March 1982

Engineering Strategy Overview

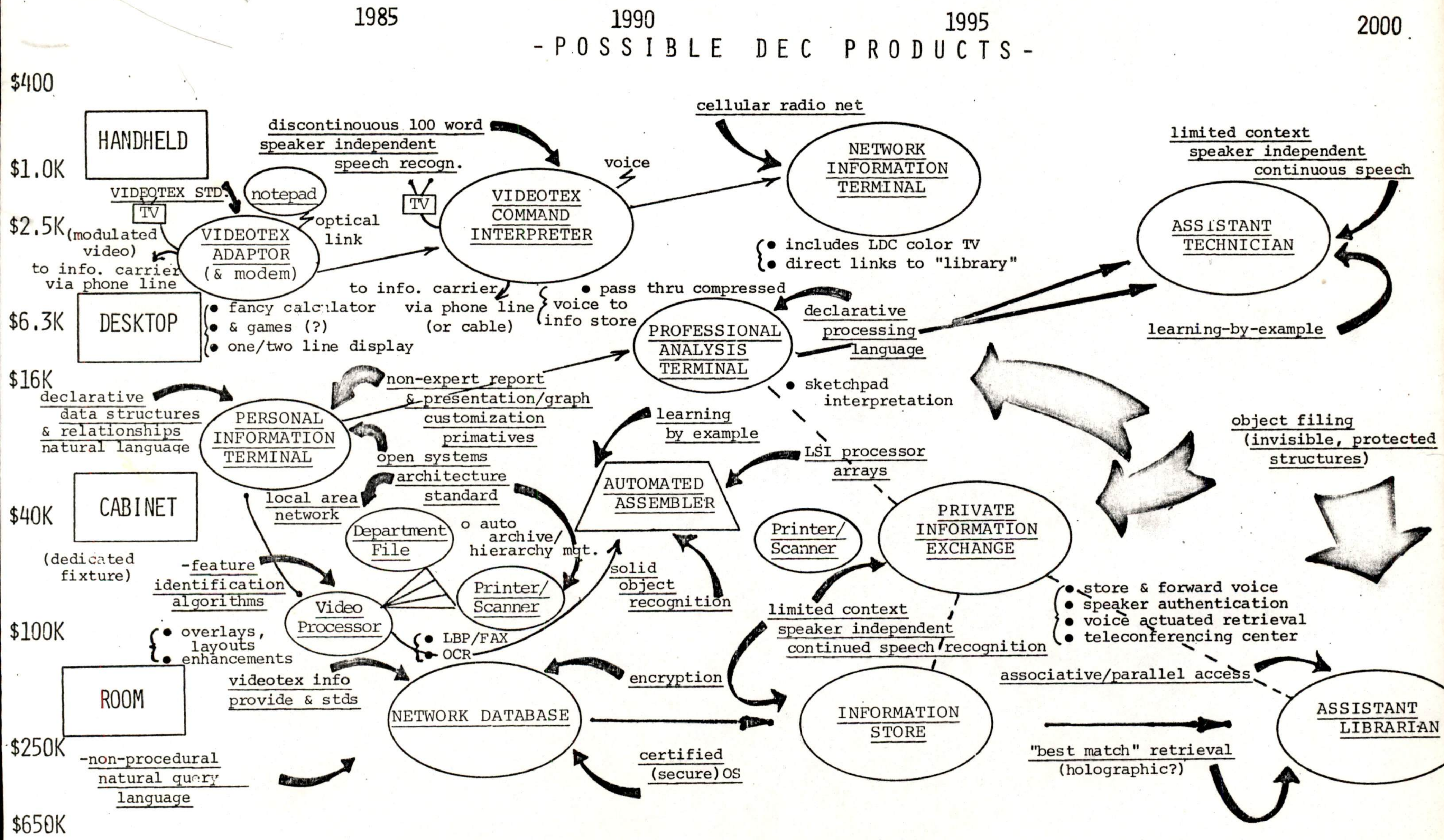
Preliminary

Company Confidential

Gordon Bell
ML12-1/A51
223-2236
#11

FEB 1 6 1981

- POSSIBLE DEC PRODUCTS -



BD 1/15/81

Vision: architecturally "B" consistent framework for "Personal & departmental computing; defensive connectivity to IBM/telecomm

16	– AZTEC & m.Wini – J11 Unibus on 10½" [1.9, 3.6]	– Graphics – J11Q22 w/ mini Wini [2.8, 3.5]
32	– relational database – IBM link (SNA-VMS) – (defensive) low end sup. – SUVAX: PC [$7.5M,	– data mgt. leadership via engines – – aggressive 32-bit board positi – strong SUVAX [$ ~~7.5M~~ $6M
36	– loosely coupled 20's – DECnet gateways [2.5, 5.5]	– database, inquiry – modern languages [4.7, 9.2]
MS	– HSC60, BDA, PINION II [2.0, 8.3M]	– wide range & accl. tech. [5.4, 13.6M]
PC	– AZTEC FILE SERVER '84 (Q2) – HANDHELD TERM. & '85 (Q2) [1.4, 3.3]	– HANDHELD TERMINAL (84, Q2) [not recommended] [1.3, 0.5]
TERM	– $8K NIP in '87; LA200 in '85 – low cost RO in '86 – lower VT200 risk; start 300 [1.3, 2.8] 12.6 14.2 13.9 15.4 16.2 20.9	– $8K NIP in '86 – low cost RO in '85 – accellerate LAN T200 (?) – intelligent keyboard [2.3, 3.4]
SEMI	– reduce risk [1.5M, 7.1M]	– VLSI MOS beyond SCORPIO – Bipolar beyond VENUS [6.3, 10.9]
SW.	– non procedural languages, Q&P data base engine, min distrib. [3.9, 5.5]	– applications tech. – distributed systems prof. [7.6, 13.3M]
P/P		
SA&T	– industrial automation (mat'l handl) – knowledge engineering; VLSI arch (0.8M, 0.7M), ~~sys.~~ XCON	

