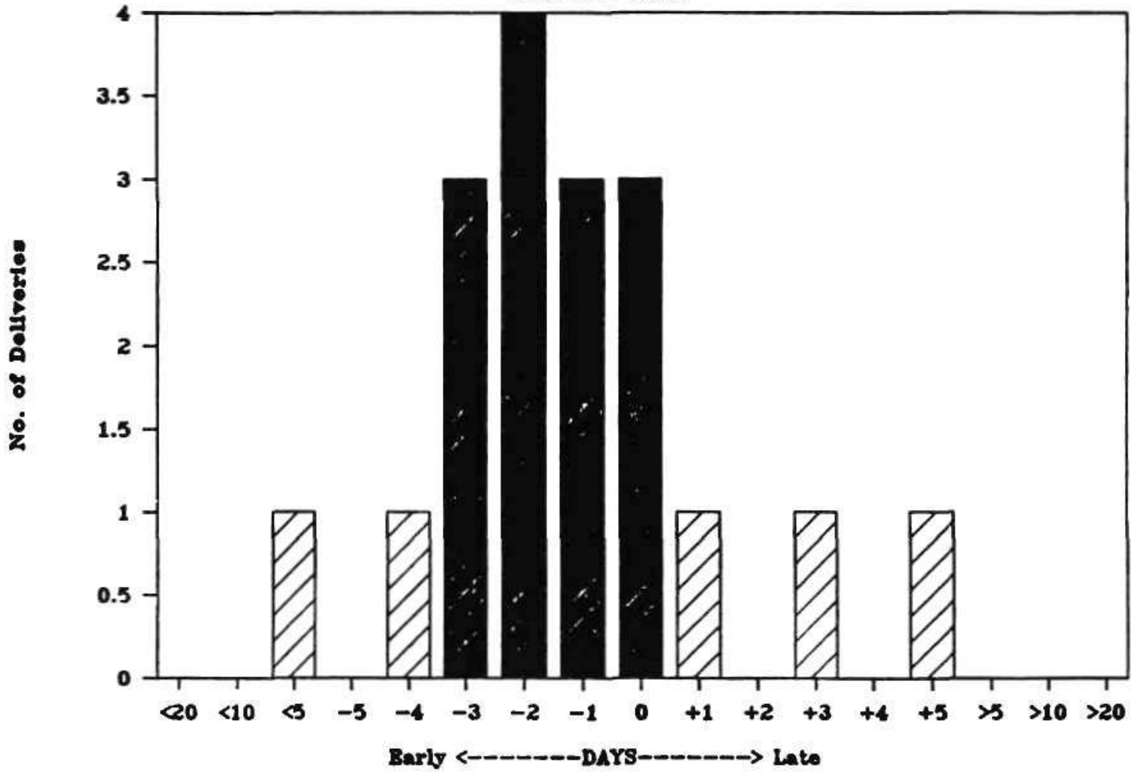
Notes:

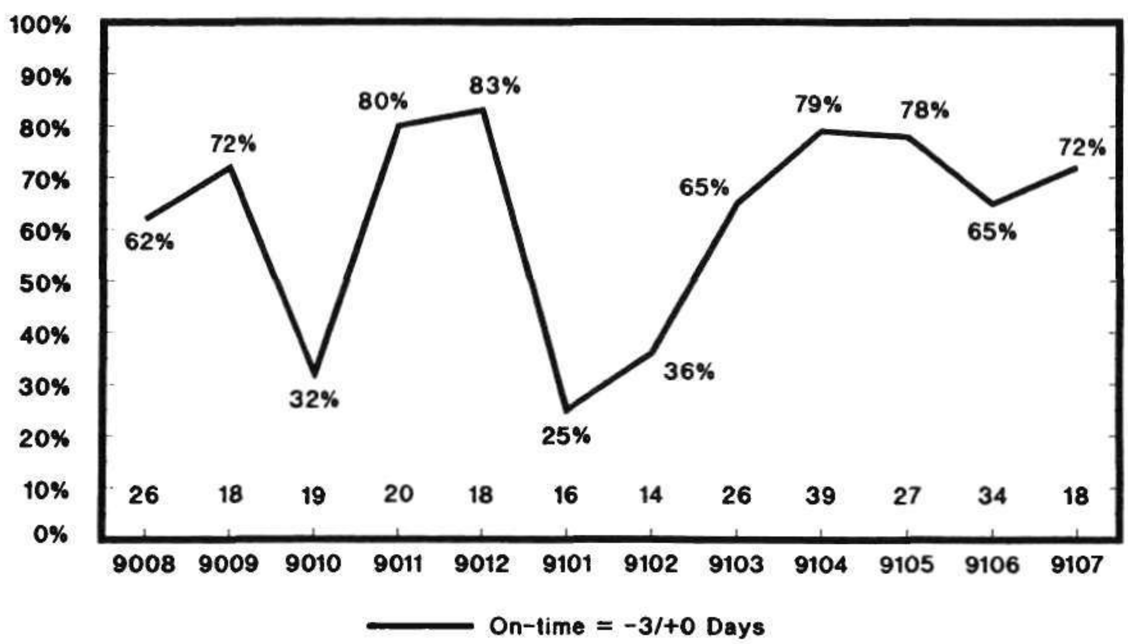
Delivery Performance for Supplier X

PERIOD = 91/07

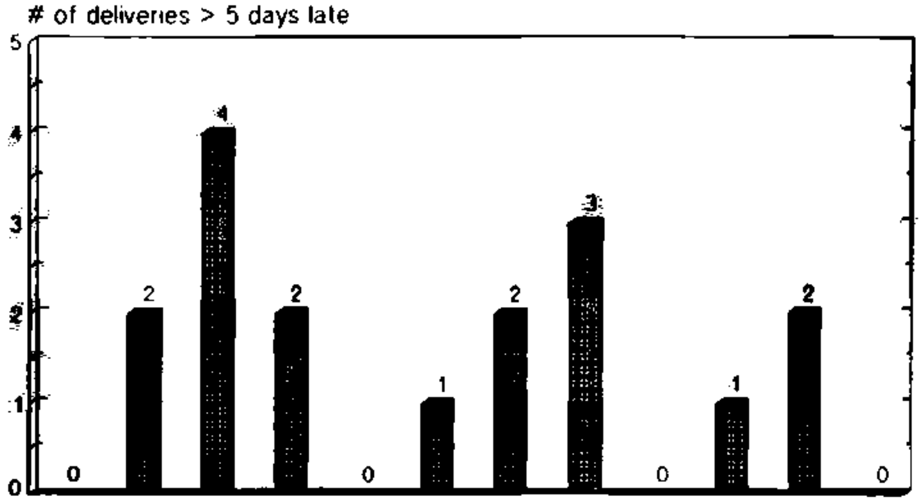


Delivery Performance for Supplier X

(Nbr of Deliveries shown along bottom)



Supplier X



	8/90	9/90	10/90	11/90	12/90	1/91	2/91	3/91	4/91	5/91	6/91	7/91
% > 5 days late	0%	4%	5%	3%	0%	1%	3%	5%	0%	1%	4%	0%
Total Deliveries	65	50	70	59	44	58	60	56	59	68	46	43

PGT/CP-Semiconductor
>5Late.GAL 9/12/91

HP PROPRIETARY

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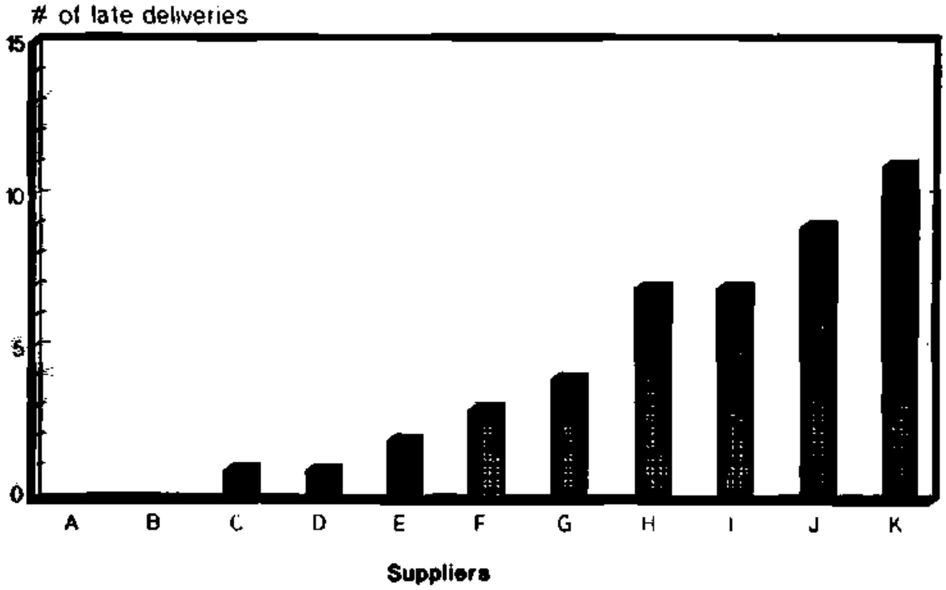
Notes:

Delivery Performance

Commodity Suppliers
2nd Quarter Calendar year '91



PGT/CP- Semiconductor

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HP Supplier Performance Expectations
Quality

- Process Control
  - Meet or Exceed HP Specifications Requirements
  - Continuous Q/R Improvements thru SPC & TQC Techniques
  - Outgoing Quality Verification (Supplier Ownership)
- Demonstrate Product Reliability by Test / When Requested
- Documentation
  - Advance Notice of Major Process & Product Changes
- Responsive to Alerts and Corrective Action Requests

Corporate Procurement
Supexptq 9/91 jk Gal10

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Supplier Quality Profile

Performance Measure	HP	Weighting Factor	Supplier	Weighting Factor
Quality	a. In-Process Failure Rate	2	a. Outgoing Quality Rate	1
	b. 'Q' of TQRDC	2		
Reliability	MTC		a. Infant Mortality	1
	a. Life Tests	1	b. Hast or 85/85	1
	b. Hast	1	c. Life Tests	1
	c. Thermal Shock	1	d. Temp Cycling	1
Process Control	a. Quality Systems Audit	1	Cpk	
			a. Icc_1	2
	b. Process Control Audit	1	b. Trac	2
			c. Icc_2	2

CP/Quality/Reliability
MB: 9/11/91 SUPQUAL1GAL.pk

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Notes:

Supplier Quality Profile Values

Performance Measures	Weight Factor	A	B	C	D	E	F	G	H	I
A. QUALITY										
1. HP In-Process (PPM)	2	80	30	50	80	90	10	30	95	40
2. Supplier quality (PPM)	1	280	50	150	260	150	30	190	80	90
3. HP Quality Survey (Max Score 4.0)	2	3.31	2.22	2.92	2.45	3.21	3.10	2.70	3.12	3.22
B. RELIABILITY										
4. HP Rel Monitoring										
a. Life Tests (FITS)	1	34	34	44	70	70	38	241	124	120
b. Hast or 85/85	1	.26%	.26%	.26%	.26%	.26%	.26%	.26%	.26%	.26%
c. Thermal Shock	1	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%
5. Supplier Reliability										
a. Infant Mortality	1	220	110	410	30	70	60	190	12	113
b. Hast or 85/85	1	4	48	50	100	16	30	8	9	60
c. Life Tests	1	9	21	143	35	10	24	48	8	12
d. Temp Cycling	1	1196	319	957	767	830	79	1630	810	829
C. PROCESS CONTROLS										
6. Supplier CPK										
a. Icc_1 (Op. Current)	2	8.12	2.32	9.03	2.51	9.20	30.50	2.38	5.48	5.09
b. Trac (Speed)	2	13.40	10.26	3.69	2.59	3.55	5.15	8.19	3.55	2.69
c. Icc_2 (Standby Current)	2	61.70	55.78	4.61	10.15	11.75	21.92	1.25	6.29	3.78
7. HP Quality Sys. Audit (Max Score 4.0)	1	3.68	2.92	3.01	3.89	3.79	3.76	2.7	3.28	3.10
8. HP Process Cont. Audit (Max Score 4.0)	1	1.71	1.75	1.98	1.07	2.12	1.52	1.98	2.10	1.88

CP/Quality/Reliability

MB: 9/11/91 SUPQUAL2.GAL.pk

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Supplier Quality Profile
Allocation of Points

Performance Measures	Weight Factor	Values: Best	Values: Ave	Values: Good	Points: 0	Points: 1	Points: 2	Points: 3	Points: 4
A. QUALITY									
1. HP In-Process (PPM)	2	10	53	95	95	74	53	31	10
2 Supller Quality (PPM)	1	30	155	280	280	218	155	93	30
3 HP Quality Survey	1	3.31	2.77	2.22	2.22	2.49	2.77	3.04	3.31
B. RELIABILITY									
4. HP Reliability Monitor									
a. Life Tests (FITS)	1	34	137	241	241	189	137	85	34
b. Hast or 85/85 (% F/K hrs)	1	0.26%							0.26%
c. Thermal Shock	1	3.3%							3.3%
5. Supplier Reliability									
a. Infant Mortality	1	12	211	410	410	311	211	112	12
b. Hast or 85/85	1	4	74	143	143	108	74	39	4
c. Life Tests	1	8	76	143	143	109	76	42	8
d. Temp Cycling	1	79	855	1630	1630	1242	855	46[illegible]	79
C. PROCESS CONTROLS									
6. Supplier Cpk									
a. Icc 1 (Op. Current)	2	30.50	16.41	2.32	2.32	9.36	16.41	23.46	30.50
b. Trac(Speed)	2	13.40	7.33	1.25	1.25	4.29	7.33	46.95	61.72
c. Icc 2 (Standby Current)	2	61.70	32.20	2.69	2.69	17.44	32.20	10.36	13.40
7. HP Quality Sys. Audit	1	3.89	3.3	2.70	2.70	3.00	3.30	3.59	3.89
8. HP Process Cont. Audit	1	2.12	1.60	1.07	1.07	1.33	1.60	1.86	2.12

CP/Quality/Reliability
MB: 9/11/91 SUPQUAL3.GAL.pk

HEWLETT PACKARD

Supplier Quality Profile

Scores = Points X Weighting Factor

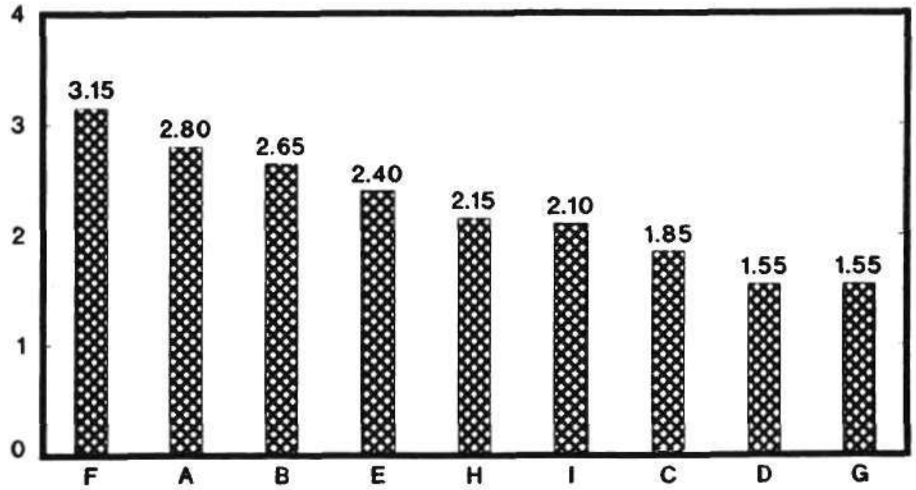
Performance Measures	Weight Factor	A	B	C	D	E	F	G	H	I
A. QUALITY										
1. HP In-Process (PPM)	2	2	6	4	2	0	8	6	0	6
2. Supplier Quality (PPM)	1	0	4	2	0	2	4	1	3	3
3 HP Quality Survey	2	8	0	6	2	8	6	4	6	6
B. RELIABILITY										
4. HP Rel Monitoring										
a Life Tests (FITS)	1	4	4	4	3	3	4	0	2	2
b 85 Deg C/ 85 % RH	1	4	4	4	4	4	4	4	4	4
c. Thermal Shock	1	4	4	4	4	4	4	4	4	4
5 Supplier Reliability										
a. Infant Mortality	1	2	3	0	4	3	4	2	4	3
b. 85 Deg C/ 85 % RH	1	4	3	3	1	4	3	4	4	2
c. Life Tests	1	4	4	0	3	4	4	3	4	2
d Temp Cycling	1	1	3	2	2	2	4	0	2	2
C. PROCESS CONTROLS										
6 Supplier CPK										
a. Icc1	2	2	0	2	0	2	8	0	0	0
b. Icc2	2	8	8	0	2	2	2	0	0	0
c Trac	2	8	6	2	0	2	2	0	4	2
7. HP Quality Syst. Audit	1	3	1	1	4	4	4	0	2	1
8 HP Process Cont. Audit	1	2	3	3	0	4	2	3	4	3
Scores		56	53	37	31	48	63	31	43	42
Weighting Factor		20	20	20	20	20	20	20	20	20
SQP		2.80	2.65	1.85	1.55	2.40	3.15	1.55	2.15	2.10

CP/Quality/Reliability

MB: 9/11/91 SUPQUAL.GAL.pk

HEWLETT PACKARD

Supplier Quality Profile Ranking

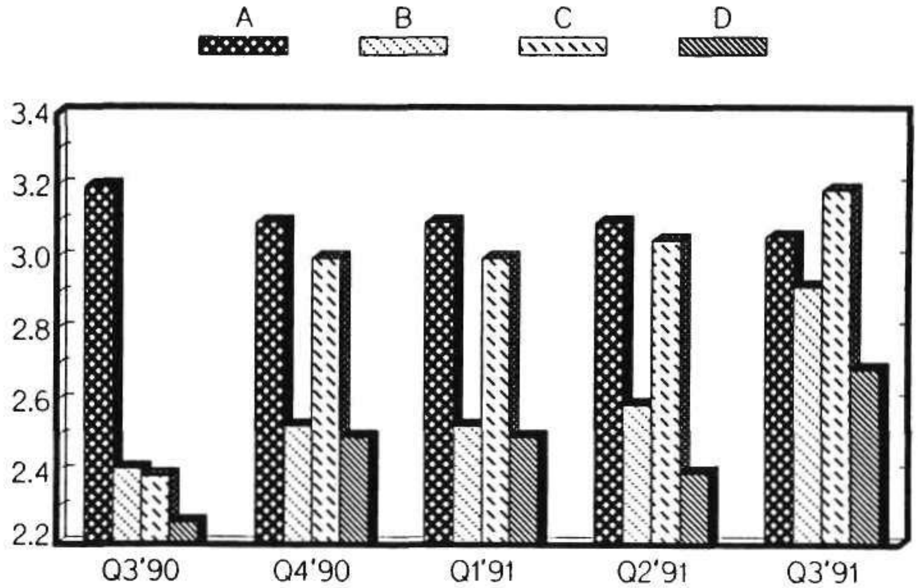


CP/Quality/Reliability
9/19/91 SQPR

HEWLETT PACKARD

Notes:

SUPPLIER QUALITY PROFILE RATINGS



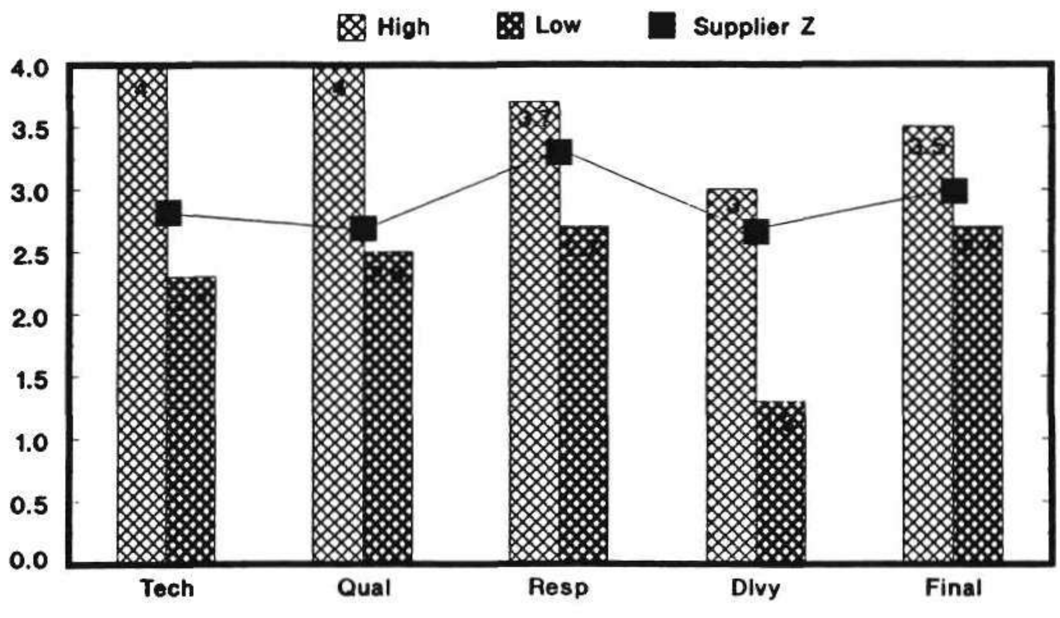
Corporate Procurement
MB: 9/91 SQPRATE2.CHTGAL.pk

HEWLETT PACKARD

Supplier Performance Survey

Supplier Z

January 1, 1991 thru June 30, 1991



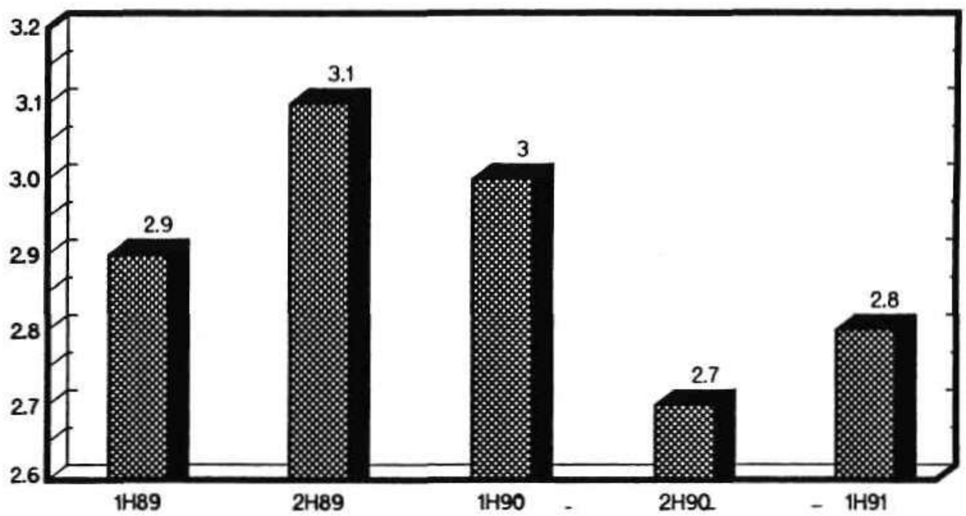
9/19/91 SPSSZ

HP Priorietary

HEWLETT PACKARD

Supplier Performance Survey

Supplier Z



PGT/CP– Semiconductor
SUPPLAGAL ML 09/16/91

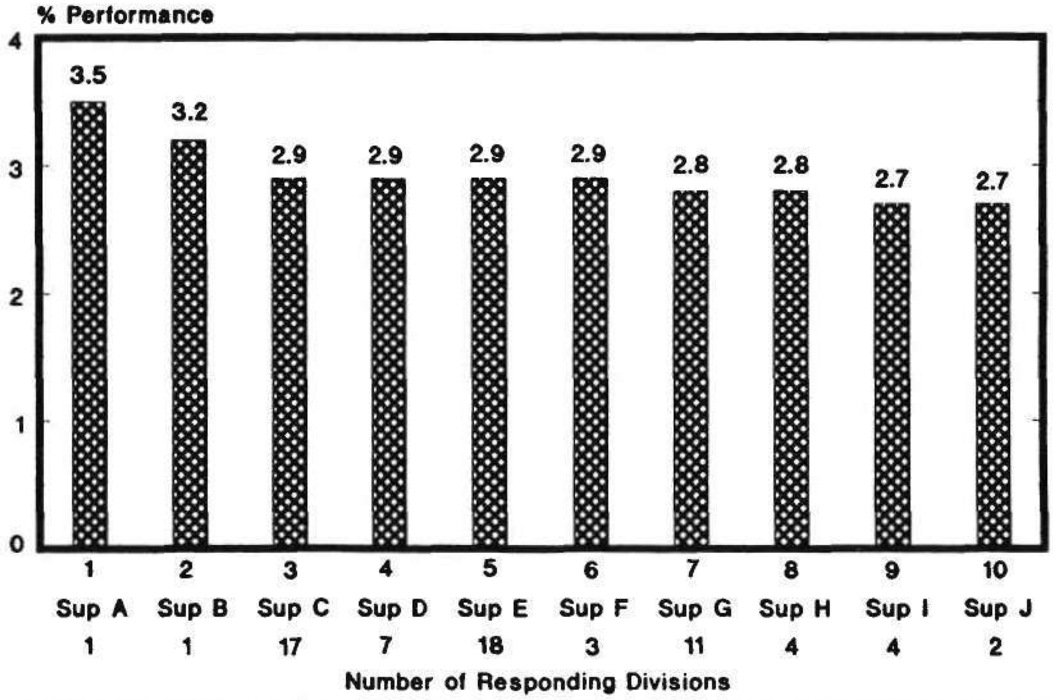
HP PROPRIETARY

HEWLETT PACKARD

Notes:

Overall TQRD Performance Summary

1st & 2nd Quarter 1991

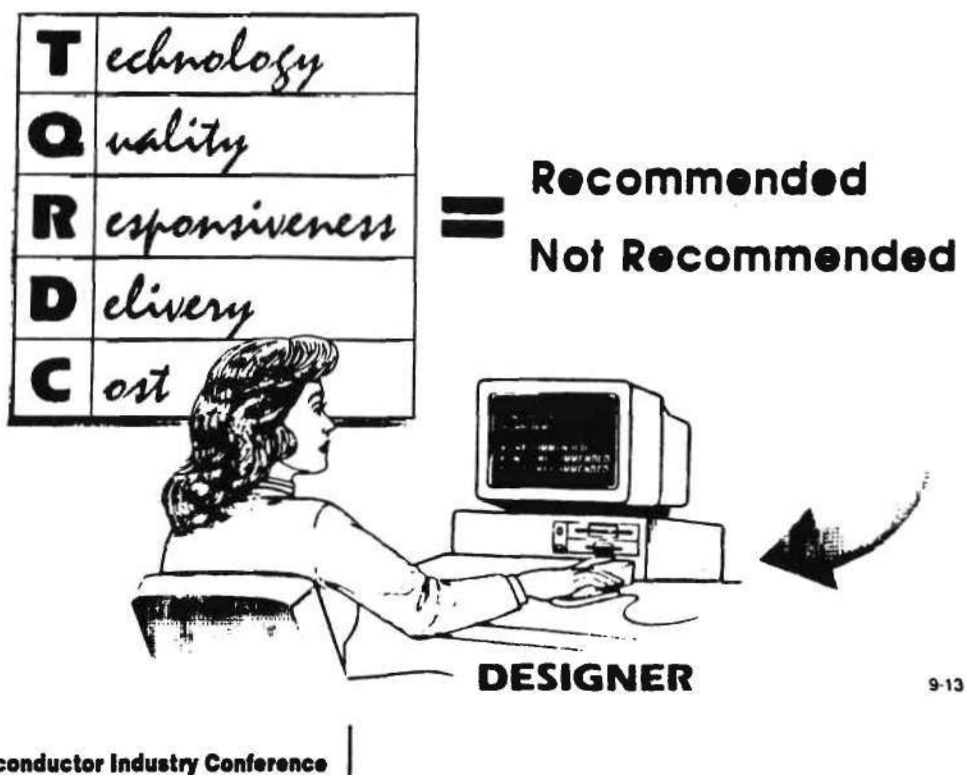


PGT/CP Semiconductors
Overall 9/19/91

HP Proprietary

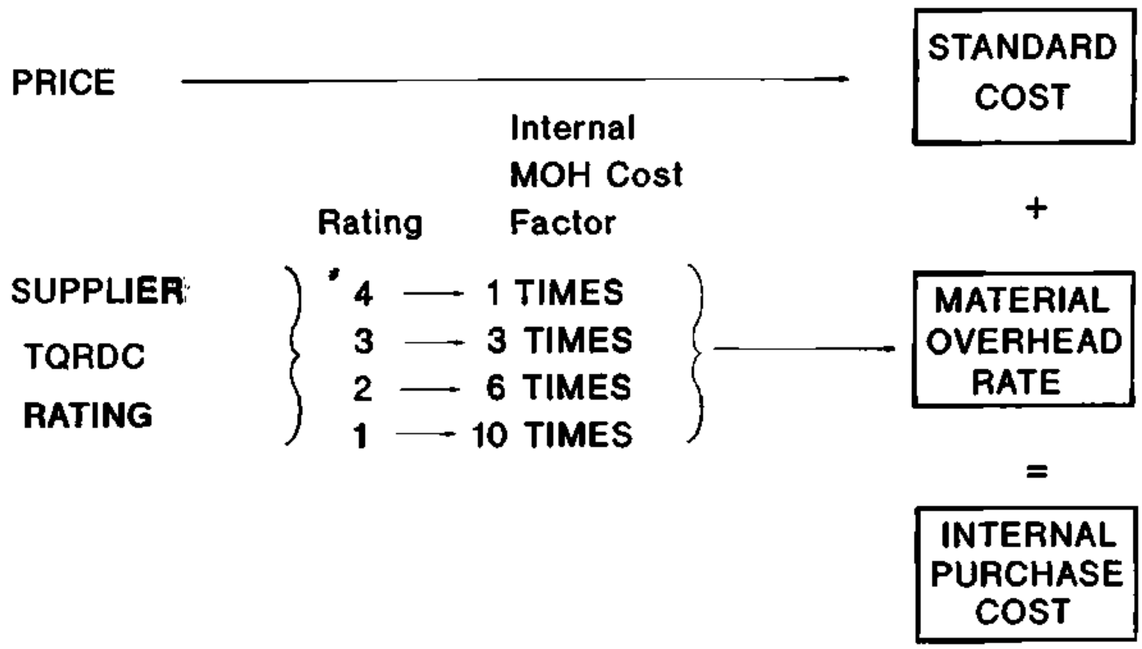
HEWLETT PACKARD

DESIGNERS VIEW OF TQRDC



9-13

FINANCIAL PART NUMBER DESIGN/PURCHASE DECISION



Product Generation Team: Corporate Procurement
DATAQCO2.GAL.pk

HEWLETT PACKARD

Notes:

Focus for the 90's

Buyers' are going to get better and better at measuring and articulating supplier performance.

Suppliers' day-to-day performance is going to grow in importance relative to their success from exploiting technical niches.

Corporate Procurement
b:90focus1 jk gal5 9/91

HEWLETT PACKARD

Focus for the 90's

T
- Closer, earlier interface.
- Concurrent engineering.

Q
- Continuous measurement.
- More aggressive objectives.
- More emphasis on administrative quality.

R
- Distribution matched to the customer.
- More schedule flexibility.

D
- Continuous measurement.
- On-time delivery a given.
- Shorter lead times.

C
- Continued world-wide competitive pressure.
- Zero-based pricing.

Corporate Procurement
B:90FOCUS2 JK GAL5 9/91

HEWLETT PACKARD

Notes:

The U.S. Semiconductor Industry and SEMATECH in the 1990s

Dr. William Spencer
President and CEO
SEMATECH

IMPLICATIONS FOR U.S. INDUSTRY OF 21ST CENTURY MANUFACTURING TRENDS

Small Number of FABS

Large Vertically Integrated Corporations Advantaged

Niche Markets Disappear

Complexity Leads to Cooperation

Continual Improvement Required

Technology Discontinuities are Possible

CONTINUAL IMPROVEMENT OF CURRENT MANUFACTURING

Technology Generations Accelerate

Close Collaboration in Equipment Development

Quality Culture

Research Results from Universities and National Laboratories

TECHNOLOGY DISCONTINUITIES

Lithography below 0.2μm

Modeling and Simulation

Computer Aided Manufacture

Notes:

DSB RECOMMENDATIONS FEBRUARY 1987

Establish Semiconductor Manufacturing Technology Institute

- $250M Initial Capitalization
- $200M/Yr Government Funding
- Focus on Leading Edge Technology
- Improve Equipment Manufacturing
- Transfer Technology to Member Organizations
- Sell Products
- DOD and Industry Assignees
- U.S. Corporations Only as Members

Establish Eight University Centers of Excellence

Increase DOD R&D Spending by 25%/Yr

Provide DOD Discretionary Funds, $50M/Yr

Establish DOD/Industry/University Forum on Semiconductors

GOVERNMENT/INDUSTRY COLLABORATION IN SEMATECH

Leverage of Government Investment

Good Return on Investment

Other Economic Regions are Cooperating

It's Better Than the Alternatives

SEMATECH IS WORKING

Accomplishments

Cooperation/Culture

We Will Meet All Our Objectives

Notes:

SEMATECH BEYOND 1992

Build on Success

Same Core Companies

Similar Budget

New Objectives/Mission

Leverage Government Ties

SEMATECH VISION/GOALS

Train Tomorrow's Managers

Continuous Improvement

Fundamental Change in Manufacturing

Return on Investment to Members

Quality Culture

SEMATECH MISSION

Create fundamental change in manufacturing technology and the domestic infrastructure to provide U.S. semiconductor companies the capability to be world-class suppliers.

SEMATECH OBJECTIVES

1. Provide unit processes and generic manufacturing methods for members to integrate into their proprietary process flows and products.
2. Ensure that there is a viable supplier infrastructure capable of meeting the members' requirements for key equipment modules, materials and manufacturing systems.
3. Reduce sensitivity of cost to manufacturing volume.
4. Provide programmable factory systems capable of responding to process changes with first pass success.
5. Cooperate with the SRC, DARPA, and national labs to develop a research and educational infrastructure necessary to sustain U.S. leadership in semiconductor technology.
6. Maintain open forums for effective communications, collaboration, and consensus building within the SEMATECH community.

Notes:

SEMATECH: INCORPORATED ON AUGUST 7, 1987

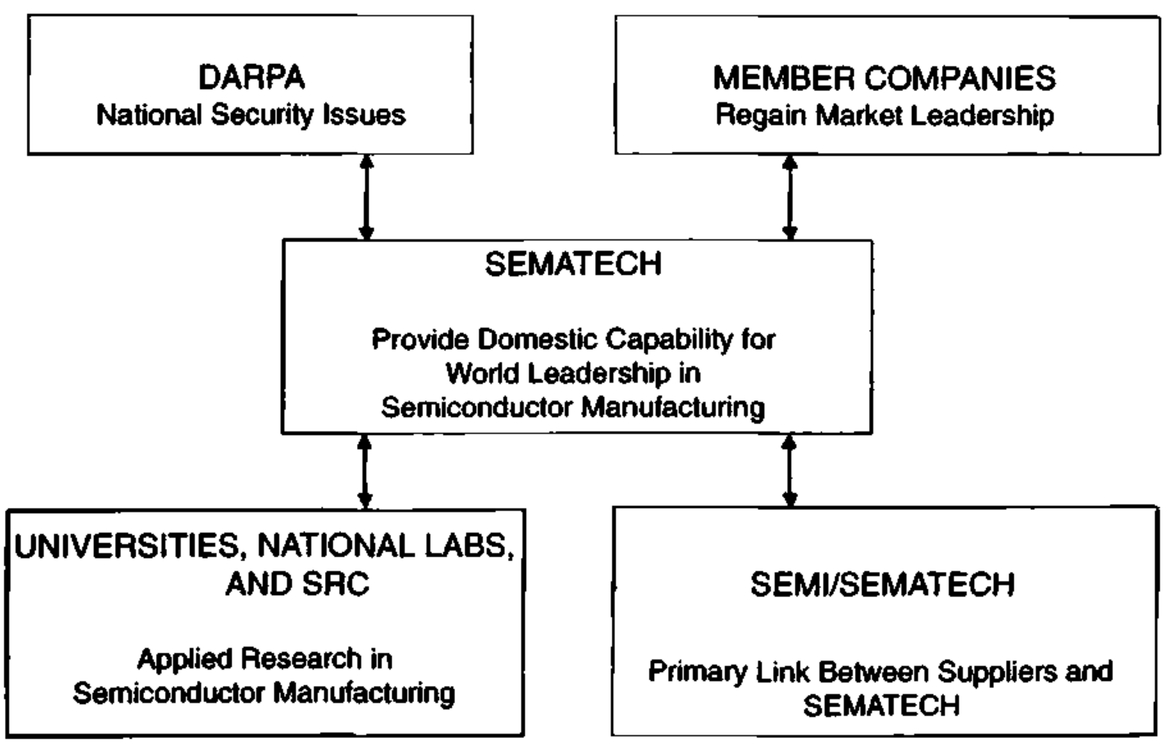
MISSION:

TO PROVIDE THE U.S. SEMICONDUCTOR INDUSTRY THE DOMESTIC CAPABILITY FOR WORLD LEADERSHIP IN MANUFACTURING

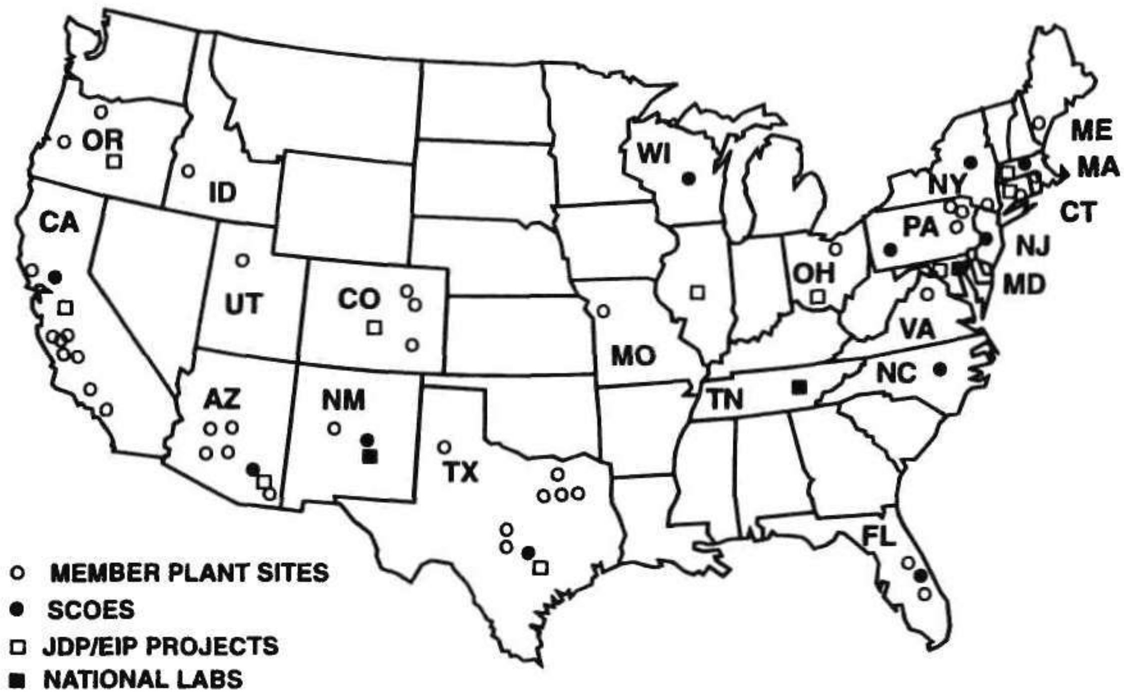
MEMBERS:

AMD
AT&T
DARPA
DIGITAL EQUIPMENT
HARRIS
HEWLETT-PACKARD
INTEL
IBM
LSI LOGIC
MICRON
MOTOROLA
NATIONAL SEMICONDUCTOR
NCR
ROCKWELL
TEXAS INSTRUMENTS

SEMATECH OPERATIONAL CONCEPT



SEMATECH: A NATIONAL MISSION WITH A NATIONAL SCOPE



Notes:

DEPARTMENT OF DEFENSE CRITICAL TECHNOLOGIES

1. Microelectronic circuits and fabrication
2. Gallium arsenide and other compound semiconductors
3. Software development
4. Parallel computer architectures
5. Machine intelligence/robotics
6. Simulation and modeling
7. Integrated optics
8. Fiber optics
9. Sensitive radars
10. Passive sensors
11. Automatic target recognition
12. Phased arrays
13. Data Fusion
14. Signature control
15. Computational fluid dynamics
16. Air breathing propulsion
17. High-powered microwaves
18. Pulsed power
19. Hypervelocity projectiles
20. High-temperature, high-strength lightweight composite materials
21. Superconductivity
22. Biotechnology materials and processing

Source: U S Department of Defense

SEMATECH OVERVIEW

Lessons Learned

SEMATECH has been a success
SEMATECH mission/accomplishments not well understood
Lack of success criteria create unrealistic expectations
Cannot get ahead by following the leader

SEMATECH Changes

Build on successes
Create new types of competitive advantages/change the rules
Clearly define metrics for each objective
Provide suppliers the capability to sustain leadership
Top-down program perspective
Focus on providing quick response to changing customer needs
Be cost-effective at all volumes
Explore vertical linkages up the food chain

DARPA/SEMATECH PARTNERSHIP

Lessons Learned

DARPA role:
- Participate in defining strategic objectives
- Provide resources
- Monitor performance
- Facilitate coordination and tech transfer to/from DoD
- Advocate the program within DoD
- Provide information to Congress/Executive branch

SEMATECH role:
- Plan
- Execute

SEMATECH Changes
- Better leverage DARPA programs
- Proactive role in DoD strategy
- Increased DoD participation in SEMATECH programs
- Full-time DoD technical transfer staff

Notes:

COOPERATION

Lessons

Pre-competitive technology includes:
- Tools and unit processes
- Materials
- Generic manufacturing methods
- Generic CIM capabilities

Does not include:
- Integrated processes
- Product design

Both horizontal and vertical teaming are important
Need balance among diverse membership requirements
Bad news travels faster than good

SEMATECH Changes

Focus on technologies important to majority of members
Continue nurturing horizontal/vertical teaming
Customer partnering program
Continue fostering environment for open communication

SCOPE

Lessons Learned

Criticality of infrastructure and limited resources narrowed focus
Cannot subsidize development of every new tool
Must continue to track other areas

SEMATECH Changes

Continue involvement in four thrust areas
Contamination Free Manufacturing thrust area
Modeling and Simulation thrust area
Shift emphasis to building distinct competitive advantages
Shift equipment infrastructure programs to emphasize:
- Providing tools necessary to sustain leadership
- Top down perspective driven from factory vision
- Exploiting technological opportunities
- Standards, technology to enable interoperability modularity
- Control systems to enable flexibility, robustness

Manufacturing systems to include automated material handling
Increase focus on generic manufacturing methods
Support communication with areas outside SEMATECH programs
Cooperate with JESSI in mutually exclusive areas

EXECUTION

Lessons Learned

Most work can be done outside of SEMATECH
SEMATECH fab cannot perform volume learning
SEMATECH fab can test high risk or disruptive ideas
Need focus on internal manufacturing methods programs

SEMATECH Changes

Maintain "fab of last resort"
Share best practices among members
Manage internal tasks to same level as external tasks
Leverage outside resources through contracts
Focal point for external cooperation
Define and utilize long-range roadmaps in all major areas

Notes:

TECHNOLOGY TRANSFER

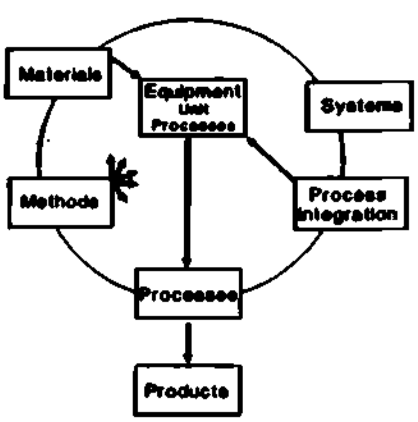
Lessons Learned

- Must go beyond publishing reports
- Much to be gained from leveraging external programs
- All members can make valuable contributions, including DARPA
- Companies that invest the most, benefit the most
- Excessive secrecy limits valuable dissemination of information

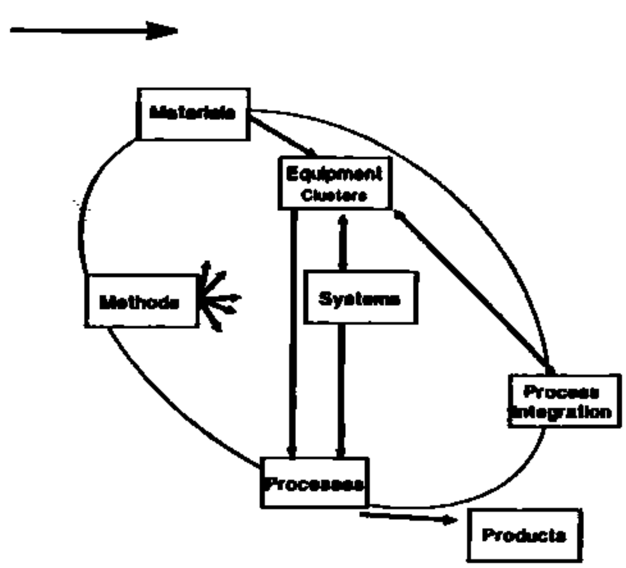
SEMATECH Changes

- Tech transfer starts with early member company buy-in
- Tech transfer doesn't end until members are using the results
- All programs should include formal training and member company access to new products

SEMATECH AREAS OF FOCUS



SEMATECH I



SEMATECH II

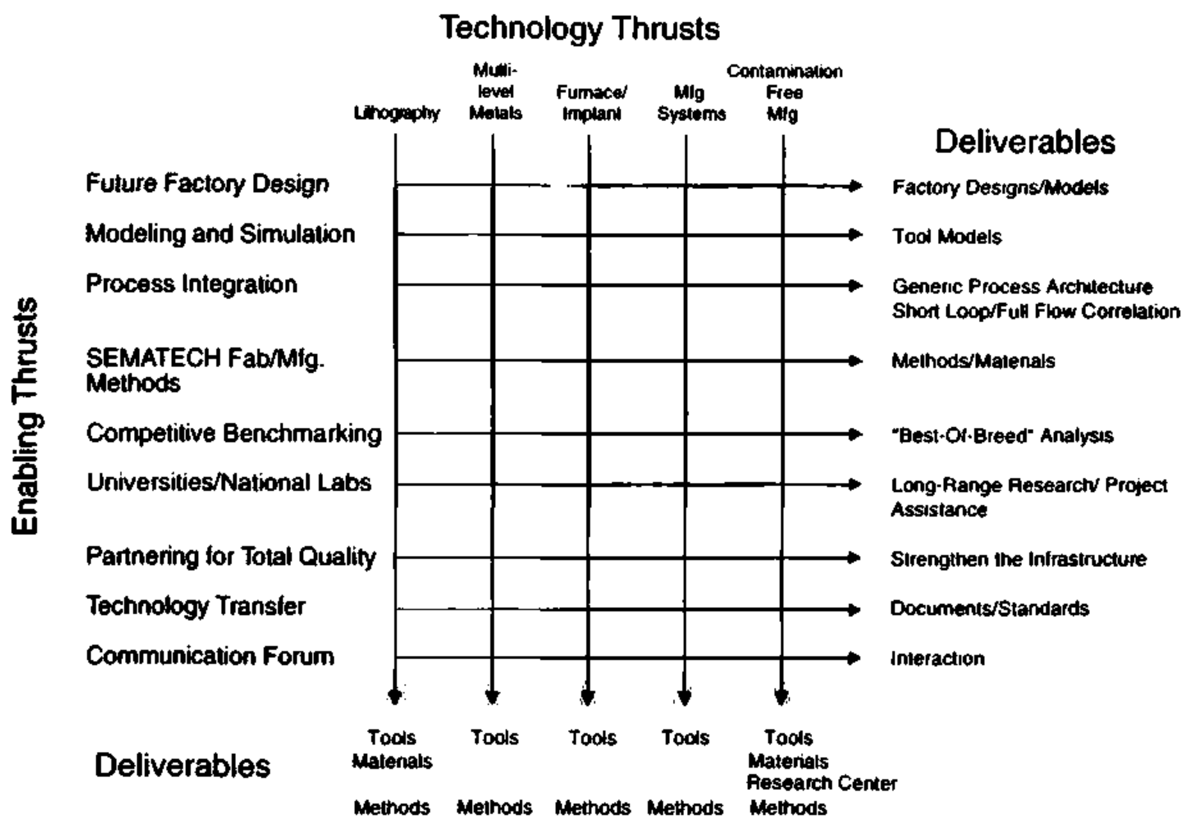
SEMATECH I MISSION:

To provide the U.S. semiconductor industry the domestic capability for world leadership in manufacturing.