$ 7.5
6.0
1.4
1.3
2.3
3.9
0.8

Δ: $ 22.2M

METRICS FOR VARIOUS PRODUCTS

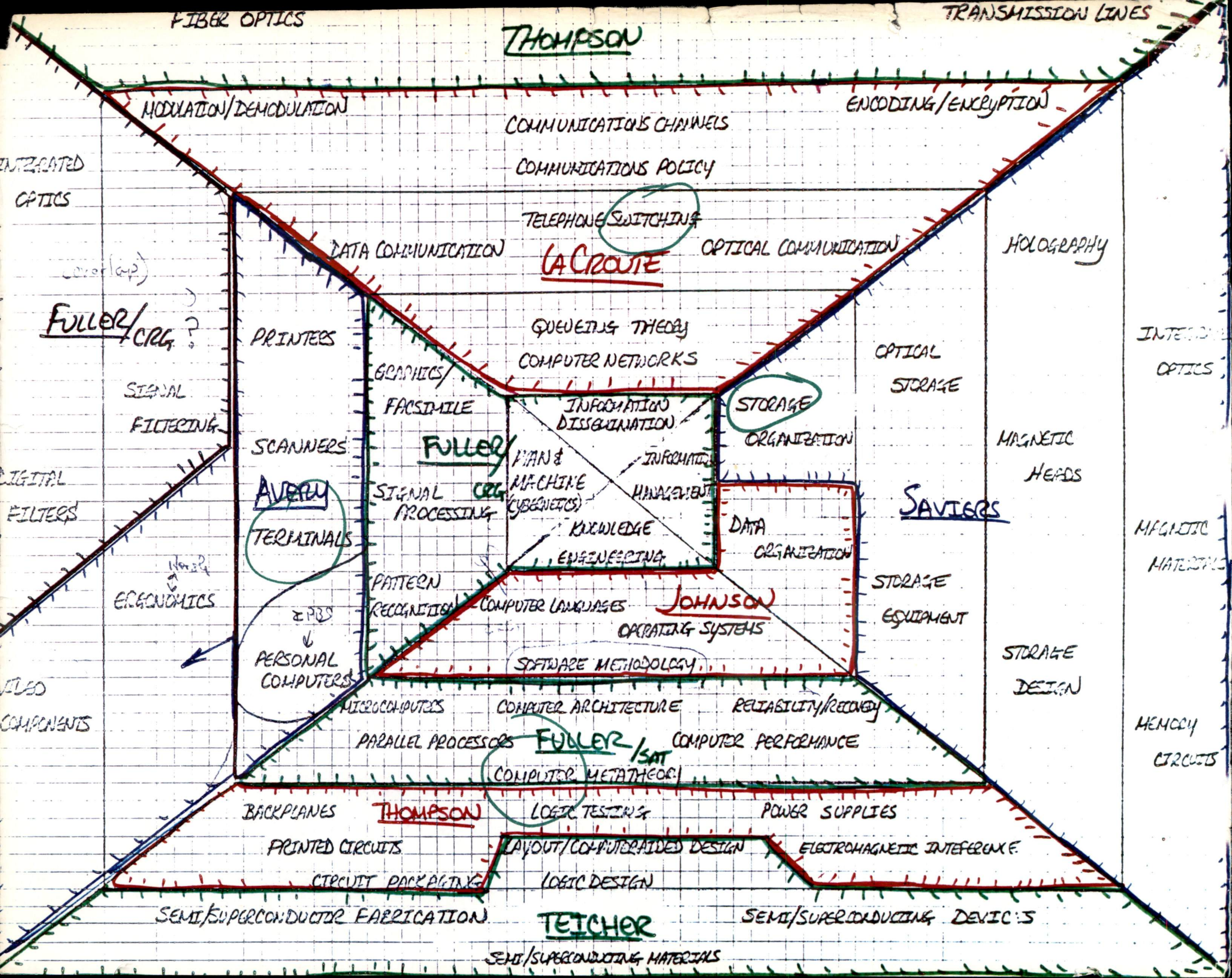
	Product	Notes	Price Band	IRR %	#Q^s to breakeven from FRS	ENG $ % NOR	TOTAL NOR	MAX CUM NEG CASH	
	SYSTEMS								
	UT278	WS78 follow-on							
	PDT150		6.25-16	49 %	1-80 8	3.8 %	144	13	9.0
	11/23 B	Dave Quimby Gene Ho - Done	16-40	71	3-81 1-84 10	0.8	429	15	3.5
	11/24 (CPU+memory+options)	CPU / SYSTEM	16-100	71	3-81 2-84 11	1.3	964	36	3.7
	J-11	Q+UNIBUS Gene Ho working							
	11/730	. Done, in Revision This is old version	40-100	89	1-81 1-84 11	1.2	1671	44	2.6
	750 (CPU+memory)		100-250	61	1-81 Act=2-81 1-84 12	1.3	2565	78	3.0
	NAUTILIS	Still in ADV. Devel. 750 follow-on	100-250						
8/80	780	CPU+Memory		69	3-78 2-82 15	1.2	3494	55	1.6
		SYSTEM	100-625	61	3-78 4-82 17	1.2	4205	87	2.1
	Scorpio	LSI-VAX in ADV. Devel	6.25-16						
2/80 2/81	VENUS	- new - Feb 81	250+	52	4-84 2-87 13	1.2	9900	252	2.5
	2080	- System / CPU		41	4-87 1-85 - 9	12.1 %	247	18	7.3
		- SYSTEM	625+	37	4-87 3-85 11	7.3 % $36M	511	37	7.2
1/81	Hydra	Carlson has study Mostly s/w - hi avail NOT DONE 2-83?	625+						
	44	Mercury - microprocessor comm. system - Carol working on	40-250						
	STORAGE								
8/80	RM05	- Buyout		53	1-81 1-84 12	0.5	347	15	4.3
1/81	RM80/RA80	in-house		29	2-81 1-85 15	4.1	664	49	2.4
	RA81								
10/80	RP07			53	3-81 1-84 10	1.7	284	16	5.6
March 80	RP20	- Buyout		49	2-81 2-83 8	1.0	35	2	5.7
	TU58	- this is an old version		45	1-81 1-84 12	1.11	290	11	3.5
11/80	TU78			33	1-81 1-85 20	1.9	356	25	7.0
	Aztec	working on							
	HSC50	- done							
	PINION	RL01/2							
	TERMINALS								
	CT	- Conklin							
10/80	VT125 + conversion kits			55	4-81 4-83 8	1.8	193	15	
	LA12			41	1-83 3-85 10	1.96	402	31	
	120			31	3-79 4-83 17	1.47	660	33	
	120AA			47	Q4-80 3-83 11	.38	93	7	
	180			31	1-76 1-80 12	2.64	93	7	
	24			47	1-82 2-84 9	1.36	354	18	
	34			23	2-79 2-84 20	2.68	463	34	
	36			31	2-75 2-79 12	1.54	332	22	
	VT100			33	9-79 1-82 12	2.09	411	40	
	101/2/131			95	2-81 1-83 7	.32	621	24	

PRINTERS LQP xx - Bob McGeary

Software

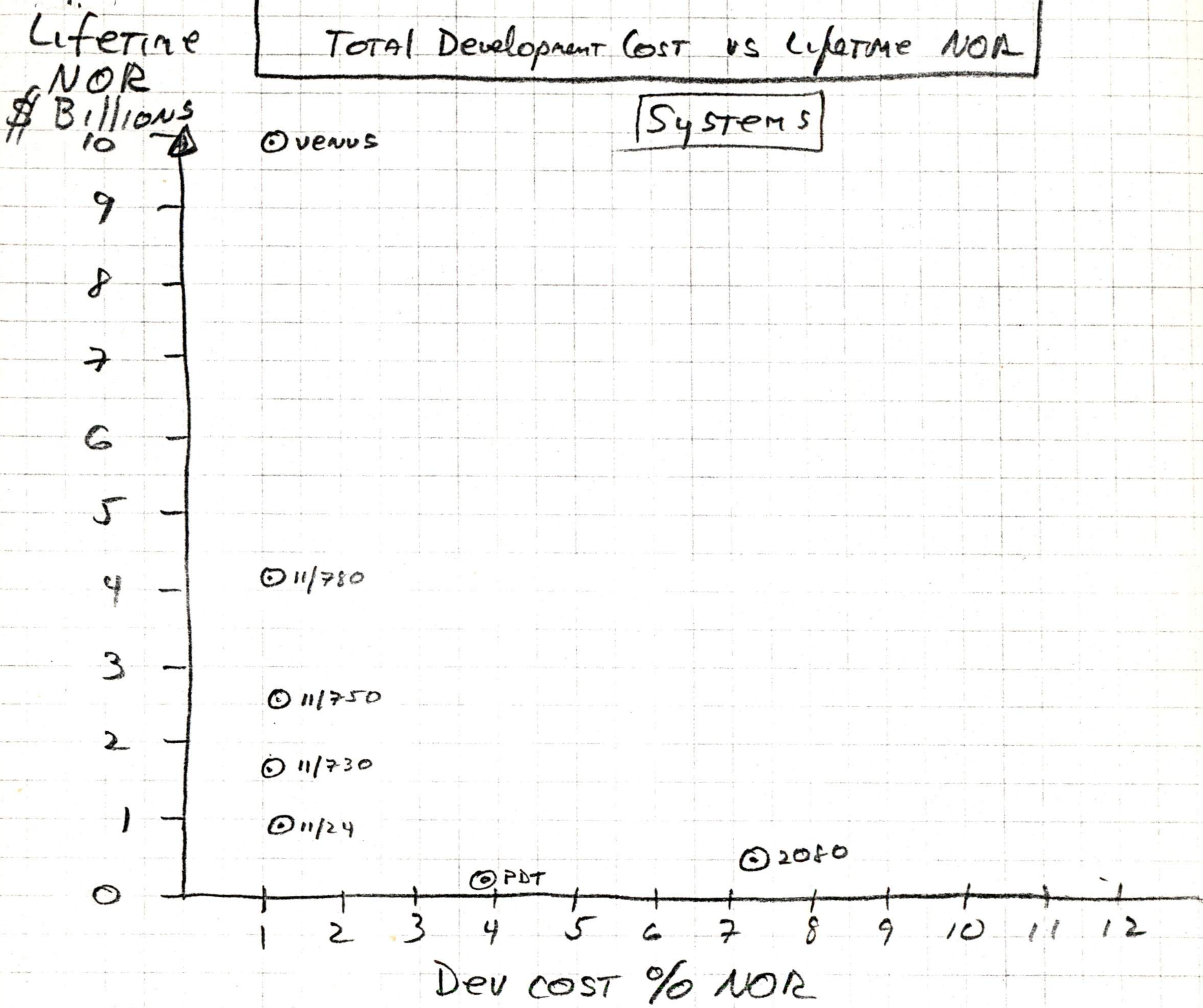
- SNA on VMS (Bill)
- OFIS (BJ)
- DBMS 32 (Bill)
- VMS V3.0 (Bill)
- FMS-11/RSTS (Si)
- DBMS 11 (Si)
- VAX/Datatrieve (Bill)
- RMS/RT-11 (Si ?)
- Small Cobol ?
- RSX-11 M/S Si