SEMATECH II MISSION:

"Create *fundamental change* in manufacturing technology and *the domestic infrastructure* to provide U.S. semiconductor companies the capability to be *world-class suppliers.*"

Notes:



SEMATECH OBJECTIVE

OBJECTIVE:

Provide unit processes and generic manufacturing methods for members to integrate into their process flows and products

THRUSTS:

- Process integration
- Tool Thrusts
- Future Factory Design
- Manufacturing Methods
- Modeling and Simulation
- Technology Transfer

EXECUTION STRATEGY:

- Finalize phase 4 CMOS process architecture
- Unit process defined to fit phase 4 CMOS process architecture
- Implement modular clust processing equipment
- Develop test structures to characterize/validate unit processes
- Develop mask designs for integrated development vehicles
- Complete tool qualification and documentation
- Increase emphasis on development, trial and assessment of manufacturing methods

SEMATECH OBJECTIVES

OBJECTIVE:

Provide programmable factory systems capable of responding to process changes with first-pass success.

THRUSTS:

Tool Thrusts
CIM/Manufacturing Systems
University and National Labs
Contamination Free Manufacturing
Modeling and Simulation

EXECUTION STRATEGY:

Develop transportable, open architecture CIM system software
Reduce costs, time in applications software development
Implement Generic Equipment Model as standard system interface Develop
sensor-based, closed-loop process controls
Develop standard cell/modular controller
Develop AMHS for integration into factory control system
Develop Distributed Factory System

Notes:

HOW ARE WE GOING TO ACHIEVE SEMATECH II'S GOALS?

Tops-down factory design

Increased early collaboration with supplier base

Align and leverage DARPA/DoD programs

Increased collaboration with SRC, national labs and universities

Emphasis on Modeling & Simulation

Focus on Manufacturing Systems

SEMATECH I & II: WHAT'S NEW

SEMATECH Now: Improve Infrastructure, Equipment, Processes

- Full-flow volume processing
- Equipment improvement and development
- Processes improvement and development
- Manufacturing methods improvement and development
- Standards

SEMATECH Future: Provide a Total Factory Solution

- Equipment improvement and development *& integration*
- Processes improvement and development *& integration*
- Standards
- Manufacturing methods improvement and development *& integration*
- *Future factory design*
- *Factory automation of processes & integrated tools*
- *Flexible manufacturing models*
- *Control systems design & integration*

SEMATECH SUMMARY OVERVIEW

SEMATECH is working

DARPA is vital to SEMATECH's success

SEMATECH proves government/industry can cooperate for the common good

SEMATECH technological achievements are directly applicable to DoD needs

Technology demands continue to grow

SEMATECH has an opportunity to create fundamental change in the industry

Notes:

Dataquest's Semiconductor Industry Forecast

Jerry Banks
Principal Analyst/Director
Dataquest Incorporated

AGENDA

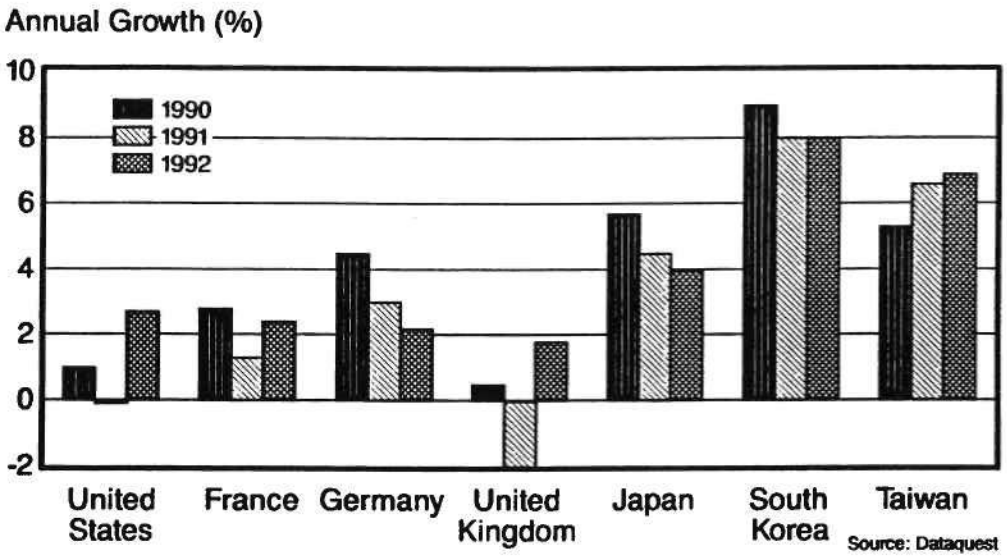
- The semiconductor forecast
- Product overview
- End use and applications
- Summary

FORECAST ASSUMPTIONS

- Economic outlook
- Exchange rates

ECONOMIC OUTLOOK

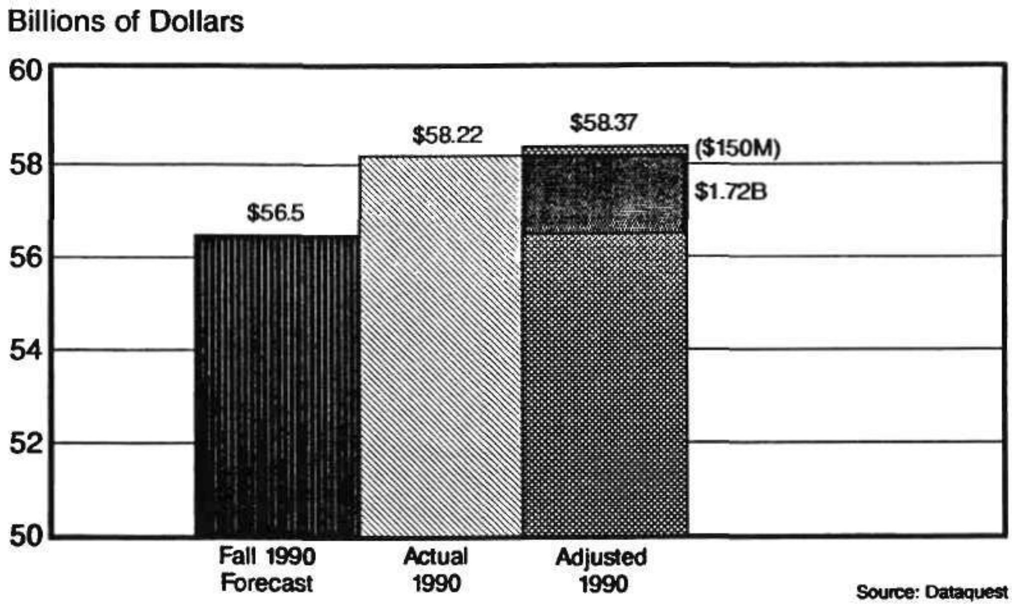
Real GNP/GDP Growth, Local Currencies



Source: Dataquest

Notes:

1990 SCORECARD



Source: Dataquest

1991 FORECAST SCORECARD

	1991
Spring 1991	13.7%
Fall 1991	9.3%

Δ = Exchange Rates

Source: Dataquest

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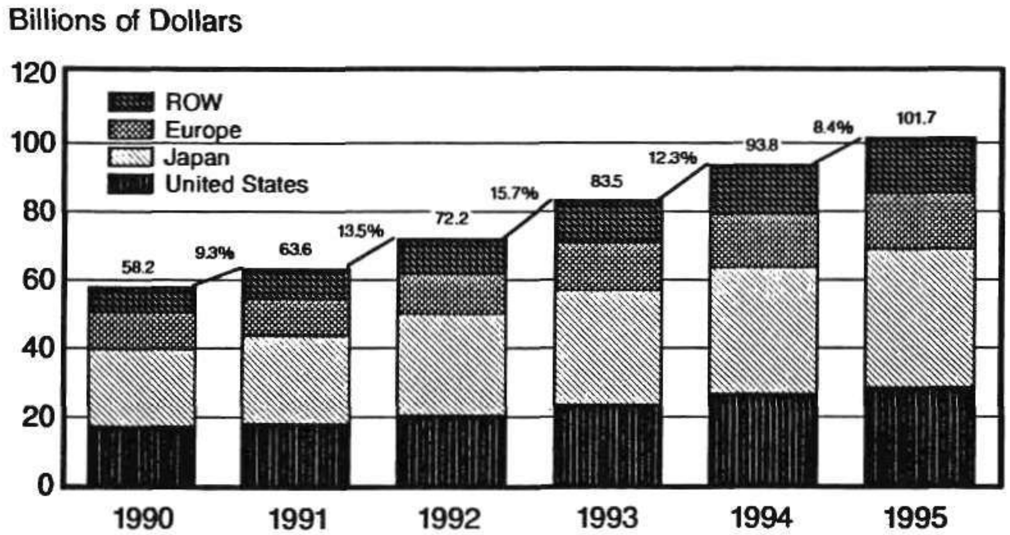
WORLDWIDE SEMICONDUCTOR CONSUMPTION FORECAST

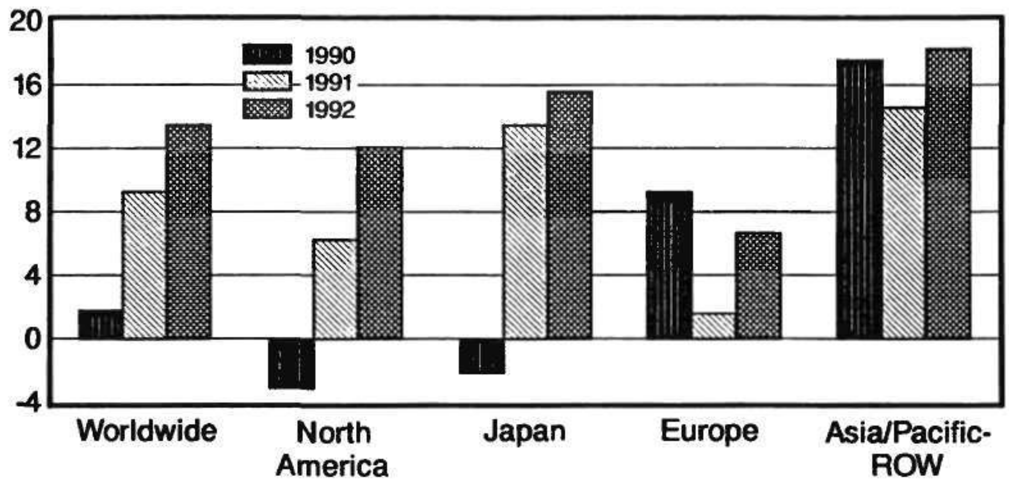


Source: Dataquest

Notes:

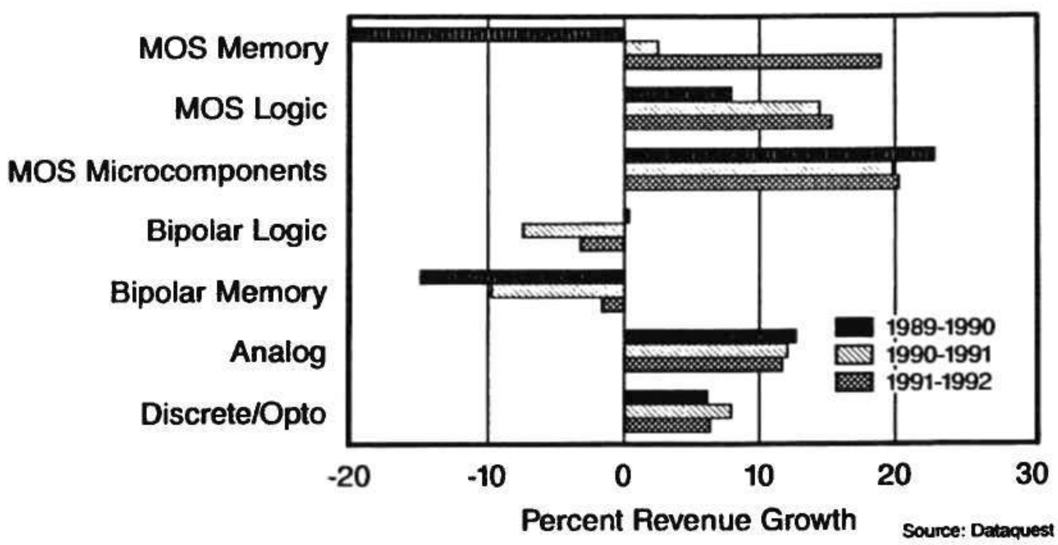
WORLDWIDE SEMICONDUCTOR REVENUE GROWTH FORECAST BY REGION

Dollar Growth



Source: Dataquest

SEMICONDUCTOR PRODUCT GROWTH FORECAST



Source: Dataquest

ANALOG

- Strong consumer market
  - Application-specific linear ICs
- Mixed signal growth = 20%
  - Driven by communications and EDP
- Functional block growth declining (Amplifiers, comparators, etc.)

Source: Dataquest

Notes:

MOS MEMORY

- Price erosion continues
- Lackluster DRAM bit growth
- Fast SRAM becoming a commodity

LOGIC

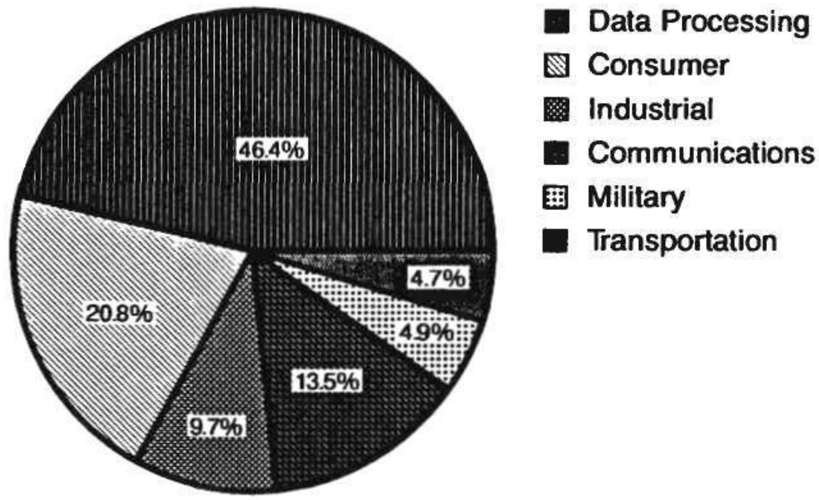
- Growth drivers
  - DP (workstations and notebooks)
  - Telecom
- ASIC densities increasing dramatically
- CMOS/BiCMOS replacing bipolar
- CPLD rapid growth continuing

MICROCOMPONENTS

- Microcontroller growth very strong
  - Driven by consumer and telecom in Europe and Japan
- Microprocessor and microperipheral markets weak
  - Attributable to soft PC demand

Notes:

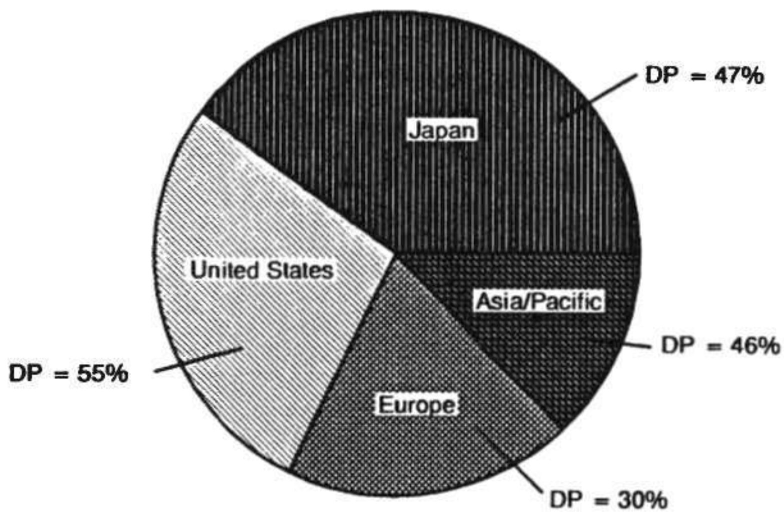
WORLDWIDE SEMICONDUCTOR CONSUMPTION BY APPLICATION



1991 = $63.6 Billion

Source: Dataquest

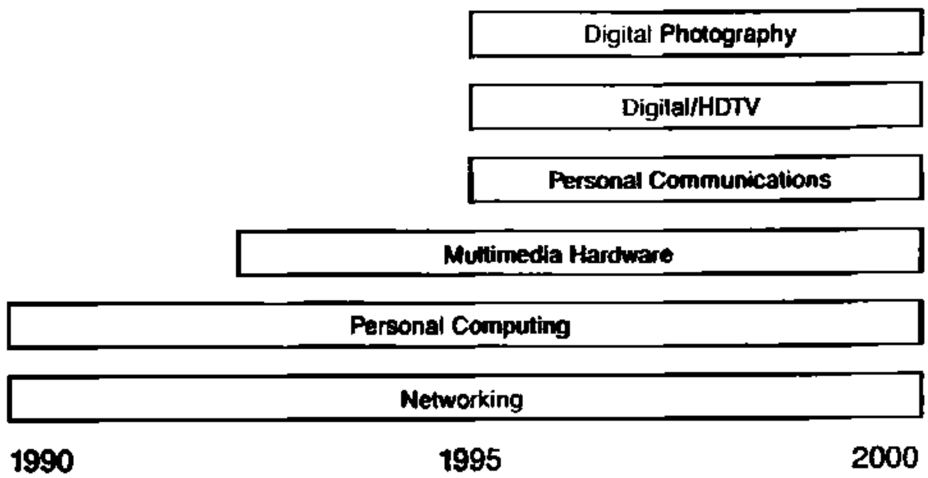
WORLDWIDE SEMICONDUCTOR CONSUMPTION BY REGION



Total = $63.6 Billion

Source: Dataquest

MARKET DRIVERS OF THE 1990s

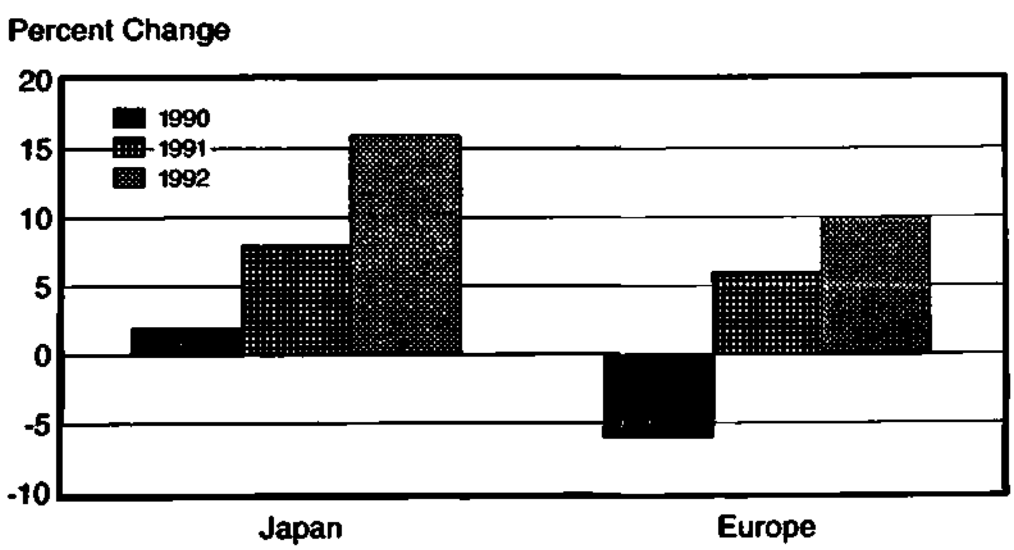


Source: Dataquest

Notes:

Summary

SEMICONDUCTOR REVENUE GROWTH FORECAST IN LOCAL CURRENCIES



Source: Dataquest

Notes:

DRAM Device and Manufacturing Trends

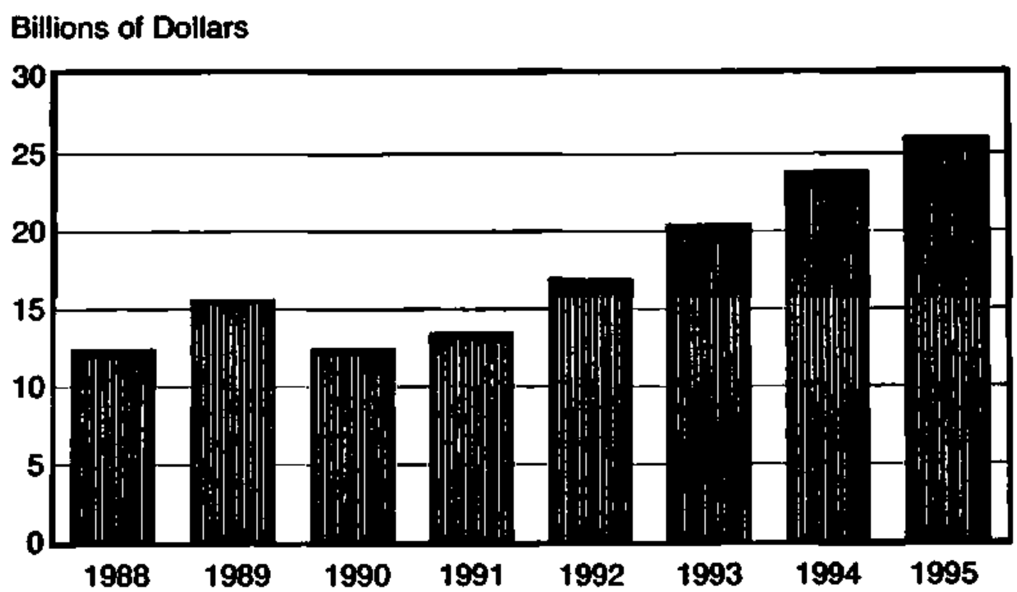
Sam Young
Memories

Dr. Peggy Marie Wood
Manufacturing Trends

AGENDA

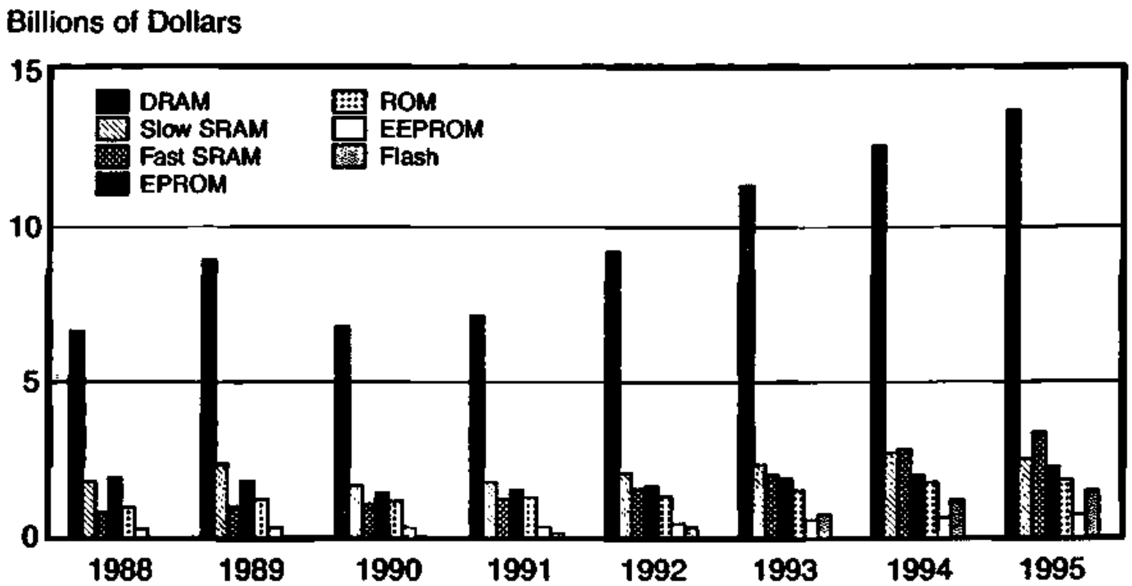
- MOS memory forecast
- DRAM ASP trends
- Manufacturing process complexity increasing
- DRAM volume peaks, life cycles, and unit forecasts
- Lithography and other DRAM process trends
- Bit growth, unit growth, and DRAM revenue forecast
- Fab strategies
- Conclusions

MOS MEMORY FORECAST -- REVENUE



Source: Dataquest

MOS MEMORY PRODUCT FORECAST -- REVENUE



Source: Dataquest

Notes:

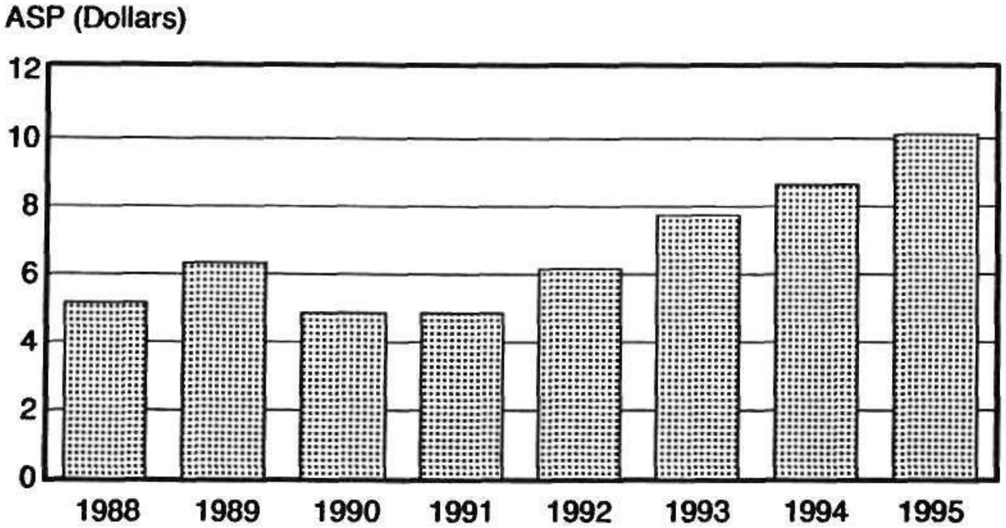
DRAM TRENDS -- ASP

- DRAM ASPs are rising
  - 1990 = $4.84
  - 1995 = $10.14
- Price per bit is now declining by a factor of 2, not 4, per generation

Source: Dataquest

DRAM ASP

ASPs Are Increasing, but So Are Costs



Source: Dataquest

MANUFACTURING PROCESS COMPLEXITY INCREASING

	1Mb DRAM	64Mb DRAM
Line geometries	1.2-0.8µm	0.4-0.3µm
Mask levels	14-16	26-30
Process steps	250-325	600-800
Wafer fab costs*	$225 million	$750 million

*No assembly/test included

Source: Dataquest

Notes:

MOVING TO LARGER WAFERS
MORE BANG FOR THE BUCK

4Mb DRAM – 20,000 wafer-per-month capacity

Wafer Diameter	6-Inch	8-Inch	8-Inch:6-Inch
Wafer area	27.4 sq. in.	48.7 sq. in.	1.80
Wafer fab cost*	$300 million	$375 million	1.25
Capital cost per square inch of silicon capacity	$545	$385	0.70

*No assembly/test included

Can achieve lower manufacturing cost per die by moving to larger wafers, but major processing hurdles must be overcome to achieve similar yield

Source: Dataquest

DRAM VOLUME PEAKS

(Units)

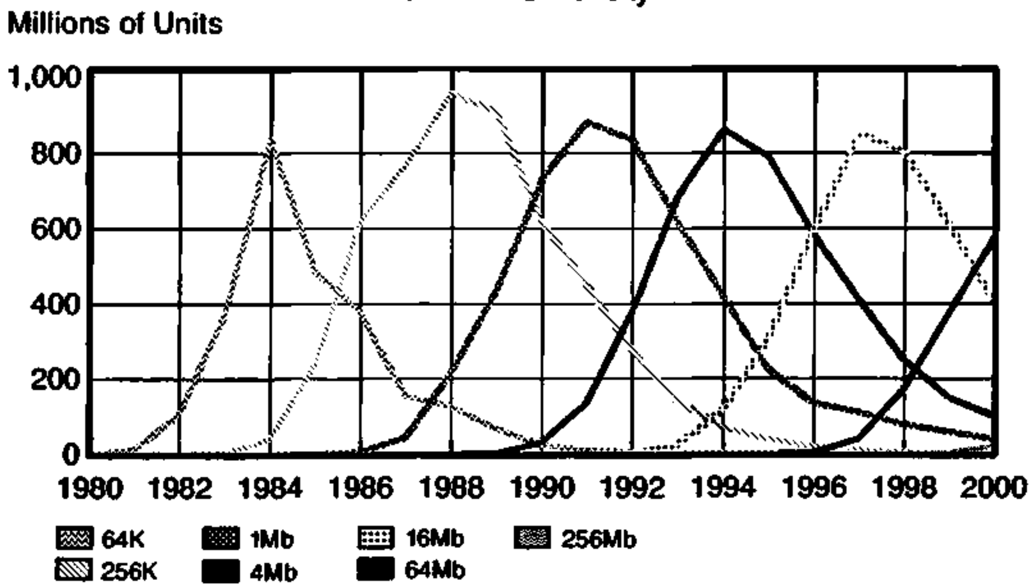
Unit volume peaks are declining for each successive generation -- 256K DRAM is the highest-volume part

Volume Peaks	Year	Volume (Millions of Units)
256K	1988	956
1Mb	1991	880
4Mb	1994	860

Source: Dataquest

UNIT LIFE CYCLES

64K-64Mb Density



Source: Dataquest

Notes:

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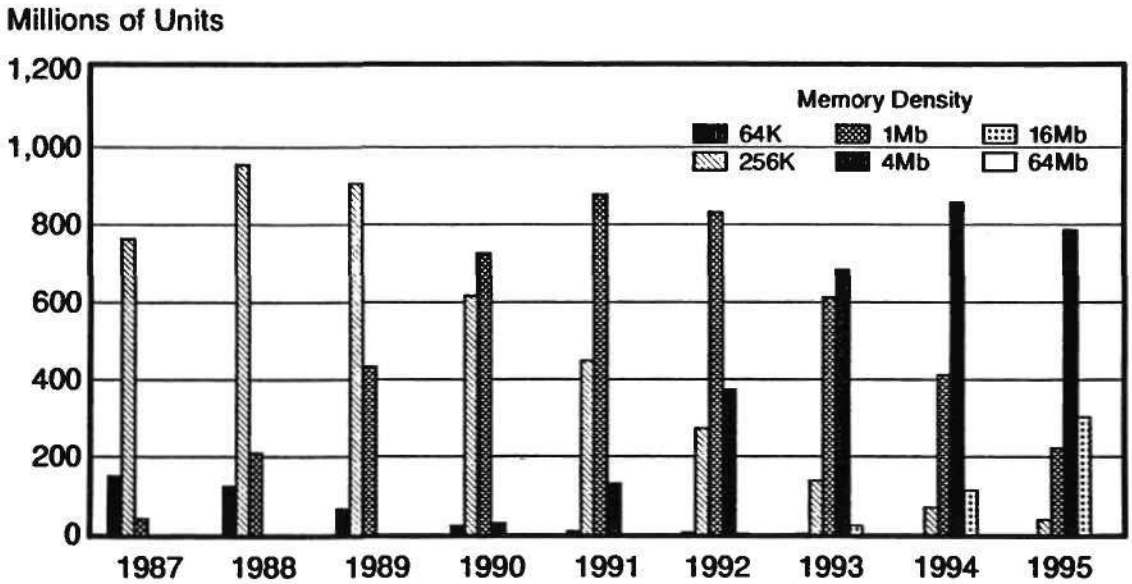
DRAM FORECAST



Source: Dataquest

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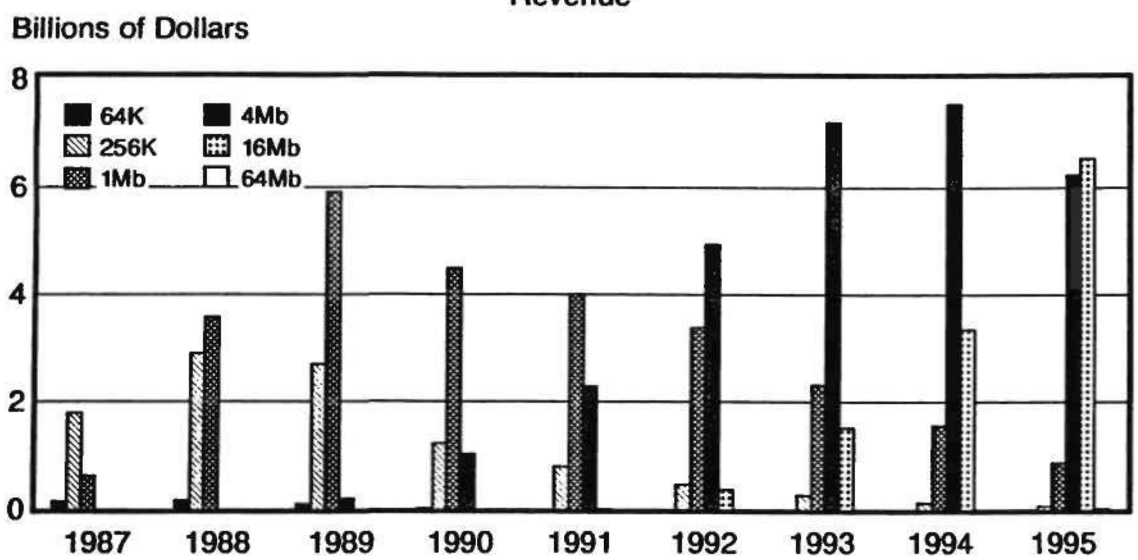
DRAM FORECAST

Revenue



Source: Dataquest

LITHOGRAPHY AND OTHER DRAM PROCESS TRENDS

- Lithography trends
  - DRAM lithography strategies
  - Phase shift masks – technical and marketing issues
  - What would it take for excimer/deep-UV to dominate?
  - Move to wide-field lenses
- Other DRAM process trends

Notes:

DRAM LITHOGRAPHY STRATEGIES

DRAM Density	Sample Year	Linewidth (µm)	Lithography Strategies
16Mb	1991	0.6-0.4	i-line
64Mb	1994	0.4-0.3	Excimer/deep-UV i-line (phase shift masks) i-line mix-and-match Point-source X ray
256Mb	1997	0.3-0.2	Excimer/deep-UV (with or without phase shift masks) i-line (phase shift masks) e-beam Point source X ray, SOR X ray

Source: Dataquest

PHASE SHIFT MASKS

Technical and Marketing Issues

- Technical issues
  - Different types of phase shift masks, no clear winner
  - Phase shifter materials limited
  - Phase shift mask inspection more complicated
  - Phase shift mask repair limited to none
- Marketing issues
  - Only suitable for highly repetitive patterns, not all device types
  - Only used on limited number of critical mask levels
  - Cost of phase shift masks is high
  - Viable competitive technologies exist

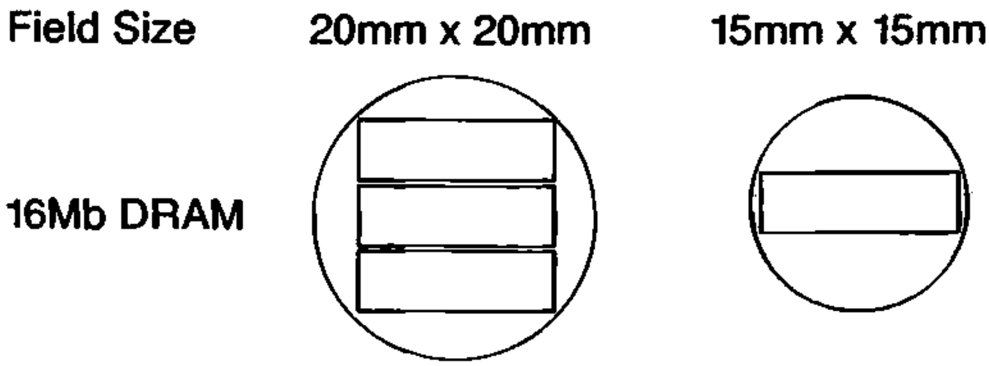
3636016.IMG 03/25/91 YOU

WHAT WOULD IT TAKE FOR EXCIMER/DEEP-UV TO DOMINATE?

- If maskmakers are unable to solve the problems necessary to commercialize phase shift mask technology by 1992
- If good availability of commercial deep-UV resists is established (resists limited today)
- If excimer laser source stability and uniformity continues along path of steady improvements
- Reality
  - Both excimer/deep-UV and i-line/phase shift mask lithography will be used for 64Mb DRAM processing. The next year will tell if one strategy will strongly dominate over the other.

Notes:

MOVE TO WIDE-FIELD LENSES



- Accommodate larger devices
- Increase system throughput by accommodating more devices in the image field

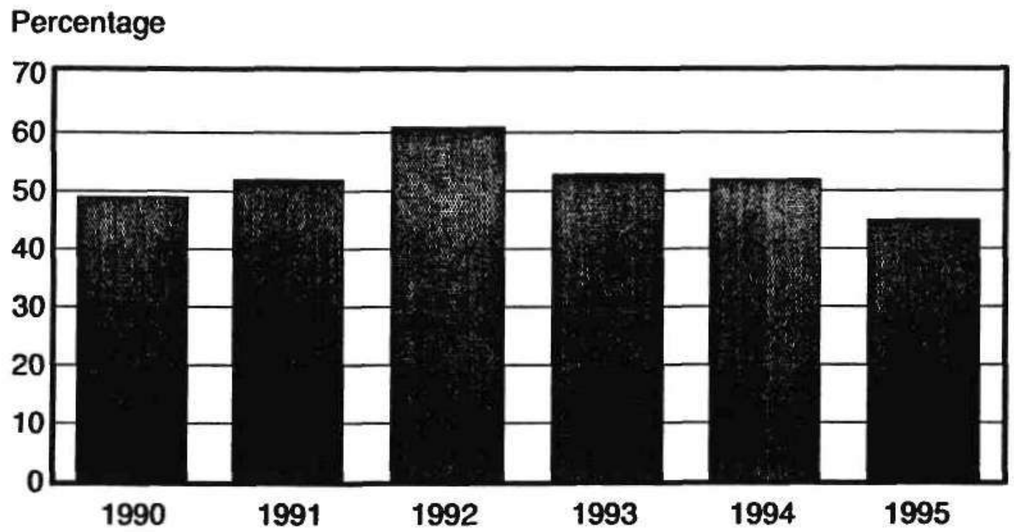
Source: Dataquest

OTHER DRAM PROCESS TRENDS

- Cell complexity issues
  - Stacked, trench, and hybrid capacitor schemes
  - New, innovative high-dielectric constant materials
- Etch/clean trends
  - Wet clean/dry etch process steps exceed mask levels
- Deposition trends
  - Double-level metal for 16Mb DRAM
  - Rapidly growing number of polysilicon films
  - Highly planarized interlayer dielectrics required
- Diffusion/implant
  - Significant shift to vertical diffusion/LPCVD processing
  - Number of implant steps increasing

DRAM BIT GROWTH

Bit Growth Rate Is Slowing Down -- Peaked Over 150% in '80s



Source: Dataquest

Notes:

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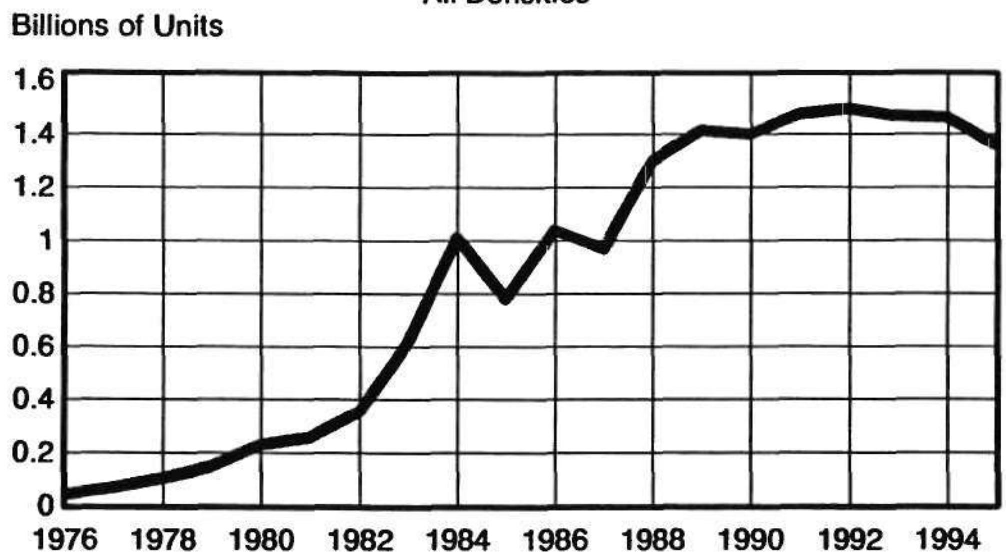
DRAM UNIT VOLUME

All Densities



Source: Dataquest

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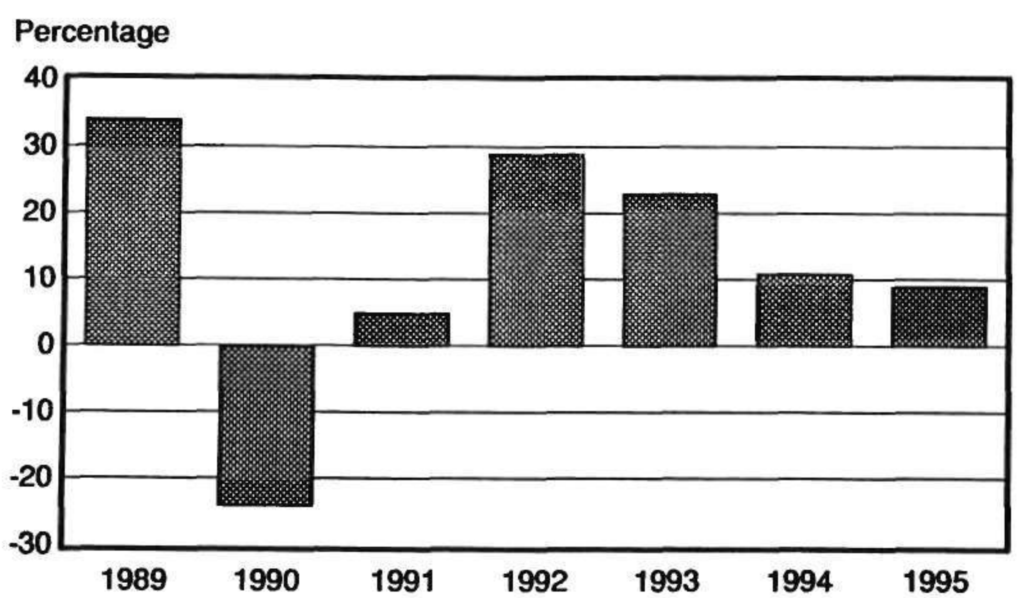
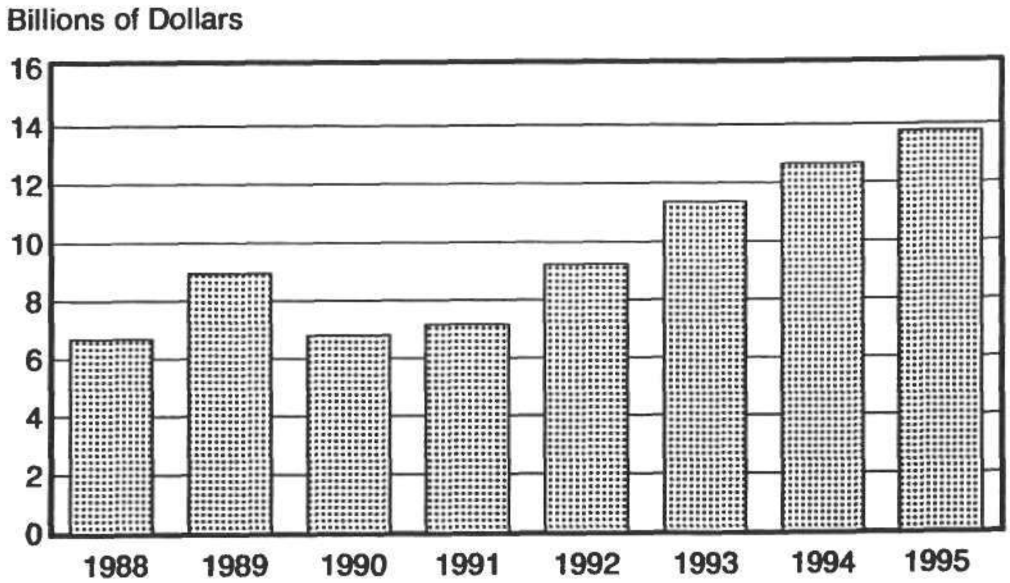
DRAM REVENUE GROWTH



Source: Dataquest

DRAM REVENUE GROWTH



Source: Dataquest

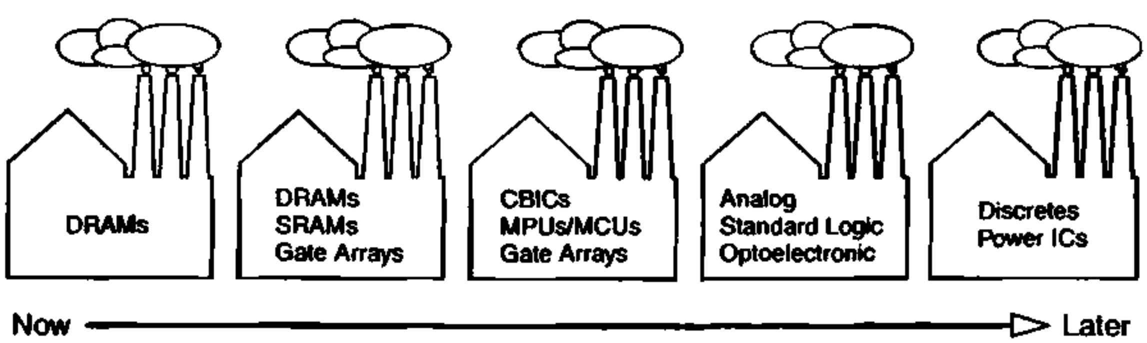
Notes:

FAB STRATEGIES

- Fab costs escalating dramatically
  - Issue at hand: How to control process development costs and extend the economic lifetime of fabs and tool sets
- Partnering!
  - IBM/Siemens 16Mb DRAM joint venture (France)
  - Texas Instruments' joint venture strategies
- Amortize the cost of an individual fab over time and over product families
- "Harmonization of processes"

FAB COST AMORTIZED OVER BOTH TIME AND PRODUCT

Span of 12 to 15 Years



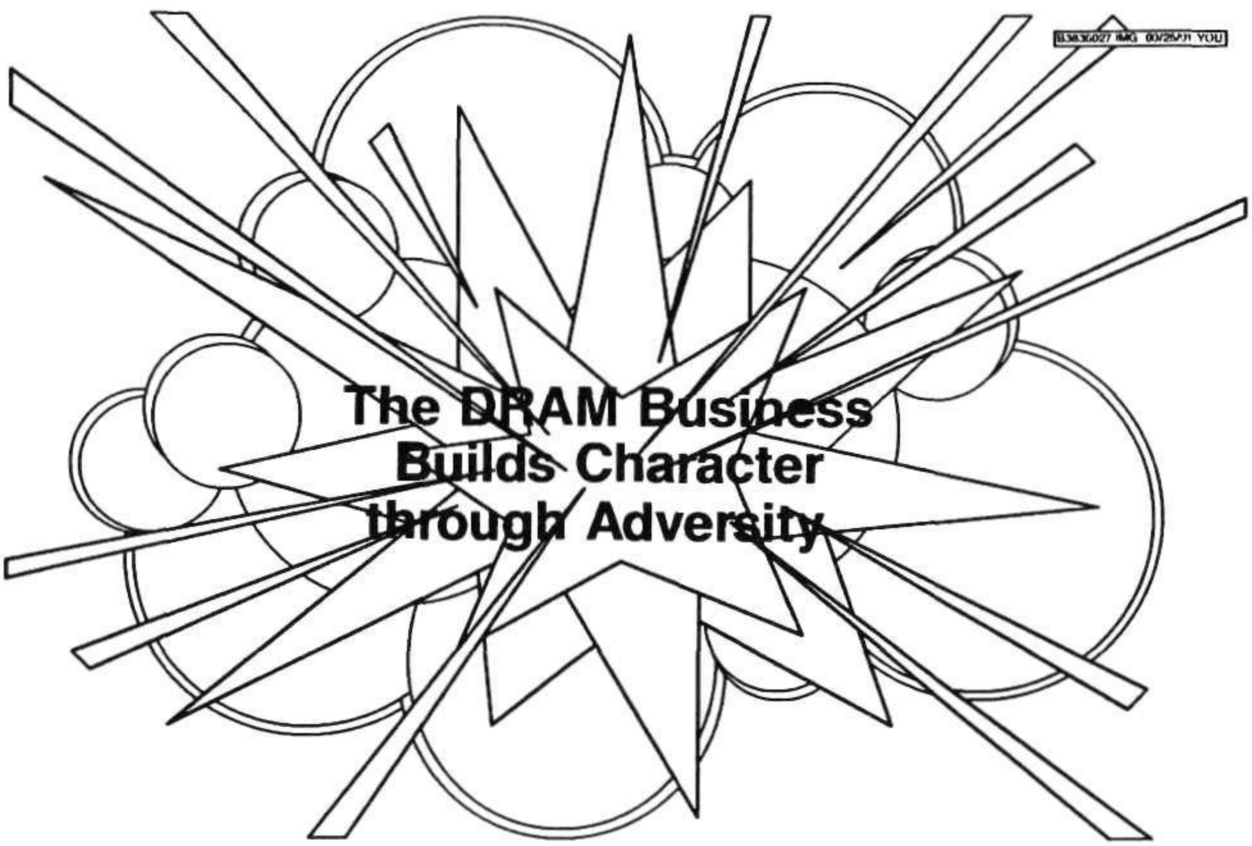
TEXAS INSTRUMENTS' HARMONIZATION PROGRAM