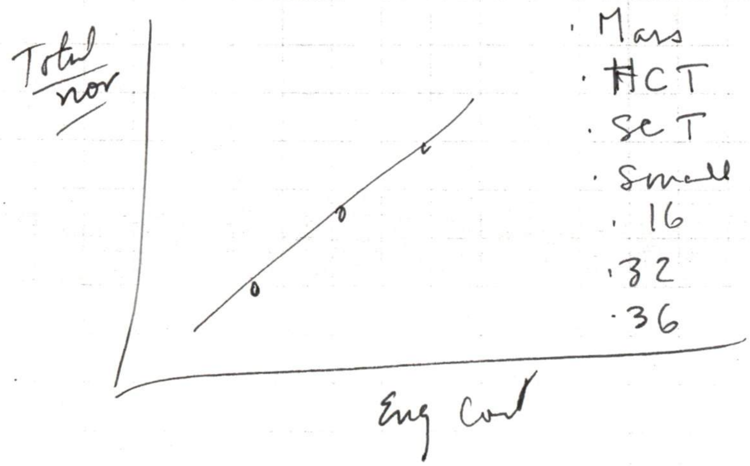
D. CLINTON
2/81


FIBER OPTICS
THOMPSON
TRANSMISSION LINES
MODULATION/DEMODULATION
ENCODING/ENCRYPTION
COMMUNICATIONS CHANNELS
COMMUNICATIONS POLICY
OPTICS
TELEPHONE SWITCHING
DATA COMMUNICATION
LACROUTE
OPTICAL COMMUNICATION
HOLOGRAPHY
FULLER/CRG ?
PRINTERS
QUEUEING THEORY
COMPUTER NETWORKS
OPTICAL STORAGE
OPTICS
GRAPHICS/
FACSIMILE
SIGNAL
FILTERING
INFORMATION DISSEMINATION
STORAGE
ORGANIZATION
SCANNERS
FULLER
MAN &
MACHINE
(CYBERNETICS)
INFORMATION
MANAGEMENT
MAGNETIC
HEADS
FILTERS
AVERY
SIGNAL
PROCESSING
CRG
SAVIERS
TERMINALS
KNOWLEDGE
ENGINEERING
DATA
ORGANIZATION
ERGONOMICS
PATTERN
RECOGNITION
COMPUTER LANGUAGES
JOHNSON
OPERATING SYSTEMS
STORAGE
EQUIPMENT
PERSONAL
COMPUTERS
SOFTWARE METHODOLOGY
STORAGE
DESIGN
COMPONENTS
MICROCOMPUTERS
COMPUTER ARCHITECTURE
RELIABILITY/RECOVERY
PARALLEL PROCESSORS
FULLER/SAT
COMPUTER PERFORMANCE
COMPUTER METATHEORY
MEMORY
CIRCUITS
BACKPLANES
THOMPSON
LOGIC TESTING
POWER SUPPLIES
PRINTED CIRCUITS
LAYOUT/COMPUTERAIDED DESIGN
ELECTROMAGNETIC INTERFERENCE
CIRCUIT PACKAGING
LOGIC DESIGN
SEMI/SUPERCONDUCTOR FABRICATION
TEICHER
SEMI/SUPERCONDUCTING DEVICES
SEMI/SUPERCONDUCTING MATERIALS

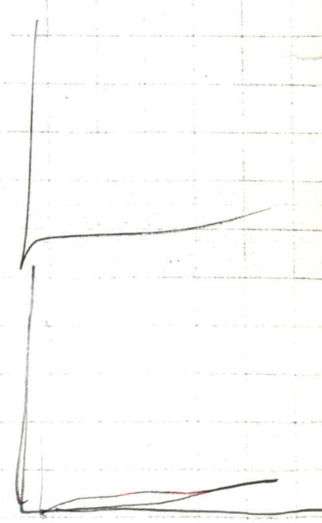
Financial Metrics

Total Development Cost vs Lifetime NOR





- Mars
- HCT
- ScT
- Small S
- 16
- 32
- 36



PRELIMINARY

ENGINEERING

STRATEGY

OVERVIEW

MARCH 1982

SECOND DRAFT

PRELIMINARY ENGINEERING STRATEGY OVERVIEW
TABLE OF CONTENTS

• Denotes change or new as compared to April 1981 edition.

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PREFACE

The "Engineering Strategy Overview" presents our vision of the technical direction of computing, an analysis of critical factors affection DEC's future, and our strategy for allocating Engineering resources to maximize the Corporation's success. It also contains numerous working papers and background data which are relevant to setting product strategy.

The preliminary edition of this document represents Engineering's viewpoint and recommendations. It will be presented to the Operations Committee for review and critical decision making in March, 1982. If the Committee makes any significant changes, a revised edition will be published.

Chapter I is the Corporate Product Strategy. The same chapter was published in last year's "Engineering Strategy Overview" and was reviewed with the Operations Committee in April, 1981. It has not changed. If anything, recent experience has only confirmed the pain of the Fifth Generation transitions which it describes and the challenge for Engineering to respond.

Chapter II contains several essays on the criteria for allocating Engineering resources. Particularly important is "Heuristics for Building Great Products" which has been updated by Gordon Bell to reflect experience from recent Engineering projects. The rest of the chapter is largely unchanged from last year.

Chapter III is devoted to strategic threats and opportunities. The major new material is the Competitive Strategy Exercise which has been added as a challenge to the reader.

Chapter IV is a report from Engineering's Technology Managers Committee. It replaces last year's sections on technology assessment (DEC vs competitors) and recommendations.

Chapter V provides a collection of important financial and other quantitative data. It has been updated and extended since last year.

CHAPTER I

THE PRODUCT STRATEGY AND TRANSITIONING TO THE FIFTH GENERATION

THE PRODUCT STRATEGY OVERVIEW

THE FIFTH GENERATION

The transition to The Fifth Computer Generation is happening. All generations changes are painful and this one could be harmful unless we recognize and ease the transition. The Fifth Generation is based on: significant 16-bit microprocessors with large memory addressing; small, low cost, 5-10 megabyte mass storage; and communication using Ethernet-type interconnection. It is marked by Personal Computers that will evolve rapidly into Personal Computer Clusters. Clusters can be used as an alternative to our departmental timeshared minicomputers, just as the mini provided an alternative to the central mainframe.

Technology continues to provide 20% per year decline in the price of computing, permitting a wide range of computing styles from a $500 "PDP-11's in a book" to "Cray 1 power" VAXs for $250,000 in 1990. Competition will be fierce as 360/370's become available at minicomputer prices and the semicomputer companies sell what was formerly mainframe power processors for zero cost and start a new industry. Digital's Product Strategy with its homogeneous architecture is aimed at being a major force in this generation.