- Goal -- design several different product families with high degree of compatibility in equipment sets and process recipes
- Benefits
  - Fab flexibility increased
  - Fab lifetimes extended
  - Product development costs reduced
  - Factories loaded more efficiently

Notes:

CONCLUSIONS

- DRAMs are still a good business to be in
  - Good revenue growth
  - Bit growth continues, albeit at a slower pace
  - But . . .
- Barriers to entry are continuously getting higher
  - Capital, capital, capital!
- Manufacturing complexity and challenges continue to increase



Notes:

ASICs, Tools, and Foundry

Ron Collett
ASICs, EDA

Howard Bogert
Foundry

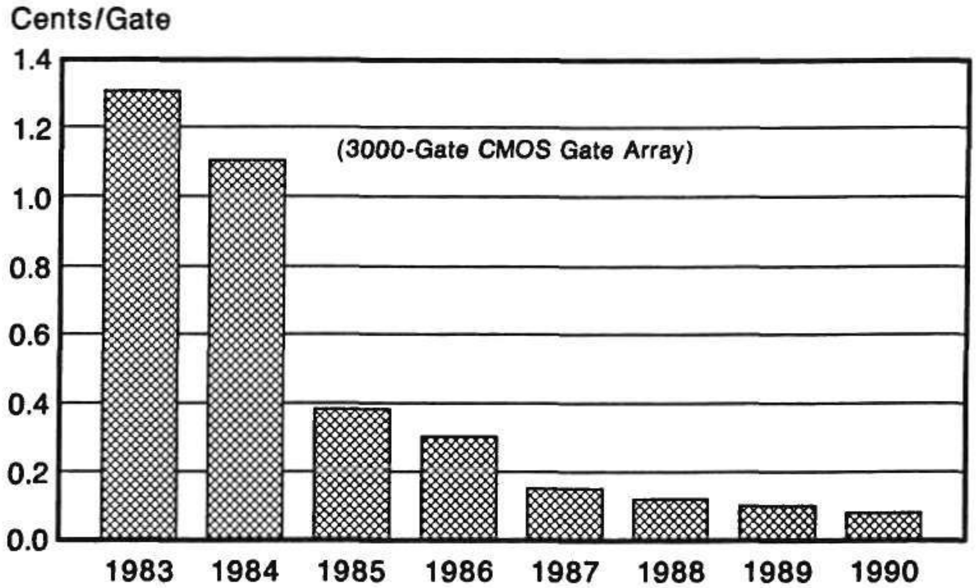
AGENDA

- The realities of the ASIC business
- Dynamic changes in the ASIC arena
- Complementary opportunities in the electronic system design market
- Summary and conclusions

AGENDA

- The realities of the ASIC business

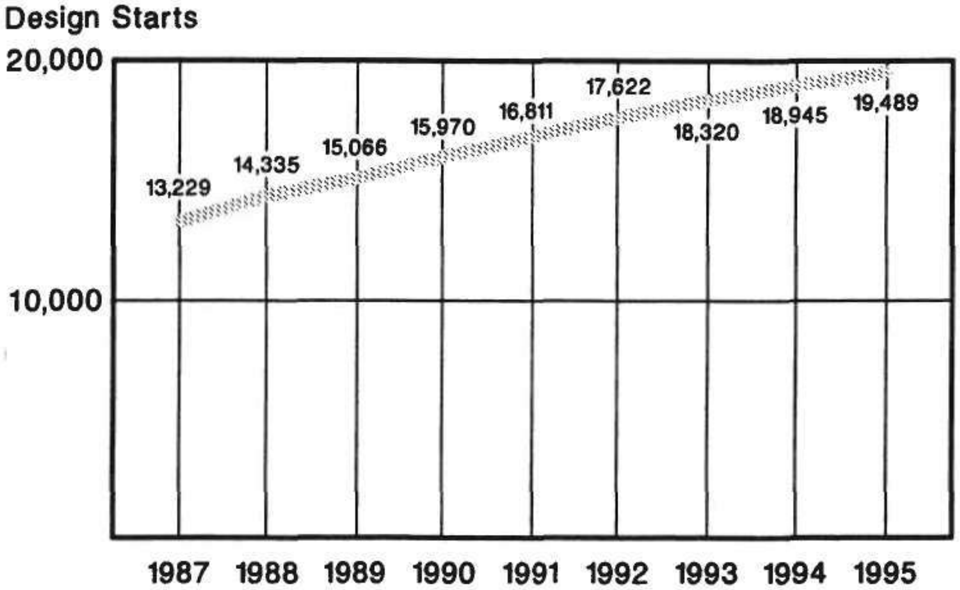
ASIC PRICES ARE STEADILY DECLINING



Source: Dataquest

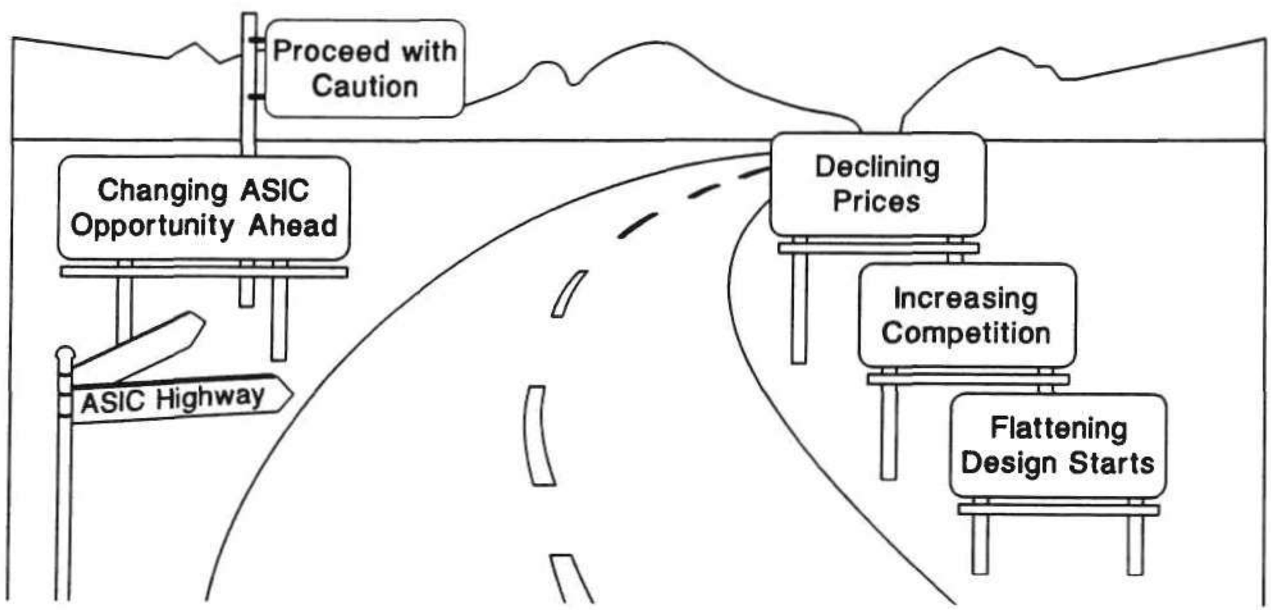
Notes:

DESIGN START GROWTH IS SLOWING



Source: Dataquest

THE RESULT: THE ASIC OPPORTUNITY IS SHIFTING

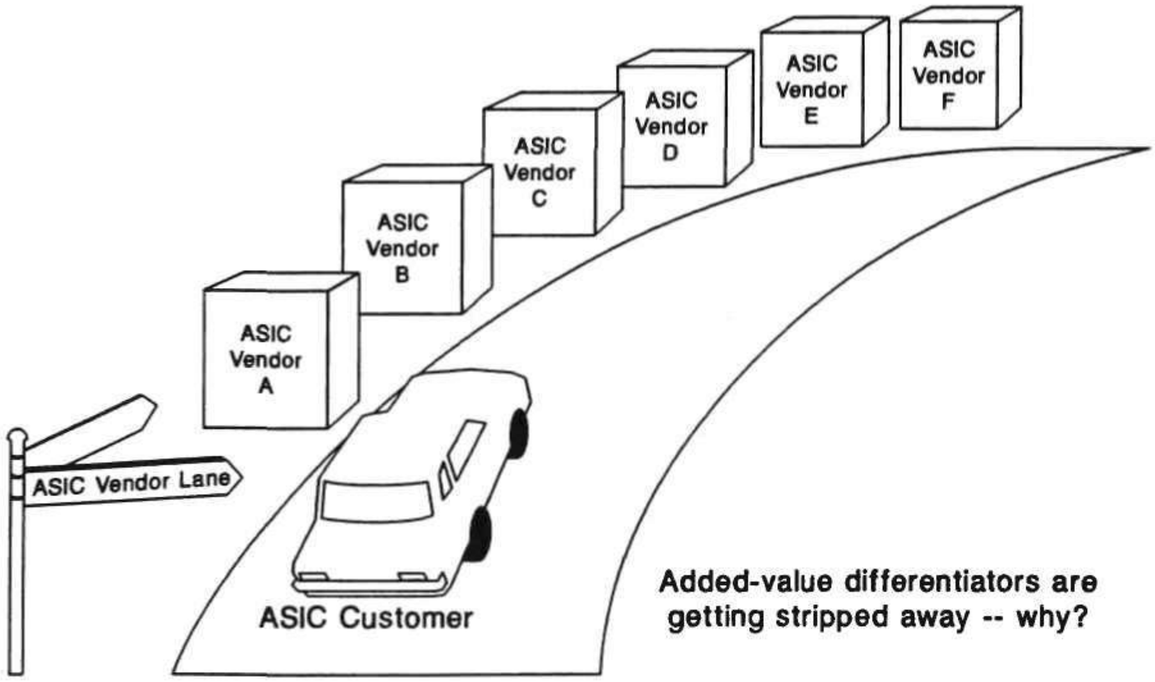


AGENDA

- Dynamic changes in the ASIC arena

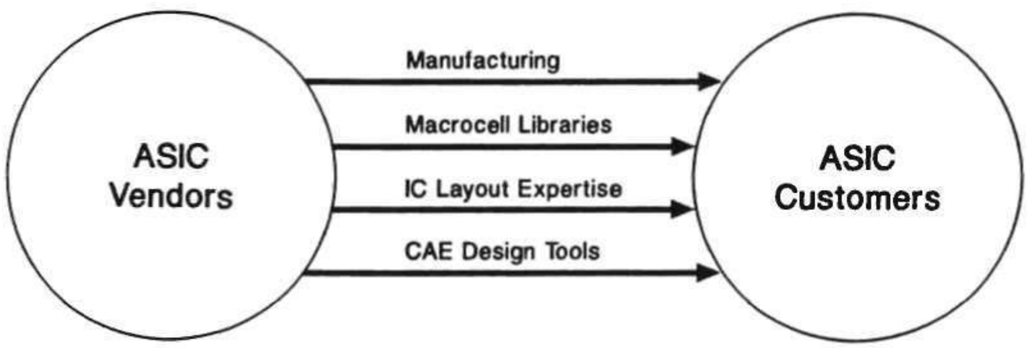
Notes:

ASIC VENDORS ARE LOSING DIFFERENTIATION



EVOLUTION OF THE ASIC INDUSTRY

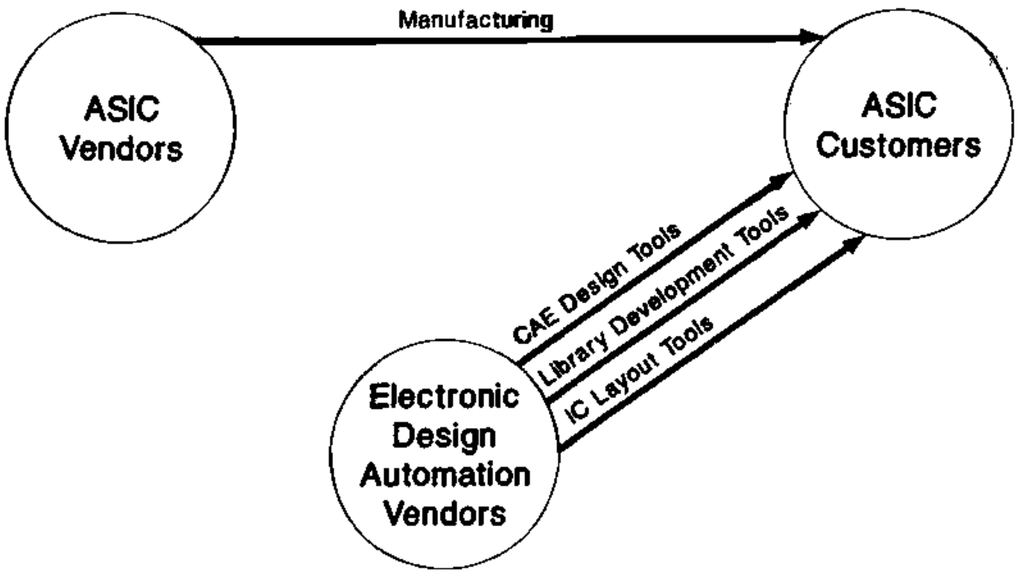
Early 1980s



Added-value differentiation is at a maximum

EVOLUTION OF THE ASIC INDUSTRY

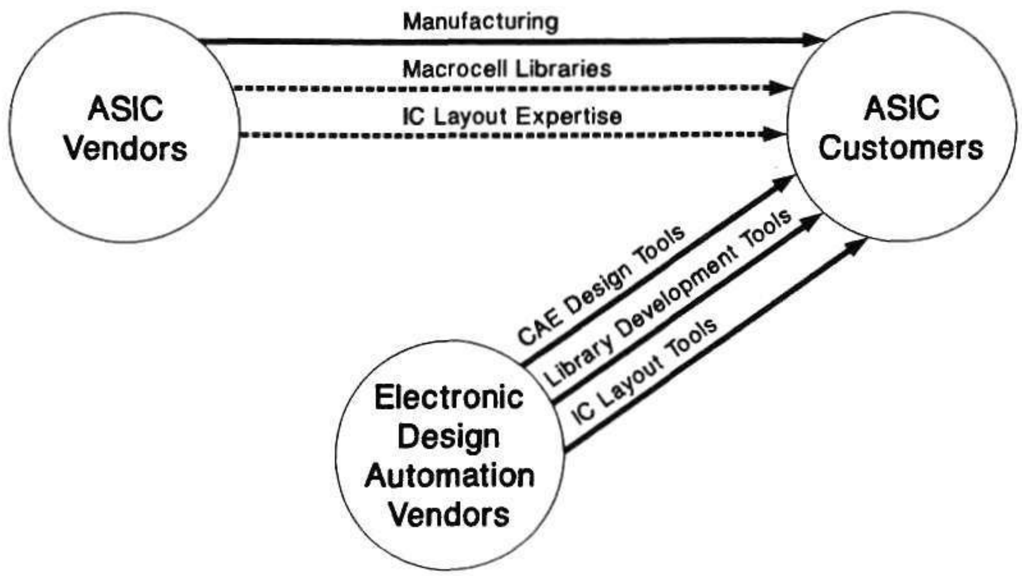
Mid-1990s



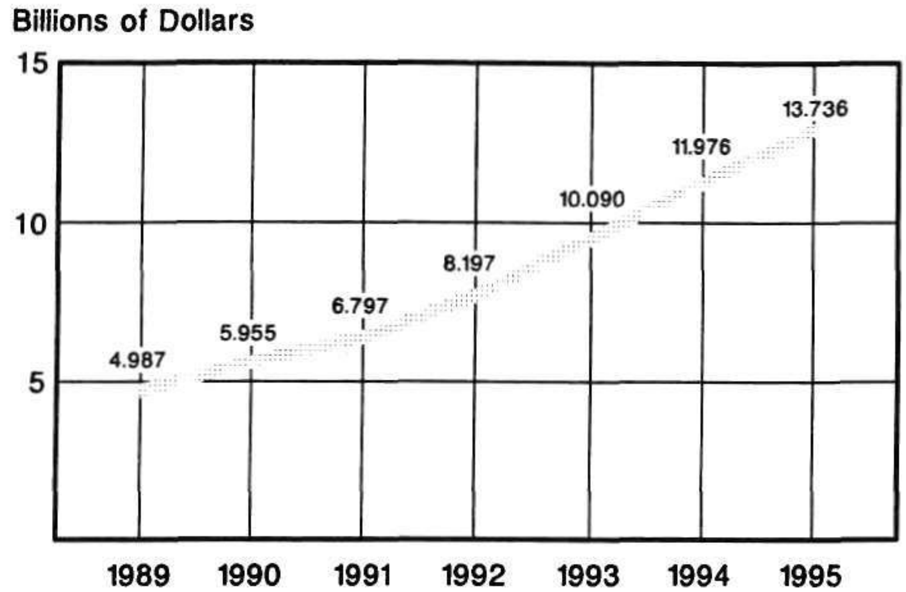
Notes:

EVOLUTION OF THE ASIC INDUSTRY

Late 1980s, Early 1990s



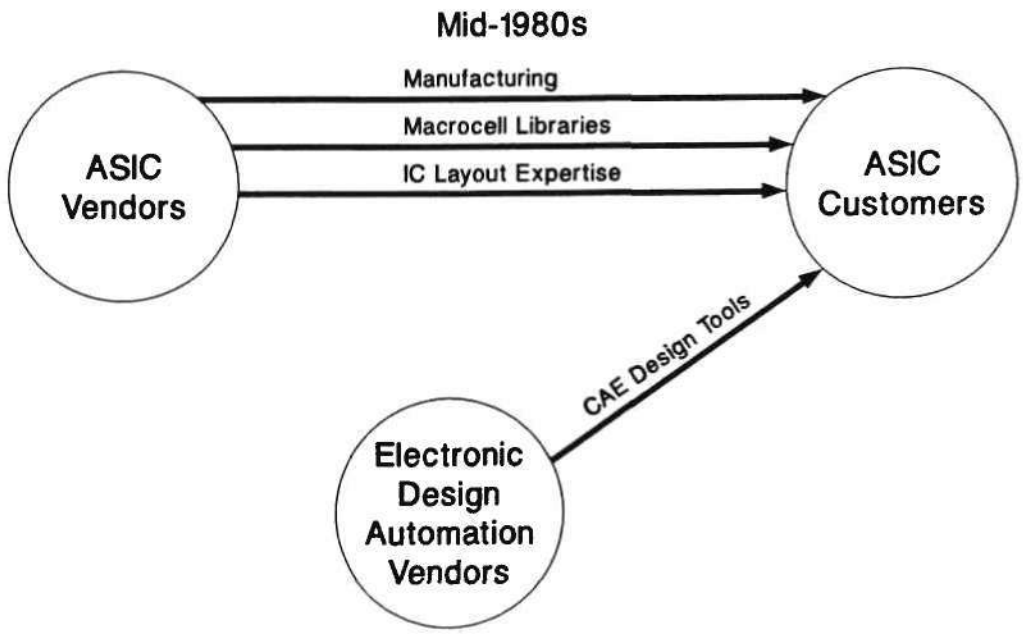
PROJECTED GROWTH OF THE ASIC MARKET*



*Includes gate arrays and cell-based ICs

Source: Dataquest

EVOLUTION OF THE ASIC INDUSTRY



Notes:

AGENDA

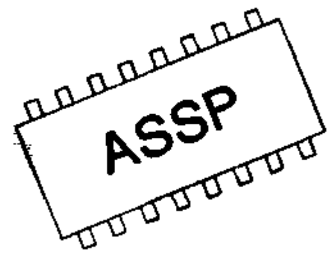
- Complementary opportunities in the electronic system design market

COMPLEMENTARY OPPORTUNITIES

- Foundry
- Application-specific standard products (ASSPs)
- Multichip modules
- Field-programmable gate arrays (FPGAs)
- Electronic Design Automation software

APPLICATION-SPECIFIC STANDARD PRODUCTS

Two Strategies to Compete:



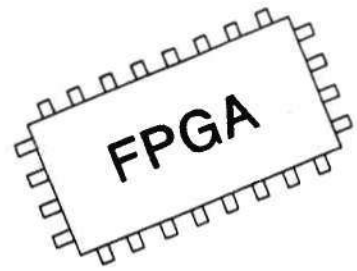
- Rapid and continuous identification of market need
  - Design expertise
  - Time to market
  - Marketing and distribution
  - Entrepreneurial, incentivized organization
- Protect the intellectual property embodying the ASSP
  - Patent
  - Add software value

Notes:

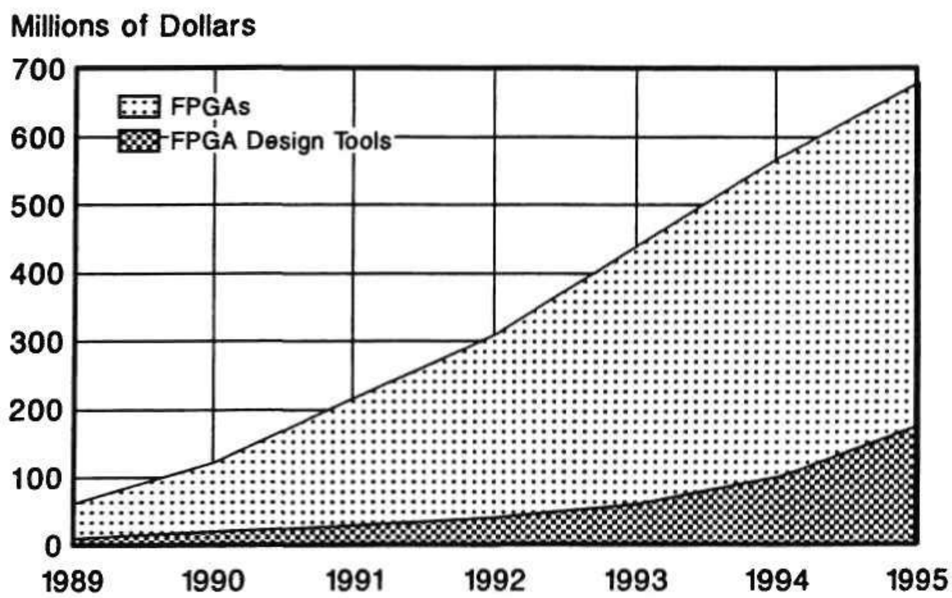
FIELD-PROGRAMMABLE GATE ARRAYS

Ingredients:

- Architectural differentiation
- Design software
- Manufacturing resources
- Strong customer support
- Aggressive marketing



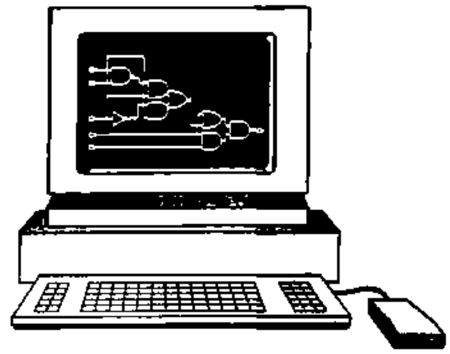
PROJECTED GROWTH OF THE FPGA MARKET



Source: Dataquest

ELECTRONIC DESIGN AUTOMATION SOFTWARE

Characteristics:



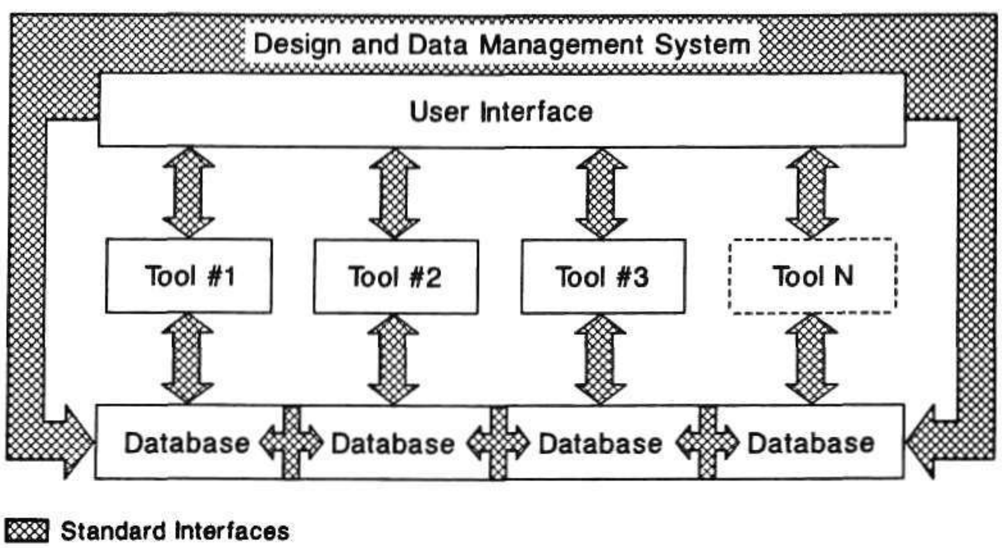
- Capital investment: low
- Manufacturing resources: none
- Distribution costs: falling
- Barriers to entry: falling
- Market demand: very high
- Intellectual property protection: strong

Notes:

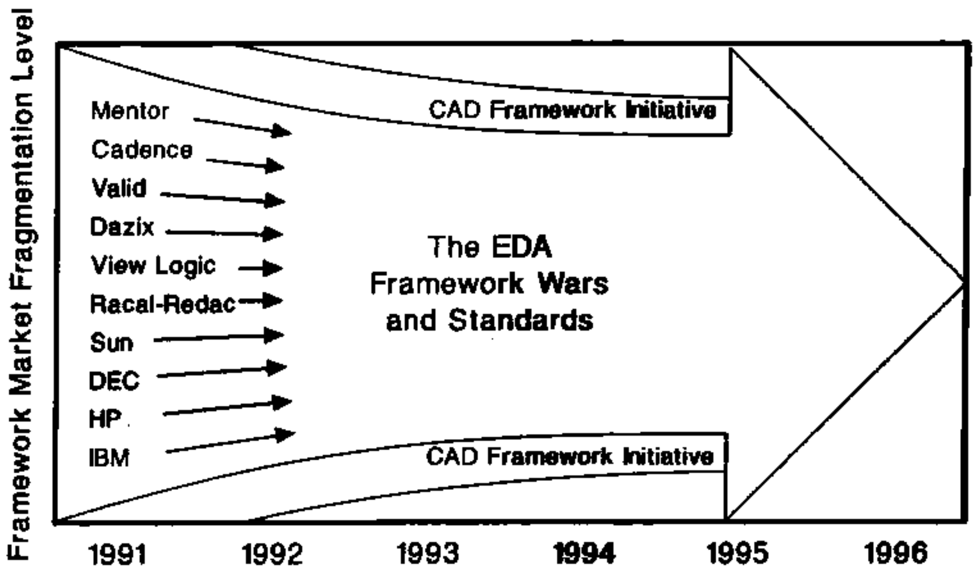
EMERGING EDA SOFTWARE OPPORTUNITIES

- Electronic system design automation
- Automatic test vector generation
- Mixed analog-digital verification
- Field-programmable gate array design tools
- Multichip module design tools

THE IMPENDING OPEN SYSTEMS REVOLUTION



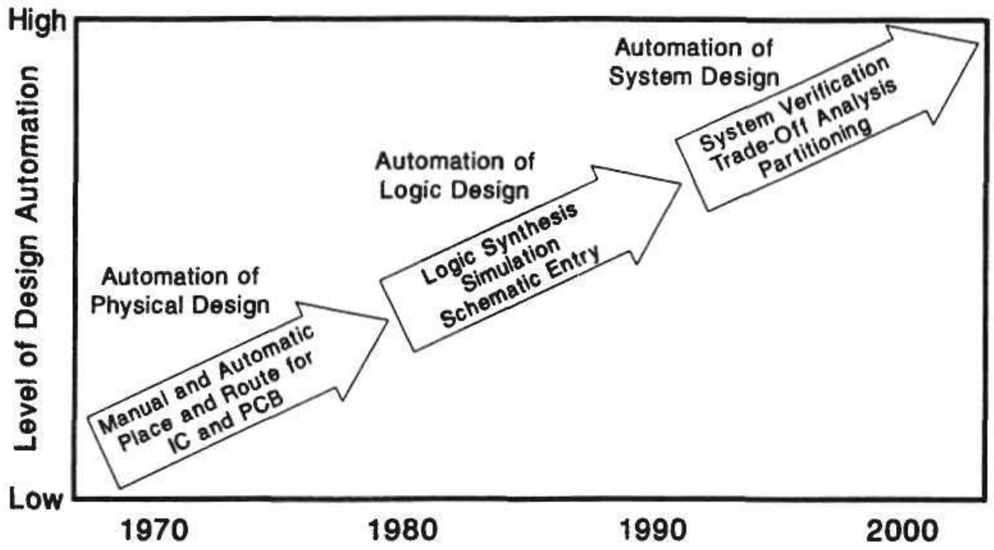
FRAMEWORK FRAGMENTATION



Source: Dataquest

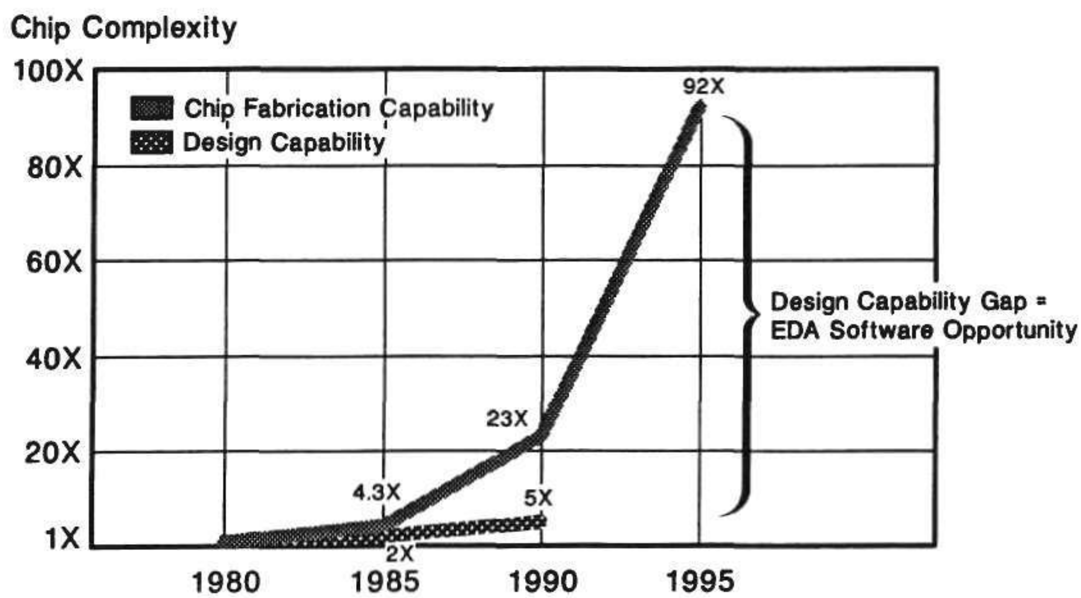
Notes:

THE EVOLUTION OF EDA



Source: Dataquest

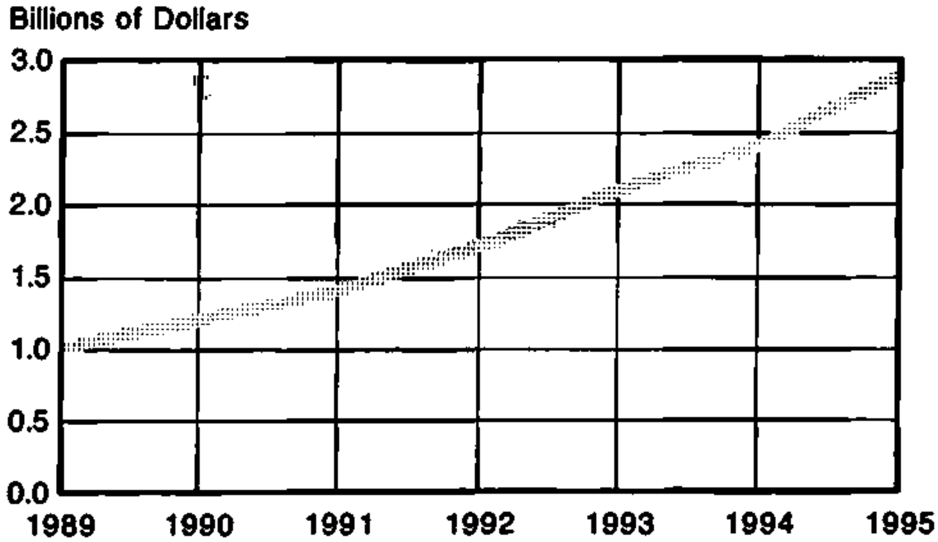
DESIGN CAPABILITY GAP



Source: Dataquest

EDA PROJECTED MARKET GROWTH

Worldwide EDA Software



Source: Dataquest

Notes:

AGENDA

- Summary and conclusions

SUMMARY AND CONCLUSIONS

- ASIC is becoming a foundry business
- A range of complementary business opportunities is emerging
- Semiconductor fabrication capabilities will enable an exponential increase in chip density
- An enormous gap potentially exists between chip fabrication capabilities and design capabilities

Notes:

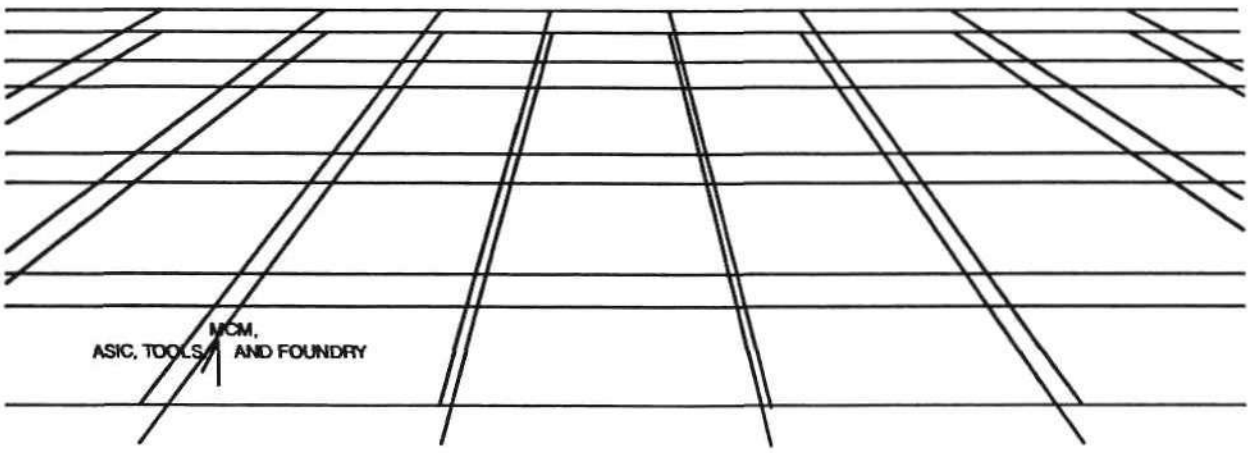
ASICs, Tools, and Foundry

Ron Collett
ASICs, EDA

Howard Bogert
Foundry

B3787001.IMG 09/27/91:BOG

Value Added
in the
Information Age



3787002.IMG 09/13/91:BOG

AGENDA

- Information-age basics
- Foundry trends
- MCM evolution
- Strategies for success

ASIC, TOOLS, MCM, AND FOUNDRY

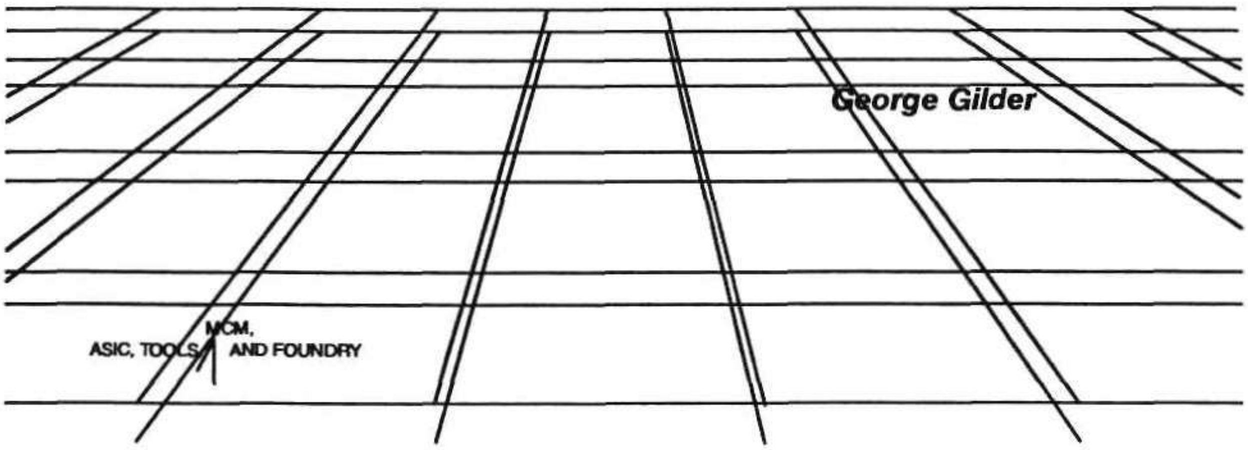
83787003 IMG 00/27/01:BUG

"The essence of

CAPITALISM

is the competitive search for a temporary

MONOPOLY "



Notes:

POWER SHIFT

	Era	Main Job	Power Source
1900	Agricultural	Farmer	Physical
1940	Manufacturing	Factory Worker	Financial
2000	Information	Knowledge Worker	Intellectual Property

ASIC, TOOLS, MCM, AND FOUNDRY

Source: Toeffler, Dataquest

INFORMATION-AGE COMPANIES

Company	Intellectual Property
Intel	MS-DOS Chip Hardware
Microsoft	MS-DOS Software
Sun	Solaris Operating System

ASIC, TOOLS, MCM, AND FOUNDRY

B3787606 IMG 00/14/01:BOG

FOUNDRY IN THE INFORMATION AGE

Notes:

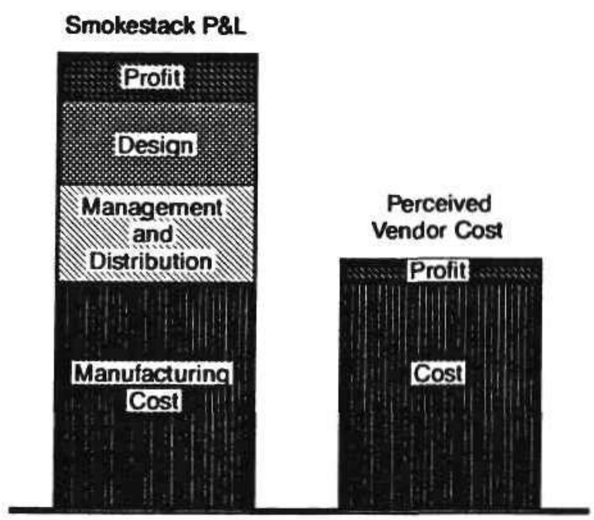
B3787007.IMG 03/15/01:BUG

A WAFER FAB IS LIKE A PET DINOSAUR

ASIC, TOOLS, MCM, AND FOUNDRY

B3787008.IMG 03/14/01:BUG

VERTICAL INTEGRATION

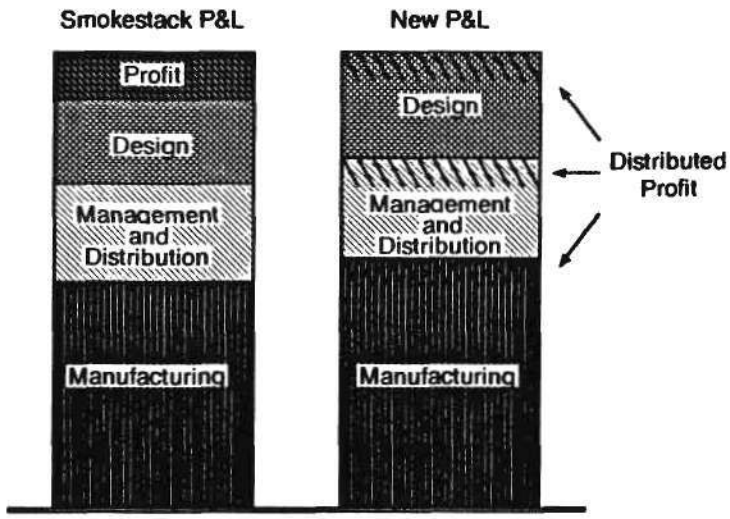


ASIC, TOOLS, MCM, AND FOUNDRY

Source: Dataquest

B3787000 IMG 00/15/91 BUG

VERTICAL DIS-INTEGRATION



MCM, ASIC, TOOLS, AND FOUNDRY

Source: Dataquest

Notes:

Use a Foundry	Be a Foundry
• Market doesn't fill fab	• Profitable business
• Maintain 100% capacity	• Help fill the fab
• Save capital	• Foundry for strategic accounts
• Productivity yardstick	• Fabless company alliances
• Proprietary multisource	• Competitiveness gauge

MCM,
ASIC, TOOLS, AND FOUNDRY

CMOS FOUNDRY HEADCOUNT

1982	--	31
1983	--	34
1984	--	31
1985	--	54
1986	--	69
1987	--	70
1990	--	112

Growth rate: 16-20%
Size: About $2 billion

MCM,
ASIC, TOOLS, AND FOUNDRY

Source: Dataquest

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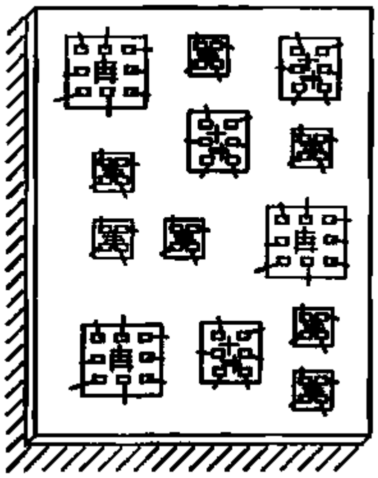
MULTICHIP MODULES



Notes:

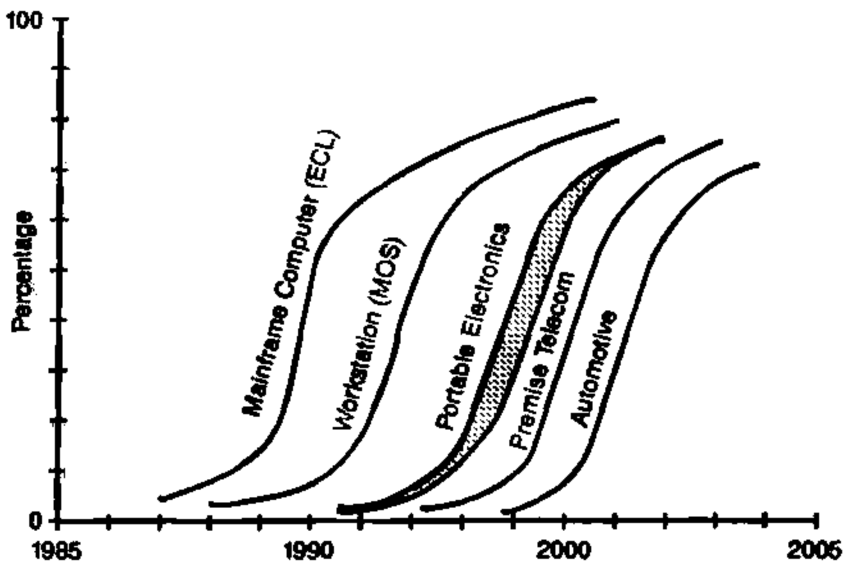
MULTICHIP MODULE DRIVERS

Period	Market Driver	Relative Price
1991-1994	Performance	100% premium
1994-1996	Size	20%-60% premium
1996-Forward	Cost	0%-30% discount

MCM, ASIC, TOOLS, AND FOUNDRY

Source: Dataquest

MCM APPLICATION PENETRATION

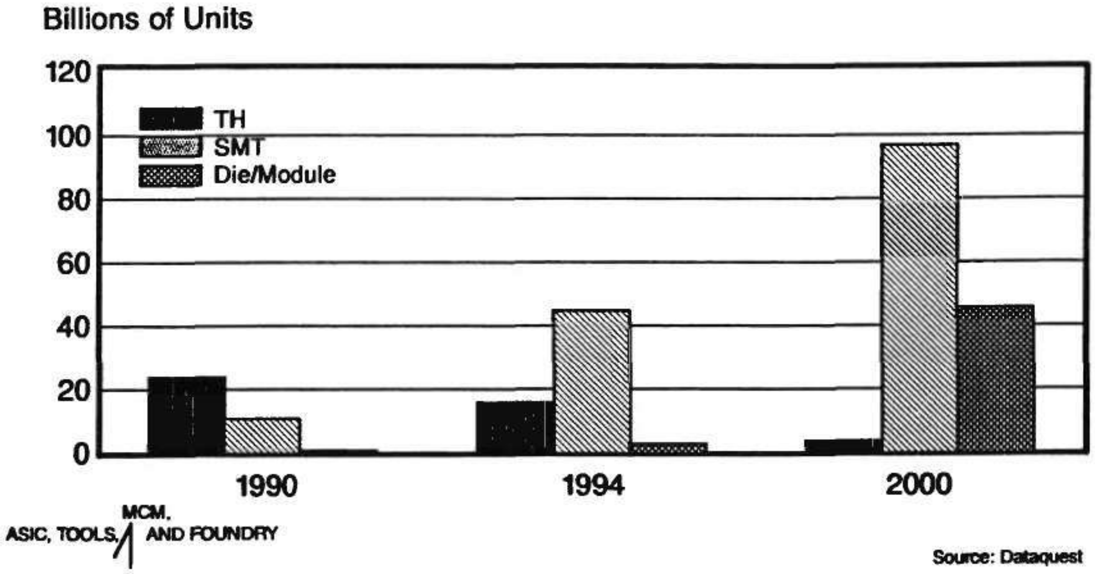


MCM, ASIC, TOOLS, AND FOUNDRY

Source: Dataquest

B3787015.IMG 00/14/91:BOG

ESTIMATED WORLDWIDE PACKAGE PRODUCTION POTENTIAL MCM MARKET



Source: Dataquest

Notes:

KEY MCM ISSUES

- CAD tools must allow concurrent interconnect and chip design
- Chip-level test must achieve AQLs equal to package-level
- Chip markets must develop

ASIC, TOOLS, MCM, AND FOUNDRY

STRATEGIES FOR SUCCESS

- Monopolize intellectual property
- Obsolete your own products
- Consider vertical disintegration
- Incorporate foundry into corporate strategies
- Position company with respect to MCMs

ASIC, TOOLS, MCM, AND FOUNDRY

Notes:

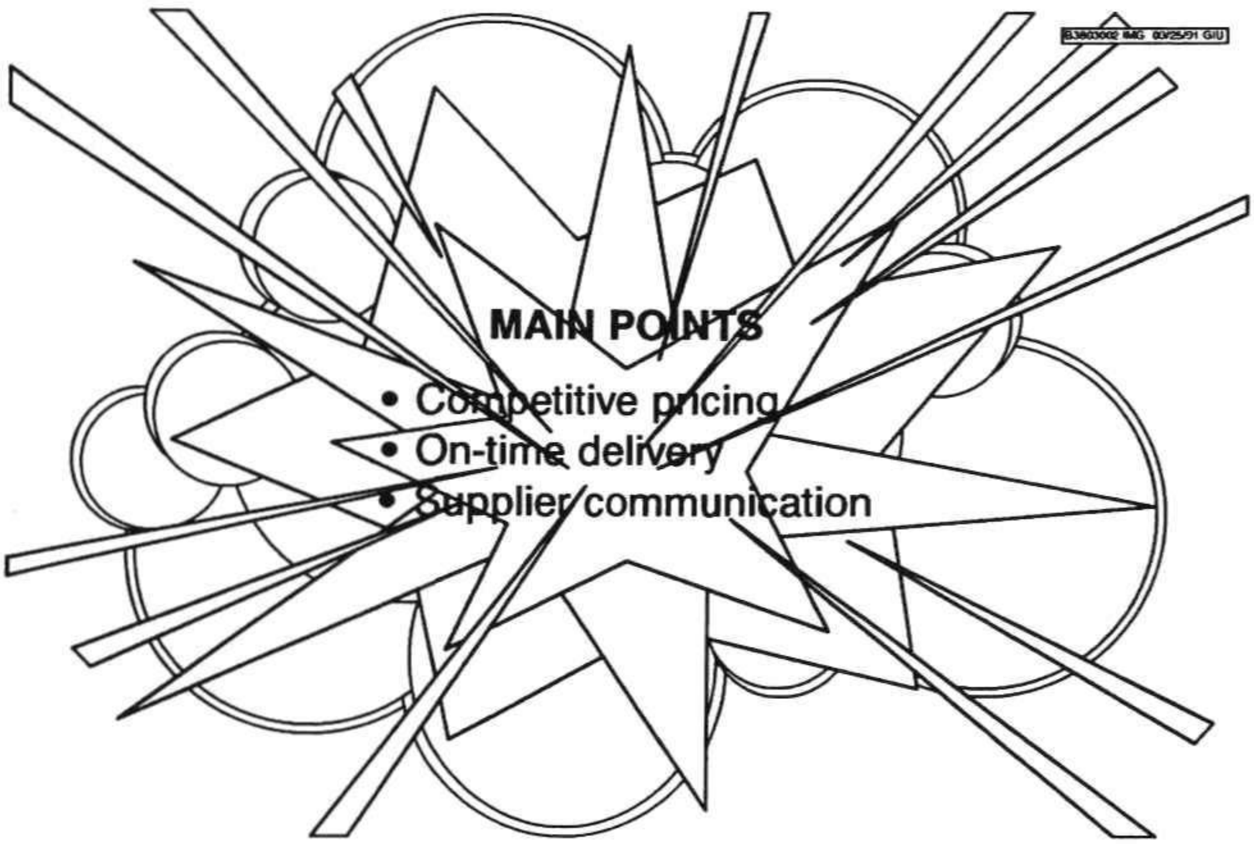
Semiconductor Pricing and Procurement Trends