THE PRODUCT STRATEGY

The product strategy of a homogeneous architecture is simply:

- adopting a single VAX-11/VMS architecture;
- implementing a wide price range of products covering the computing styles of **Personal (Individual) Computing, Timeshared Departmental Computing**, and **Central Computing**;
- interconnecting these in a homogeneous network, including the formation of Personal Computer Clusters; and
- building critical and unique applications.

RATIONALE FOR THE STRATEGY

The basis for a winning strategy is:

- ability to build a homogeneous, network architecture which will greatly benefit the customers, by:

  - providing a wide range of price and styles for our varied customers, preserving their data, programming and training investments; and
  - allowing a user to compute, dynamically, anywhere across the compatible range without conversions;

- fewer systems to support across Digital, while covering a very wide price range, as processor cost becomes a smaller part of the total system cost;
- fewer systems also imply lower costs with higher quality and greater reliability by moving further down learning curves;
- a clear internal and external mission which both aids productivity and quality;
- product uniqueness and superiority against the emerging commodity-produced mainframes in our minicomputer price band and the semicomputer company "mainframes" fueling the emerging fifth generation computer system building boom; and
- support of our customer base and transition to this new computing style.

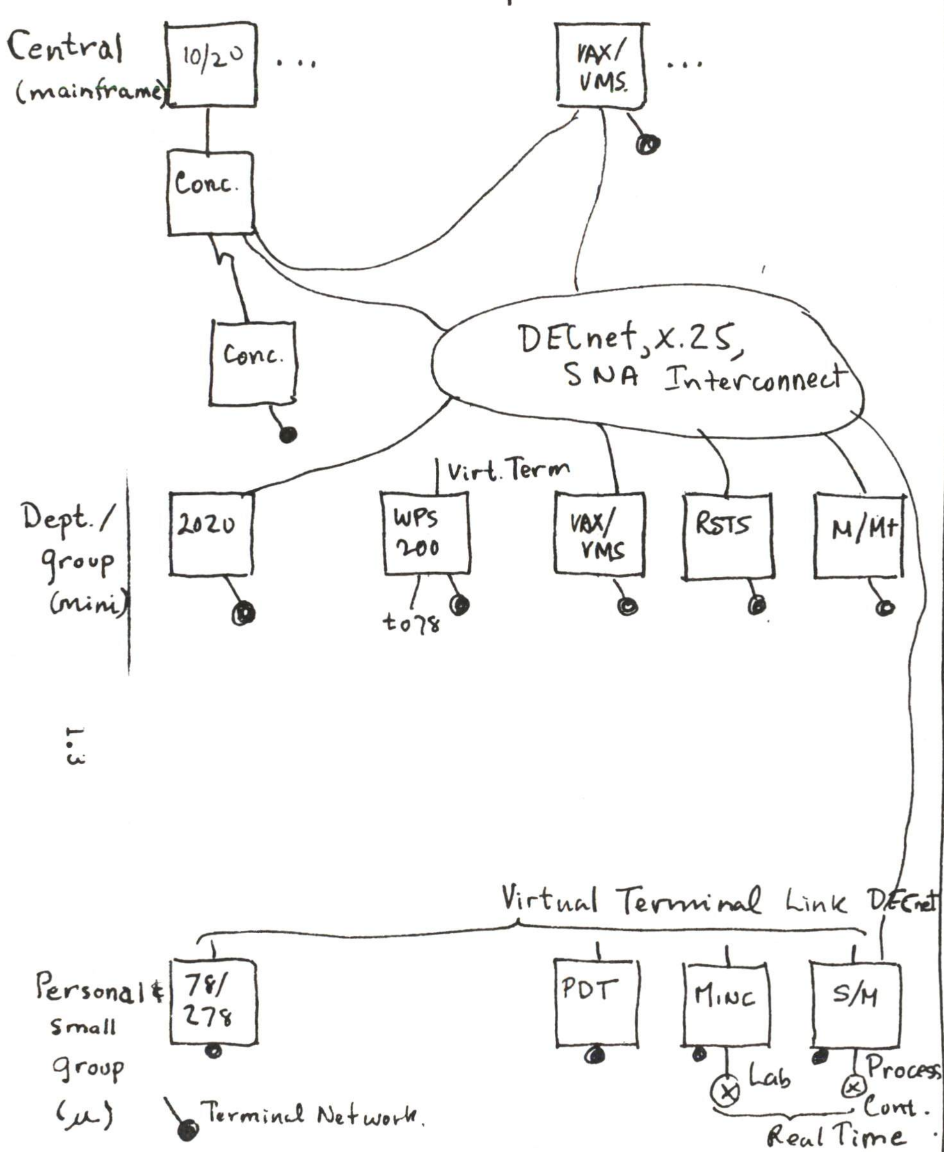
IMPLEMENTING THE STRATEGY

Implementation includes continuing to deliver significant 8- and 10/20-based products and building the necessary coexistence hardware and software to make the transition to VAX-11/VMS. The 11, using RSX-11/M will be the basis of Personal Computing until VAX-11/VMS is implementable as a low cost Personal Computer, PC, and Personal Computer Cluster, PCC. Homogeneity must be maintained via files, language, and interconnection standards enabling customers to preserve their data and program investment. RSX-11/M aids this transition because VAX-11/VMS provides a compatible environment. Immediately we must develop unique applications on VAX-11/VMS that cannot be built on competitive 360/370's and semicomputers.

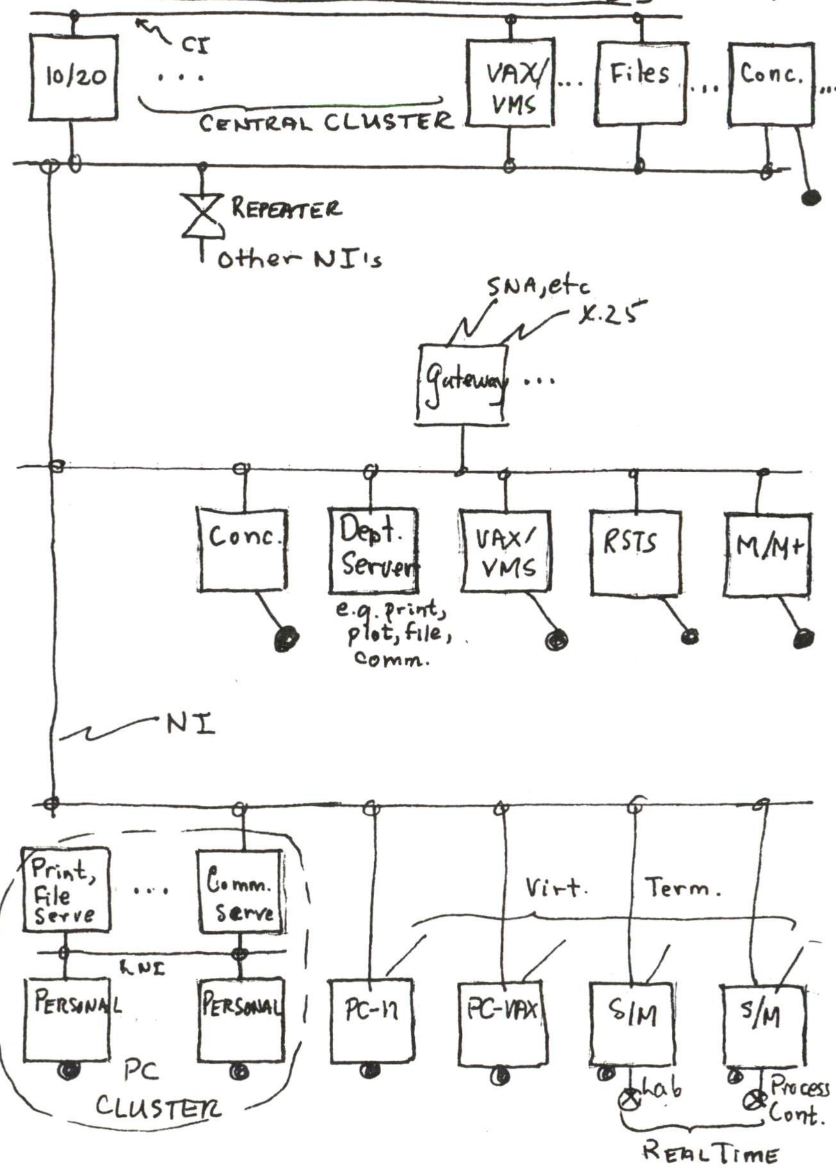
This evolutionary strategy, as ratified two years ago, is the result of the 1975 decision to build VAX-11 together with the technology push and market pull to further distribute processing via Personal Computers and our own Local Area Network.

In the last two years since its inception, the strategy has proven increasingly attractive because no competition appears to have the same focussed vision, capacity and capability.

Today



The Product Strategy



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THE TRANSITIONS

TECHNOLOGY TRANSITION

Transition based on technology evolution is continuing at 20% cost decline per year as shown in the following figure, permitting an incredibly wide range of useful computing devices to be built. The generation period of seven years and the seven generations, 55 year period from 1945 to 2000, is described in the appendix on the fifth and sixth computer technology generations. Economy of scale, also known as Grosch's law, does not hold today for any system or component except very large disks. However, there is diseconomy of scale for large systems primary memory.

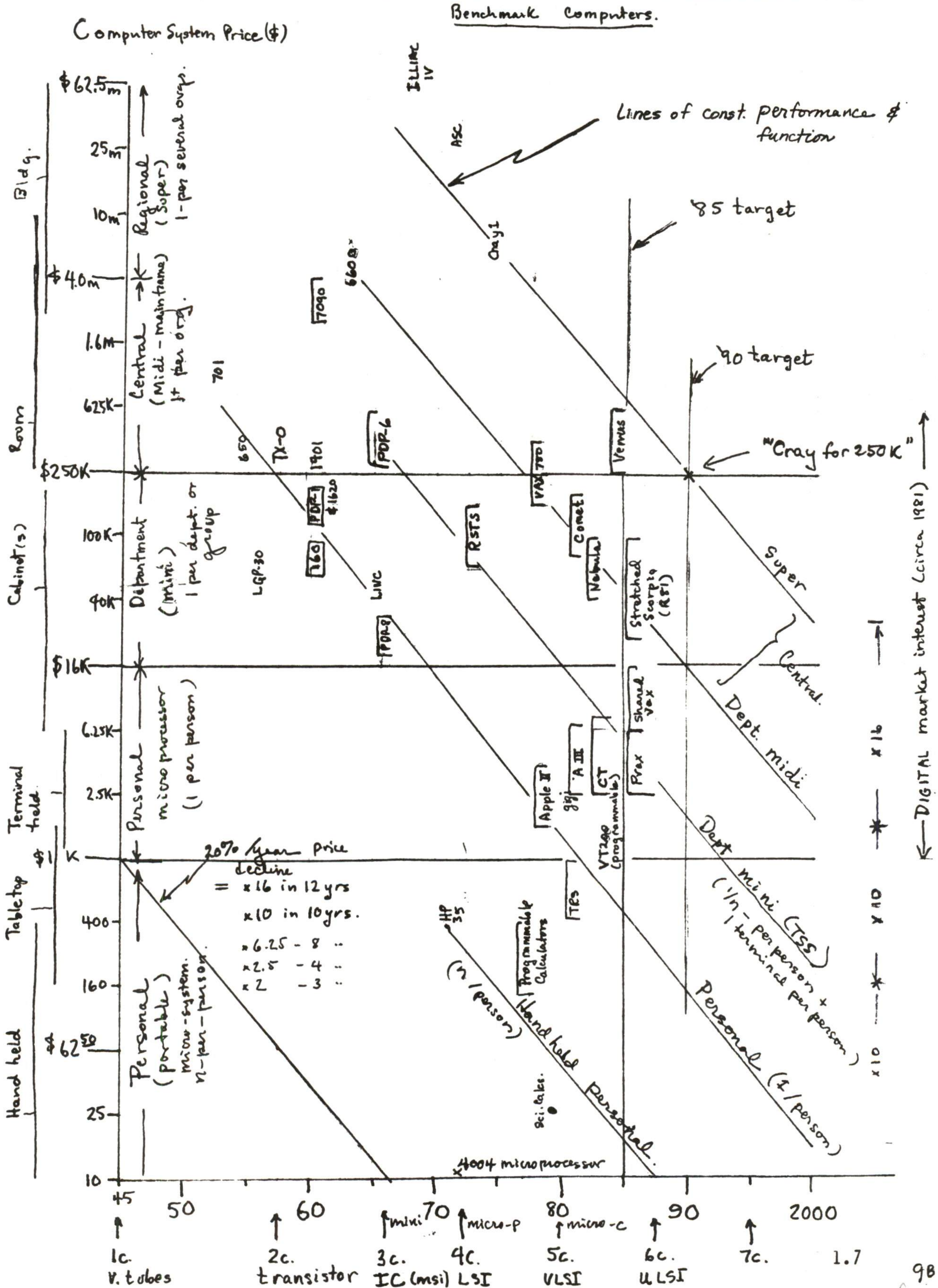
From the generations graph, we can observe the following:

- there is a wider range of useful systems, and these will be appealing to our customers, us and others; For example, in 1985 we could be selling $1,000 computing terminals with the power of the original LINC, and $600K 10/20's.
- the wide range of useful systems will force all suppliers to be more competitive and selective as new suppliers enter on a point product basis and as the 370 becomes a commodity;
- IBM, Fujitsu, and others are likely to offer a 4341-2 class machine in our $40,000 to $100,000 minicomputer heartland;
- competitors, could be targetting the following (for 1985):

    - Cray 1 power, $625K (or in 1990 for $250K);
    - x3+ Comet power for $100K;
    - 780 power for $40K;
    - a sharable VAX (or big micro) in $6.25K to $16K range;
    - a personal VAX (or big micro) for under $6.25K;
    - a computing terminal with VT100 capability, and power of Apple II, or original LINC, for $1,000;
    - computers in $400 to $1,000 range;

- we have not provided aggressive enough products, because:
- the Q and U bus form factors have constrained system cost and size;
- the 19" rack and stack, palletable form factor together with poorly packaged components, has been retained; Packaging in other, lower cost form factors enabling cardboard box shipment and customer merge is essential.
- the terminal has not been used as a package; and

Fig. GC <u>Computer System Price Versus Time for Various Benchmark Computers.</u>



1.7

GB 3/7/81!

(based on 2.75 modu[illegible])

- point products have been insufficiently high quality, software supported, or cost-effective. Even $200 calculators are modular with mass storage, printer, modem and display options.

TRANSITION TO DISTRIBUTED COMPUTING BASED ON NI

The Network Interconnect, NI, based on Ethernet is the Local Area Network intercommunication medium for connecting all the computers within a building or set of buildings at a single location. Because it operates at 10 Mhz., it should have a long product life and be useful for interconnecting:

- departmental and central computers to each other;
- Personal Computers to form clusters;
- several thousand voice channels at 2 Khz;
- several hundred picture channels at 50 Khz;
- computer components together to form a computer; and
- functional server components in a distributed processing system. For DEC, we need to reduce the number of network possibilites that are a product of:
    - hardware systems;
    - the 12 operating systems we support; and
    - the desirable protocols including X.25, IBM, DECnet and other vendors.

By using the server concept on a network wide, rather than a cluster basis, each system can be connected to NI, and then build specialized servers for the network nodes. We must build the following network-wide specialized servers:

- concentrators for interconnecting dumb terminals and personal computers to all nodes of the network. This permits both concentration and switching to all nodes.
- gateways to systems using other protocols; This would be done once and not in each system requiring communication with a particular system using a particular protocol.
- repeaters and interfaces allowing various networks to communicate with one another;
- central functional servers for the network, including printing;
- real time front ends for interfacing real time control computers to the network.

TRANSITION TO PERSONAL COMPUTERS FROM MINIS AND MAINFRAMES

Personal computers are already beginning to affect the use of departmental level minicomputers and central mainframe timeshared computers in several ways:

- direct, stand alone use;
- more terminal load can be put on a given computer when personal computers are attached to it using terminal emulation, thus lessening the need for more shared computing; (The leading edge university market shows this trend.)
- interconnected clusters of personal computers are a direct alternative and provide nearly all the advantages of timeshared computers.

The concept of Personal Computers interconnected via a Local Area Network Link, like NI, forming Personal Computer Clusters and using functional servers to handle communications, files, printing and interface to people is described in a following section. The Personal Computer has enormous market appeal because it:

- potentially covers the widest range of use on a cost per terminal basis, beginning with one user;
- is personal, non-sharable, and purchasable by an individual;
- has the best response time for what we think of as trivial computation tasks such as word processing; These highly interactive tasks require much computation and direct access to the screen for data manipulation.
- offers every capability that a dumb terminal has, including installability, yet is only slightly more expensive;
- can carry out many of the tasks that timesharing systems do; and
- can operate within a cluster to have virtually all the important attributes of a large, timeshared system.

We must get the necessary architecture for the clustered systems. Many systems have been built using this distributed server structure. Experimental systems are being planned or built by the Office Group, Laboratory Data Products, Small Systems, VMS, Research, the Computing Terminal base system and DECnet/ Distributed Systems. These systems have to have a standard interface for this level of communication so they can communicate with one another.

TRANSITION FROM CONVENTIONAL RACK AND STACK 16-BIT COMPUTERS
The transition from our current 16-bit rack and stack and Q and Unibus systems business must be made. They are not declining in price according to the technology and are being rendered uncompetitive. Also, every application involving a signficant amount of programming must evolve from the limits of the 16-bit address. The threats:

- 16-bit microprocessor cards and systems which have 22-bit memory address space and supplied by both semicomputer companies and their OEMS who are building competitive systems; UNIX and other approaches to building transportable systems are aimed at establishing hardware to be a commodity.
- board and box level systems that are oriented to modern special chip i/o as supplied by the semicomputer suppliers;
- Personal Computer and Clusters, as described above;
- 32-bit architectures, including the VAX architecture;
- better box-level form factors not possible with 19", FAT produced, Q- and Unibus systems; Systems must be shipped in cardboard boxes, integrated by the customer, and when broken, self-diagnosing with customer replaceability.