Mark Giudici
Procurement Trends

Ron Bohn
Pricing

AGENDA

- Procurement issues
- Pricing issues
- Supply base management
- Questions and answers



PROCUREMENT ISSUES

1991		1990	1989	1988
1	Pricing	2	2	2
2	Availability	4	1	1
3	Cost control	3	7	4
4	JIT/inventory control	5	6	9
5	Quality/reliability	6	4	6
6	On-time delivery	1	3	3
7	New products/obsolescence	7	8	8
8	Government regulation	10	–	–
9	Petroleum-based pricing issues	–	–	–
10	Reducing vendor base	8	–	7

Source: Dataquest

Notes:

1991 PROCUREMENT ISSUES

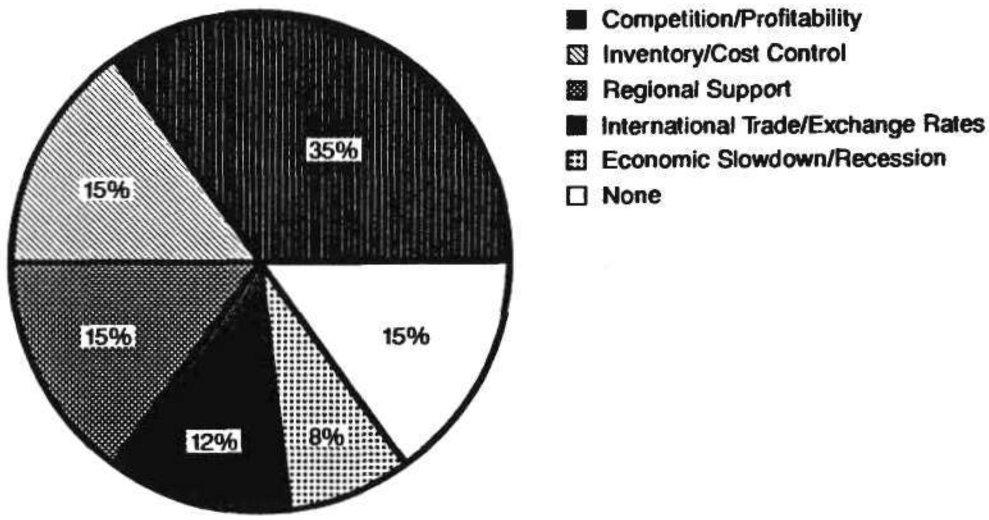
8/91 Survey Rank		12/90 Survey Rank
1	Pricing	1
2	On-time delivery	6
3	Availability	2
4	Quality/reliability	5
5	Forecasting/lead times	–
6	New products/obsolescence	7
7	Packaging standards	–
8	Cost control	3

Source: Dataquest

1992 PROCUREMENT ISSUES

1	Pricing
2	On-time delivery
3	Availability
4	Lead times
5	Forecasting
6	Inventory

1992 MACROECONOMIC PROBLEMS FACING INDUSTRY



Source: Dataquest

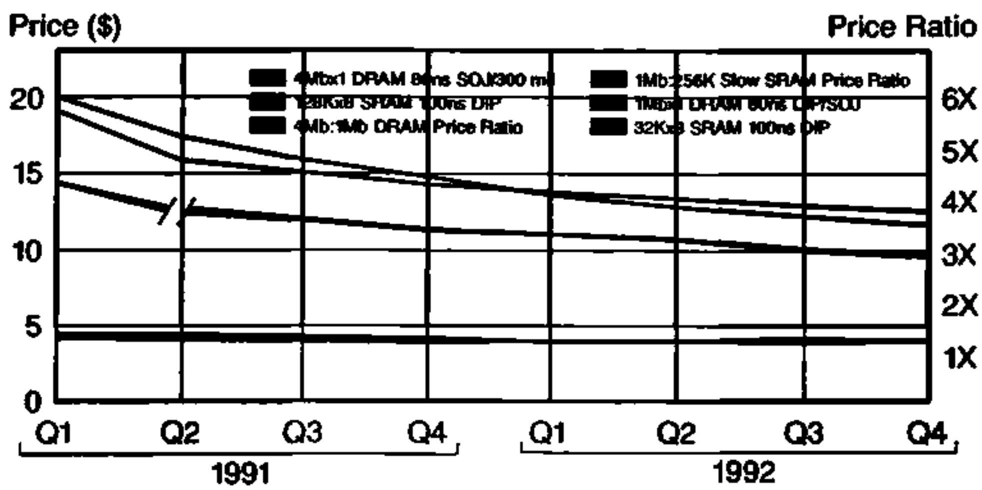
Notes:

AGENDA

- Procurement issues
- Pricing issues
- Supply base management
- Questions and answers

4Mb DRAM AND SLOW DRAM CROSSOVERS

Estimated North American Bookings; Contract Volume*



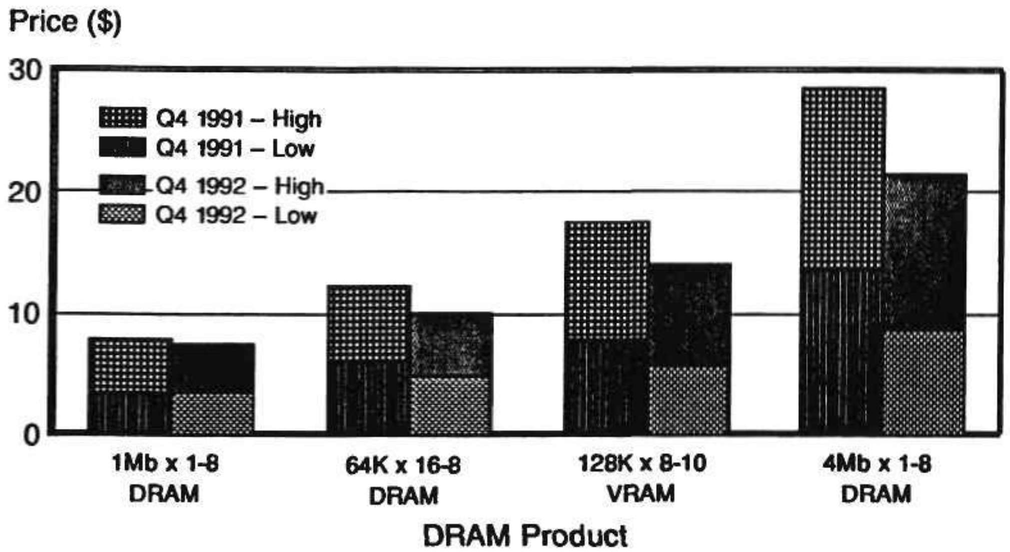
Note: Line break shows 4X crossover point. This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated September 1991.

* Contract volume = at least 100,000 per order for DRAM, 50,000 per order for slow SRAM.

Source: Dataquest

DRAM PRICE RANGES

North American Bookings (September 1991)

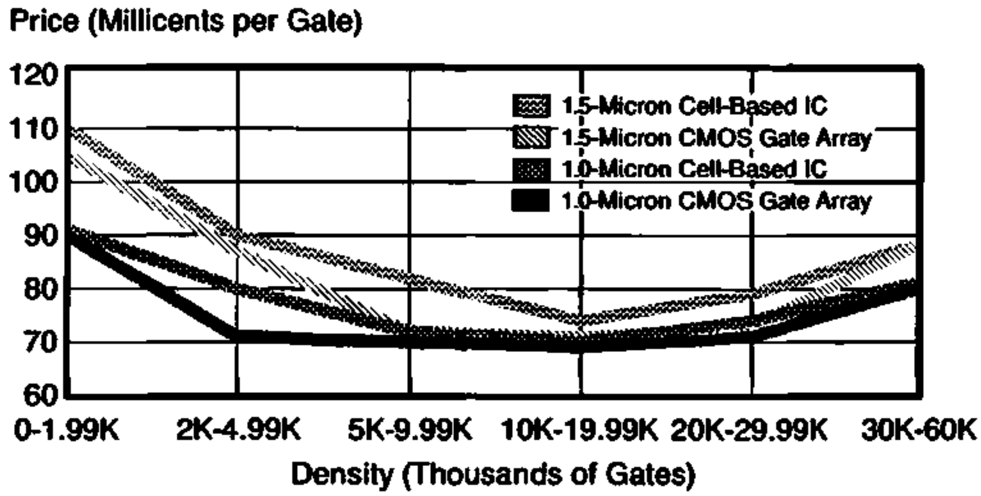


Source: Dataquest

Notes:

ESTIMATED 1992 ASIC PRICE TRENDS

North American Production Bookings

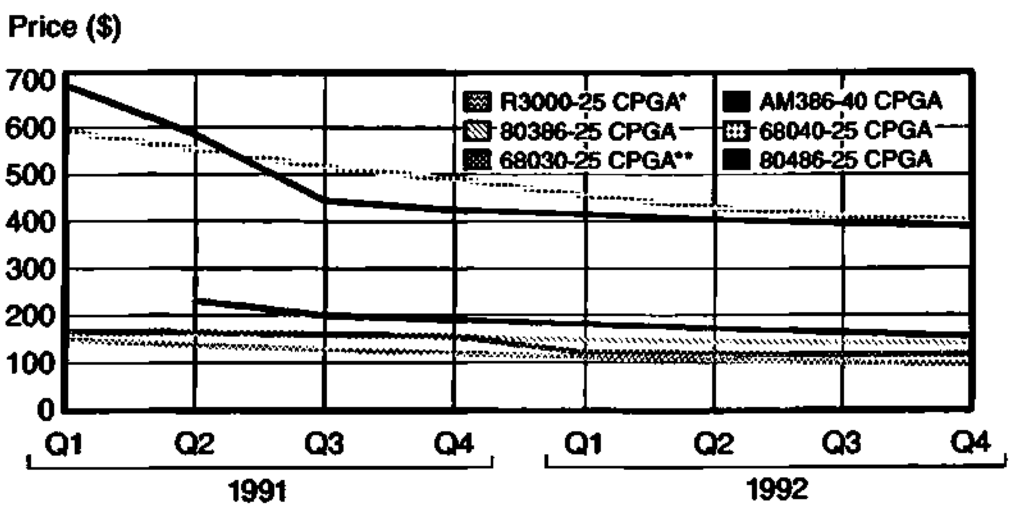


Note: 64-pin PLCC for <10K gates; 160-pin PQFP for 10K-29.9K; 208-pin PQFP for 30K-60K.
This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated September 1991

Source: Dataquest

MICROPROCESSOR PRICE TRENDS

Estimated North American Bookings; Volume 1,000-5,000



Note: This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated September 1991.
* Price for this device excludes FPU, memory management, and related accessory ICs
** 68030-25: CQFP for 1992

Source: Dataquest

SR03012 IMG 09/24/91 GIB

AGENDA

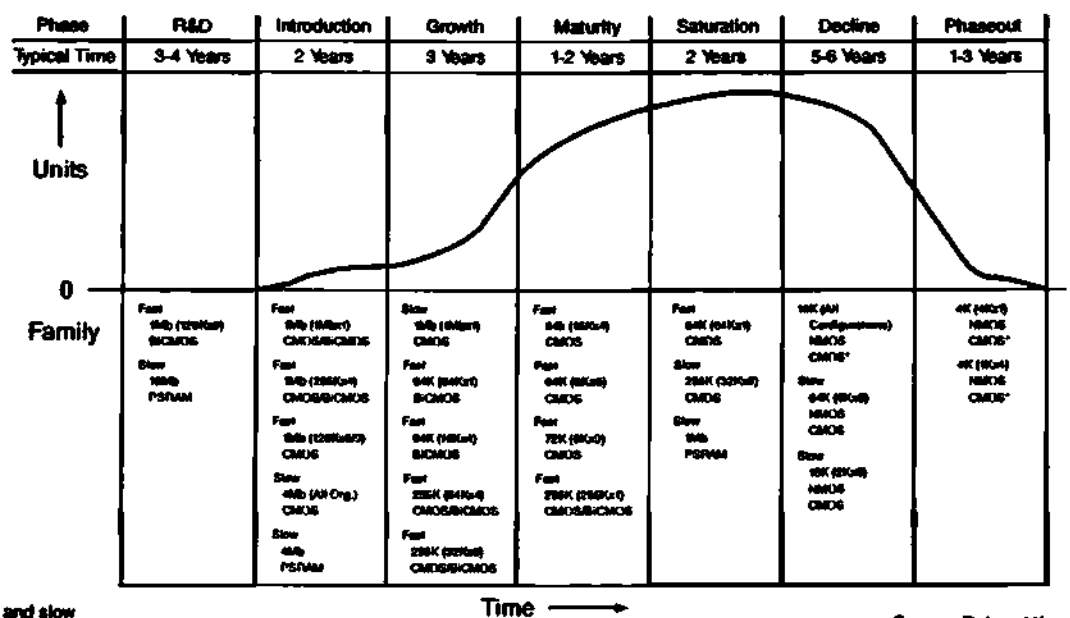
- Procurement issues
- Pricing issues
- Supply base management
- Questions and answers

Notes:

SUPPLY BASE MANAGEMENT

- Product
- Inventory
- Outsourcing

SRAM PRODUCT LIFE CYCLES BY CONFIGURATION (AS OF SEPTEMBER 1991)

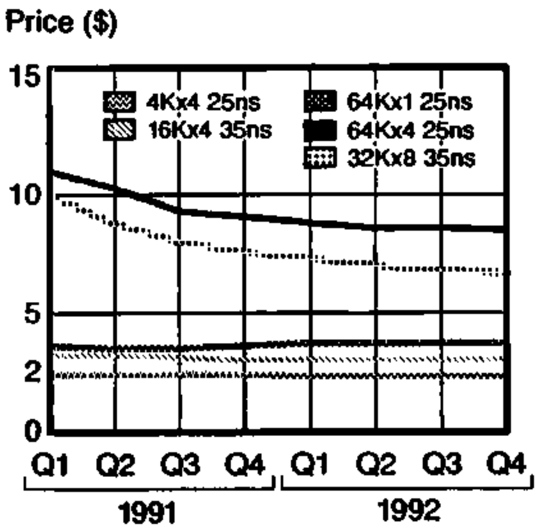


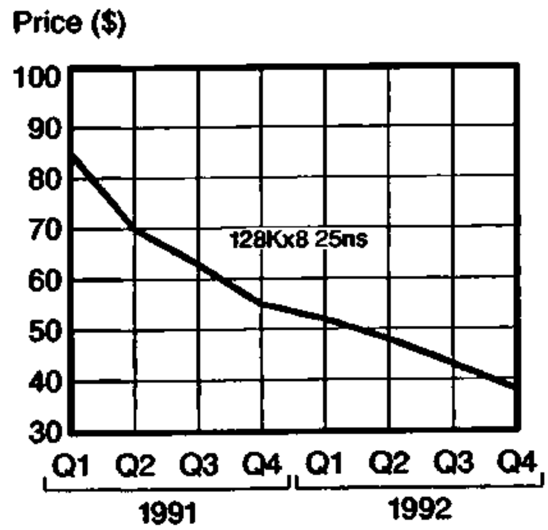
*Fast and slow

Source: Dataquest

SRAM PRICE TRENDS

Estimated North American Bookings, PDIP; Volume 20,000



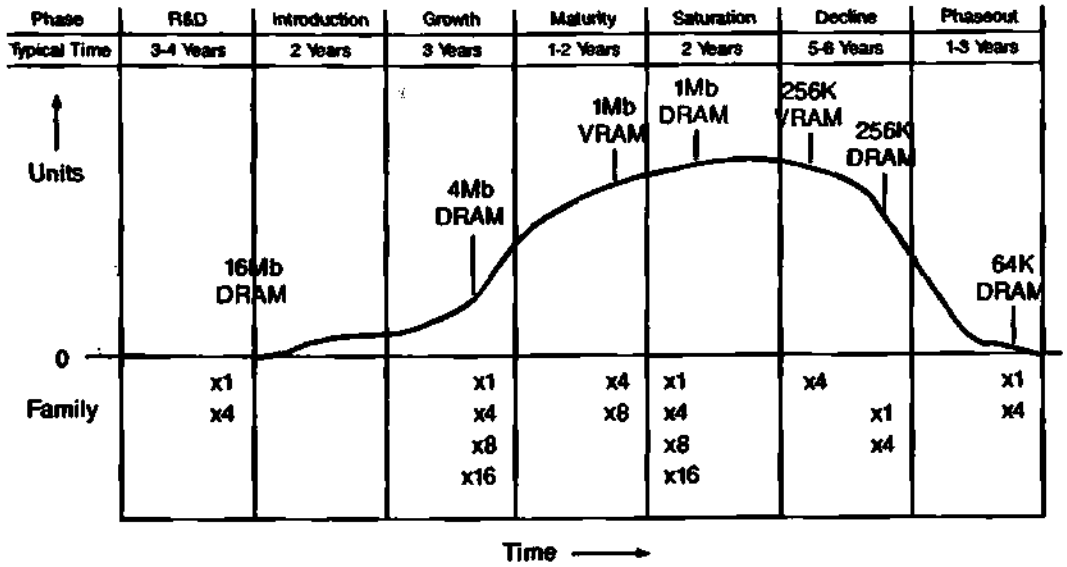


Note: This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated September 1991

Source: Dataquest

Notes:

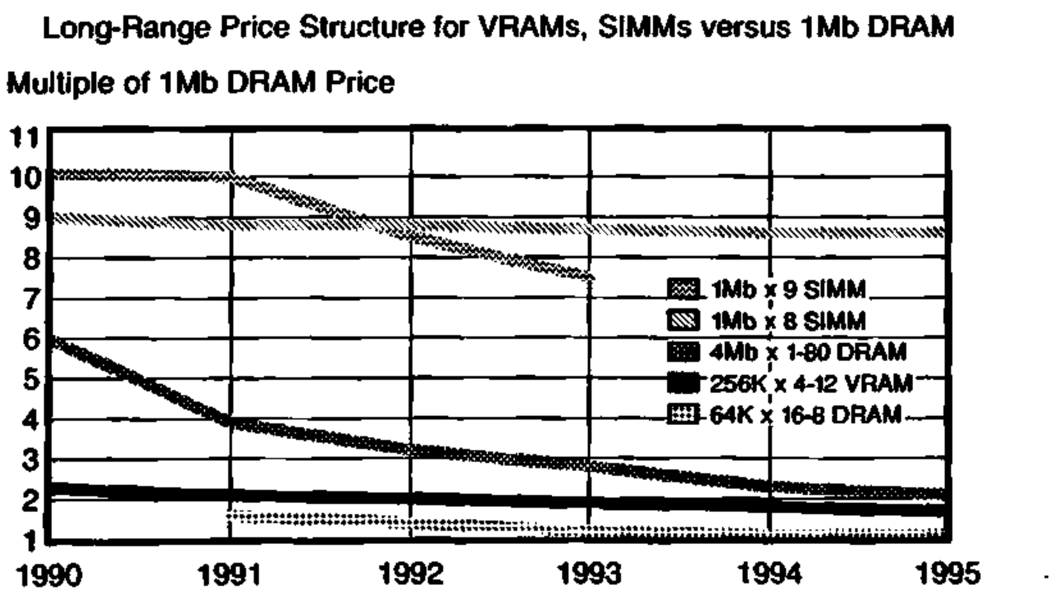
DRAM PRODUCT LIFE CYCLES BY CONFIGURATION (AS OF SEPTEMBER 1991)



*Fast and slow

Source: Dataquest

DRAM PRODUCT PROLIFERATION



Source: Dataquest

SUPPLY BASE FOR 32-BIT MICROPROCESSORS (1990)

Leading Products	Product's Share of Total 32-Bit MPU Market (%)	Supplier's Share of Respective Product Segment (%)
80386	42.3	Intel-100
68020	16.3	Motorola-100
68030	13.5	Motorola-100
32x32	5.1	National Semiconductor-100
80486	4.8	Intel-100
R3000	3.0	LSI Logic-36.7 IDT-32.8 Performance Semiconductor-30.5
Others	15.0	

Total Market Share = 8.5 Million Units

Source: Dataquest

Notes:

3803019.IMG 09/25/91:GIU

SUPPLY BASE MANAGEMENT

- Product
- Inventory
- Outsourcing

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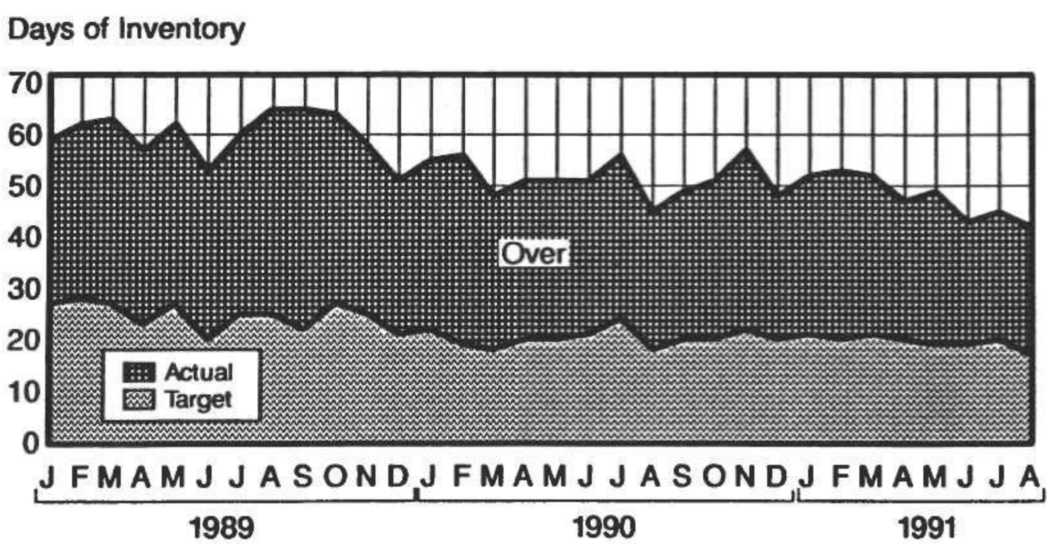
SUPPLY BASE MANAGEMENT

Semiconductor Inventory Control Trends -- Target vs. Actual



Source: Dataquest

SUPPLY BASE MANAGEMENT

Future Inventory Direction

- 58% of survey -- $\leq$30 days semiconductor inventory level target
- 46% of survey were over targeted levels
  - 75% of those over target were less than 15% over
- 45% of survey were at current targeted inventory levels

Source: Dataquest

Notes:

SUPPLY BASE MANAGEMENT

- Product
- Inventory
- Outsourcing

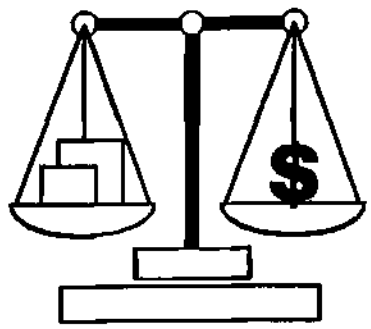
SUPPLY BASE MANAGEMENT

Outsourcing

- To build or to buy
- Core center of excellence
- Supplier communication

OUTSOURCING -- BUILD OR BUY

- Flexibility
  - Time to market
  - Product life cycle
- Cost
  - Leverage resources
  - Competitive advantage



Notes:

OUTSOURCING -- CORE CENTERS OF EXCELLENCE

- Do what you do best -- outsource the rest
  - Risk versus opportunity
- Critical focus
  - Core/strategic technologies
  - Proprietary processes
  - Personnel assets
- Outsource examples
  - Assembly/test
  - ASIC products
  - Commodity procurement

OUTSOURCING -- SUPPLIER COMMUNICATION

- Selection of contract manufacturer
  - Quality
  - Inventory control/on-time delivery
  - Total cost
- Communication
  - Start-up
  - Long-term
- Commitment
  - Profitable partnership

MAIN POINTS

- Competitive pricing
- On-time delivery
- Supplier communication

Notes:

AGENDA

- Procurement issues
- Pricing issues
- Supply base management
- Questions and answers

Notes:

Semiconductor Manufacturing Trends

Jeff Seerley
Manufacturing

Mark FitzGerald
Materials

Krishna Shankar
Equipment

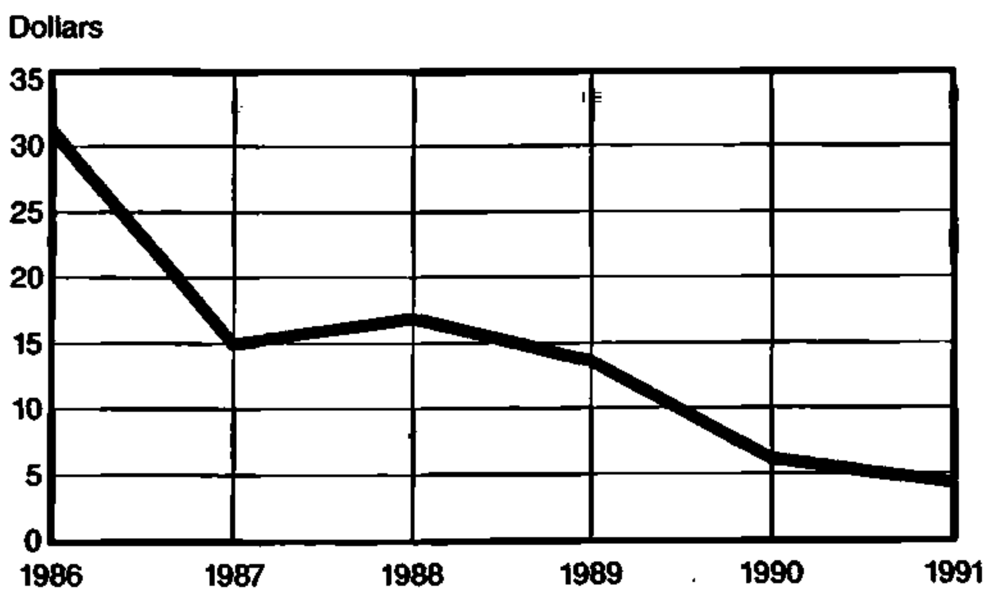
MATERIALS INDUSTRY IS SMALL

1990 Revenue (Billions of Dollars)

Semiconductor Industry	62.0
Front-End Materials Industry	5.2
Silicon Wafers	2.6
Photomask	1.2
Gases/Chemicals	1.1
Photoresist	0.3

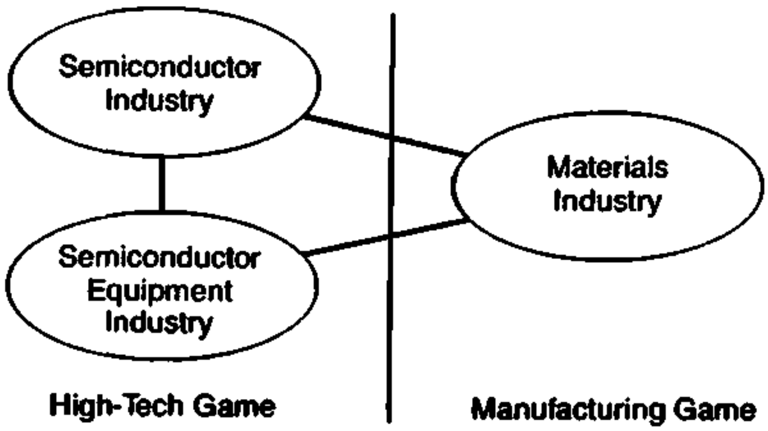
Source: Dataquest

1Mb DRAM PRICING FORECAST



Source: Dataquest

MATERIALS VENDORS ARE DIFFERENT



Notes:

DISTINGUISHING DIFFERENCES

Semiconductor/Equipment

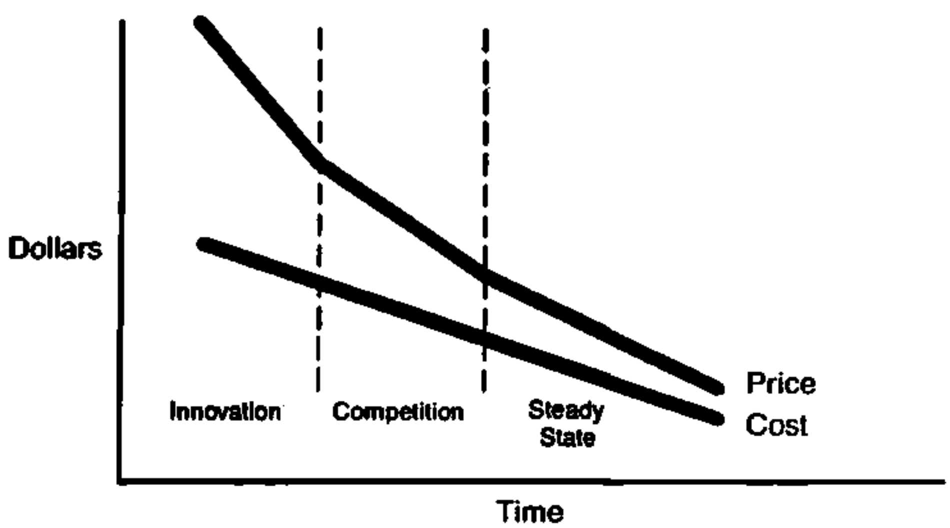
- Positioned at the leading edge because of their advanced process technologies
- Highly focused, flexible, and able to move out of stagnant markets and into high-growth markets
- Willing to develop new markets
- Aggressive in building strategic alliances to develop new applications

Materials

- Rarely any technical advantage – the best are very good at lowering manufacturing costs
- Large, diversified multinational companies – good at managing maturing markets
- Willing to invest in growing markets
- Aggressive in building new plants to serve regional markets

Source: Dataquest

PRICE PREMIUM OVER COST



Source: Dataquest

IMPROVEMENTS NEEDED TO MEET 1991 TO 1996 PHOTOMASK NEEDS

Year	1990/1991	1992/1993	1994/1995	1996/1997
Registration (Pattern Gen.)	Upgrade or new	New (faster)	New + multiple write	
CD Control	Improved process	New material and processing More automation Concern with edge profile		
	Improved CD standards needed			
Edge Roughness	Acceptable	Improve Measure every mask		
Defect Detection	Available	Significant development needed		
Substrate	Quartz – No domestic source			
Metrology	Available	Will need improved CD and length-measuring tools		
Phase Shift Masks	Develop technology	Routine use		
X-ray Masks		Prepare		

Source: DuPont Photomask

Notes:

IMPROVEMENTS NEEDED TO MEET 1991 TO 1996 PHOTORESIST

- Multiple resists (i-line, deep-uv, X-ray)
- Microcontamination (i.e., metals)
- Dispense volumes decreasing
- Faster photospeed

IMPROVEMENTS NEEDED TO MEET 1991 TO 1996 GASES/CHEMICALS NEEDS

- Higher purity
- New purifier technologies
- Environmental issues
- New materials

IMPROVEMENTS NEEDED TO MEET 1991 TO 1996 SILICON NEEDS

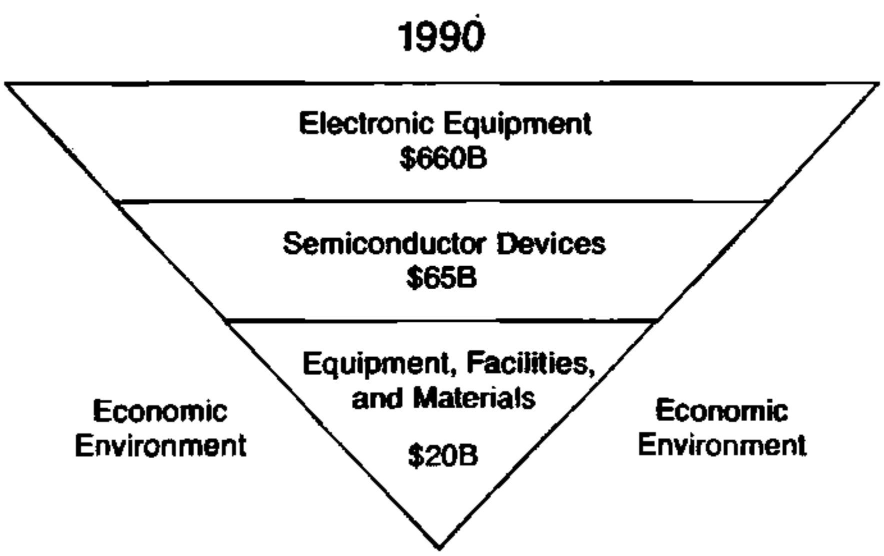
- Move to 300mm wafers
- Tighter oxygen control
- Reduce particles
- Improved flatness specifications
- Lower metals

Notes:

CAPITAL INVESTMENT DECISIONS FOR MATERIAL VENDORS

- As design rules decrease, specifications get tighter
- New equipment is required
- Prices must go up to ensure a return on investment

ELECTRONICS INDUSTRY FOOD CHAIN



Source: Dataquest

SEMICONDUCTOR MANUFACTURING TRENDS

Material Trends

Notes:

Semiconductor Manufacturing Trends

Jeff Seerley
Manufacturing

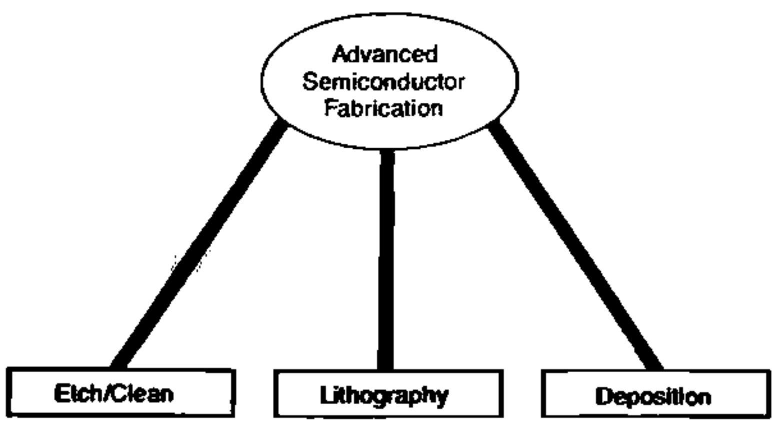
Mark FitzGerald
Materials

Krishna Shankar
Equipment

AGENDA

- Key wafer fab equipment technology trends
- Escalating equipment ASPs and ROI issues
- The evolving process-integration market
- Wafer fab equipment marketing strategies

WAFER FAB EQUIPMENT TECHNOLOGY
The Three Cornerstones



Concurrent development will be needed in the three core technologies to advance semiconductor fabrication processes

LITHOGRAPHY EQUIPMENT TRENDS

- I-line emerges as mainstream production technology
- Excimer/deep-UV technology improves steadily
- Intense phase-shift mask development efforts extend i-line and excimer/deep-UV technology lifetimes

Notes:

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LITHOGRAPHY EQUIPMENT TRENDS

- Key applications for direct-write e-beam lithography
  - Advanced prototype fabrication
  - High-volume production for specific mask levels
- Mix-and-match lithography strategies likely

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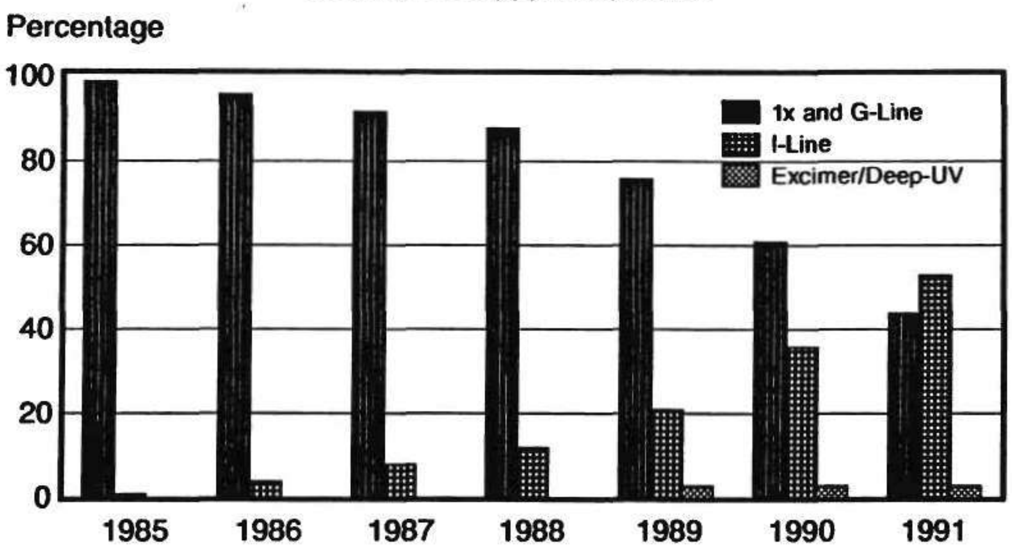
EMERGENCE OF I-LINE STEPPERS

Worldwide Stepper Shipments



Source: Dataquest

DEPOSITION EQUIPMENT TRENDS

- CVD continues role as key technology driver
- Metal CVD will be high-growth segment
- Blanket tungsten CVD moves into production
- New metal CVD films: DCS tungsten silicide, titanium nitride, copper
- Poly CVD emergence as high-growth technology market
- TEOS/ozone thermal CVD processes proliferate
- Integration of metal CVD and aluminum PVD?

Notes:

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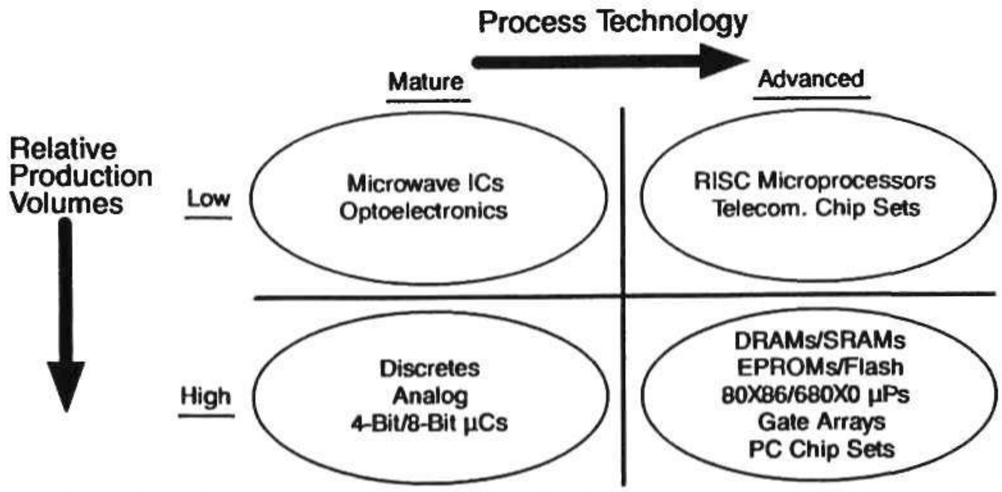
WAFER FAB EQUIPMENT MARKET SEGMENTS
Define Your Target Market Carefully!



Manufacturing processes and fabrication equipment will become increasingly device-application oriented

Notes:

EQUIPMENT MARKETING STRATEGIES
Sell Solutions, Not Technology!

1985	1991
Enabling Technology	Strategic Marketing
	Tool ROI Issues
	Global Customer Support
	Key Partnerships
	Company Image
	Technology

The technology playing field has leveled off!

CONCLUSIONS

- Lithography, deposition, and etch/clean equipment are the three cornerstones of advanced wafer fabrication
- High-technology development costs are rapidly escalating equipment ASPs and raising ROI questions
- Competition is leveling off the technology playing field
- Sell "soft strategic partnership solutions," not "hard technology products"!

Notes:

Notes:

Semiconductor Manufacturing Trends

Jeff Seerley
Manufacturing

Mark FitzGerald
Materials

Krishna Shankar
Equipment

JOINT DEVELOPMENT/PRODUCTION

- AT&T/NEC (development)
- IBM/Siemens (development/production)
- TI/Acer
- LSI/Kawasaki Steel

TEXAS INSTRUMENTS' HARMONIZATION PROGRAM

- Goal: Design several different product families with high degree of compatibility in equipment sets and process recipes
- Benefits
  - Fab flexibility increased
  - Fab lifetimes extended
  - Product development costs reduced
  - Factories loaded more efficiently

CONSORTIA

- Leverage R&D dollars
- "Grand scale" projects
- Marshal resources to develop infrastructure
- Respond to common industry problems

Notes:

FABLESS

- Avoid capital investment
- Choose best combination of technology, quality, and cost
- Focus on design and marketing
- Define product strategy using a marketing orientation rather than production orientation

MICROENVIRONMENTS

A Technology Whose Time Has Come?

- Improvements in yield and operating costs--not in construction costs
- Easy upgrades
- Flexibility

LEADING-EDGE MPU FAB

- Minimum line geometry: 0.8µM
- CMOS, BiCMOS processes
- Facility cost: $150 million
- Tool cost: $350 million

Source: Dataquest

Notes:

LEADING-EDGE MPU FAB

- 70,000 square foot Subclass 1 clean room
- 8" wafers
- Wafer start capacity per four-week period: 20,000
- Products manufactured: MPUs, FSRAMs

Source: Dataquest

LEADING-EDGE DRAM FAB

- Minimum line geometry: 0.5µM
- CMOS process
- Fab cost: $150 million
- Tool cost: $400 million

Source: Dataquest

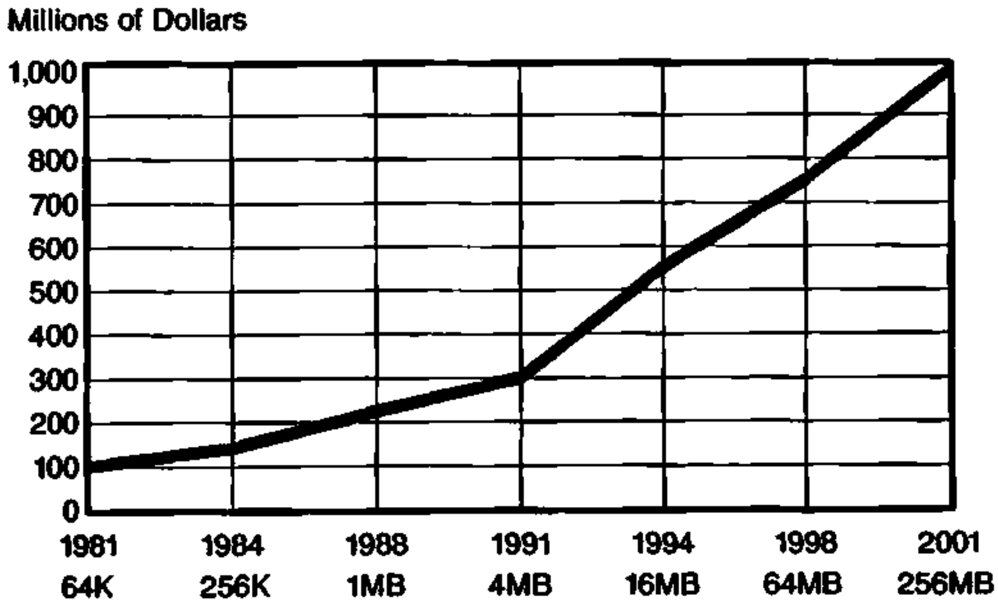
LEADING-EDGE DRAM FAB

- 100,000 square foot Subclass 1 clean room
- 8" wafers
- Wafer start capacity per four-week period: 30,000
- Products manufactured: DRAMs, SRAMs, ASICs, MCUs

Source: Dataquest

Notes:

FAB COSTS BY DRAM GENERATION



Source: Dataquest

SEMICONDUCTOR CAPITAL SPENDING

Top Ten (1991 Preliminary Estimate)

Company	Millions of Dollars
Intel	900
NEC	822
Fujitsu	799
Texas Instruments*	790
Toshiba	747
Hitachi	747
IBM	733
Mitsubishi	650
Motorola	640
Matsushita	553
	7,381

*Includes $330 million in non-TI-funded JVs

Source: Dataquest

AGENDA

- Semiconductor capital spending
- Fab costs by DRAM generation
- Leading-edge fabs
- Fab cost reduction alternatives

Notes:

SECOND DAY

A New Way of Looking at the Electronics Industry— Networking for Competitive Advantage

Stan Bruederle
Vice President and Director
Dataquest Incorporated

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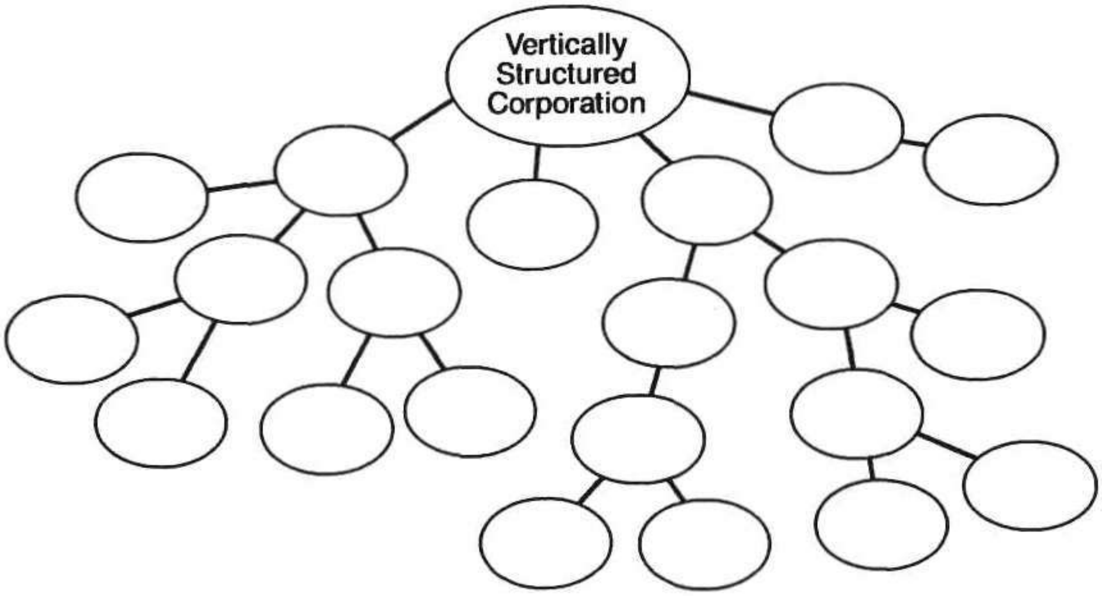
THE HIERARCHICAL INDUSTRY STRUCTURE



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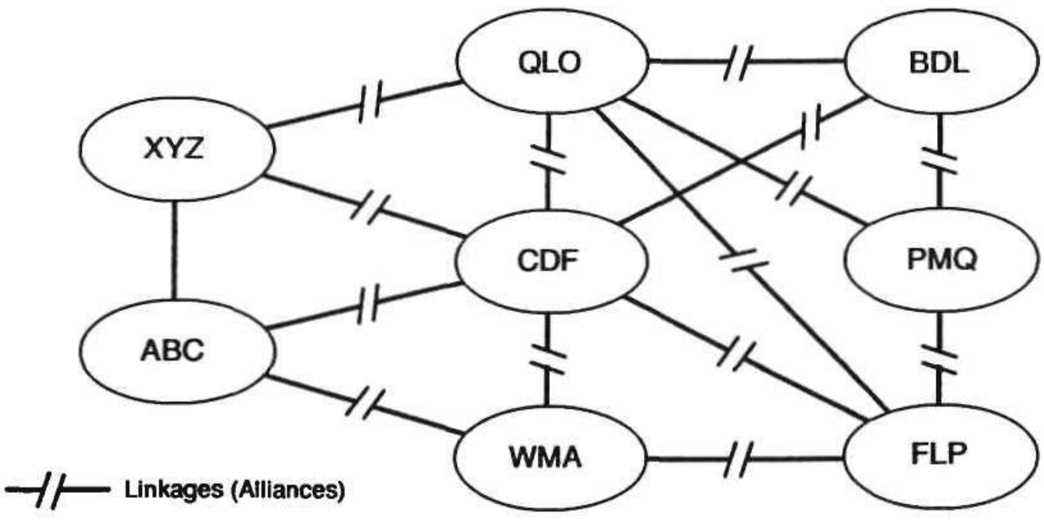
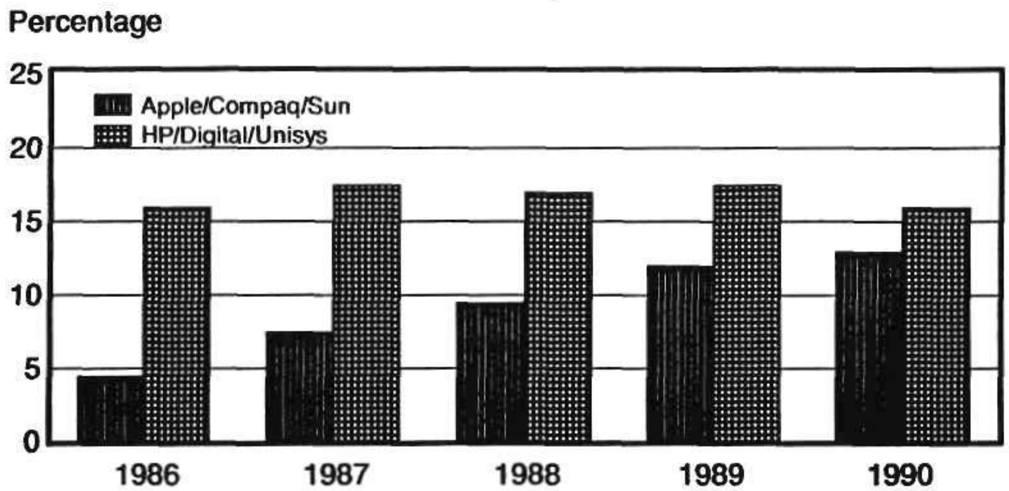
THE NETWORKED INDUSTRIAL STRUCTURE



THE NEW GUARD VERSUS THE OLD GUARD (UNIVERSE = NON-IBM PORTION OF MARKET)

Worldwide Factory Revenue



Source: Dataquest

Notes:

1986 Semiconductor Megatrends

1986 SEMICONDUCTOR MEGATRENDS

Five Key Trends
How Have They Affected the Industry?

- The system is the chip
- The dawn of application-specific logic products
- Hardware design versus software design
- The commoditization of the computer industry
- The growing importance of strategic alliances

The System Is the Chip

Notes:

THE SYSTEM IS THE CHIP

- Chip manufacturers are driving the standards
- Chip manufacturers are driving the designs
- Customers are becoming systems integrators
  - Assemble boxes
  - Market solutions
  - Manage partners

The Dawn of Application-Specific Standard Logic

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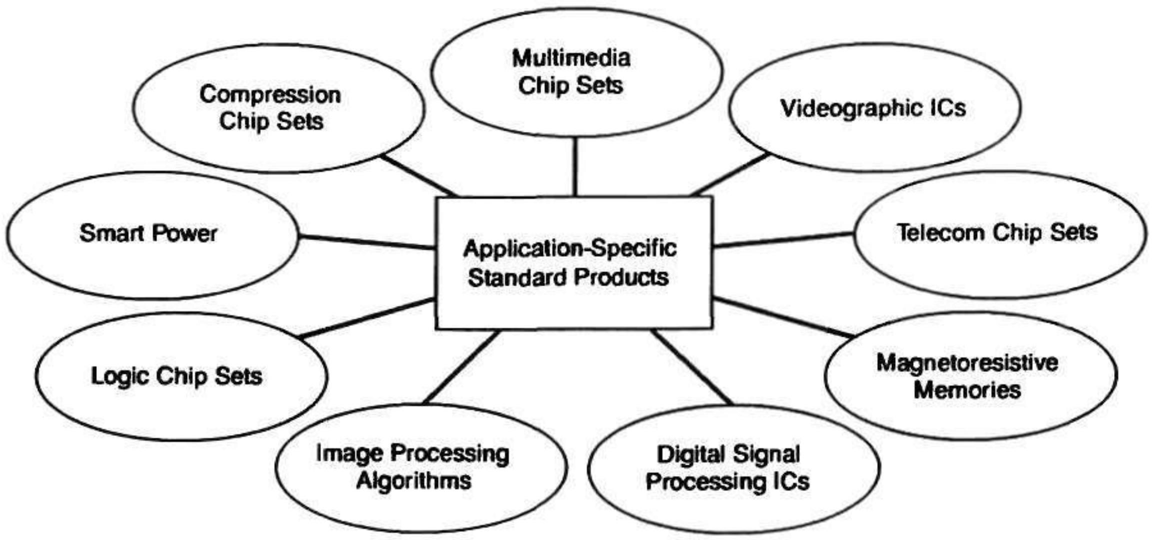
THE DAWN OF APPLICATION-SPECIFIC STANDARD LOGIC

30 Semiconductor Start-Ups



Notes:

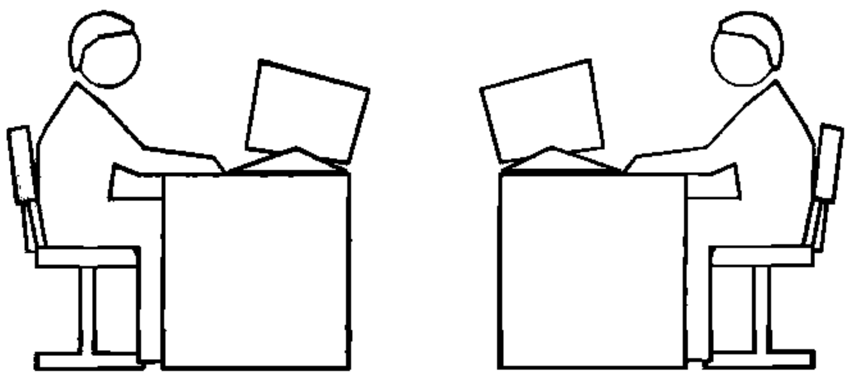
. . . AND OPPORTUNITIES PROLIFERATE

Function	Information Class	Key New Technologies
Input	Touch	Touch screen
	Voice	Neural networks
	Vision	Digital signal processing
	Sense	Sensors
Output	Control	
	Touch	Actuators, smart power
	Voice	Voice synthesis
	Vision	Active matrix LCD displays
Processing	Image	Compression/decompression
	Voice	Contextual analysis
	Touch	Adaptive controllers
	Sense	Fuzzy logic
Communication	Data	Fiber-optic technology
		Compression/decompression

Source: Dataquest

Hardware Design Versus Software Design

HARDWARE DESIGN VERSUS SOFTWARE DESIGN



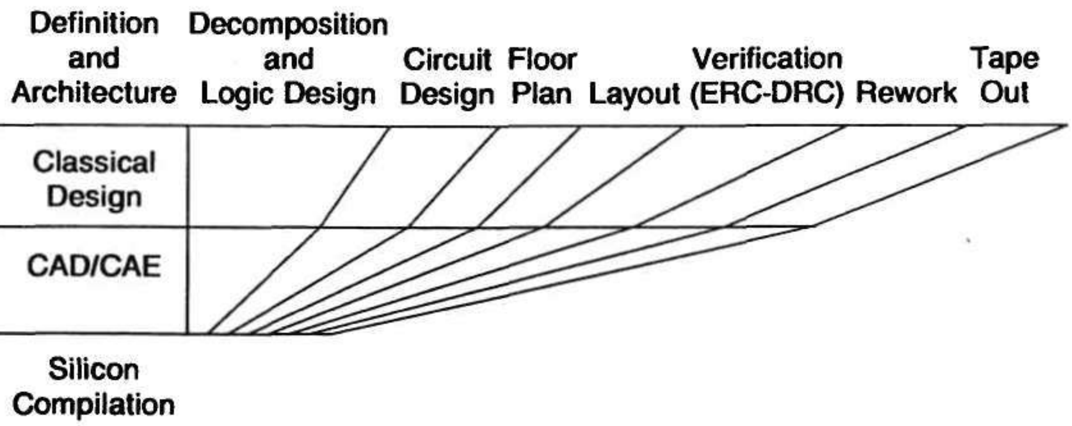
Hardware Designer

Software Designer

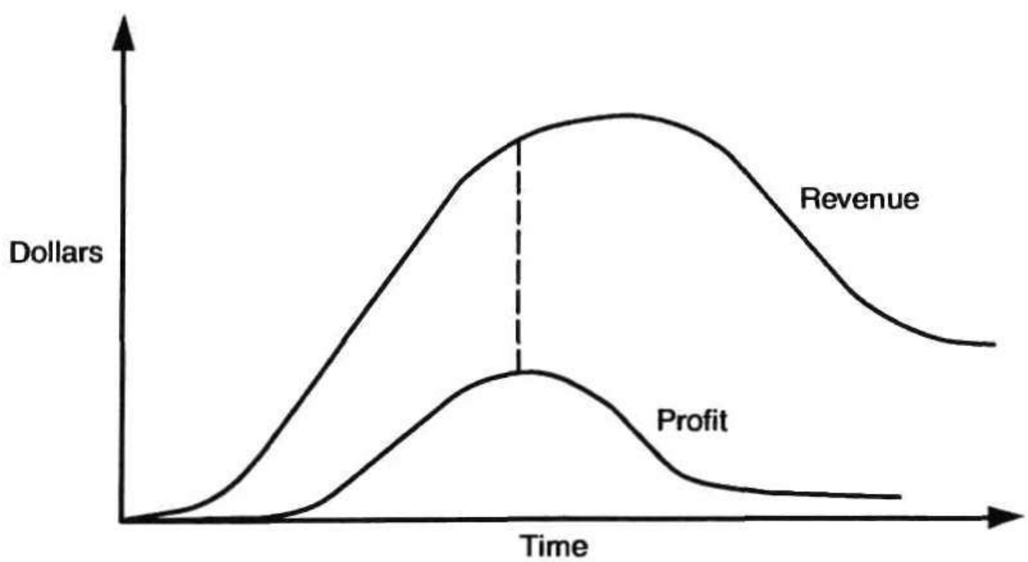
Can you tell the difference?

Notes:

ACCELERATING DESIGN CYCLES



PROFITS AND LIFE CYCLES



The Commoditization of the Computer Industry

Notes:

PRICE/PERFORMANCE OF SYSTEMS TWO CONCEPTS

Concept I: Constant Price, Increased Performance

Rackmount
- Supercomputer — Supercomputer
- Mainframe — Mainframe

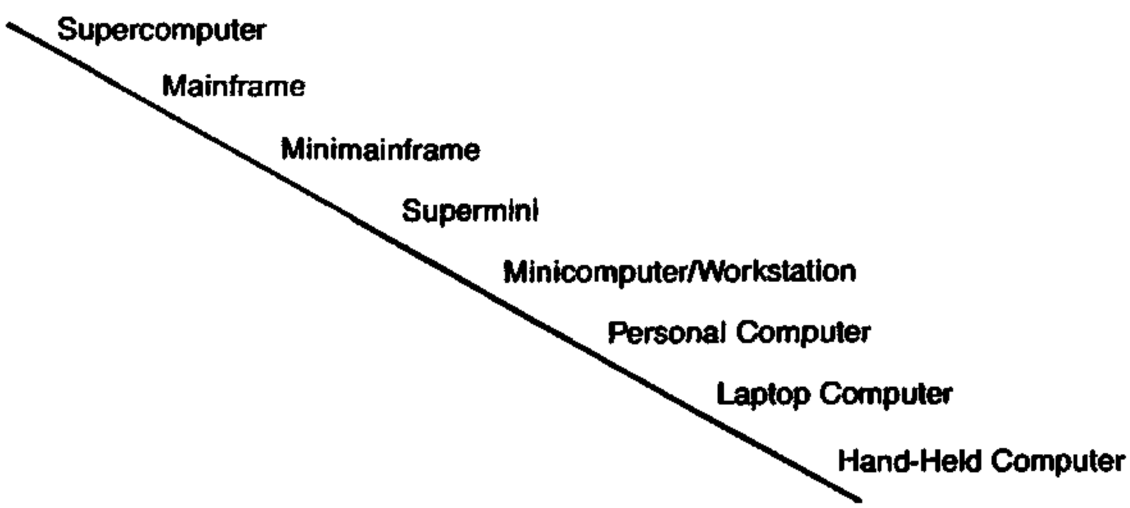
Desktop
- Minicomputer — Workstations/Servers
- Personal Computer (Component) — Desktop Publishing System (System)

Portable
- Transportable — Laptop — Notebook

Evolving markets in each segment subject to displacement by other segments

PRICE/PERFORMANCE OF SYSTEMS

Concept 2: Decreasing Price, Constant Performance



OVERVIEW OF PRODUCT SEGMENT PARTICIPATION BY VENDOR

	Home PC	PC Business Portable	PC Business Desktop	Business Workstation	Technical Workstation	Business Midrange	Technical Midrange	Business Mainframe	Technical Mainframe
IBM	A	A	A	A	B	A	A	A	A
Digital			C	A	A	A	A	C	
HP		C	C		A	B	A		
Unisys			C	C		A		B	
Apple	A	B	A						
Compaq	C	A	A			C			
Sun			?	A	A	C			
Fujitsy	C		C			A		A	A
Hitachi			C		C	C		A	A
NEC		A	A		C	B		A	A

Codes: Worldwide Revenue Basis (1990)

A = Top 5
B = #6-#10
C = Lower rank than #10
Blank = Nonparticipant

Source: Dataquest

Notes:

The Growing Importance of Strategic Alliances

ALL THE SMART GUYS WORK SOMEWHERE ELSE

Future Electronics – A New Paradigm

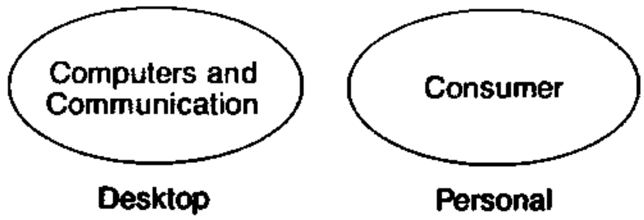
- The old paradigm

Computers	*Communication*	*Consumer*
Computer Room Business	Desktop Business	Personal

ALL THE SMART GUYS WORK SOMEWHERE ELSE

Future Electronics – A New Paradigm

- Present paradigm

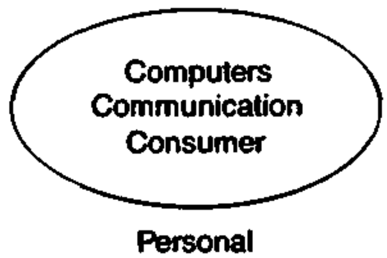


Notes:

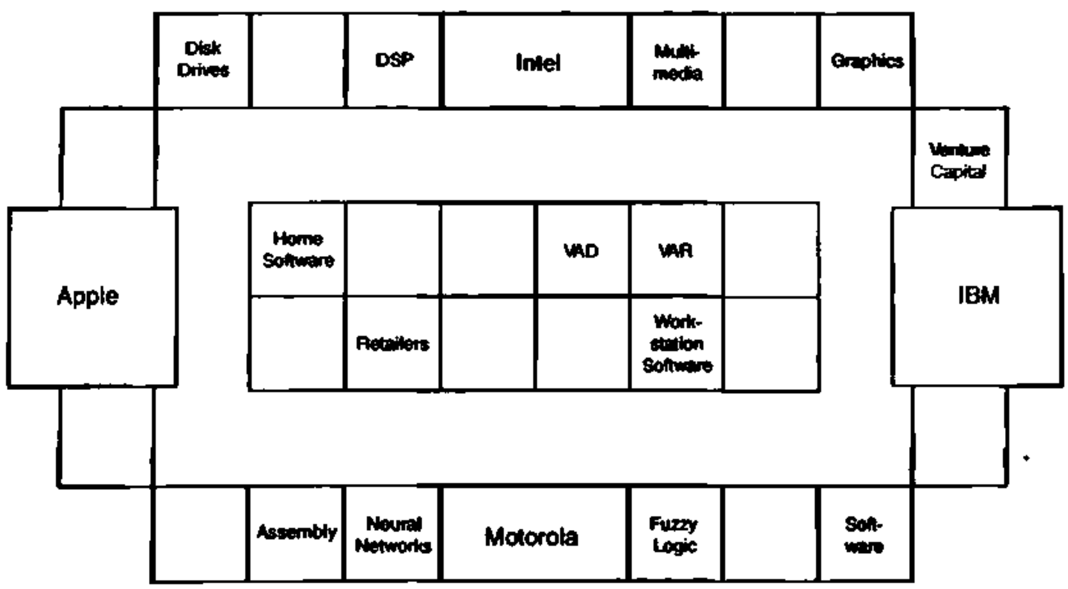
ALL THE SMART GUYS WORK SOMEWHERE ELSE

Future Electronics – A New Paradigm

- Future paradigm



THE INDUSTRIAL SHOPPING MALL



CONCLUSIONS

- One company cannot successfully develop all technologies needed to produce sophisticated products of the future
- Companies will focus resources on development of core technologies and outsource everything else
- Companies will market core technologies in the merchant market to establish market dominance in those key technologies

Notes:

CONCLUSIONS

- Companies will market products through a vast array of marketing channels to serve a vast array of markets
- Vertically structured companies will continue to struggle
- Networked companies will continue to grow and prosper

The Network's the Competitive Edge!

Notes:

Multimedia, What Is It?
Where Is It Going?

Dr. David C. Nagel
Vice President
Advanced Technology Group
Apple Computer Inc.

Telecommunications Trends in the 1990s
Today's Desktop Need is Tomorrow's Communications Market

Stagg Newman
Assistant Vice President
Technology
Pacific Telesis Group

Application Trends

- Personal Communications
- Image Communications
- Distributed Processing

Enabling Technologies

- Digitization
- Speech and Image Processing
- Fiber Optics
- Intelligent Control

Personal Communications Services

Customer Service Characteristics

- Tetherless and tethered access
- Service Independent Personal Number
- Personal Call Management
- Voice and Data Services

Personal Communications Services is much more than just wireless access!

Notes:

Tetherless Communications

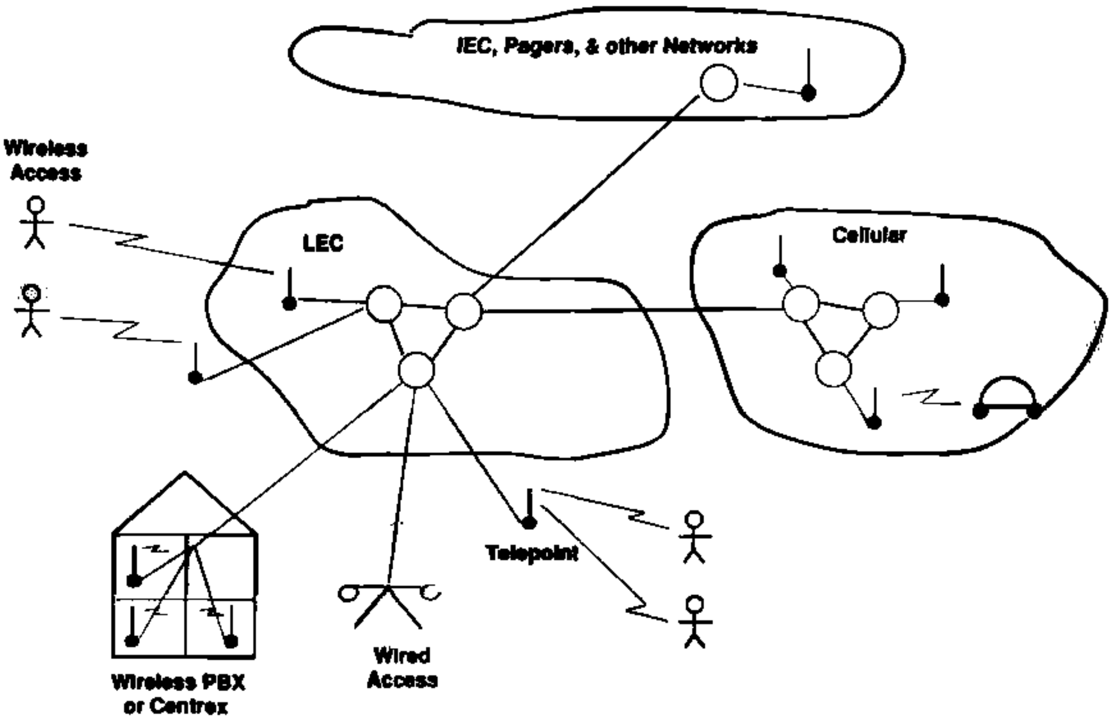
	From	To
Handsets	Analog < 1 MIP	Digital 30-100 MIPs
# of Users	2% of Population	10% - 50%
Applications	Voice	Voice Data Multimedia

Tetherless Access

- Cellular
- Wireless Access to the Wireline Network
- Public Station Access (e.g., Telepoint)
- Corporate Networks (e.g., Wireless PBX & Centrex)
- New Service Providers

Tetherless access will be provided in many ways by multiple providers.

Tetherless Access



Notes:

Service Independent Personal Number

TODAY			TOMORROW
Stagg Newman's phone #'s			
Service	**#'s**		
Business	1-415-555-3229	→	1-STAGNEWMAN #service indicator
Secretary	1-415-555-3635		(i.e., 1-782-463-9626 # service indicator)
FAX	1-415-555-6714		
Telex	1-415-555-1234		
Voice Mail	1-800-555-8781		
E-Mail	stagg@troy.telesis.com		
Home	1-415-555-0474		
Cellular	1-415-269-5555		

The challenge is to develop this control structure and forge the needed agreements among providers without stifling innovation.

Personal Call Management

CONCEPT

Use of Intelligent Networks and End-to-End Signaling to provide individuals the call control capability that an executive gets with an executive secretary.

E.g., Hypothetical Call Screening Lists

Call Disposition	**Originating Calling Number**
Forward overseas - *called party pays*	415-555-3220, 415-555-0474
Forward overseas *if Calling Party Pays*	*none*
Forward domestic - *called party pays*	415-555-3220, 415-555-0474, 415-555-4564
Forward domestic *if calling party pays*	*All other*
Send to VoiceMail	
Send to home	
Send Reject-a-Jerk message	415-Car-sale

To realize this concept, problems of data base ownership, privacy, security & billing must be addressed.

Data Services

- Tetherless laptops
- Tetherless User Friendly Electronic Mail
- Fax + for the non-computer literate

HYPOTHESIS: Growth of wireless data in '90s will be analogous to the growth of wired data in the '70s.

Notes:

Image Communications

Observations

- People are visual creatures
- Ears are a 1 Megabit/second device
  Eyes are a 1 Terabit/second device
- Semiconductors are making visual
  Telecommunications possible
- Image communications is now a business
  productivity tool

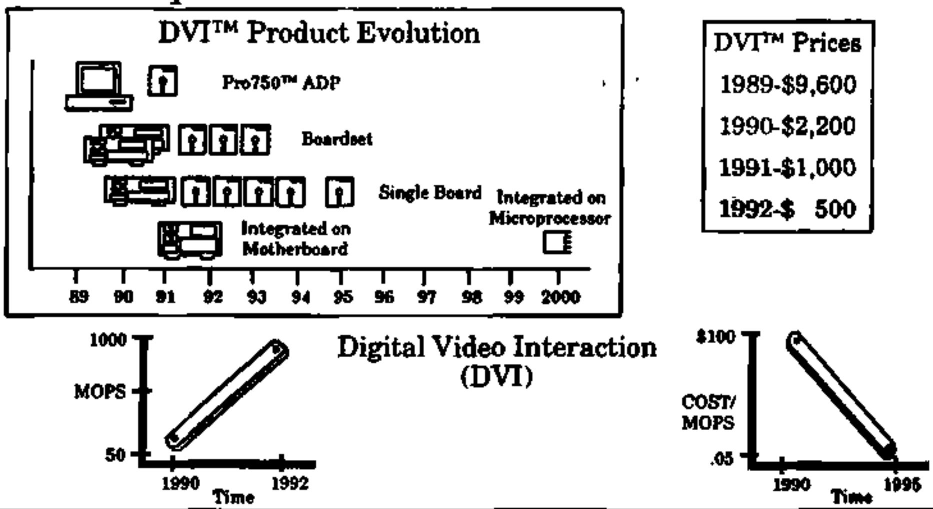
Video and PCs - A Possible Marriage

Enabling Technical Factors

- Digital Technology
  - Video digital signal processing chips
- Standards
  - Intel's DVI (Digital Video Interactive) as an emerging de facto standard
  - At the higher level there is considerable alliancing, battling, etc. among major players (IBM, Apple, AT&T, Microsoft
- Simplicity
  - The WIMP (Windows, Icons, Mouse, and Pulldown, e.g., Macintosh) as a user friendly interface
- Connectivity
  - LANs and LAN bridging interconnect

Video and PCs - A Possible Marriage

Desktop Evolution - Multimedia Solutions



Million Operations Per Second (MOPS)

Source: INTEL

Notes:

Image Communications

Hypothesis:

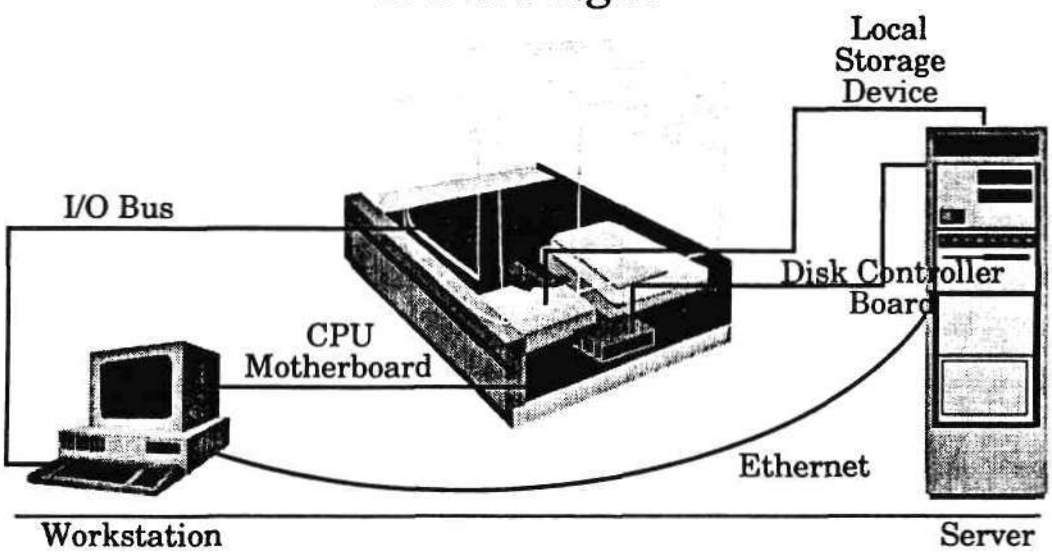
Business image networking today

≈

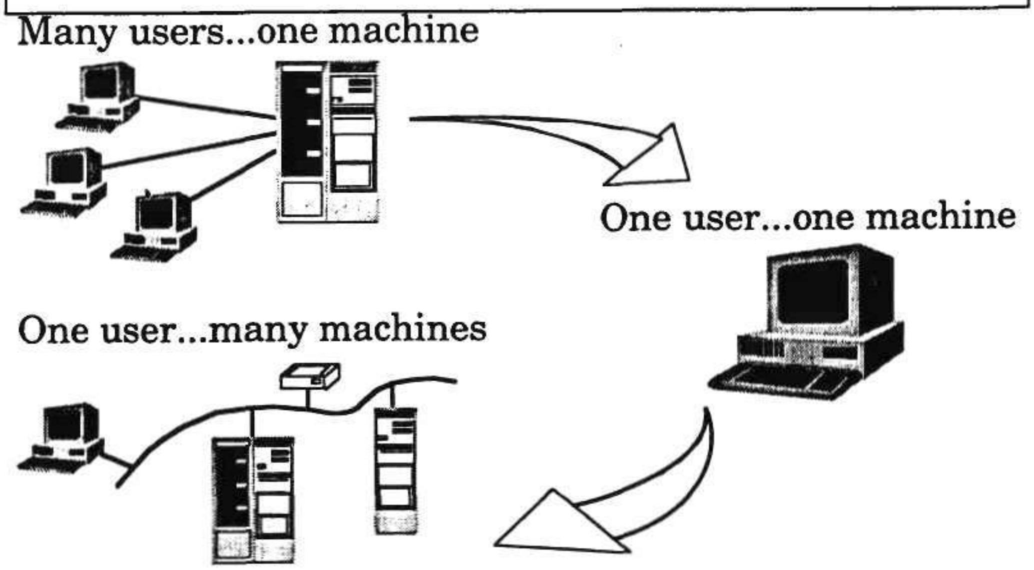
Data networking of the 60s

Distributed Processing and Client Server Architectures

A Paradigm



Evolution Driving High-Speed Data Needs



Notes:

1993 Dream PC

From Infoworld February 8, 1988

Processor	80586 40 MIPS
Bus Speed	50 MHz
Memory	16 MByte
Storage	1 GByte
Monitor	2000 X 2000 pixel
Communications	Bottleneck?

Distributed Processing and Telecommunications

Breaking the Bottleneck

- Fiber
- Intelligent Control
  - New Protocols
  - Call Management Services
- New Services
  - Switched and Non-Switched 56 Kbs to 45 Mbs
  - Packet Services
    - X.25
    - Frame Relay
    - Switched Multi-Megabit Data Service
  - ISDN and Broadband ISDN

High Speed Data Communications

Hypothesis:

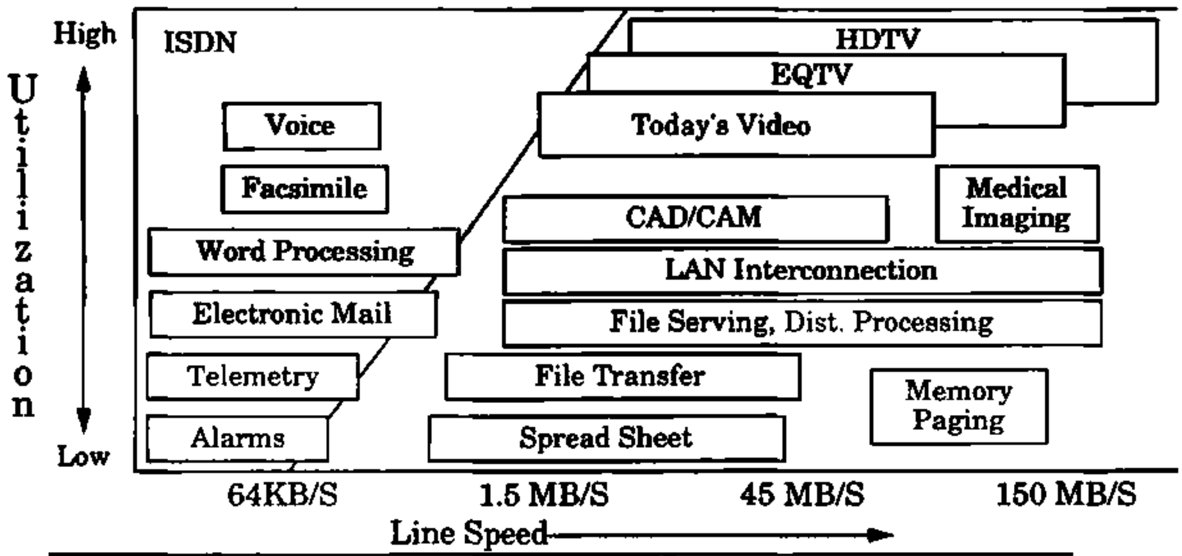
High speed data networking today

≈

Low speed data networking of the 60s

Notes:

Diverse Requirements of Applications



Conclusion

The enabling technologies of digitization, speech and image processing, fiber optics, and intelligent control will fuel an explosive growth in voice, data, and visual telecommunications during the '90s, both tethered and tetherless

Jointly users and communications providers imaginations can create the applications that ignite the explosions

Notes:

Directions of Strategic Semiconductors: Will They Match User Needs?

Moderator:
John Jackson
Vice President and Director
Dataquest Incorporated

Panelists:
Gordon Campbell
Chairman and CEO
Chips and Technologies Inc.

Craig Barrett
Executive Vice President
Intel Corporation

H. Egawa
Senior Vice President and Director
Toshiba Corporation

Wilf Corrigan
Chairman and CEO
LSI Logic Corporation

SEMICONDUCTOR USERS' ISSUES/NEEDS

- Global competition has forced OEMs to:
  - Shorten their product cycles
  - Struggle for product differentiation
  - Reexamine their basic marketing strategies

SEMICONDUCTOR USERS' ISSUES/NEEDS

- New and better-defined user needs have developed:
  - Users need better, long-term relationships with like-minded suppliers
  - As OEM products have lost differentiation, users need more customer-specific solutions
  - Total cost has emerged as the new measurement tool:
    - Delivery
    - Quality
    - Price
    - Technical support
    - Customer service

SEMICONDUCTOR USERS' ISSUES/NEEDS

- Emerging semiconductor applications demand new technological innovations timed with end-market needs

Notes:

Notes:

Notes:

Notes:

Notes:

Industry Shifts in Value Added: An Investor's Perspective

Tom Thornhill
Vice President
Semiconductor Analyst
Montgomery Securities

Notes:

Notes:

Dataquest's Semiconductor Application Markets Forecast

Greg Sheppard
Senior Industry Analyst
Dataquest Incorporated

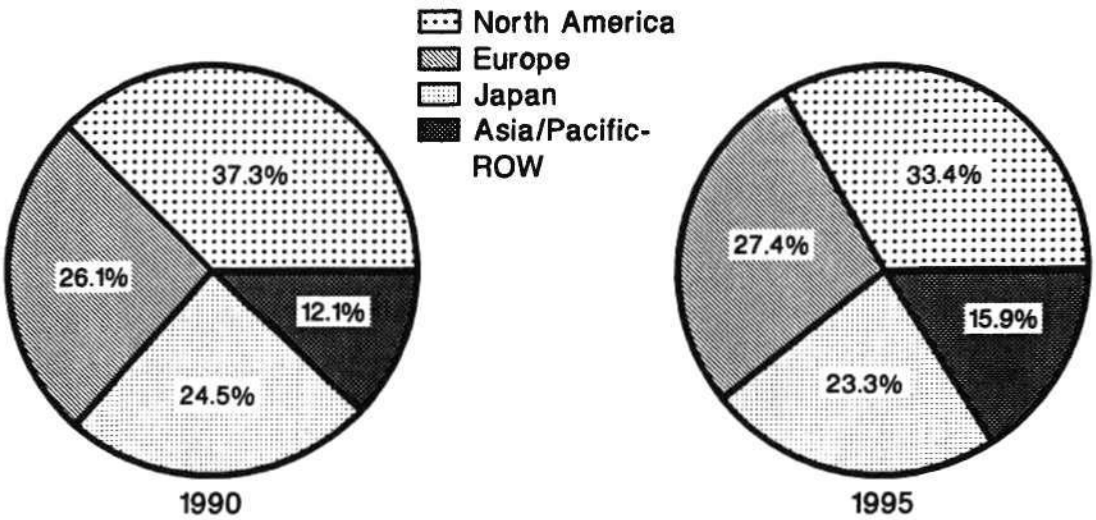
Semiconductor Application Outlook

AGENDA

- Semiconductor application outlook
- Application drivers
- Implications

ELECTRONIC EQUIPMENT PRODUCTION

By Region

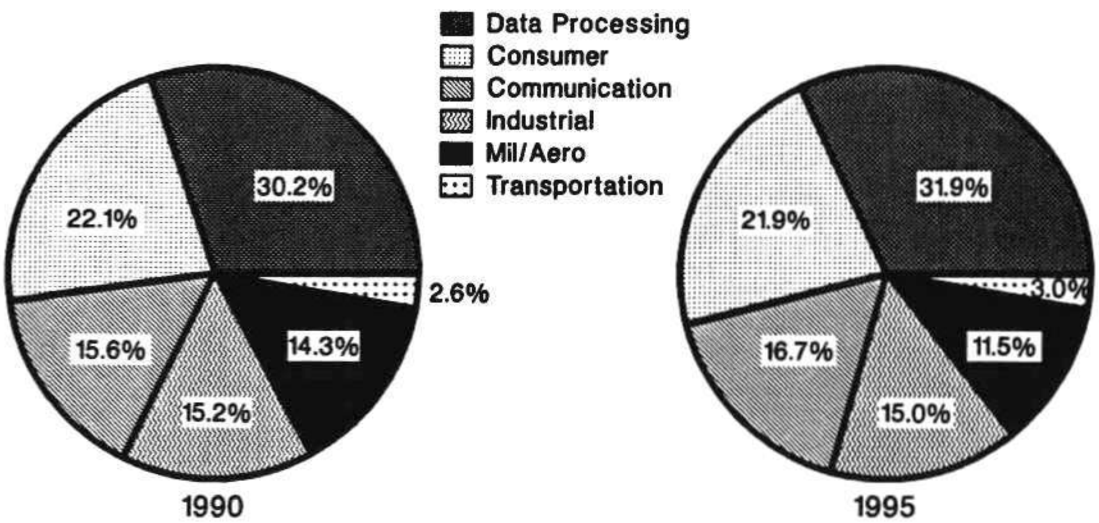


Source: Dataquest

Notes:

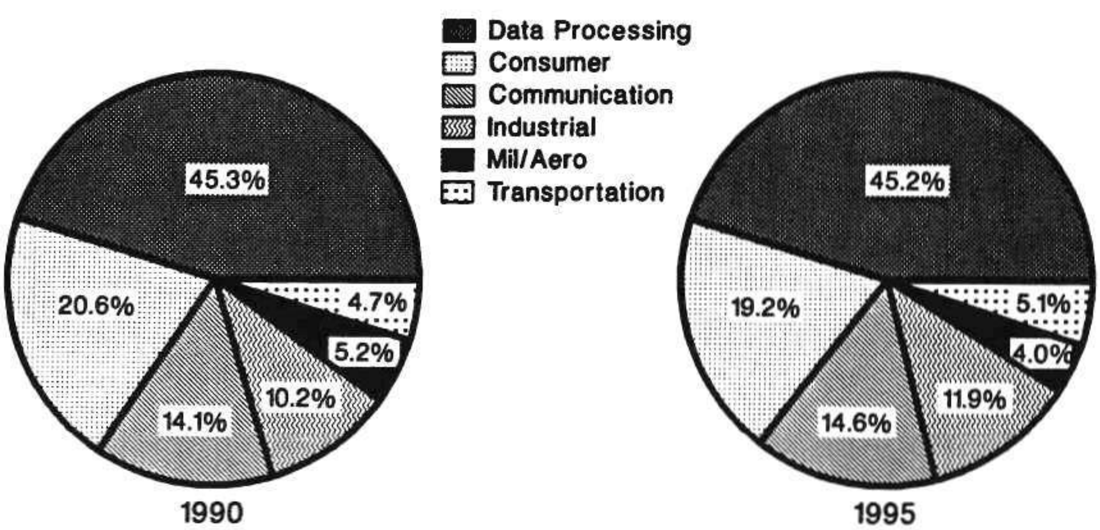
ELECTRONIC EQUIPMENT PRODUCTION

By Application



Source: Dataquest

SEMICONDUCTOR END USE

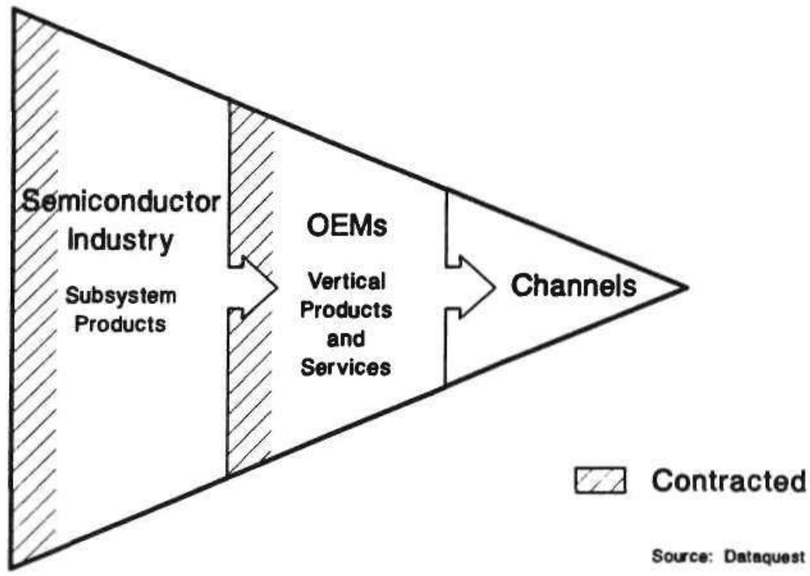


Source: Dataquest

Application Drivers

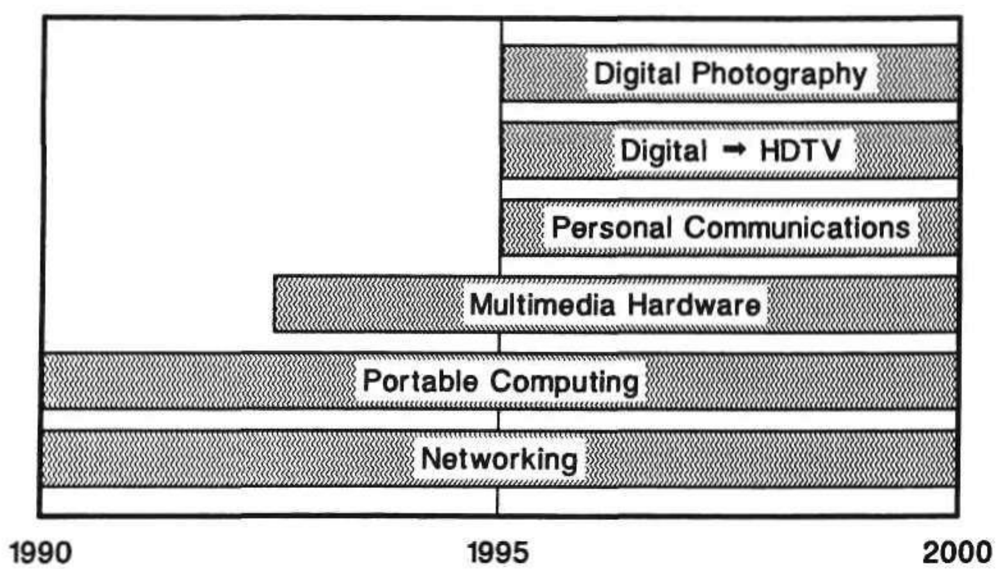
Notes:

VALUE-ADDED SHIFT



Source: Dataquest

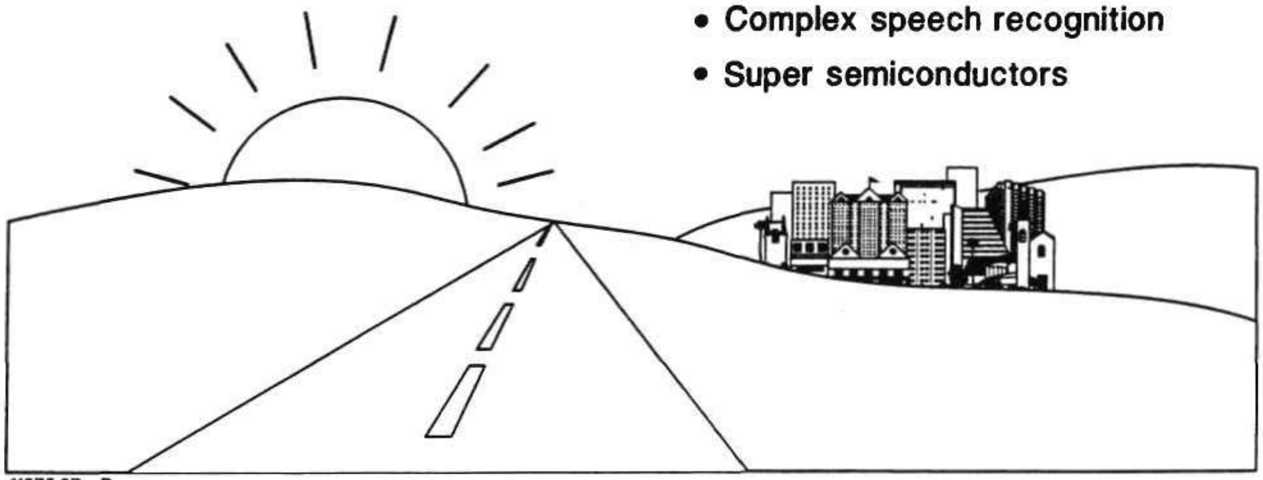
MARKET DRIVERS



Source: Dataquest

OVER THE HORIZON

- Parallel computing
- Nueral computing
- Artificial vision
- Complex speech recognition
- Super semiconductors



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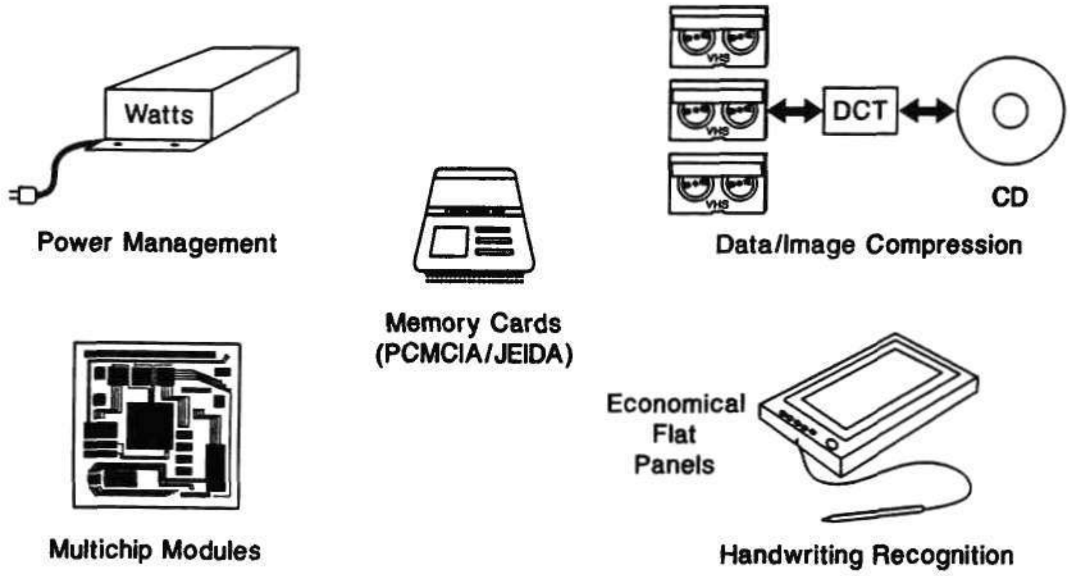
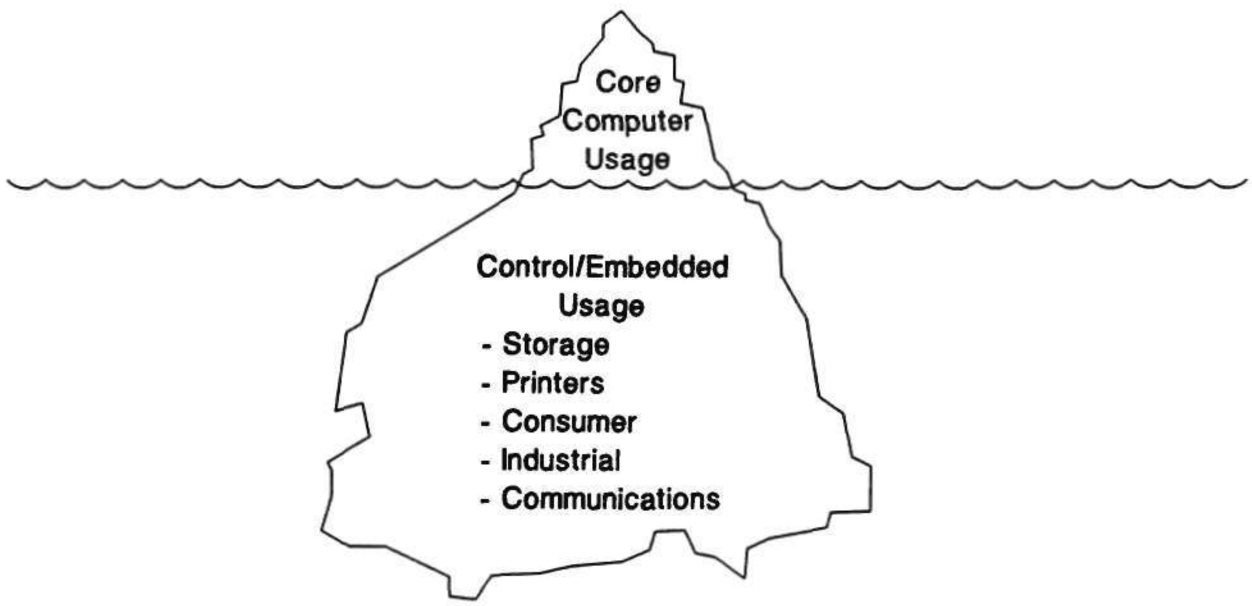
Notes:

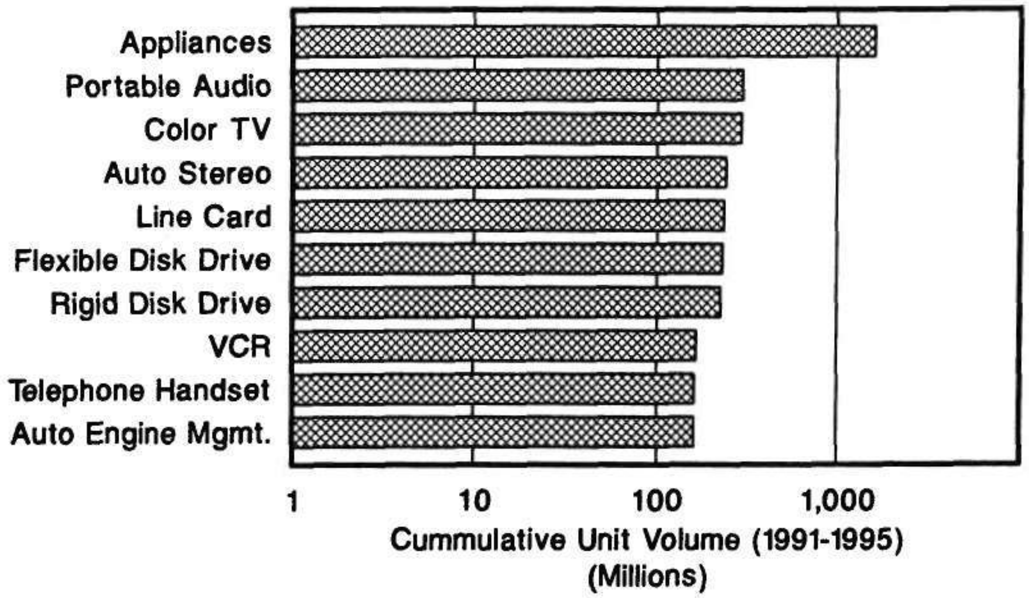
ENABLERS/STANDARDS



MORE THAN MEETS THE EYE



CONTROL APPLICATIONS



Source: Dataquest

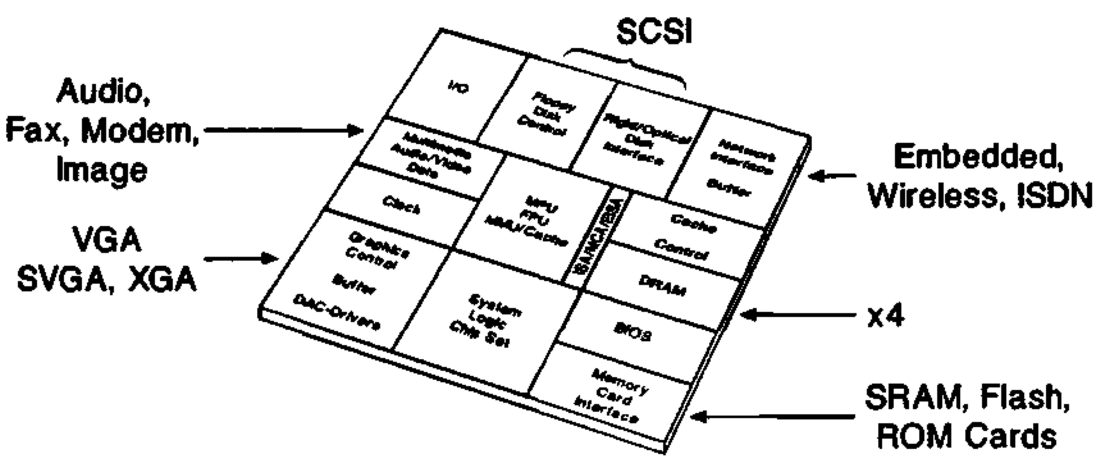
Notes:

THOSE PERVASIVE COMPUTERS

	Semiconductor Consumption (% of Total Worldwide Market) 1990	1995
PCs	15.2	16.7
Workstations	1.4	4.2
Laser Printers	2.0	2.3
Rigid Disk Drives	1.9	1.9
	20.5	25.1

Source: Dataquest

MOTHERBOARD DYNAMICS



- Semiconductor content = $325
- Modularity

Source: Dataquest

COMPUTER APPLICATIONS

Equipment	Unit* CAGR% (1991-1995)	Design Factors	Key Semiconductor Technology
Hand-Held	108	Power, ruggedness	LCD, memory
Pen-Based	174	Power, ruggedness	LCD, memory
Notebook PC	76	Power, weight	LCD, memory
Desktop PC	(3)	Cost	MPU, ASSP, memory
Workstation	15	Performance, cost	MPU, ASIC, ASSP, memory
Midrange-Super	4	Performance, I/O	ASIC, memory

*Worldwide

Source: Dataquest

Notes:

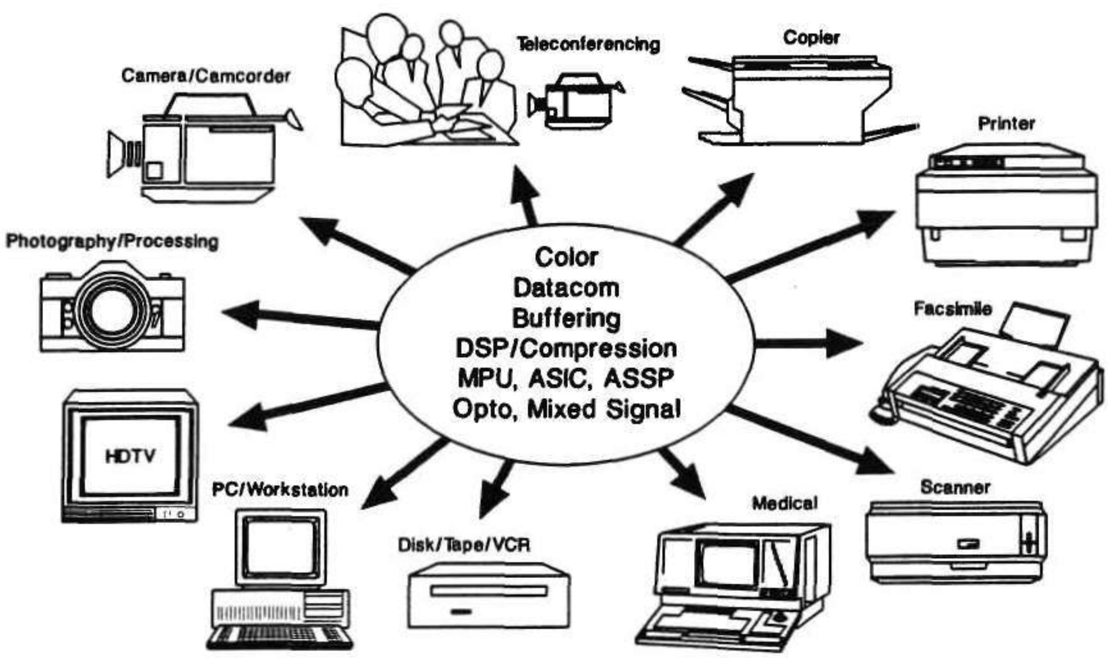
PERIPHERAL APPLICATIONS

Equipment	Unit* CAGR% (1991-1995)	Design Factors	Key Semiconductor Technology
Rigid Disk Drives (2.5")	45	Cost	Mixed signal, memory
Optical Disk Drive	67	Cost, performance	Opto, mixed signal
Laser Printers	18	Performance, cost	MPU, opto, ASSP, memory
Ink Jet	17	Cost, performance	ASSP
X-Windows Terminal	53	Cost, performance	MPU, memory
Digital Video Cards	60	Standards, software, performance	DSP, ASSP, mixed signal

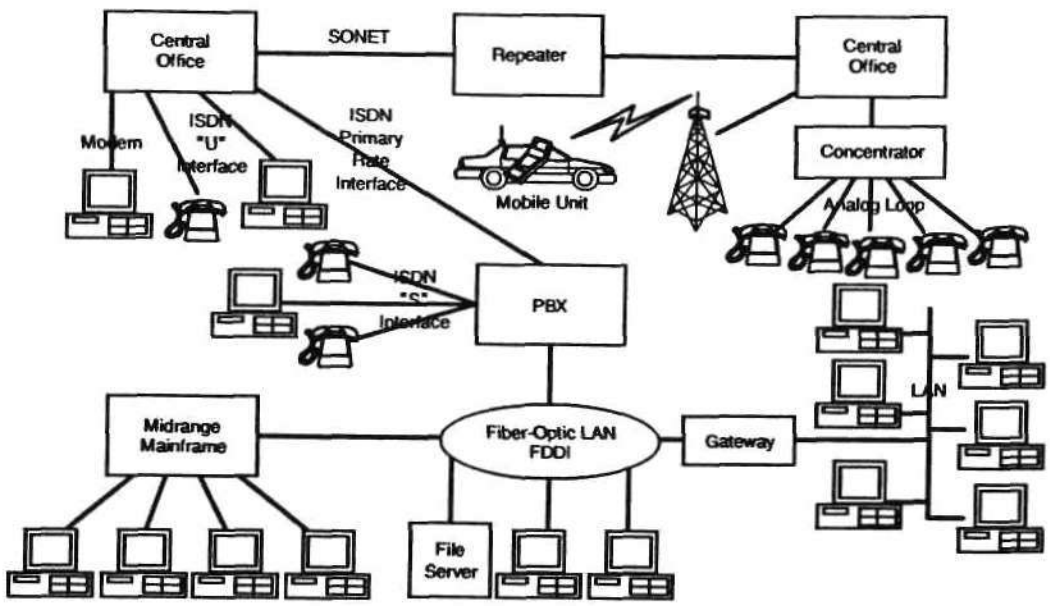
*Worldwide

Source: Dataquest

DIGITAL IMAGING



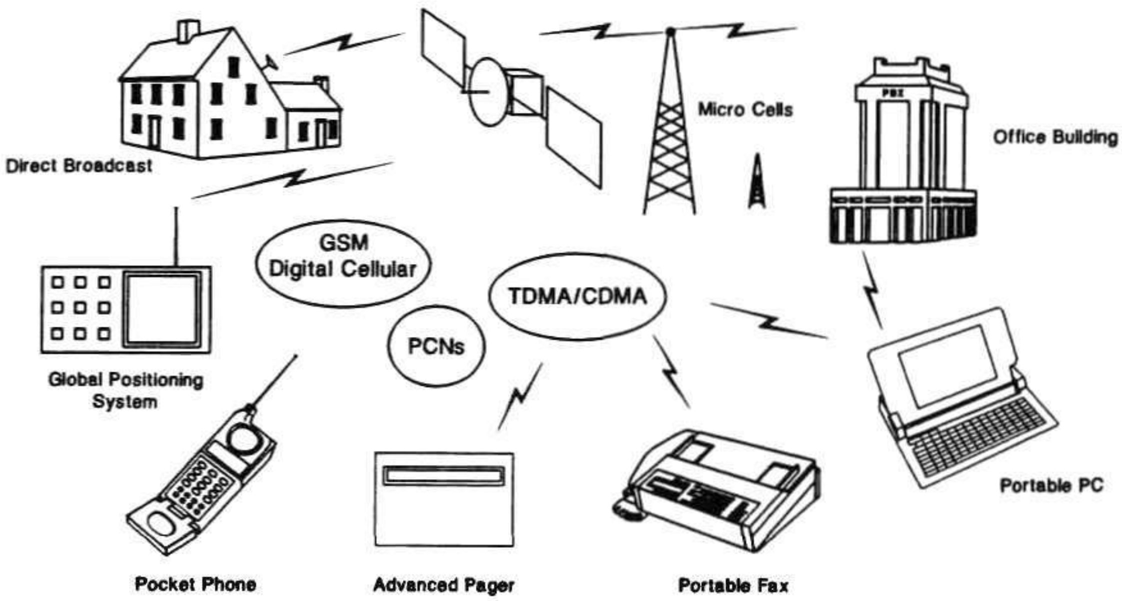
DEMAND FOR CONNECTIVITY



Source: National Semiconductor
Dataquest

Notes:

GOING WIRELESS (AND DIGITAL)



Source: Dataquest

COMMUNICATIONS APPLICATIONS

Equipment	Unit* CAGR % (1990-1994)	Design Factors	Key Semiconductor Technology
LAN Cards	26	Differentiation	ASSP
ISDN Terminal Equipment	69	Differentiation	ASSP
Facsimile Machines	16	Cost	ASSP, memory, CCD
PC Fax Cards	35	Performance, cost	ASSP
Voice Messaging Systems	13	Differentiation	DSP
Video Teleconferencing Systems	33	Performance	DSP, compression
Interactive Voice Response Systems	37	Performance	DSP
Cellular Phones	27	Cost, power, performance	DSP, RF

*U.S. market

Source: Dataquest

CONSUMER APPLICATIONS

- Saturated first world market
- Growing disposable income in developing countries
- Multimedia (players and PCs)
- Digital TV ➡ HDTV (VCR and camcorder)
- Smart home?
- Analog prevails; DSP and MCUs grow

Notes:

INDUSTRIAL APPLICATIONS

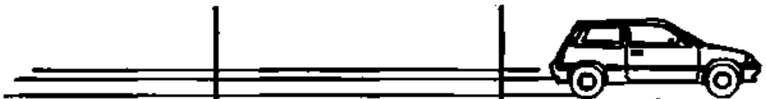
- Factory controls -- busses and embedded systems
- Motor controls and sensors -- more silicon
- Automatic test equipment (ATE) -- change creates change
- Portable/bench instruments -- cost and performance
- Medical -- embedded systems, DSP, cost
- MPU/MCU, ASICs, mixed signal, power

MILITARY/AEROSPACE APPLICATIONS

System Opportunities

- Upgrades/replacements
- Add-ons
- Electro-optics
  Modular digital controls
  Standard computers
  Microwave/milimeter-wave
  Unmanned platforms
  Space
  Test equipment
  Training systems
- Commercial airlines, air traffic control

AUTOMOTIVE APPLICATIONS



Phase I	Phase II	Phase III	Phase IV
	↑ Legislation	↑ Legislation	
Entertainment–Analog	Entertainment–DSP Power train I	Power train II Antilock braking Electronic suspension Electronic steering Airbag/restraints	Multiplexing Collision avoidance Navigation Intelligent highways

Source: Dataquest

Notes:

AUTOMOTIVE APPLICATIONS

- 6 MCUs ➡ 9 MCUs
- 200 control applications (22 unique sensors)
- $105 of semiconductors per vehicle
- Mixed signal, smart power, sensors
- Cost pressure . . .

GEOGRAPHICALLY SPEAKING

Europe	Japan	North America	Asia/Pacific
ISDN	Video/multimedia	Networking	Consumer
Cellular/PCN	Cellular/PCN	Portable PC	Peripherals
Automotive	ISDN	Workstation/servers	Portable PC
PC/peripherals	Factory controls	Multimedia	Communication
Consumer	PC	ISDN	Automotive
		Cellular/PCN	

Source: Dataquest

Implications

Notes:

IMPLICATIONS

- Plenty of application opportunities
- Maturing electronics industry
- Increasing emphasis on life cycle extensions
- Costs complement performance in decisions
- Increased design partnerships
- Increased hardware outsourcing
- Application specificity prompts "fabless" and "with-fab" companies

Notes:

Personal and Wireless Communications

Dr. Steve Sazegari
Communications

Dr. Jonathan Drazin
Applications

Gary Grandbois
Semiconductors

AGENDA

Personal Communications

- Cellular telephone
- Paging
- Personal Communications Network (PCN)
- Conclusion

CELLULAR TELEPHONE

- Service inaugurated in 1983
- More than 300 urban areas on-line
- Rural Service Area franchises being awarded by FCC
- More than 5 million telephones in service
- Broadening market penetration
  - Softening service prices
  - Declining telephone prices
- Growing popularity of portable telephones

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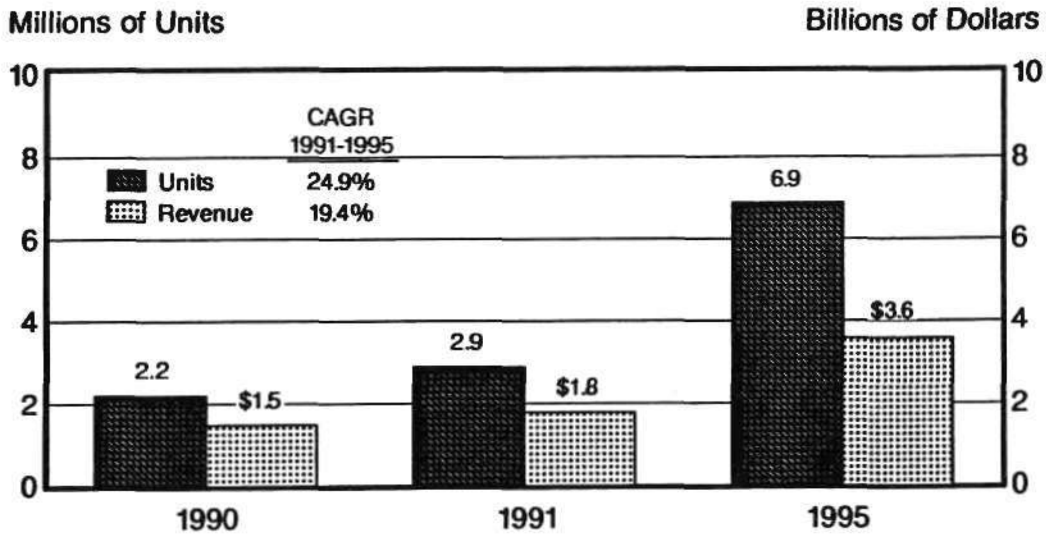
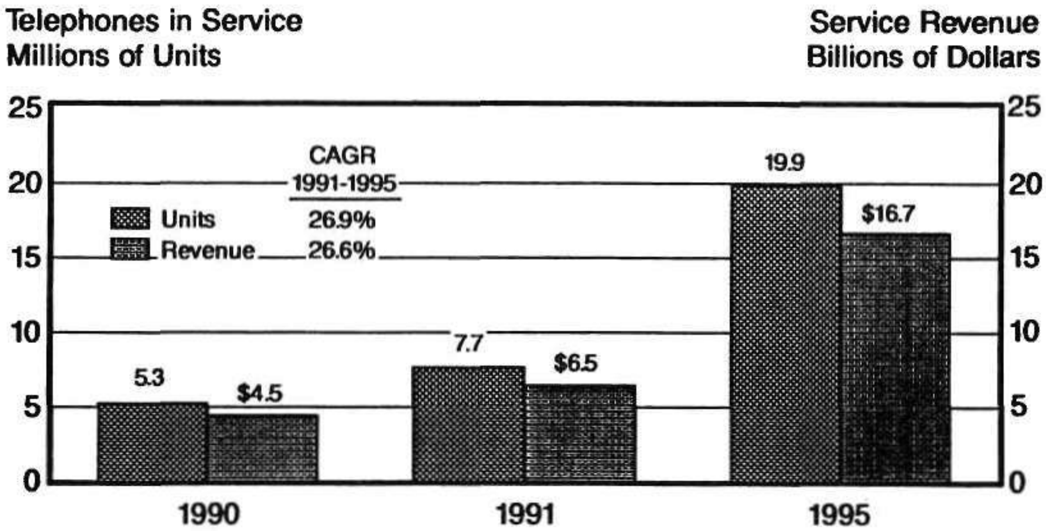
ESTIMATED U.S. MARKET FOR CELLULAR TELEPHONES



Source: Dataquest

Notes:

ESTIMATED GROWTH OF THE U.S. CELLULAR SERVICES MARKET



Source: Dataquest

DIGITAL CELLULAR RADIO

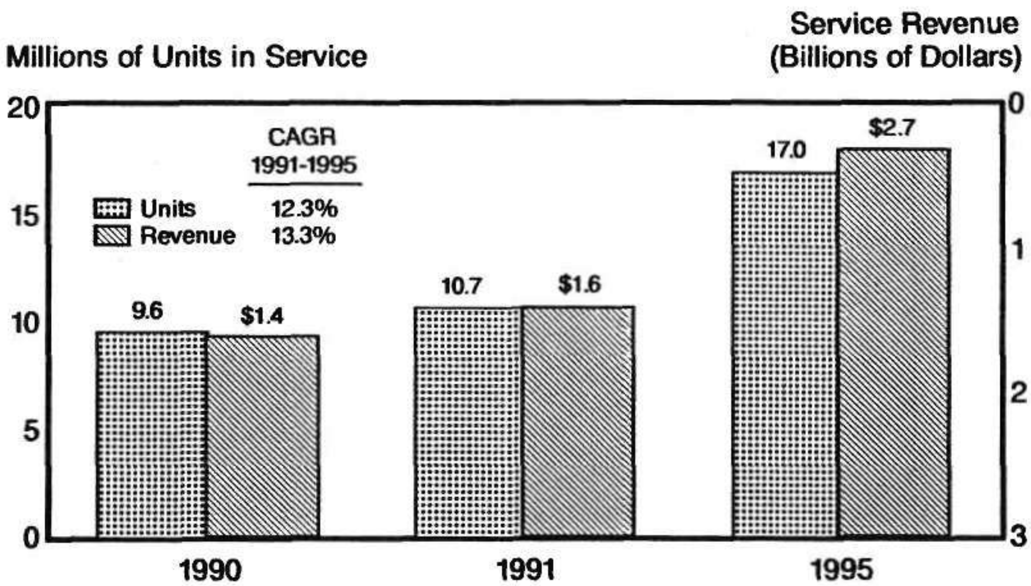
- Cellular radio will evolve
  - Analog ➡ dual mode ➡ digital
- Significant increase in system capacity
- TDMA is now standard; CDMA a future contender
- Comparable or better voice quality
- New ISDN-like service possible
- Security

PAGING

- Evolution from "paging" to messaging market
- Supplement to, not substitute for, alternative forms of wireless communication
- Deployment of new technologies
  - FM sideband
  - Wristwatch pager
- Nationwide paging services
- Integration with other functions such as voice mail

Notes:

ESTIMATED U.S. PAGING MARKET



Source: Dataquest

PERSONAL COMMUNICATIONS

Definition

- Anywhere
- Anyone
- Anytime

PERSONAL COMMUNICATIONS INNOVATIONS

- Cordless telephone systems
  - CT2, Telepoint
  - DECT (CT3)
- PCN
  - Satellite systems

Notes:

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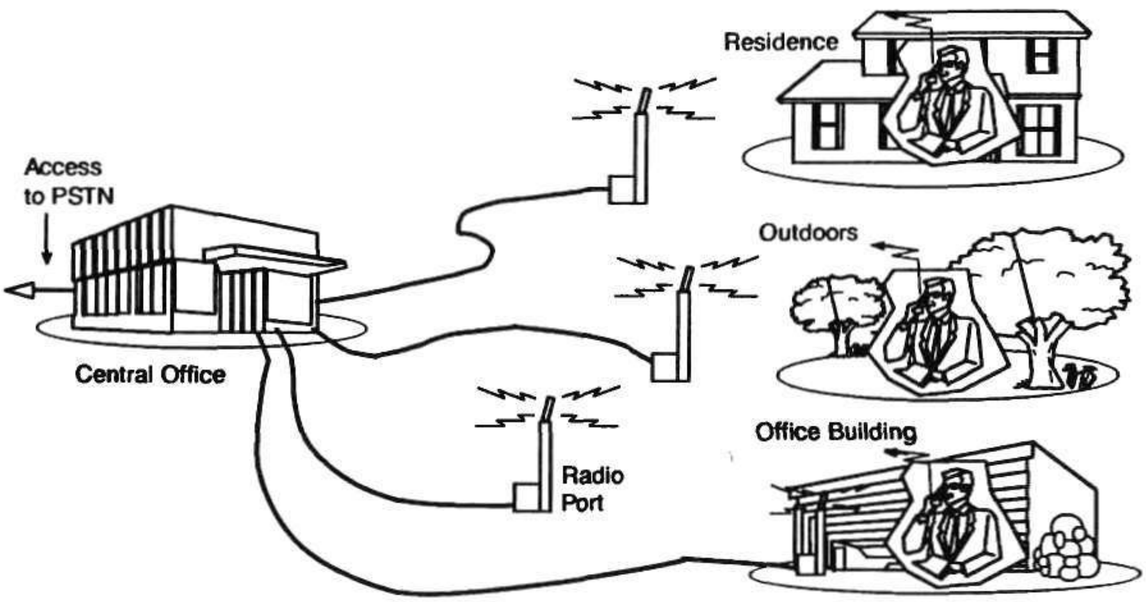
POSSIBLE CT2 AND PCN INTEGRATION WITH PSTN



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CT2

- Concept developed in the United Kingdom
- Attractive substitute for public pay phone
- Four licenses issued in United Kingdom
- DECT standards nearing completion
  - Improvement over CT2
- Window of opportunity in the United States

PCN

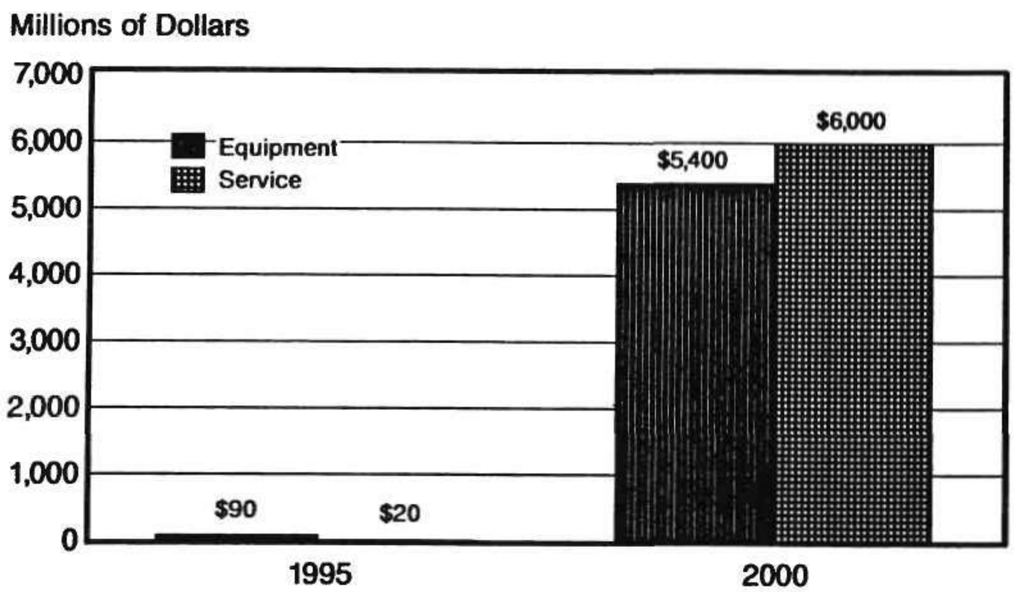
- Extension of cellular concept
  - Microcells
- PCN being implemented in United Kingdom
- Digital Cellular System 1800 (DCS 1800) standard in Europe
  - Based on GSM
  - Under consideration by ETSI
- U.S. standards under consideration
  - CDMA the likely technology

Notes:

PCN IN THE UNITED STATES

- Experimental PCN licenses granted by the FCC
  - PCN America (Millicom subsidiary)
    - Houston, Texas
    - Orlando, Florida
  - Graphic Scanning
    - Detroit, Michigan
    - Chicago, Illinois
    - White Plains, New York
  - Motorola
  - NYNEX
  - BellSouth
- License applications pending for:
  - American Personal Communications, Inc.
  - Ameritech
  - McCaw
  - GTE
  - Others

ESTIMATED U.S. PCN MARKET



Source: Dataquest

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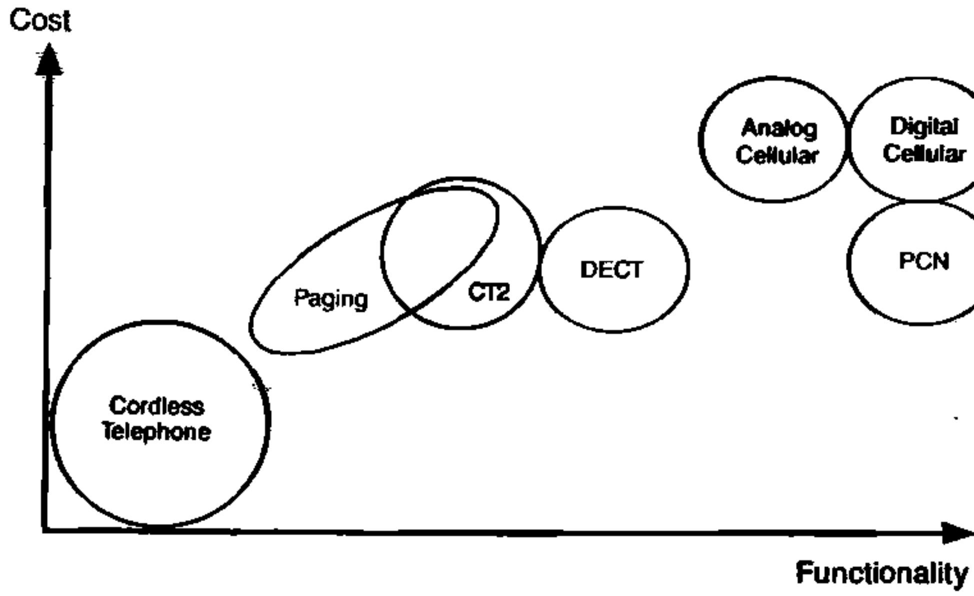
MOBILE COMMUNICATIONS SYSTEMS



Source: Dataquest

Notes:

FUNCTIONAL COMPARISON OF PERSONAL COMMUNICATIONS DEVICES

	CT2	Paging	Cellular	PCN
Function	Originate	Receive	Originate/receive	Originate/receive
Communications Range	200m	Metro area	>2 Miles	200m
Mobility	Limited; no handoff	High	Automobile	Pedestrian
Terminal Cost	Low ($100)	Low ($100)	High ($400-$700)	Low ($100)
Terminal Size	Small	Small	Medium/Large	Small
Base Station Cost	Low	Medium	Very high	Low

Source: Dataquest

PCN TRIALS

- Test feasibility of technology
  - CDMA, spread spectrum
  - Microcell structure
- Explore 2-GHz operational issues
- Test user acceptance
  - Demand
  - Price
  - Functionality

PERSONAL COMMUNICATIONS

U.S. Regulatory Issues

- Frequency allocation
- Industry structure
  - PCN entry
  - Telepoint entry
  - Licensing
  - Service regulation
- Standards and equipment licensing
- FCC Notice of Inquiry (June 1990)
  - Decision not likely before year-end 1991
- FCC Notice of Proposed Rule Making not expected before 1992/1993

Notes:

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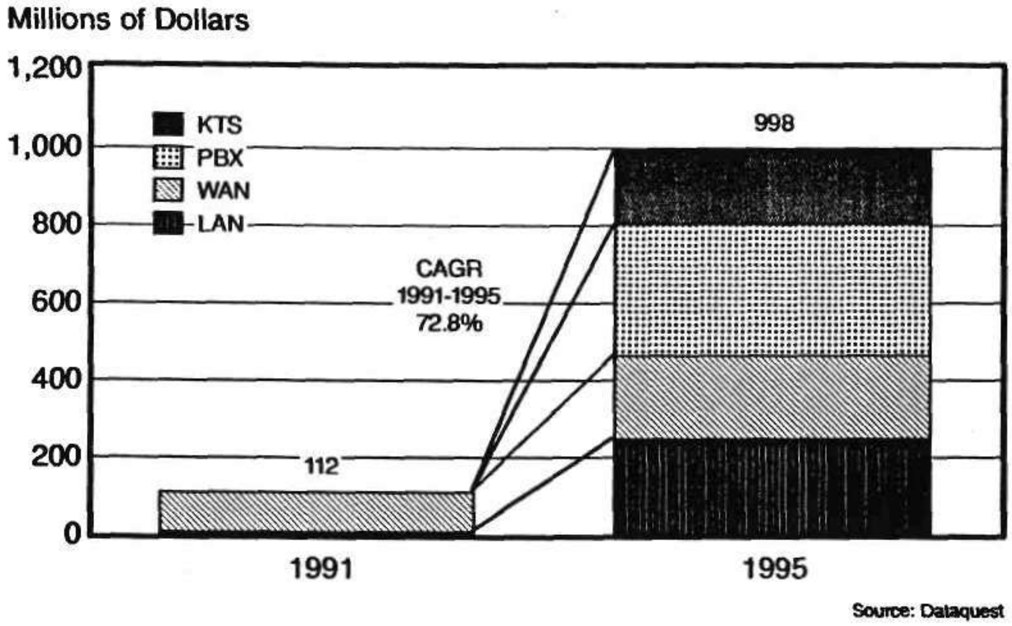
ESTIMATED U.S. WIRELESS MARKET



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CONCLUSION

Personal communication is opening up new vistas -- and new opportunities

Notes:

Personal and Wireless Communications

Dr. Steve Sazegari
Communications

Dr. Jonathan Drazin
Applications

Gary Grandbois
Semiconductors

EUROPEAN PERSPECTIVE

AGENDA

THE SYSTEMS:

CT2
DECT
GSM
DCS 1800

THE SEMICONDUCTORS

MARKET SUMMARY

CT2

- Low cost digital cordless phone
- Originally British .... now European
- Existing manufacturers:
  - GPT
  - Motorola
  - Orbitel
  - Shaye
- CT2 is an interface ... not a network
- Not geographically contiguous

CT2: ITS APPLICATIONS

- Originally intended for "Telepoint"
- Poor performance for Telepoint in UK:
  - Economic recession
  - Few basestations, limited coverage
  - Equipment delays
  - Handset cost
  - Poor marketing?
- Large basestations: DECT is cheaper

Notes:

CT2: DEVELOPMENT IN EUROPE

- Political wrangling between EC and ETSI
- EC: "CT2 must not hinder DECT"
- ETSI: "Let the market decide"
- Telepoint limited mainly to UK and France, so far
- Germany undecided, problems with trials

CT2: THE FUTURE

- CT2 still expensive: $350 dollars
- But better features:
  - High quality speech
  - More channels
  - No eavesdroppers
  - No fraud
- Rapid price erosion expected
- Consumer product: Japanese interest

DECT

- DECT: Digital European Cordless Telephone
- Pan-European
- Spectrum fully allocated: 1.9GHz
- Very wide uptake expected

Notes:

DECT: ITS APPLICATIONS

- Wireless PABX extensions and handsets
- Very light handsets expected (<200g)
- Data communications: PC laptop transceivers
- Wireless LANs
- Companies to watch: Alcatel, Ericsson, Olivetti and Philips

CT2 vs DECT: THE DIFFERENCES

	CT2	DECT
Transmission protocol	FDMA	TDMA
Total channels	40	132
Maximum channels per basestation	8 approx	60 approx
Peak power	10mW (per channel)	12.5mW (per carrier)
Frequency	864-868 MHz	1.88-1.9 GHz
Data capacity	9.6kbps	>144kbps
Hand-over	No	Yes

Source: Dataquest

CELLULAR vs CORDLESS KEY DIFFERENCES

	DIGITAL CELLULAR	DIGITAL CORDLESS
Cell size	<70km	<100m
Handset power	1-20W	10mW
Equalization	Yes	No
Voice coding	RPE-LTP	ADPCM
Channel data rate	6.5 - 13kbps	32kbps

Source: Dataquest

Notes:

GSM

- GSM: Groupe Speciale Mobile
- Skeleton services in: Denmark, Finland, Germany and Sweden
- Will replace wide diversity of analog systems
- Network competition will boost GSM
- Operator duopolies expected in most countries

GSM vs RIVALS

- Cordless will not erode cellular
- Poor compatibility between GSM and analog cellular will slow early uptake
- Spectrum and capacity will force the issue
- No new spectrum being allocated for analog cellular

DCS 1800

- DCS: Digital Cellular System
- A derivative of GSM:
  - Higher frequency
  - Greater bandwidth
  - Smaller cells/lower power
  - Infrastructure sharing
- Three operators licensed in the UK
  - Services start late 1992
  - Positioned to compete with local loop

Notes:

DCS 1800: ROLLOUT

- Smaller cells mean more investment
- Unlikely to be viable alternative to cellular in UK for at least 3 years
- Rollout will commence in cities
- Targetted to office and pedestrian users
- No concrete plans elsewhere in Europe

SYSTEM COMPLEXITY ANALOG vs GSM

	ANALOG	GSM
Number custom chips	3	5-6
Total chips	14	12
Silicon area (sq.mm)	110	330 (excl. RAM/ROM)
Equivalent gates	10k	150k
Analog filter poles	40	10
MIPS - control processor	0.2	1
MIPS - DSP	-	60
Program size (kbytes)	50	200
Number DACs	2	8
Number ADCs	4	7

Source: Dialog Semiconductor

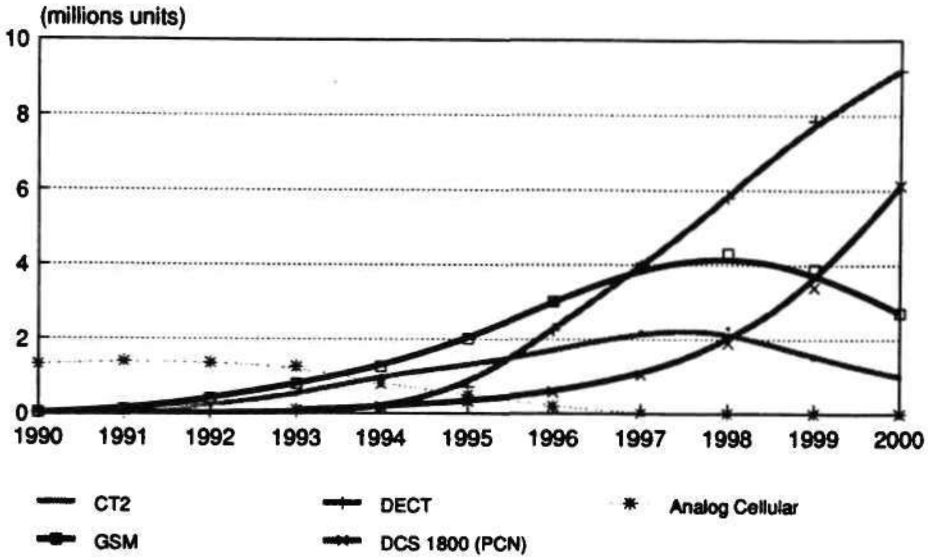
ESTIMATED SEMICONDUCTOR CONTENT
1ST GENERATION GSM CLASS IV TRANSPORTABLE

Speech codec	CMOS DSP/ASIC	$ 18
Channel equalizer	CMOS DSP/ASIC	$ 18
Frequency synthesizer	CMOS DSP/ASIC	$ 14
Channel codec	CMOS ASIC	$ 14
Channel modulator	Bipolar ASIC	$ 15
Baseband conversion	BiCMOS ASIC	$ 14
Other		$ 58
TOTAL SEMICONDUCTOR		$151

Source: Dataquest

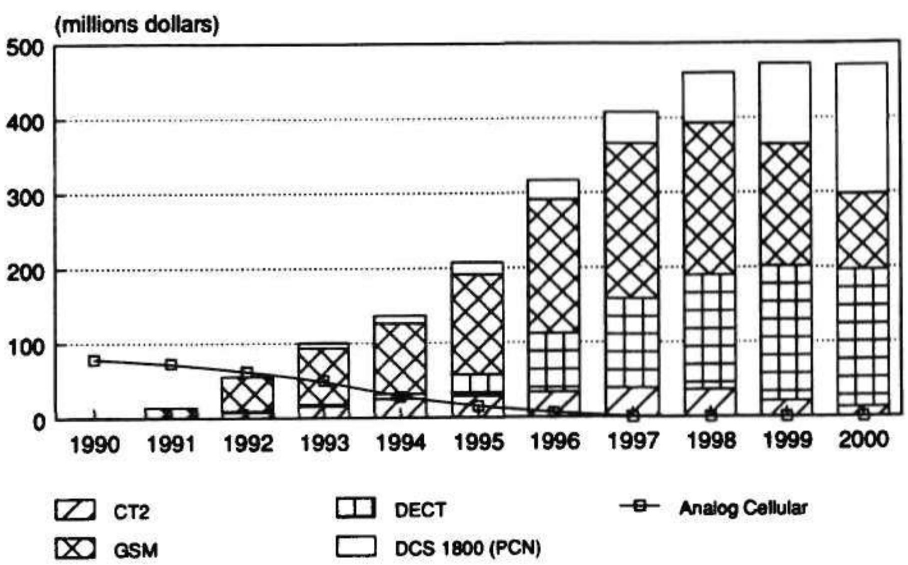
Notes:

Forecast European Handset Consumption by Wireless Standard



Source: Dataquest

Forecast Semiconductor Consumption by European Handset Standard



Source: Dataquest

Notes:

Personal and Wireless Communications

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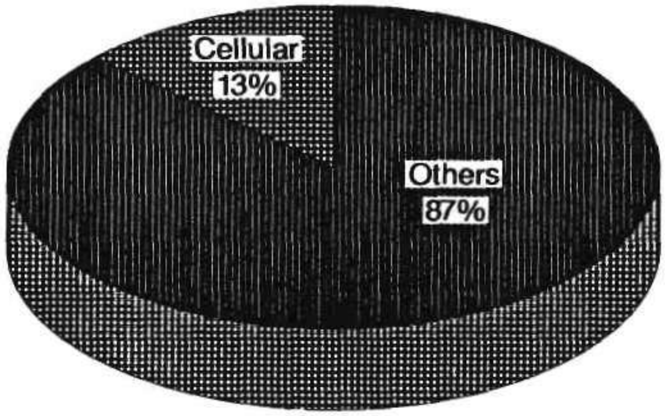
Applications

Gary Grandbois
Semiconductors

TELECOMMUNICATIONS

Analog and Mixed-Signal Revenue



1990 = $1,122 Million

Source: Dataquest

PERSONAL COMMUNICATIONS

Semiconductors in Cellular

1990 Revenue ($M)	207
1990-1995 CAGR (%)	26
Discrete (%)	19
Analog and Mixed (%)	21.5
Digital (%)	38

Source: Dataquest

SEMICONDUCTORS IN PERSONAL COMMUNICATIONS

- Discretes
  - RF silicon
  - GaAs
- Linear ICs
  - RF and audio processing
- Mixed-analog/digital ICs
  - Conversion/DSP support
- Digital ICs
  - DSP
  - Control

Notes:

PERSONAL COMMUNICATIONS MARKET FOR GaAs

- Receiver low-noise detector/amp
- Frequency divider
- RF power amp

1990 Revenue of $26 Million

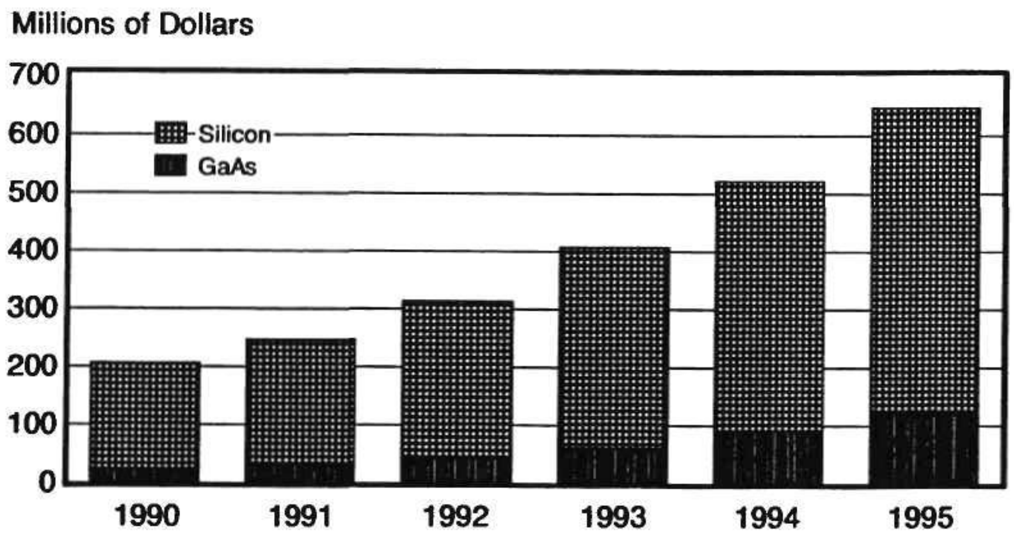
Source: Dataquest

PERSONAL COMMUNICATIONS TECHNOLOGY CONSIDERATIONS

- GaAs
  - RF
  - Opto
- Bipolar
  - RF
  - Amplifiers
  - Power
- CMOS
  - Digital and DSP
  - Mixed-signal ICs
- BiCMOS
  - Bipolar and CMOS functions
  - Higher level of integration

PERSONAL COMMUNICATIONS

Semiconductor Forecast



Source: Dataquest

Notes:

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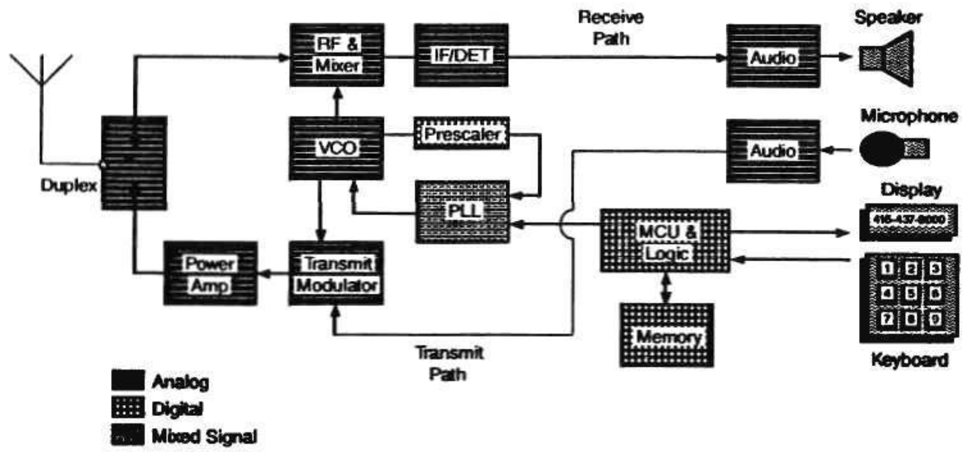
SIMPLIFIED ANALOG CELLULAR PHONE



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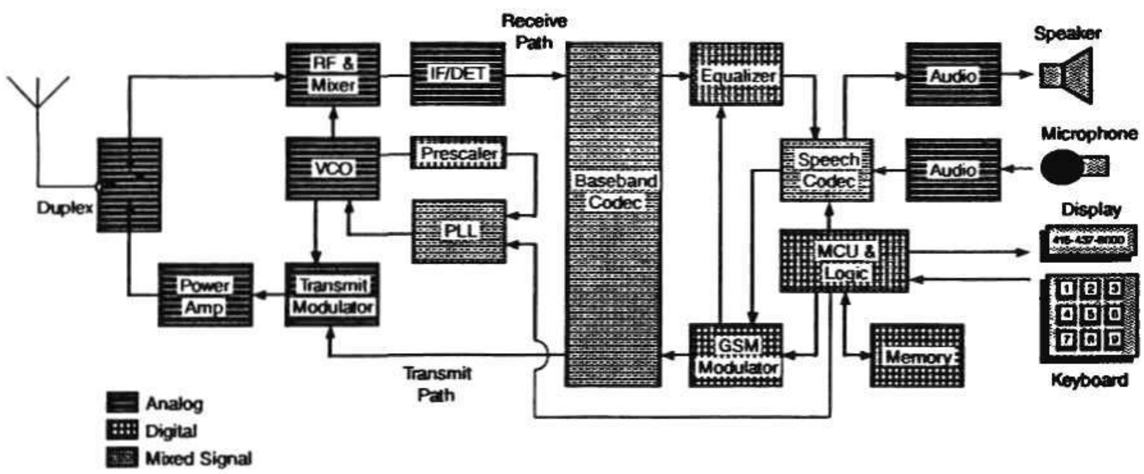
SIMPLIFIED DIGITAL CELLULAR PHONE (GSM)



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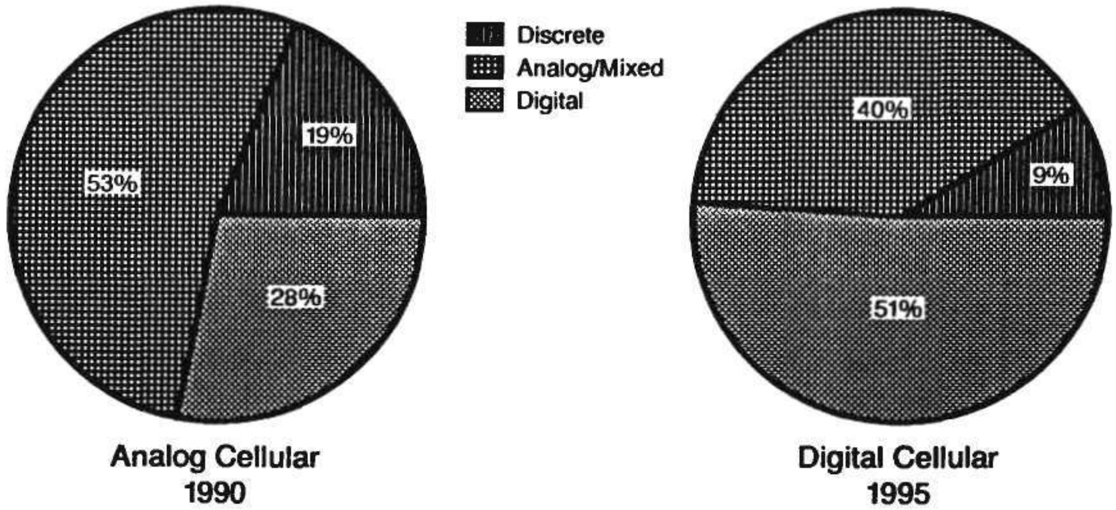
PERSONAL COMMUNICATIONS

Semiconductor Content Forecast by Type

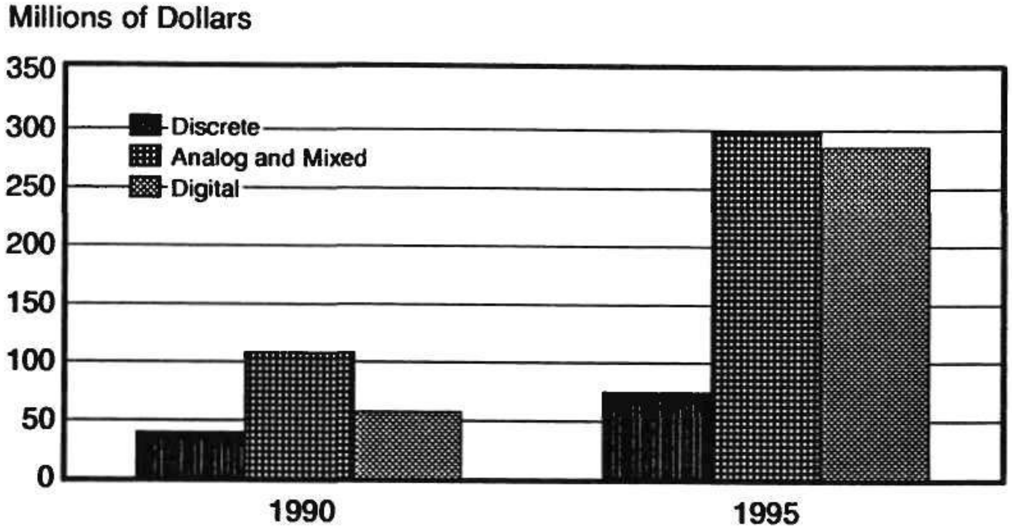


Source: Dataquest

Notes:

PERSONAL COMMUNICATIONS

Semiconductor Forecast by Type



Source: Dataquest

SUMMARY

- Broad spectrum of semiconductors will grow with personal communications market
- Digital ASICs/ASSPs and mixed-signal Codecs likely to show strongest growth
- GaAs is expected to participate vigorously

Notes:

PCs and Personal Workstations

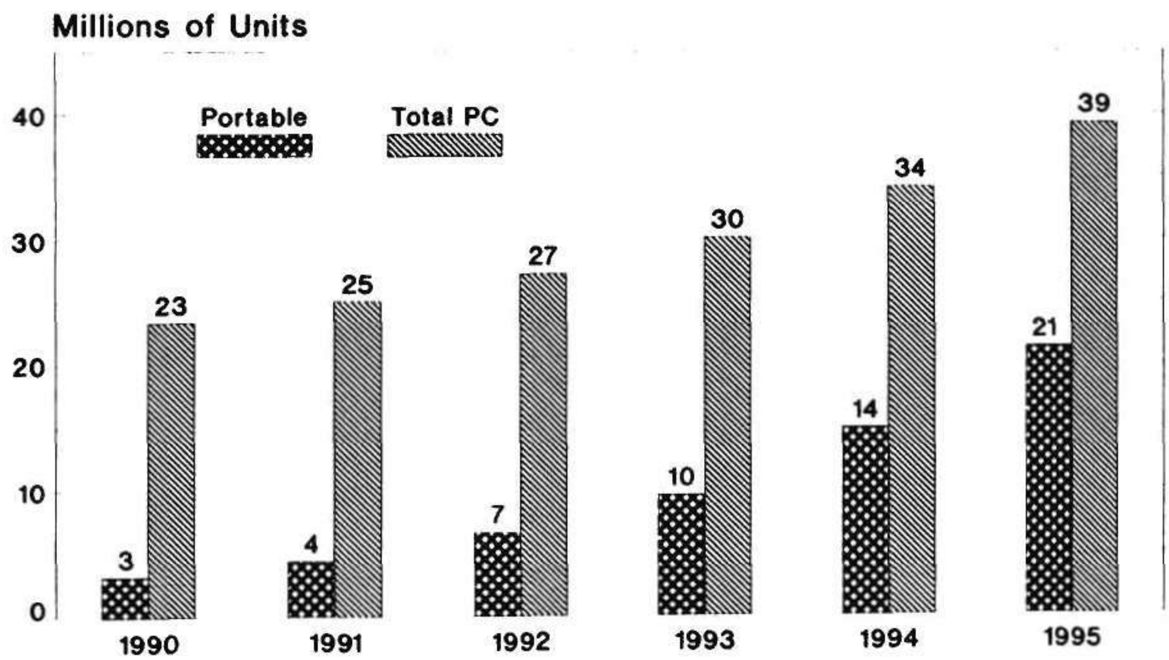
Andrew Seybold
Portable PCs

Kenneth Lowe
Microcomponents

AGENDA

- Portable issues for the 1990s
- Worldwide market projections
- Notebook PC issues
- A look ahead to 1996

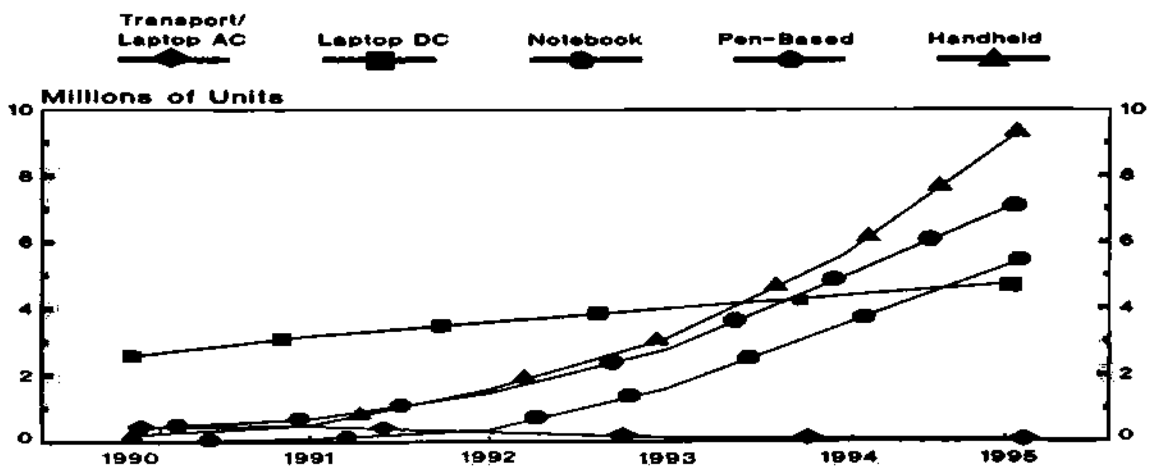
PROJECTED PORTABLE PC GROWTH AS A FUNCTION OF TOTAL WORLDWIDE PCs



Source: Dataquest

PORTABLE SYSTEMS MARKET PROJECTIONS
WORLDWIDE MARKET

- No compromise in:
  - Size, weight, transportability
  - Memory and storage capacity
  - battery life and ruggedness
- End-user requirements
  - Demand increase performance
  - MS-DOS and Windows compatibility
  - Expandable with communications



Source: Dataquest

Notes:

WHAT'S HOT

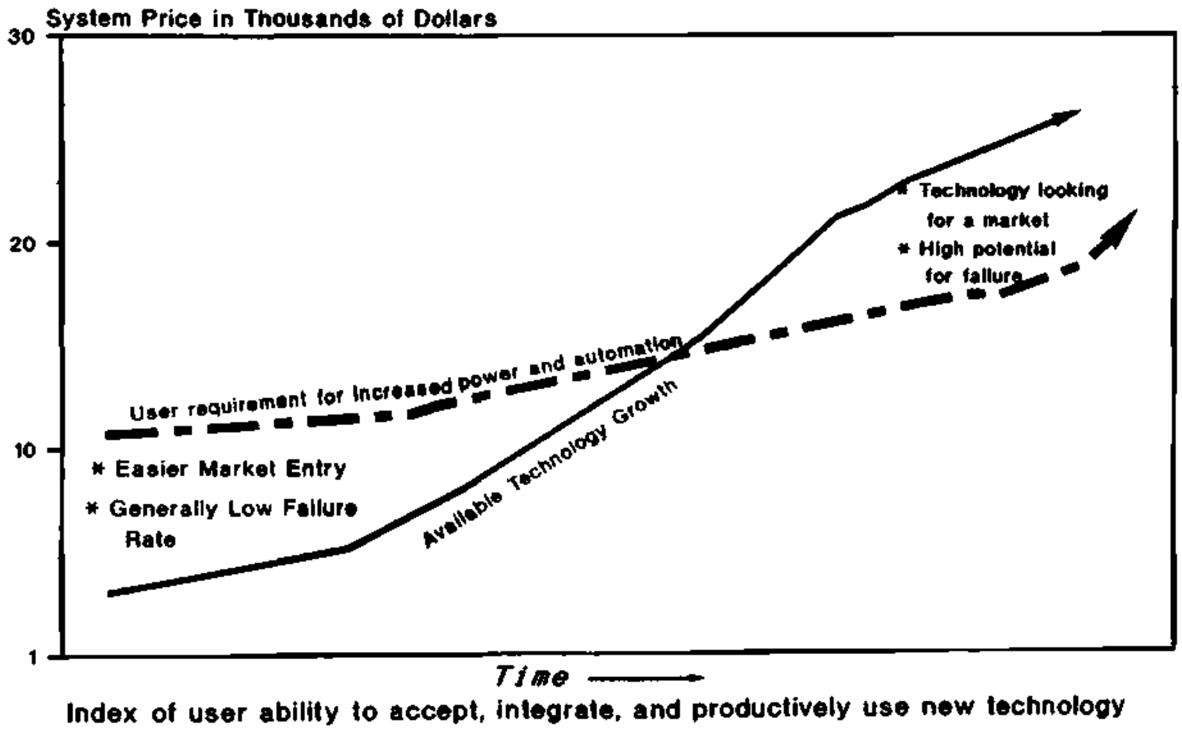
- Portable computing
  - Notebooks
  - Hand-held systems
  - Pen-based systems
  - Communications
- High-end computing
  - Local area networks and servers
  - High-performance systems
  - PC crossover into workstations area

WHAT'S HOT

- High-end computing
  - Add-in and add-on devices
  - Home computing
  - Multimedia
- Communications
  - Marriage of computing to transmission methods
  - Cellular phones, wireless LANs, worldwide access

TECHNOLOGY VS. APPLICATION

When is enough too much?



Source: Dataquest

Notes:

NOTEBOOK ISSUES

- A look ahead to 1996
  - Storage
    - CD technologies
    - Chip based
    - Card based
    - Hard disk based

NOTEBOOK ISSUES

- A look ahead to 1996
  - Applications
    - Fully interactive with desktops
    - Optimized for portables
    - Notebooks become the companion PC
  - Storage requirements
    - Increased due to graphics, but decreased due to datacomm

NOTEBOOK ISSUES

- Communications
  - Wireless
    - Licensed vs. unlicensed
    - Frequency coordination
    - 902 to 928 MHz spectrum issues
  - Cellular
    - Systems today
    - Future satellite use
    - Specialized wireless service providers

Notes:

NOTEBOOK ISSUES

- A look ahead to 1996
  - Costs
    - Average selling price: $2,500 includes:
      - Fully integrated PC and communications
      - Battery life: about 12 hours
      - Weight: 2 to 3 lbs
      - Pen or key entry
      - Full color
      - Fulltime use

Portable Design Trends
More Power & Less Weight

August 20 **PC Week** 1990

PC Buyers want more power, and better screens

" As the market moves to Windows☆ software, 386... (architecture) will be very important - but not at the expense of size. The machines should not get any heavier than they are now."

Notes:

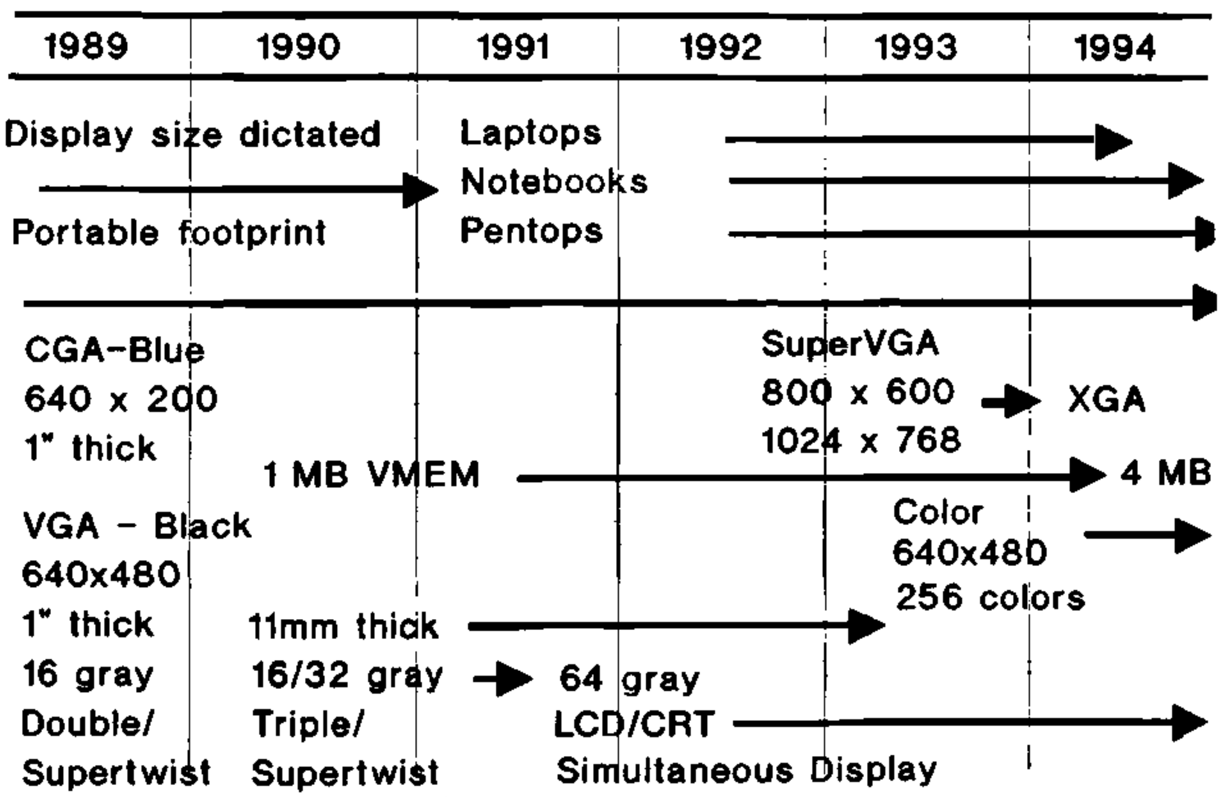
MAJOR CUSTOMER BUYING CONCERNS

Extracted from PCWEEK Survey of Low-Cost, lightweight 386SX notebook users

April 1, 1991

Priority	Buying Concern
1	Quality and readability of display
2	Size, weight, transportability
3	Quality of construction, ruggedness
4	Quality of keyboard
5	System performance
6	Battery life and recharge time
7	Disk performance
8	Convenience of accessories
9	Expandability
10	Quality of documentation

DISPLAY TRENDS

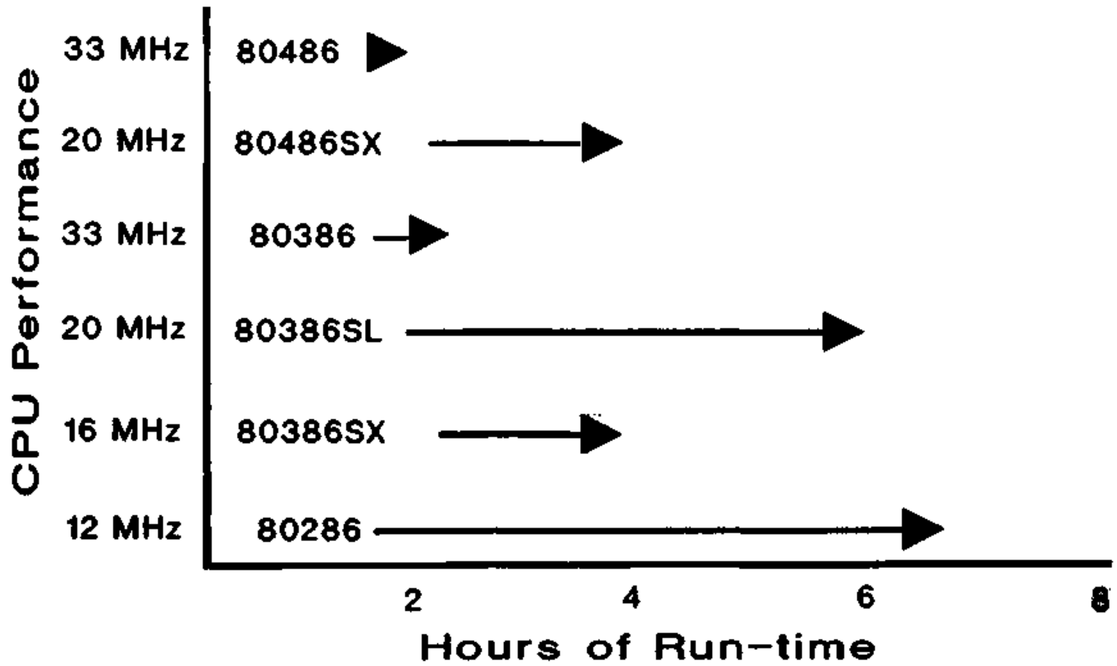


DISPLAY TRENDS

- Color technology will follow B/W trends for portables
- CGA was common in 1989/1990
- VGA was common in late 1990 and 1991
- High quality VGA is appearing on larger footprint laptops
- Lower quality (duty cycle) color panels will be the initial offerings for Notebooks and Pentops

Notes:

NOTEBOOK TRENDS
BATTERY LIFE
1991



DESIGN EVOLUTION

Portable Products

Features	Transportables	Laptops	Notebooks
Size	Big and heavy 28 - 32 Pounds	Cumbersome 12 - 18 Pounds	Sleek and light 4 - 7 Pounds
Processor	→ 80286-80486	→ 80386SX	→ 80386SL
Memory	→ 8MB	→ 16MB	→ 16MB
Storage	→ 120MB	→ 120MB+	→ 60 - 180MB
Display	Mono and Color	Mono and Color	Mono and Color
Power	AC	Battery / AC	Battery / AC

NOTEBOOK TRENDS

	1991	1993	1995
Weight	4 - 7 Pounds	3 - 6 Pounds	2 - 4 Pounds
Processor	386 (SX,SL)	486	386,486, and more
Memory	2 - 16 MB	8 - 20 MB	16 - 32 MB
Drive	60 MB	80 - 120 MB	120 - 210 MB 500 MB - 1 GB
Display	VGA 640X480 B/W	Super VGA 800X600 B/W	XGA 1024x768 B/W, Color
Communications	Modem/FAX 2400 bps / LAN	Modem/FAX 2400 bps / LAN	Modem/FAX/Cellular V.32 bis/ISDN - LAN

Notes:

KEY DESIGN CONCERNS

Group I

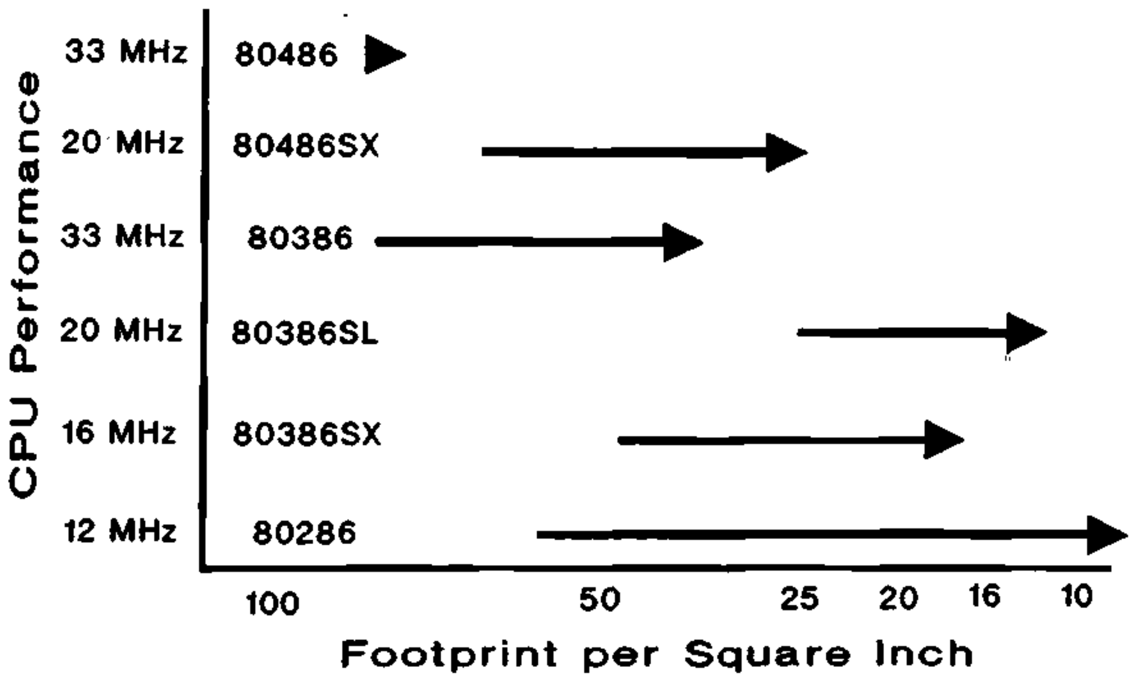
- DISPLAY QUALITY
  - Screen size, gray shades video memory, resolution
- SIZE AND WEIGHT
  - Footprint, height, traveling weight
- RUGGEDNESS
  - Environmental, physical, robust

Group II

- SYSTEM PERFORMANCE
  - Type CPU, CPU speed, memory size / speed
- DISK PERFORMANCE
  - Access time, disk size, shock / vibration (operation)
- BATTERY LIFE
  - Run-time vs. weight, charge time, ease of exchange

TRADEOFF AREAS

NOTEBOOK TRENDS
PRINTED CIRCUIT per SQUARE INCH



Headline 1996

May 22 **PC Week** 1996

PC Buyers want more information better video, and better sound

" As the market moves to Multi-Media software, high definition (architecture) will be very important - but not at the expense of size. The machines should not get any heavier than they are now."

Notes:

DATAQUEST OUTLOOK

- Entry into markets is very costly
- Most major players will remain as major players
- Intense battle for market share
  - Top 10 players account for 42% of the market
  - There are over 100 vendors competing for the balance of the available market
- Mergers, partnerships, and alliances will be key to survival

Source: Dataquest

DATAQUEST OUTLOOK

- Marketing and distribution expertise is as important, if not more important than the product
- U.S. PC reseller margins will continue to decrease
- U.S. PC channel will continue to consolidate
- Major channel shifts to mass merchants, superstores, and direct response marketing will continue

DATAQUEST OUTLOOK

- The industry shakeout will be felt in the bottom 60% of the market
- Major players will have to work smarter AND harder
- Smaller vendors will have to align themselves with strategic partners
- Niche markets will provide a higher probability of success

Source: Dataquest

Notes:

THE LAST SIX MONTHS

Mergers, consortiums, and acquisitions portend the future:

- IBM buys Metaphor
- Borland buys Ashton-Tate
- Novell buys Digital Research
- Symantec buys Zortech and Dynamic Microprocessor Associates
- Microsoft, MIPS, Compaq, Acer, SCO, Digital, (and others) form ACE
- IBM and Apple agree to form software company

THE RESELLER SHAKEOUT MERGERS AND ACQUISITIONS 1990 through 1991

Driving reasons for channel consolidation

- IE buys Connecting Point
- JWP buys Neeco
- JWP buys Businessland
- ComputerLand buys Nynex
- Inacomp and ValCom merge
- CompuCom buys Computer Factory

CAN PC MAKERS STILL MAKE IT?

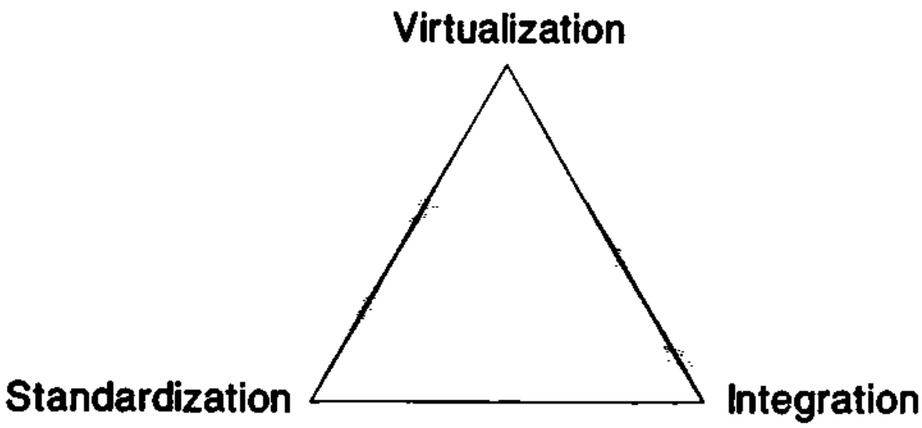
Notes:

PCs and Personal Workstations

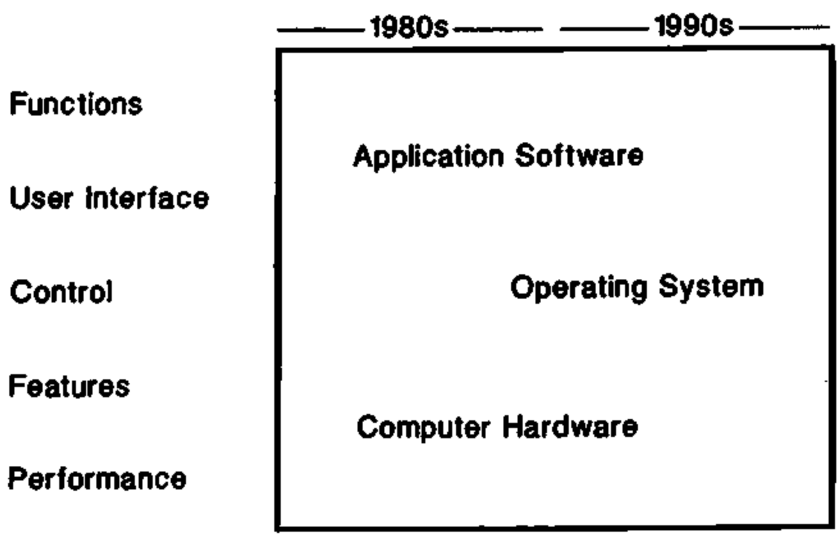
Andrew Seybold
Portable PCs

Kenneth Lowe
Microcomponents

MICROPROCESSOR CONCEPTUAL DIRECTIONS

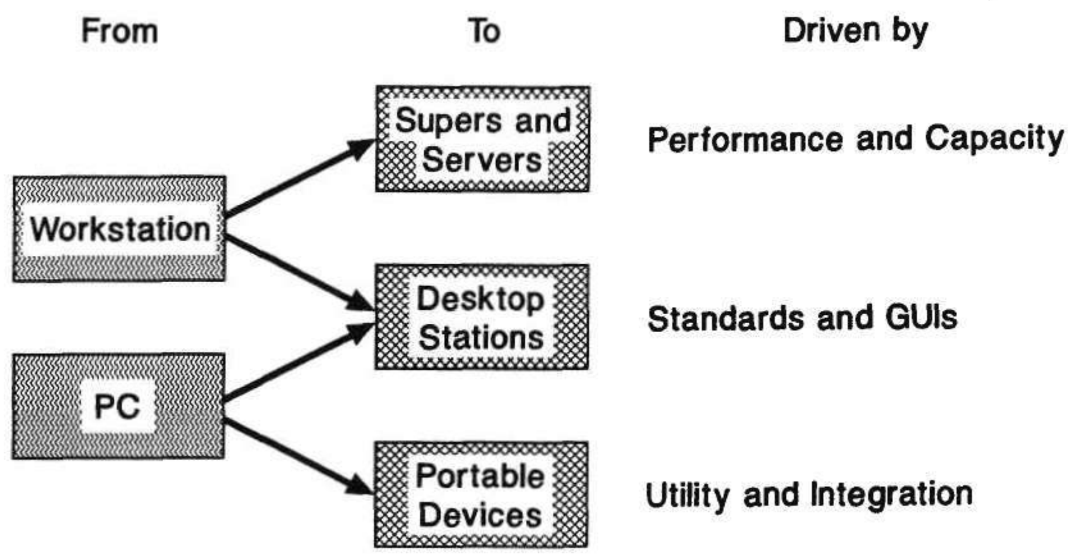


THE SHIFT FROM HARDWARE TO SOFTWARE ARCHITECTURE



Source: Dataquest

DISTINCTIONS ARE BLURRING AND SEPARATING



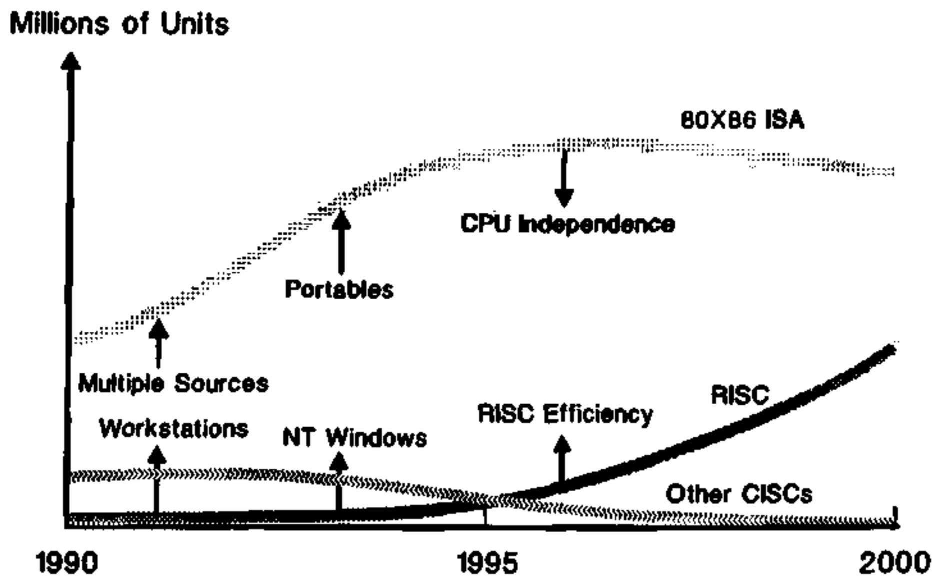
Notes:

DEFINITIONS AND ASSUMPTIONS

- RISC = 

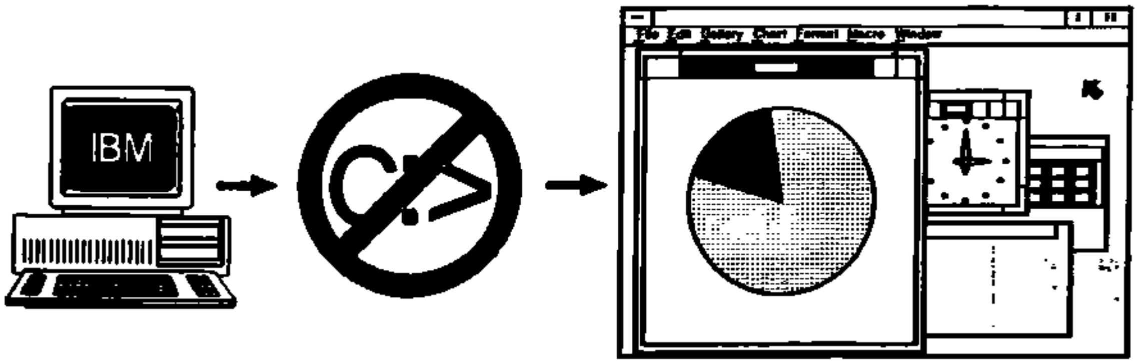
  Accessible direct hardware instructions
- NT windows operating system will ship in 1992
- Portable PCs will be 50% of 1995 units
- Desktop stations will migrate to the same standards

LONG-TERM PLATFORM PROCESSOR OUTLOOK



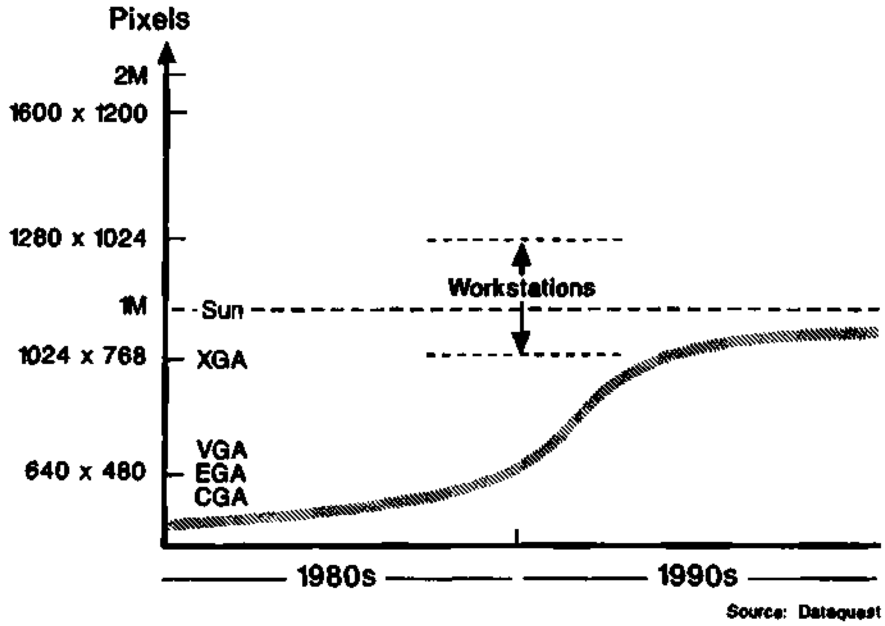
Source: Dataquest

PC USERS ARE MIGRATING TO GUIs



Notes:

DESKTOP GRAPHICS RESOLUTION TRENDS



DESKTOP GRAPHICS STRATEGIES MERGE

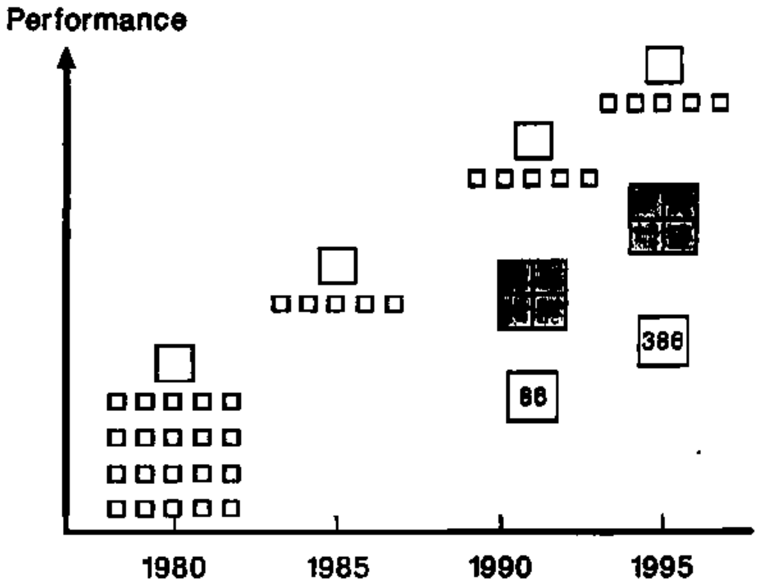
	CPU →	Rasterizer →	Memory →	Display
Entry Workstations:	RISC	Custom	VRAM	1M pixels
Performance PCs:	CISC	XGA or AcVGA	VRAM DRAM	1M pixels

TRENDS IN MICROPERIPHERAL STANDARDS

Networking →	Ethernet (Token-Ring on certain IBM desktops)
Storage →	SCSI (IDE on low-end desktops)
Graphics →	XGA and accelerated VGA (Custom on high-end desktops)
Bus →	ISA (EISA and MCA for high-end desktops)

Notes:

INCREASING LEVELS OF INTEGRATION



Source: Dataquest

SUMMARY & CONCLUSIONS

- PC architectures are rapidly changing
- RISC processors will eventually lead
- Graphics technology is now critical
- Microperipheral standards are solidifying
- Systems integration is moving to the semiconductor level

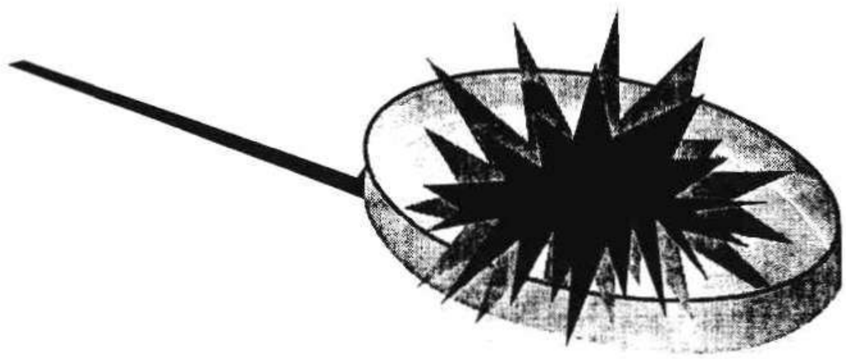
Notes:

Mass Storage

Phil Devin
Disk Drives

Nick Samaras
Applications

FLASH MEMORY



FLASH SEMICONDUCTOR DISKS

- Take less power than RDDs
- Are faster to access than RDDs
- Do not require battery to hold data on power down
- Have good industry standards for interconnect

"Pretty soon, nobody will make a 10MB or 20MB hard disk. The cards will eat into the disk drive market from below."

Lou Hebert
Product Manager, Intel Corporation
July 7, 1991

Notes:

LOOK OUT, DISK DRIVES!

August 1991 Prices

	Capacity (MB)	OEM Price ($)	End-User Price ($)	Technology
Intel	4	650		Flash card
Poqet	4		1,400	Flash card
3M	4		10	Diskette, 3.5"
Seagate	40	132	179	3.5" disk drive
Seagate	420	680	1,200	3.5" disk drive
Syquest	44		79	Disk cartridge
Syquest	44		330	Disk drive

FLASH SEMICONDUCTOR DISKS

- Cost 100x more than RDDs
- Are 30x slower to update than RDDs
- Wear out and must be replaced after 100,000 updates

SUMMARY

- If you need flash – you will pay for it
- Broad acceptance as mass storage in portable computing impossible because of price

Notes:

Mass Storage

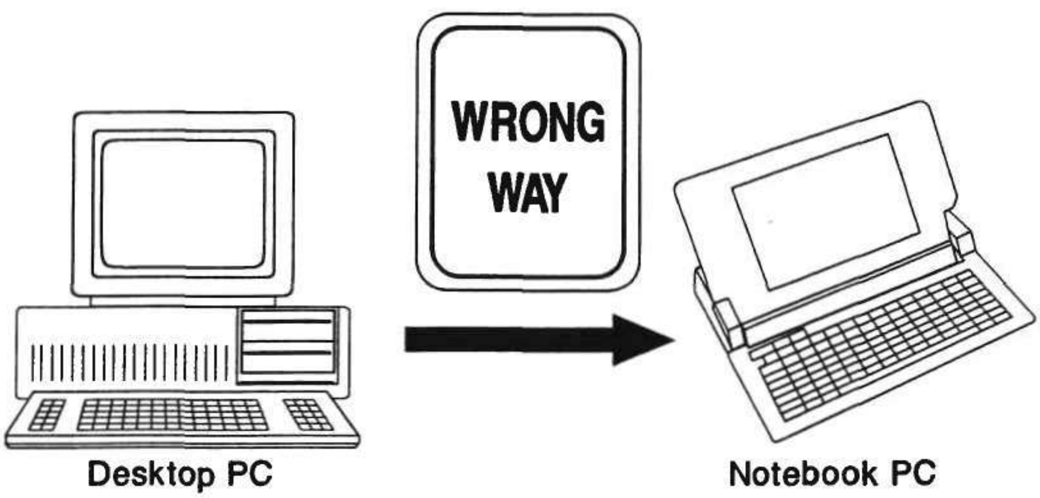
Phil Devin
Disk Drives

Nick Samaras
Applications

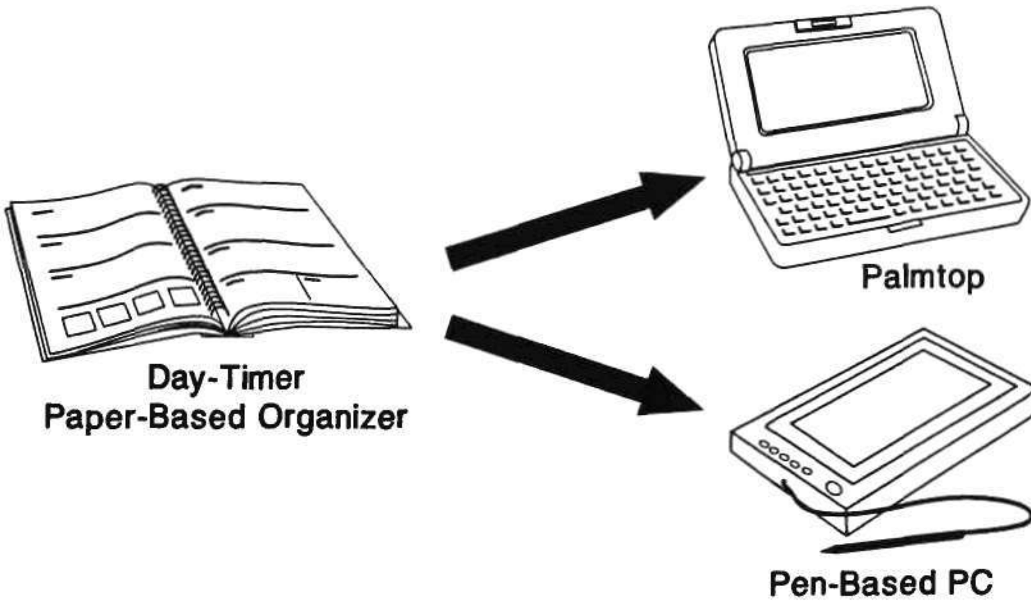
AGENDA

- RDD perspective
- Semiconductor perspective
- Conclusions

DOWNSIZING

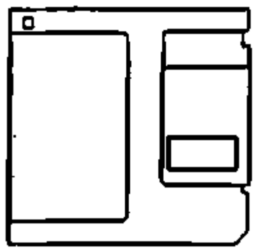


EMULATION OF FUNCTION



Notes:

THE COST OF USING INFORMATION



3.5" Floppy

Memory Card

	Cost
Floppy:	$1
Notebook:	$3,000
Total	$3,001

	Cost
Memory Card:	$300
Palmtop:	$600
Total	$900

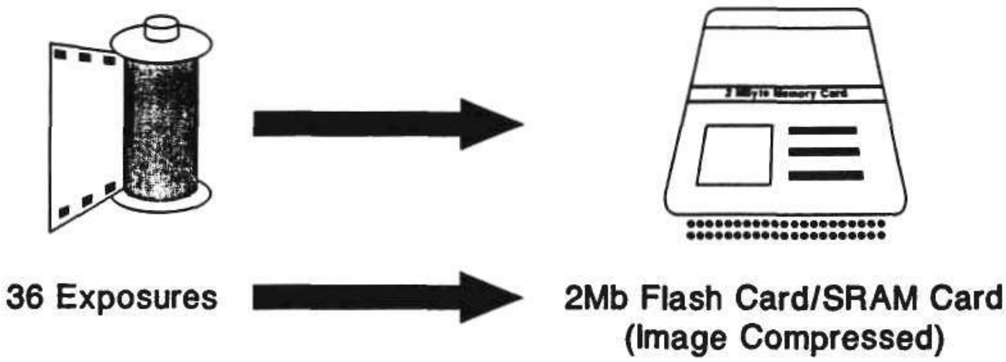
The Floppy Is More Expensive!

CONCLUSIONS

- SSD will not replace RDD
- Memory cards are an enabling technology
- Growth in storage will come from new markets

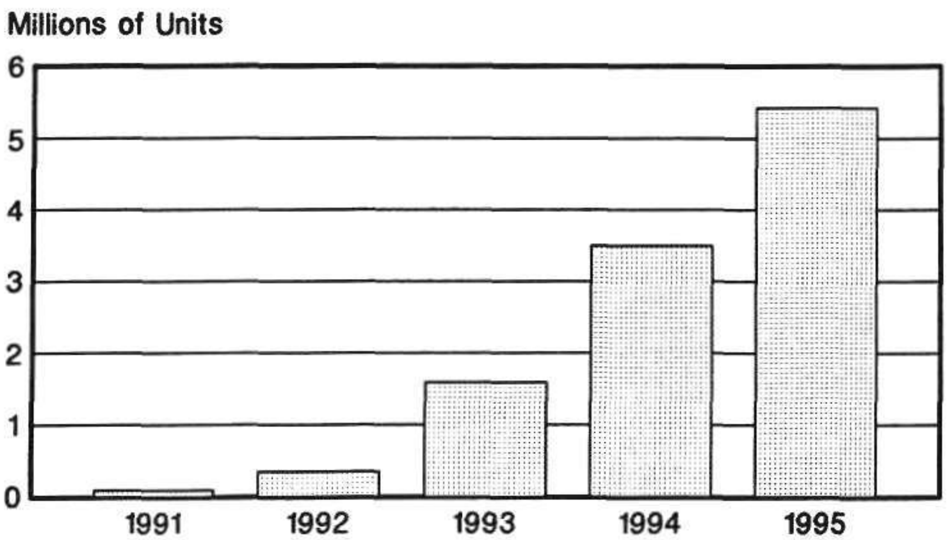
Notes:

ELECTRONIC PHOTOGRAPHY



PEN-BASED PCs

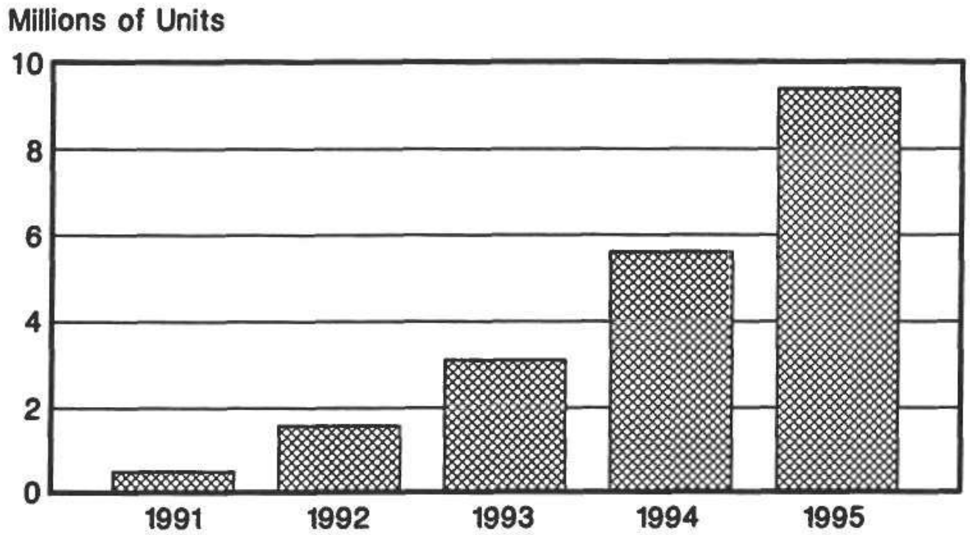
Worldwide Forecast



Source: Dataquest

HAND-HELD PCs

Worldwide Forecast



Source: Dataquest

Notes:

Flat Panel Displays

Joe Grenier
Technology

Katherine Bull
Market Issues

AGENDA

- Flat panel display overview
- Thin film transistor AMLCDs
- Strategic importance of display technology
- Summary

Flat Panel Displays--Overview

ADVANCED DISPLAY TYPES

- CRT (1887)
  - Conventional
  - Flat
  - Field Emission Display (FED)
- Plasma (1964)
  - AC plasma
  - DC plasma
- Electroluminescent (EL) (1936)
  - AC thin film
  - DC thick film
- Liquid crystal technology (1889)
  - Passive
  - Active matrix

Source: Dataquest

Notes:

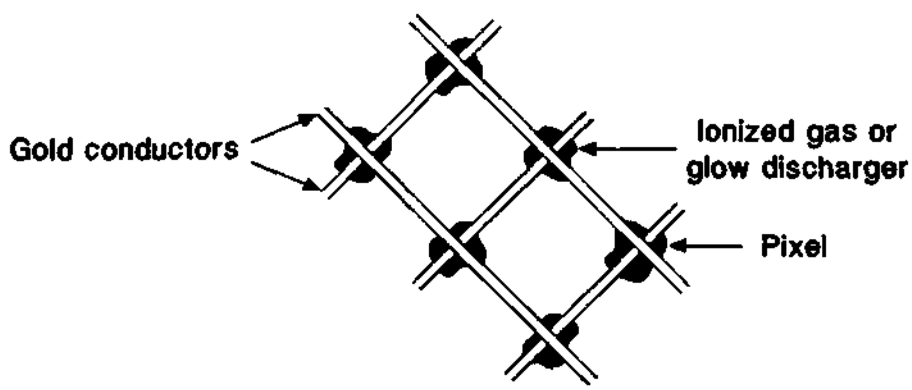
LIQUID CRYSTAL DISPLAY TYPES

- Passive
  - Twisted nematic (TN)
  - Super twisted nematic (STN) (DSTN)
  - Ferroelectric liquid crystal (FLC)
  - Others
- Active matrix
  - 2 or 3 terminal diode elements
  - Thin film transistor (TFT) element
    - Amorphous silicon TFT
    - Polysilicon TFT

Source: Dataquest

PLASMA FLAT PANEL DISPLAY

Monochrome

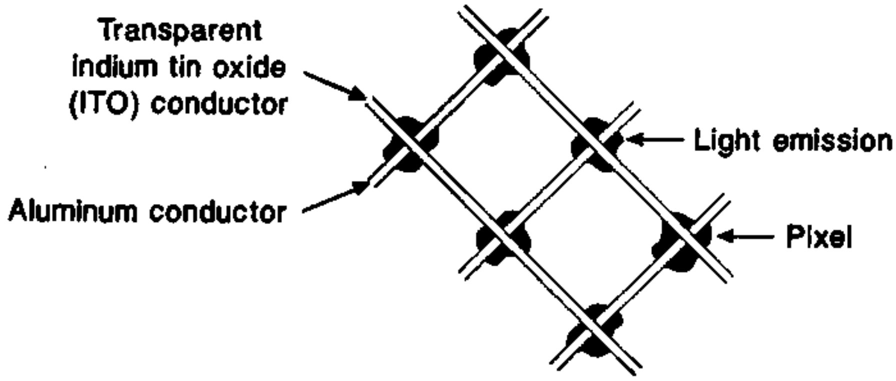


An electric field applied between conductors creates a plasma, or glow, discharge at intersections of conductors.

Source: Dataquest

ELECTROLUMINESCENT (EL) FLAT PANEL DISPLAY

Monochrome



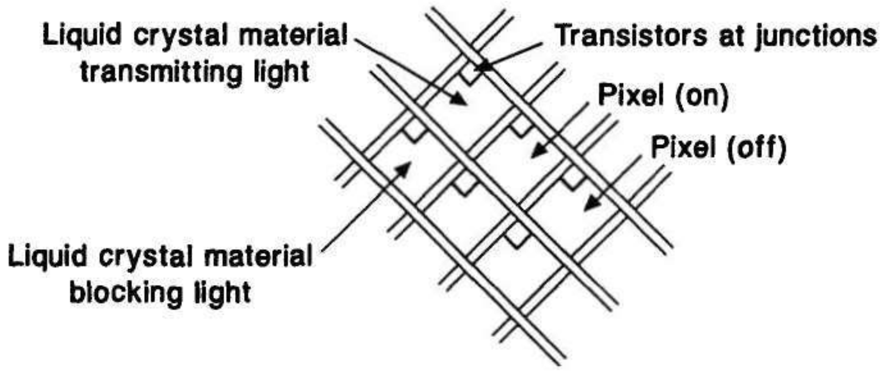
An electric field applied between conductors creates light emission from the solid crystalline material at intersections of conductors.

Source: Dataquest

Notes:

THIN FILM TRANSISTOR (TFT) ACTIVE MATRIX LCD FLAT PANEL DISPLAY

Monochrome

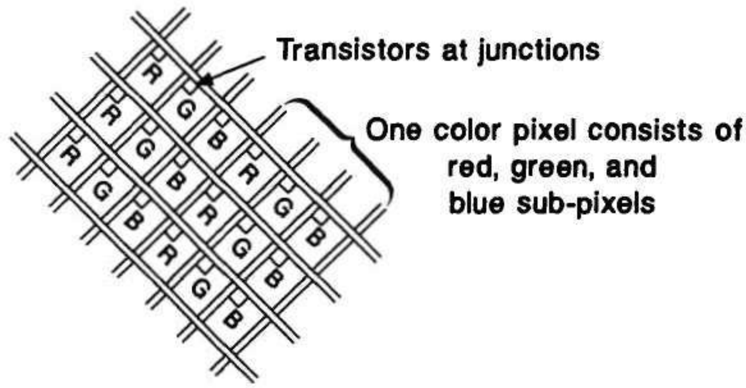


When the transistor is switched, light is either transmitted or blocked by the liquid crystal material.

Source: Dataquest

THIN FILM TRANSISTOR (TFT) ACTIVE MATRIX LCD FLAT PANEL DISPLAY

Color



Red, green, and blue sub-pixels are switched to give the range of colors required.

Source: Dataquest

FLAT PANEL DISPLAY STATUS--PLASMA

- Monochrome only, red-orange
- Large size to 1.5M diagonal (2,048 x 2,048 pixels)
- Rugged, long life
- High brightness and contrast ratio
- Very wide viewing angle
- Applications
  - High-performance laptops
  - Military
  - Avionics
  - Instrumentation
- Color under development
- Low R&D investment versus LCDs
- U.S.: Plasmaco, Photonics, Electro Plasma
- Japan: Matsushita
- Europe: Thomson Tubes Electroniques

Source: Dataquest

Notes:

FLAT PANEL DISPLAY STATUS--ELECTROLUMINESCENCE

- Monochrome only (amber)
- Sizes to 17.8" diagonal (1,024 x 864 pixels)
- Rugged, long life, wide temperature range
- Wide viewing angle
- Applications
  - Military
  - Avionics
  - Biomedical instrumentation
  - Industrial electronics
  - Telecom
  - Laptops
- 2-color displays being introduced, 3-color under development
- U.S.: Cherry, Planar (will have color display 1992)
- Japan: Matsushita, NEC, Sharp (all have 2-color displays)
- Few developers, very low investment versus LCD

Source: Dataquest

FLAT PANEL DISPLAY STATUS-- COLOR THIN FILM TRANSISTOR AMLCDs

- Size: 10.4" diagonal
- Red, green, blue subpixels
- Standard resolution: (640 x 3) x 480 = 921,600 pixels
- High resolution: (1,120 x 3) x 780 = 2,620,800 pixels (Hitachi)
- 5-micron transistors, redundant matrix
- 8 mask levels
- Cost: $2,000 to $3,500 (including drivers)
- U.S.: OIS Optical Imaging Systems
- Japan: Hitachi, Toshiba, Sharp, NEC, Matsushita, Hosiden
- Enormous investment in Japan ($1 billion in 1990)

Source: Dataquest

Color Thin Film Transistor Active Matrix LCDs

Notes:

TFT AMLCD MANUFACTURING ISSUES

- Intense competition among Japanese color AMLCD producers
  - Cost is driver
  - Short window of opportunity
- Substrate yields, defect density, throughputs highly confidential
- Redundant matrix to increase yields
- Substrate inspection and repair will be key
- Manufacturers will strive toward 100% substrate yield
  - Clean rooms and clean processing equipment important
  - Automation may be key

Source: Dataquest

PROCESS EQUIPMENT REQUIRED FOR TFT AMLCD MANUFACTURING

- LCD Fabrication
  - Lithography
  - Photoresist processing
  - Etch and strip
  - CVD
  - PVD
  - Ion implantation
  - Furnace
- Inspection
  - Prober
  - Test
  - Repair

Source: Dataquest

JAPANESE EQUIPMENT VENDORS FOR FABRICATION OF ACTIVE MATRIX LCDs

- Anelva
- Canon
- Chuo Riken
- Dainippon Screen
- Enya
- Hakuto
- Hitachi
- Kaijo
- Kuwano
- Kyowa Riken
- M-Setek
- Nikon
- Osada Vacuum
- Pilot Seiko
- Plasma Systems
- Samco
- Sankyo
- Shimada
- Shimazu
- Sigma Giken
- Tazmo
- Tokudo
- Tokyo Electron
- Tokyo Ohka
- Ulvac

Source: Dataquest

Notes:

U.S. AND EUROPEAN VENDORS FOR FABRICATION OF ACTIVE MATRIX LCDs

Aktis Corporation	Rapid thermal processing	United States
ASM International	Deposition	Netherlands
Applied Materials	Deposition	United States
Convac	Photoresist processing	Germany
Hamatech	Photoresist processing	Germany
Insystems	Inspection	United States
KLA Acrotec	Inspection	U.S./Japan Joint Venture
Leybold-Hereaus	Deposition	Germany
Machine Technology	Track	United States
Micrion	Repair	United States
MRS	Lithography	United States
Photon Dynamics	Inspection/repair	United States
Plasma-Therm	Dry etch	United States
Semitool	Wet process	United States
Watkins-Johnson	Deposition	United States

Strategic Importance of Displays

ADVANCED DISPLAYS AS SUBSYSTEMS

Display Panel	• Various flat panel manufacturers
+	
Display Drivers	• Driver chips made by semiconductor manufacturers
+	• Attached to panel with COG or TAB technologies
Display Electronics	• Smart electronics for display made by semiconductor manufacturers, i.e., Chips & Technologies' flat panel controllers

Displays will be a subsystem embodying not only display technology, but IC technology as well.

Source: Schlam, Dataquest

Notes:

ADVANCED DISPLAYS ARE A STRATEGIC TECHNOLOGY

- Display of choice in future will be flat panel
- Displays will be a very important product differentiator
- Displays will be high-value-added subsystems
- Displays will be larger percentage of total electronic systems cost
- Displays will drive other technologies
  - Assembly/packaging (COG, TAB)
  - Manufacturing equipment
  - Smart chips, drivers
- Humans are visual animals

Success in the electronics industry will depend more and more upon the display subsystem.

Source: Hart, Dataquest

ADVANCED DISPLAYS ARE A STRATEGIC TECHNOLOGY

- Before
  - Build the electronic system and add the display
- Now
  - Design the electronic system around the display

Source: Dataquest

JAPANESE STRENGTHS IN DISPLAY TECHNOLOGY

- Huge investment in color TFT AMLCDs
- Great variety of applications for AMLCDs, particularly in consumer area, laptops
- Strong consensus in Japan on the strategic importance of displays, particularly AMLCDs
- Strong IC industry
- Strong equipment industry
- Vertical integration of electronic equipment companies

Source: Hart, Dataquest

Notes:

U.S. PRESENCE IN DISPLAY TECHNOLOGY

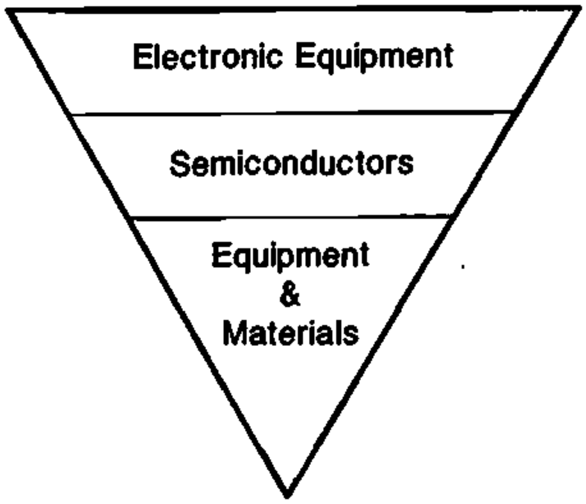
- Investment in AMLCDs is in the noise
- Competitive in plasma displays and a leader in EL displays
- Investment too low in plasma and EL; development may be too slow to compete with AMLCDs
- HDTV--Plasma, EL, AMLCD all contenders, but AMLCD may win, because of huge investment in Japan
- Xerox and Sarnoff Labs
- Various DARPA projects
- National Information Display Laboratory (NIDL)

Source: Hart, Dataquest

Summary

ELECTRONICS INDUSTRY FOOD CHAIN

Old



Source: Dataquest

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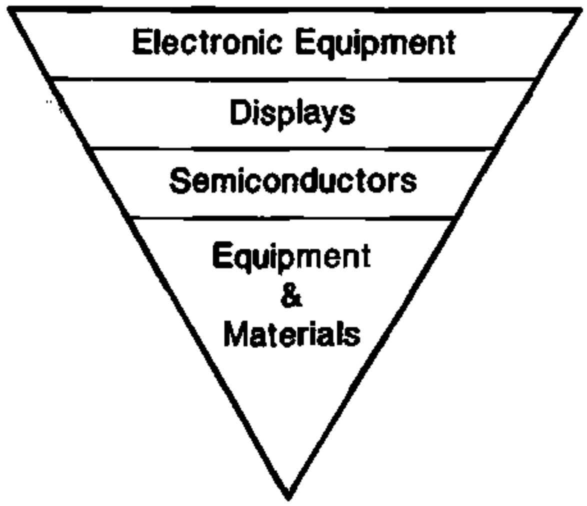
Notes:

ELECTRONICS INDUSTRY FOOD CHAIN

New



Source: Dataquest

Notes:

Flat Panel Displays

Joe Grenier
Technology

Katherine Bull
Market Issues

AGENDA

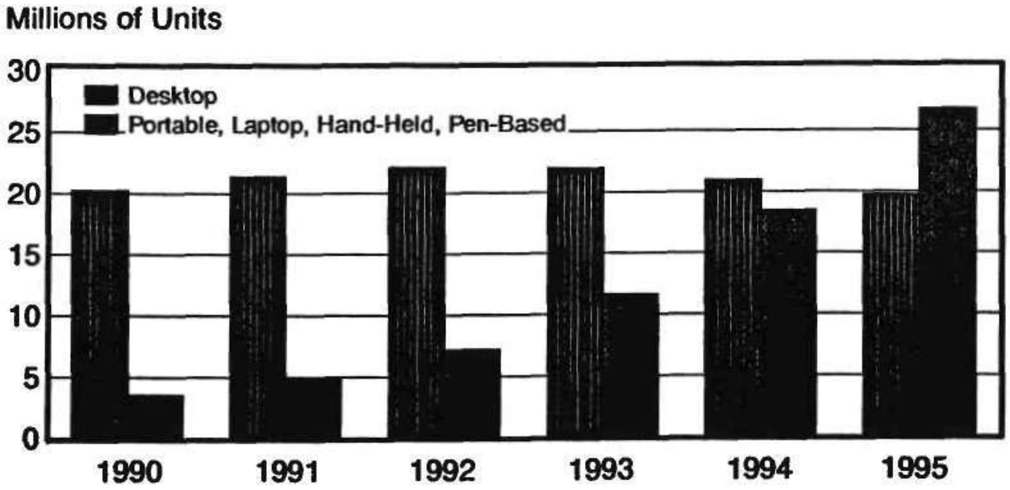
- What is driving the market?
- What is restraining the market?
- Flat panel displays versus CRT displays
- Summary

MARKET DRIVERS

- Explosive growth in portable computers
- Japanese investment in all aspects of display technology
- Electromagnetic emissions???

MARKET DRIVERS

1990-1995 Estimated Worldwide
Personal Computer Unit Shipments



Source: Dataquest

Notes:

MARKET DRIVERS

Features

- Compactness and portability
  - 14-inch color CRT monitor = 35 lbs.
  - 10-inch color AMLCD laptop = 17 lbs.
- Battery power
- Low power consumption
  - CRT monitor = high power @ 100 watts
  - Active matrix = low power @ 10-20 watts
  - Passive matrix = lower power @ 3-5 watts

MARKET DRIVERS

Japanese Presence in All Aspects of Display Technology

Company	CRT	LCD	AMLCD	EL	Plasma	Systems	IC
Citizen		X				X	
Fujitsu					X	X	X
Hitachi	X	X	X			X	X
Hosiden		X	X				X
Kyocera		X	X			X	
Mitsubishi	X					X	X
Matsushita	X	X	X		X	X	X
NEC	X	X	X		X	X	X
Oki					X		X
Optrex		X					
Sanyo Electric		X	X			X	X
Seiko Epson		X	X			X	X
Sharp		X	X	X		X	X
Sony	X	X	X			X	X
Toshiba	X	X	X		X	X	X

Source: Dataquest

MARKET DRIVERS

Electromagnetic Emissions???

- Accelerated end-user concern
- Driven by Swedish recommendation
- CRTs will comply within 1-2 years

Notes:

MARKET RESTRAINTS

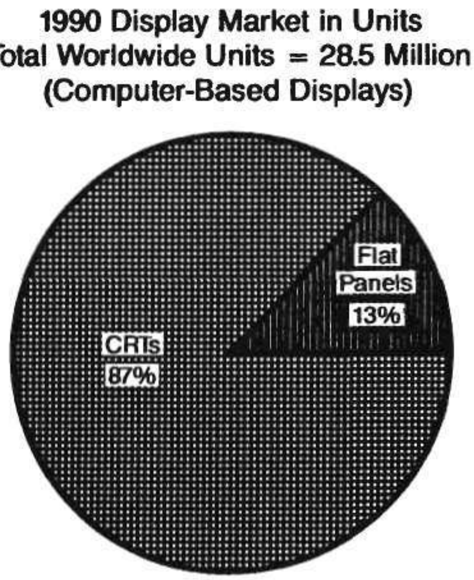
- Yields
  - 1990 = 5%-10% (?)
  - 1991 = 10%-30% (?)
- Manufacturing cost
  - 14-inch color CRT = $40-$60
  - 10-inch color AMLCD = $2,000-$3,000
- Price to end user
  - 14-inch 640x480 color monitor = $325
  - 10-inch 640x480 color AMLCD = $3,000-$3,500

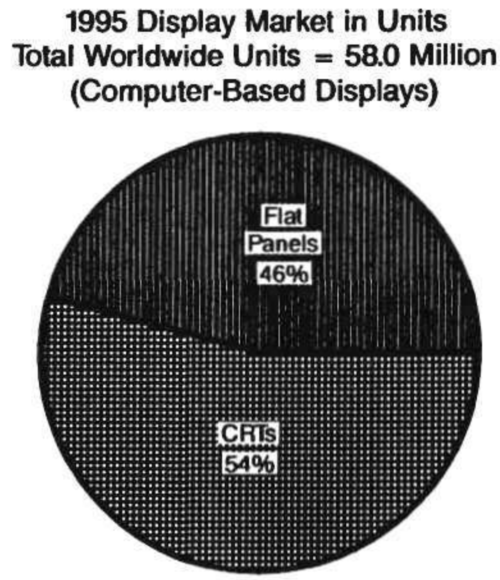
Source: Dataquest

MARKET RESTRAINTS

- Limitations in use for desktop
  - Size
  - Display quality
  - Windows 3.X
  - GUIs
  - Cost of color

FLAT PANELS VERSUS CRTs



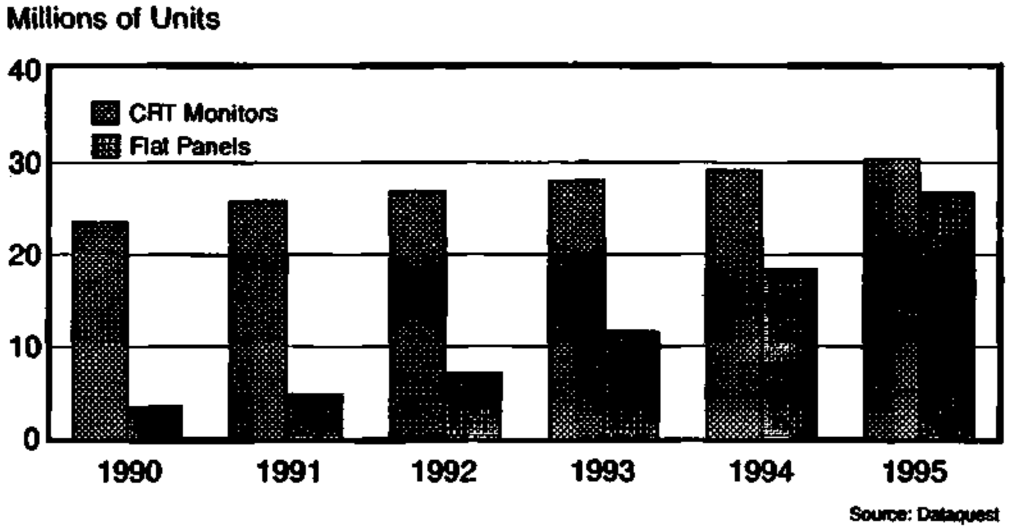


Source: Dataquest

Notes:

FLAT PANELS VERSUS CRTs

1990-1995 Estimated Worldwide Display Unit Shipments
(Computer-Based Displays)



FLAT PANELS VERSUS CRTs

CRTs still dominate because of:

- Screen size advantage
- Cost to manufacturer
- Price to end user
- Display quality

SUMMARY

Today

- Flat panel displays do not compete with CRT displays

Notes:

SUMMARY

Future

- Japan will remain market leader in display technology
- CRTs will continue to dominate the desktop because of cost
- CRTs and flat panels will address separate markets and differing applications
- If yields and cost can be improved, flat panels could encroach upon the dominance of CRTs on the desktop

Notes:

SPEAKERS AND MODERATORS

Jerry Banks

Mr. Banks is a Principal Analyst/Director for Dataquest's Semiconductor Group. He is responsible for analyzing the general semiconductor market and future technology trends. Prior to joining Dataquest, Mr. Banks spent 12 years in the electronics industry in various marketing and engineering roles. Most recently, he was Product Marketing Manager for WaferScale Integration Inc. During his four years there, Mr. Banks was responsible for international marketing/sales support and product planning for the company's high-performance NVM and ASIC product lines. Before joining WaferScale, he held marketing and applications engineering positions at Signetics Corporation and engineering positions at Hewlett-Packard Company and Hughes Aircraft Company. Mr. Banks received a B.S. degree in Electrical and Electronic Engineering from California State University at Sacramento.

Dr. Craig Barrett

Dr. Barrett is Executive Vice President of Intel Corporation. In that capacity, he is responsible for the company's internal operations. Previously, Dr. Barrett was General Manager of Intel Corporation's Microcomputer Components Group; prior to that, he was responsible for all component technology development and manufacturing there. Before joining Intel, Dr. Barrett was an Associate Professor of Materials Science at Stanford University and a Fulbright Fellow at Danish Technical University in Denmark. Dr. Barrett received his B.S., M.S., and Ph.D. degrees in Materials Science from Stanford University.

Howard Z. Bogert

Mr. Bogert is a Senior Staff Analyst in Dataquest's consulting organization. He specializes in multichip modules, semiconductor manufacturing trends, and emerging technologies. Mr. Bogert developed the concept of ASICs; and under his direction, Dataquest was the first market research company to follow that market. During his 31 years in electronics, Mr. Bogert has held management positions in market research, product planning, long-range planning, research and development, and engineering. Mr. Bogert holds six patents in the MOS VLSI field, and he developed the first MOS circuit to use charge storage. He was also an early contributor to the design of linear integrated circuits. Mr. Bogert received a B.S. degree in Electrical Engineering from Stanford University, an M.S. degree from the University of Maryland, and an M.B.A. degree from the University of Santa Clara.

Ronald A. Bohn

Mr. Bohn is an Industry Analyst for Dataquest's Semiconductor Procurement service, responsible for research and analysis in semiconductor pricing trends and lead times. He assesses semiconductor life cycles and the supplier base from a purchasing and component engineering perspective. He has developed a database listing the top-ranked electronic equipment producers' purchasing locations by application market, which serves as the survey base for Dataquest's Supplier of the Year awards. Prior to joining Dataquest, Mr. Bohn was with a market research firm involved in analysis of worldwide markets for electronic components and systems. He was International Market Research Manager for the Korea Trade Center in the United States. Mr. Bohn received a B.A. degree from Cornell University, an M.B.A. degree from the University of California at Berkeley, and a J.D. degree from Hastings College of the Law.

Speakers and Moderators

Stan Bruederle

Mr. Bruederle is Vice President and Director of Semiconductor Custom Consulting at Dataquest. He is responsible for the company's semiconductor consulting program. Before joining Dataquest in 1982, Mr. Bruederle spent 10 years at Signetics Corporation and 5 years at Motorola Semiconductor Inc., where he held a variety of management positions in marketing and strategic planning. He has 17 years of engineering and marketing experience in the semiconductor industry. Mr. Bruederle received a B.A. degree in Electrical Engineering from the University of Wisconsin and has completed work toward an M.B.A. degree from Arizona State University.

Katherine M. Bull

Ms. Bull is an Industry Analyst in Dataquest's Graphics and Displays industry service. She has responsibility for the research and analysis of monitor products, markets, and vendors for the PC, Macintosh, and workstation platforms. Prior to joining Dataquest, Ms. Bull was the Market Analyst in the Computer Graphics Division at Nichimen America Inc., a Japanese import-export trading company. At Nichimen, she researched and wrote marketing reports on the worldwide computer graphics industry for the company's headquarters in Tokyo. Ms. Bull received a B.A. degree from the University of Notre Dame.

Gordon A. Campbell

Mr. Campbell is Founder, President, and Chief Executive Officer of Chips and Technologies Inc. His company supplies VLSI CHIPSets, firmware, and design services to manufacturers of personal computers. Prior to founding Chips, Mr. Campbell cofounded SEEQ Technology Inc., a manufacturer of electrically erasable memory technology. He served as SEEQ's President and Chief Executive Officer. Mr. Campbell is a 20-year semiconductor industry veteran, having held engineering, sales, and marketing positions at a variety of companies, including Intel Corporation, Intersil Inc., Honeywell Incorporated, and Motorola Incorporated.

Ron Collett

Mr. Collett is a Principal Analyst/Director of Dataquest responsible for application-specific IC (ASIC) and electronic design automation (EDA) research. He manages and directs all Dataquest ASIC and EDA research and consulting activities worldwide. Prior to joining Dataquest, Mr. Collett spent five years with *Electronic Systems Design* magazine as Senior Technical Editor. In that position, he reported on several areas of technology, including EDA, ASIC design, and microprocessor development systems. Previously, he was an editor with *Electronics Test* magazine. Before becoming a technical journalist, Mr. Collett held various engineering positions at GTE's Communication Systems Division. Mr. Collett received a B.S. degree in Electrical Engineering from Drexel University and a Law degree from Santa Clara University. He is an active member of the California State Bar.

Wilfred J. Corrigan

Mr. Corrigan is Chairman and Chief Executive Officer of LSI Logic Corporation. Previously, he was President, Chairman, and Chief Executive Officer of Fairchild Camera and Instrument Corporation. Mr. Corrigan joined Fairchild in August 1968 and held a series of management positions before becoming President and CEO in July 1974 and becoming Chairman in May 1977. Prior to his positions at Fairchild, Mr. Corrigan was Director of Transistor Operations at Motorola Incorporated's Semiconductor Products Division in Phoenix, Arizona. He is a member of the Board of Directors of Silicon Power Corporation and LucasArts Entertainment Company. Mr. Corrigan received a B.Sc. degree in Chemical Engineering from the Imperial College of Science, London, England.

Phil Devin

Mr. Devin is Principal Analyst/Director of Dataquest's Computer Storage industry service. His primary responsibility is analysis of small-diameter rigid disk drives in the computer storage industry. He also handles company analyses, consulting reports, and client projects. Mr. Devin has 27 years of experience in the computer industry, in positions ranging from early process control system design to marketing management in the computer storage industry. He has been an active member of ANSI subcommittees. Mr. Devin received a bachelor's degree in Engineering from Iowa State University.

Dr. Jonathan P.V. Drazin

Dr. Drazin is a Senior Industry Analyst for Dataquest's European Components Group, European Semiconductor Application Markets service, based at Denham, England. Prior to joining Dataquest, Dr. Drazin was a Principal Research Engineer for STC Technology Limited in Harlow, where he worked on VLSI design and semiconductor process characterization. Previously, he was a post doctoral fellow at Imperial College, London, where he researched e-beam lithography. Dr. Drazin has a B.Sc. degree in Physics and a Ph.D. degree in Semiconductor Materials from Imperial College, London. He also holds an M.B.A. degree from City Business School, London, and is a member of the Institution of Electrical Engineers.

Hideharu Egawa

Mr. Egawa is Senior Vice President and Director of the Board of Toshiba Corporation, as well as Group Executive of the company's Semiconductor Group. Since joining Toshiba in 1955, he has held various manufacturing and management positions including Group Executive of Technology for the Semiconductor Group, General Manager of the Integrated Circuit Division, and Vice President and Group Executive of the Semiconductor Group. Mr. Egawa graduated from the Department of Engineering at the University of Tokyo.

Mark F. FitzGerald

Mr. FitzGerald is a Senior Industry Analyst for Dataquest's Semiconductor Equipment, Manufacturing, and Materials service. He is responsible for research and analysis of semiconductor materials. Prior to joining Dataquest, Mr. FitzGerald was Western Region Sales Manager for Materials Technology, a manufacturer of epitaxial susceptors and high-performance ceramic coatings. Previously, he worked as an Application Chemist in the Applied Research and Development Department of the Semiconductor Group at Air Products and Chemicals Inc. and as a Research Chemist in Exxon Corporation's Long Range Research Group. Mr. FitzGerald received a B.A. degree in Literature and a B.S. degree in Chemistry from McGill University in Montreal, Canada, and an M.B.A. degree from Duke University in Durham, North Carolina.

Mark A. Giudici

Mr. Giudici is Principal Analyst/Director for Dataquest's Semiconductor Procurement service. He is responsible for worldwide research of semiconductor costs and of strategic semiconductor procurement practices and issues. He supports the semiconductor procurement, component, and design engineering functions of client electronic system companies. Prior to joining Dataquest, Mr. Giudici spent eight years in the computer and semiconductor industries, where he held a variety of financial and marketing positions. Most recently, Mr. Giudici was a Product Marketing Engineer with Gould-America Microsystems Inc., where he was responsible for cost modeling and marketing semicustom and custom semiconductor components. Mr. Giudici received a B.S. degree in Business Administration from California State University at Chico and an M.B.A. degree in Business Management from the University of Oregon.

Gary Grandbois

Mr. Grandbois is a Senior Industry Analyst for Dataquest's Semiconductor Group. His responsibilities include market research and product, market, and industry analysis for analog and mixed-signal products. Mr. Grandbois has extensive experience in the semiconductor industry in both the application engineering and marketing areas. He has held positions as Applications Manager at Siliconix Inc., Product Marketing Manager at Precision Monolithics Inc., and Vice President of Marketing/Sales at Teledyne Semiconductor. Mr. Grandbois received B.S.E.E. and M.S.E.E. degrees from San Jose State University.

Joseph Grenier

Mr. Grenier is Director of Dataquest's Manufacturing and Applications Group. He is responsible for managing the research activities of the Semiconductor Equipment, Manufacturing, and Materials service; the Semiconductor Application Market service; and the Semiconductor Procurement service. Prior to joining Dataquest, Mr. Grenier was Product Marketing Manager at GCA Corporation, where he managed marketing activities for the reactive ion etch program. He was also International Marketing Manager at GCA and was responsible for the overseas marketing of wafer processing equipment. Previously, he worked as a Product Manager at Varian Associates/Instrument Division, as a Systems Engineer at the USAF Satellite Test Center, and as a Test Engineer at General Motors' Noise Vibration Laboratory. Mr. Grenier received a B.S.E.E. degree from the University of Detroit and an M.B.A. degree from the University of Santa Clara.

John B. Jackson

Mr. Jackson is Vice President and Director of Dataquest's Semiconductor Components Group. He is responsible for managing and directing Dataquest's semiconductor industry research and analysis. Mr. Jackson has been with Dataquest for nine years and has held a variety of positions in sales management and marketing, including that of Sales Vice President. Prior to joining Dataquest, he held positions in sales and marketing at Signetics Corporation and Burroughs Corporation. Mr. Jackson received a B.A. degree in Economics from California State University at Fullerton and an M.B.A. degree from Pepperdine University.

Kenneth A. Lowe

Mr. Lowe is a Senior Industry Analyst for Dataquest's Semiconductor industry service, specializing in microcomponents. He is responsible for research, analysis, and forecasting of microprocessors, microcontrollers, and microperipherals (including controllers for graphics, networks, and storage). Previously, he was Dataquest's Senior Industry Analyst for graphics processors. Prior to joining Dataquest, Mr. Lowe was President of Performix Technology, a start-up company that developed and marketed Windows graphics accelerator boards for PCs. Mr. Lowe has more than 12 years experience in the electronics industry, having served in marketing management positions at Sigma Designs Inc., Wyse Technology Inc., Personal CAD Systems Inc., and the Design & Test Systems Division of Gould Inc. He also served as a hardware design engineer for microcomputer-based test systems at Watkins-Johnson Company. Mr. Lowe received a B.S. degree in Electronic Engineering from California Polytechnic State University.

David C. Nagel

Dr. Nagel is Vice President for Advanced Technology at Apple Computer, directing research and strategic planning for future products and applications. Dr. Nagel's group develops new hardware and software technologies, and his role in strategic planning is to tailor the company's research effort in ways that best fit Apple's future direction. His group also focuses on process technologies to help Apple's design and manufacturing teams produce products more efficiently. Dr. Nagel has been instrumental in petitioning the FCC to allow radio frequencies to be used for wireless data communications, which will permit high-capacity computer information to be shared among people using personal computers. Previously, he was a research scientist and head of the Aerospace Human Factors Research Division at NASA Ames Research Center. Dr. Nagel holds undergraduate and graduate degrees in engineering and a Ph.D. in Experimental Psychology from the University of California at Los Angeles.

L.S. (Stagg) Newman

Mr. Newman is Assistant Vice President for Advanced Products and Technology Laboratories at Pacific Bell. His organization develops new services and products and analyzes technology trends and opportunities. Previously, he was Assistant Vice President of Technology for Pacific Telesis Group. Prior to that, Mr. Newman was Manager of the Data Communications Technology Division, which produced the technical requirements for packet switching networks, ISDN, BISDN, and switched multimegabit data services at Bellcore, the research and engineering arm of the regional telephone companies including Pacific Bell. He formerly managed the Broadband Service Concepts, which worked on new services for the communications highway of the future including high-speed data, high-definition television, intelligent network services, and multimedia services. He also headed the Network Performance Division, which was responsible for setting performance objectives for network telephone services, designing new testing methods and systems, and measuring network performance. Previous assignments with Bellcore and, before divestiture, with Bell Laboratories were in systems engineering for data switching and electronic toll switching and in development and field testing of network fault detection. Mr. Newman was an assistant professor at Baruch College of C.U.N.Y. before joining Bell Labs. Mr. Newman received a B.S. degree in Mathematics from Davidson College and both M.S. and Ph.D. degrees in Mathematics from Cornell University.

Gene Norrett

Mr. Norrett is Corporate Vice President and Director of Marketing for Dataquest. Previously, he was Vice President and General Manager of the Technology Information Division, with additional responsibility for managing the Ledgeway Group, a new Boston-based subsidiary of Dataquest focusing on the information needs of the support and service industry. Prior to this position, he was Vice President of the Semiconductor Group, responsible for worldwide semiconductor research. Mr. Norrett joined Dataquest in 1982 to initiate the Japanese Semiconductor industry service. Before joining Dataquest, he spent 14 years with the Motorola Incorporated Semiconductor Product Sector, serving in various marketing and management positions. Mr. Norrett received a B.A. degree in Mathematics from Temple University and an M.S. degree in Applied Statistics from Villanova University.

Geno Ori

Mr. Ori is Senior Vice President and Director of Customer Relations, Motorola Semiconductor Products Sector, Motorola Incorporated. He has held several managerial positions at Motorola including Senior Vice President, Discrete Semiconductor Group, which included bubble memories and electronic materials; Vice President and Semiconductor Group Director of Operations; and Vice President and General Manager, High-Frequency and Optical Products Division. Mr. Ori joined Motorola in 1963 as a marketing trainee, later becoming a Product Service Engineer in germanium transistor product marketing, a Group Manager, a District Sales Manager, a Product Engineering Manager in small signal plastic transistors, and finally Operations Manager. Mr. Ori received a B.S.E.E. degree from the University of Utah and has completed some studies toward an M.B.A. degree from Arizona State University.

R. Gene Richter

Mr. Richter is Executive Director of Corporate Procurement at Hewlett-Packard Company. His central procurement team negotiates supplier contracts for approximately one-half the production components and materials used in Hewlett-Packard plants worldwide. Prior to joining Hewlett-Packard, Mr. Richter was Vice President of Purchasing for Black and Decker. He began his career at Ford Motor Company as a trainee buyer. During his tenure at Ford, Mr. Richter progressed through positions in cost analysis, production control, scheduling, worldwide coordination, and procurement. Mr. Richter received a B.S. degree from the University of Maryland and an M.B.A. degree from the University of Michigan.

Nicolas C. Samaras

Mr. Samaras is a Principal Analyst/Director in Dataquest's Semiconductor Group. He is responsible for both analyzing semiconductor consumption in data processing applications and tracking trends in nonvolatile memory products and markets. Previously, Mr. Samaras founded Telamon, a marketing and research firm specializing in the emerging smart card/memory card technology. Prior to that, he was Director of the Microcomputer Division of Catalyst Semiconductor Inc. During his tenure at Catalyst, he was the principal developer of a new serial EEPROM architecture (CAT35C704), which was named best of both 1988 and 1989 by *Electronic Design* magazine. Mr. Samaras received a B.S.E.E. degree from McGill University in Montreal, Canada. Currently, he is pursuing an M.B.A. at the University of Phoenix.

Dr. Steve Sazegari

Dr. Sazegari is a Principal Analyst/Director in Dataquest's Telecommunications Group. His major areas of responsibility include coverage of ISDN, Signaling System 7, intelligent networks, fiber optics, local loop carriers, public networks, video teleconferencing, wireless communications, enhanced services, packet data switching networks, RBOCs, independent telcos, and long distance carriers. In his more than 20 years of industry experience, Dr. Sazegari has worked for AT&T, Bank of America, Fujitsu America, Pacific Bell, US Sprint Communications Company, and US West. He also headed his own telecommunications consulting business for several years. Dr. Sazegari received a B.S.E.E. degree in Telecommunications and Computers from London University in England, an M.B.A. degree from Golden Gate University in San Francisco, and M.S.E.E. and Ph.D. degrees in Telecommunications and Computers from the Naval Post Graduate School in California.

Jeff Seerley

Mr. Seerley is an Industry Analyst for Dataquest's Semiconductor Equipment, Manufacturing, and Materials service. His primary responsibility is research and analysis of worldwide semiconductor manufacturers. Before joining Dataquest, Mr. Seerley was a Business Analyst for SEMATECH's competitive analysis organization, where he analyzed competitive information relative to semiconductor manufacturing. Previously, he worked at Rockwell International's Semiconductor Products Division as a Manufacturing Program Manager, with responsibility for directing the manufacturing activities within operations. He also worked for Intel Corporation in the area of manufacturing operations. Mr. Seerley received a B.S. degree in Management from Pepperdine University and an M.B.A. degree in Finance from Golden Gate University.

Speakers and Moderators

Andrew M. Seybold

Mr. Seybold is a Principal Analyst/Director of Computer Technologies for Dataquest. His responsibilities include in-depth analysis, evaluation, forecasting, and research of personal computer hardware and software products. He is also responsible for customized consulting focused on the microcomputer industry. With more than 21 years of experience in the computer and communications industries, he has authored many articles on microcomputers and a number of books about computers and communication. His particular areas of expertise include systems planning, implementation and applications, and software development and evaluation. He is considered an authority on laptop productivity and the portable personal computer market and was the cofounder of The Computer School in Los Angeles. Mr. Seybold received a B.S. degree in Electrical Engineering from Northwestern University.

Krishna Shankar

Mr. Shankar is a Senior Industry Analyst in Dataquest's Semiconductor Manufacturing and Applications Group. His responsibilities include market research and consulting in the areas of semiconductor manufacturing equipment, process technology trends, and semiconductor device applications in end-use electronic systems. Prior to joining Dataquest, Mr. Shankar was a Senior Process Engineer at Cirrus Logic, where he was responsible for foundry program management and evaluation of advanced CMOS foundry processes. Previously, he worked at Advanced Micro Devices in the areas of CMOS process development, device characterization, multilevel interconnect processes, and technology transfer of new processes from development fabs to production fabs. Mr. Shankar holds a B.S. degree in Chemical Engineering from the Indian Institute of Technology, an M.S. degree in Chemical Engineering from the University of Southern California, and an M.S. degree in Management from Stanford University.

Gregory L. Sheppard

Mr. Sheppard is a Senior Industry Analyst in Dataquest's Semiconductor Application Markets Group with responsibility for coordinating worldwide semiconductor applications research. Besides general applications trends, he specializes in workstation, large computer, military, automotive, and imaging (multimedia) applications. Prior to Dataquest, Mr. Sheppard worked at Fairchild Semiconductor Corporation as Corporate Manager of Business Analysis. He was also a board member of Worldwide Semiconductor Trade Statistics Inc. and Fairchild's liaison to the SIA and the AEA. Earlier, Mr. Sheppard was a Hardware Design Manager and a Systems Engineer at GTE Government Systems where he specialized in C3I systems, man-machine interfaces, and design of decision-aid systems. Mr. Sheppard received a B.S.E.E./C.S. degree from the University of Colorado and an M.S. degree in Systems Management from the University of Southern California.

Dr. William J. Spencer

Dr. Spencer is President and Chief Executive Officer of SEMATECH. Prior to SEMATECH, Dr. Spencer was Group Vice President and Senior Technical Officer in the Corporate Research Group at Xerox Corporation and, before that, Manager of the Integrated Circuit Laboratory of the Xerox Palo Alto Research Center. Dr. Spencer also served as Director of Systems Development at Sandia National Laboratories, Livermore, and Director of Microelectronics at Sandia National Laboratories, Albuquerque. He was a Research Professor of Medicine at the University of New Mexico School of Medicine and began his career at Bell Laboratories. He is chairman of the University of California at Berkeley Management of Technology Advisory Board and serves on advisory boards of the National Research Council, Carnegie Mellon University School of Computer Science, and Cornell University Engineering College. Dr. Spencer received an A.B. degree from William Jewell College and an M.S. degree in Mathematics and a Ph.D. degree in Physics from Kansas State University.

Thomas A. Thornhill III

Mr. Thornhill is Vice President and Senior Semiconductor Analyst for Montgomery Securities. He is responsible for analyzing industry and technology trends from both a macro and a micro perspective. His primary responsibility is related to company-specific investment analysis. Prior to joining Montgomery, Mr. Thornhill held a similar position with Lehman Brothers. He has been involved in technology analysis and specifically in semiconductor investment analysis for more that 10 years. Mr. Thornhill is a C.F.A. and received a B.A. degree from Grinnell College in Iowa and an M.B.A. degree from the Stanford Graduate School of Business.

Dr. Peggy Marie Wood

Dr. Wood is a Senior Industry Analyst for Dataquest's Semiconductor Equipment, Manufacturing, and Materials service. Her responsibilities include research and analysis of the semiconductor industry with respect to wafer fabrication equipment, electronic materials for semiconductor processing, and the technology trends of semiconductor manufacturing. Prior to joining Dataquest, Dr. Wood was a postdoctoral research affiliate in the Department of Chemistry at Stanford University. While at Stanford, she supervised the installation of new research facilities and was responsible for the purchase of optical, electronic, and laser equipment. In addition to pursuing her own research in nonlinear chemical dynamics, she taught undergraduate laboratory courses and supervised graduate student research. Dr. Wood received a B.S. degree in Chemistry from California State University at Sacramento and a Ph.D. in Chemistry from Stanford University.

Sam I. Young

Mr. Young is a Principal Analyst/Director of Worldwide Memory Research for Dataquest's Semiconductor Group with responsibility for directing and managing Dataquest's worldwide activities in memory research. He joined Dataquest from Performance Semiconductor where he was Manager of Memory Marketing. Prior to that, Mr. Young was a founder and Director of Marketing and Sales for Exel Microelectronics. He also held senior marketing or engineering positions at Hitachi America Ltd., Mostek Corporation, Unisys Corporation, and Raytheon Corporation. From 1977 to 1981, Mr. Young chaired the EIA JEDEC JC42 standards committee dealing with MOS, bipolar, and bubble memories. He has published more than 20 articles and papers including four cover stories in key electronics magazines and has organized, chaired, and presented technical papers at more than 10 technical sessions for the ELECTRO, WESCON, MIDCON, AND SOUTHCON program committees. Mr. Young received a B.S.E.E. degree from Pratt Institute and did work toward an M.B.A. degree at Seton Hall University.

ATTENDEES

Attendees

AT&T

David Duncan
Manager, Purchasing Integrated Circuits

E.N. Fuls
Manager, Intellectual Property

Bill Wiley Smith
Director, Program Products

Roger Stricker
Manager, Intellectual Property

C. J. Uhl
Manager, Engineering

AT&T Microelectronics

Ken Dando
Manager, Business & Operations Planning

Steve Sparks
Vice President, MOS Memory, Marketing & Development

Advanced Micro Devices, Inc.

David Bostwick
Director of Strategic Marketing

Advantest America, Inc.

Keith Lee
Group Business Manager

Michael A. Silverstein
Vice President, ATE Sales

Air Products & Chemicals, Inc.

Dean Duffy
International Marketing Manager, Electronic Division

Glenn Stewart
Area Manager, Western U.S.A., Electronic Division

Airco/BOC

Philip Blakey
Vice President, Electronics

Alcatel Information Systems

Jean Lemeumer
Manager, Purchasing Department

Alcatel-Bell Telephone

Julien De Wilde
Director, Strategy & Corporate Services

Alphagaz/Liquid Air Corporation

Grace Malley
Director, Marketing & Strategic Planning

Ambit-Acer

Kuang-Lu Lee
President

Analog Devices, Inc.

Tom Cate
Director, Strategic Programs

Anelva Corporation

Sanetada Mizumachi
General Manager

Apple Computer, Inc.

Heidi Hedlund
Purchasing Manager

Terry Kaspar
Manager, Semiconductor Group

David Nagel
Vice President, Advanced Technology Group

Applied Materials, Inc.

Don Fuller
Manager, Marketing Services

Noella Kwan
Market Industry Analyst

James M. Moriarity
Director, Corporate Marketing

Michelle Ryan
Manager, Investor Relations

Bechtel National, Inc.

John Henri
Manager, Microelectronics

Bipolar Integrated Technology, Inc.

Art Swift
Vice President, Marketing

Attendees

Burr-Brown Corporation
Michael Pawlik
Vice President, Marketing

Campbell and Associates
George H. Campbell
Chief Executive Officer

Canon USA, Inc.
Hiroshi Matsumoto
Manager, Sales Administration

Capital Associates International Inc.
Reza Saffarian
Assistant Vice President, Asset Management

Chips and Technologies, Inc.
Gordon A. Campbell
President & CEO

Cirrus Logic, Inc.
George Alexy
Vice President, Marketing
Michael Hackworth
President & CEO
Michael Liccardo
Vice President, Mass Storage Business

Comlinear Corporation
Wayne Lonowski
Director of Marketing

Compaq Computer Corporation
Larry Stringfellow
Purchasing Manager

Coopers & Lybrand
Michael Foley
Manager
Jon Wellman
General Practice Manager

Credence Systems
Jim Healy
President & COO
Greg Illes
Marketing Manager

Crestronics Company, Ltd.
Katsuhiko Ohara
President

Cymer Laser Technologies
Uday Sengputa
Vice President, Marketing

DAW Technology
Randy Schoeck
Marketing Procurement

DQ Alliances
Darwin Throne
Managing Director

Daiwa Institute of Research
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Dataproducts Corporation
Larry Nyi
Program Manager

Dataquest Europe Ltd.
Jonathan Drazin
Senior Industry Analyst

Dataquest Incorporated
Jerry Banks
Principal Analyst/Director
Howard Bogert
Senior Staff Analyst
Ronald Bohn
Industry Analyst
Stan Bruederle
Vice President/Director
Katherine Bull
Industry Analyst
Anna Cahill
Industry Analyst
Ron Collett
Principal Analyst/Director
Phil Devin
Principal Analyst/Director

Marc Elliot
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Gerald Streater
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K. W. Kim
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Union Carbide Industrial Gases Inc.

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Levy Gerzberg
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To

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Expense Record

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To

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Date	Description	Amount	Tax
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Meeting Notes

Date:	Notes:
Attendees:	
Attendees:	

Meeting Notes

Date:	Notes:
Attendees:	
Attendees:	

Dataquest

Dataquest is a leading market research and consulting company specializing in electronics industries. Dataquest has tracked the semiconductor industry since 1974. The Semiconductor Group develops, maintains, and updates databases that cover the total spectrum of semiconductor products and markets.

The company collects, interprets, and analyzes data from our offices in Japan, England, Taiwan, and Korea, as well as San Jose, California, in order to provide country-by-country, regional, and global perspectives to our research.

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Japanese Emerging Fabs: Capital Investment Analysis
Multichip Modules: Issues and Trends

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Focus: Semiconductor industry trends

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Focus: *DQ Monday*, semiconductor industry trends

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Focus: Analog, mixed-signal ICs, semiconductor packaging, gallium arsenide semiconductors, semiconductor industry trends

Jim Handy
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Trip Report

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