TRANSITION FROM TERMINALS TO COMPUTING TERMINALS

The major transition for terminals is semantic. That is, just what is a terminal? It is clear that there will be no dumb or fixed function terminals by 1985. Every future terminal we introduce must be a computing terminal. Terminals must change in the following ways:

- larger Personal Computers are an alternative to our conventional, dumb terminals;
- all terminals introduced beginning in FY83 must be customer programmable with at least firmware ROMs and RAM buffers;
- the interconnection, whether it be U. S. or European Modem, NI, or IBM emulator, must be built into the terminal;
- decreasing memory cost will offer fully programmable screens, which in turn will automatically provide graphics; and
- higher resolution, full-page and color displays.

TRANSITION TO SOFTWARE FOR END USE VERSUS PROGRAMMER TOOLS

Although we will continue to supply software for the systems and applications programmers, we are beginning to supply tools for generic applications such as word processing. Using a computer in the office is contrary to our successful past, where we could use ourselves as the model user. Fortunately, we have offices within DEC, and must use them as a laboratory for building effective products. Specifically, we can identify these needs:

- direct use in the office, including providing the ability for OEMs, office managers, organization, and the individuals to tailor their systems;

- better human engineering at the screen and in documentation; Documents and help should be built-in.
- all products must be modifiable for use with any natural language; We sell products in all countries, and these products must operate in the mother tongue.
- applications building tools that professionals who understand various businesses can use to write applications programs for particular professional and commercial environments.

TRANSITION IN HARDWARE DESIGN SKILLS

The transition in the way we design systems is quite radical, especially as we move into the sixth generation where our current mid range systems are placed on a single chip. At this time, we would expect constant cost mid range systems to be able to store and process voice and images and to be able to communicate with everyone at their own level. The immediate transitions for system designers includes:

- standardization and use of general purpose controllers and processors for conventional controllers; We are not using enough standard VLSI! This also implies that virtually all options are programmed in ROM (firmware), with programs that are fundamentally real time operating system applications. We are failing to recognize and manage this transition at this time.
- use of gate arrays and other LSI to lower cost of all jelly bean and non-processor logic; This requires a significant investment in CAD and designer training. Although this design approach will be used throughout the next generation, it is interim until VLSI design is understood.
- VLSI design, where processors and controllers are placed on a single chip; Currently this is so expensive, that we are not developing chips or design skills outside the Semiconductor Engineering Group to any extent. We need tools so that a basic design can be done in the same time as a PC Board layout; furthermore the PC Board layout and acquisition time must be reduced to one week. We must engage in more VLSI design as a means of cost reduction in some of our high cost peripherals (eg. the electronics constitute 1/2 the cost of the R8Ø!).
- identification of either general purpose or special purpose computers based on VLSI for building the non-processor portion of systems to drastically reduce system cost. Processor design has been the past focus, and now we must optimize the total system cost, including maintenance (life cycle cost) and use.

PERSONAL COMPUTER CLUSTERS, PCC, ARE AN ALTERNATIVE TO TIMESHARED COMPUTERS WITH DUMB TERMINALS

We must establish the 11 as the Personal Computer standard, and build Personal Computer Clusters and Networks compatible with VAX files, and languages. We must introduce a VAX Personal Computer by 1985.

The opening statement of the August 1979 CMU Research Proposal for Personal Computers was "Timesharing is dead, to be replaced by networks of Personal Computers in the 80's". Research groups have built and are building Personal Computer Networks (PCNs) using PCs costing $20K-50K and interconnected by high speed links like the Ethernet. Xerox Research PARC, the developer of the "distributed server" architecture, is the archetype of this environment with several hundred Alto personal computers and service facilities (e.g. File Servers, Printer Servers, Network Server for interconnection to outside computers, and a Tenex Computation and File Server) interconnected over 3 Ethernet segments of several kilometers. Apollo has just introduced a PCN, based on a ring structure and using the M68000, aimed at the technical professional. Three Rivers are delivering PERQs to the CS community and Convergent Technology has announced a clustered, professional workstation. The Datapoint computer system is built using the "distributed server" structure. Apple is likely to introduce Apple-net in 1981 to interconnect their PC's, forming Personal Computer Networks (PCN's). Wang and other WPSs are organized around a co-axial ring, using file and printer servers, and distributing the processing in the terminal computer, forming a limited, single cluster (PCC). Semiconductor companies have again lowered the barrier for entry into the lower part of the computer market.

The PC has evolved from a tiny computer with a serial link to a dumb terminal (glass teletype). New PC's must have the ability to save and restore a complete screen, as the screen is mapped into the processor's primary memory, and to be able to use a screen to help the user more, in a similar fashion to the TV games. This very high speed communication will dictate a whole different Operating System philosophy for screen management. Equally important is "distributing" the operating system to clusters of PC's using the emerging high speed links such as Ethernet.

COMPUTERS ARE A NEW COMPUTER GENERATION
Personal Computers, Personal Computer Clusters, and Personal Computer Networks all form alternatives to our small, medium

and large timesharing systems (TSS's) for various reasons and, therefore, we have no choice of ignoring them! The figure shows a guess at how the computing style (batch, shared, RJE, personal, PCC, PCN) has evolved and will evolve from 1950-1990.

Given that a terminal has video, keyboard, power supply, control logic in the form of a microprocessor, a package constrained by the video and keyboard, it is only slightly more expensive to increment the primary memory and add a secondary memory to get a complete computer capable of standing alone and acting as a terminal emulator.

As an example of a terminal evolving into a PC, GIGI has a ROM which gives it Microsoft BASIC capability. Although we provide no secondary memory for programs, our customers probably will. Therefore, the forces to make every terminal evolve into a personal computer are:

- constant overhead of the terminal;
- high cost of people sitting at the terminals (e.g. $20K- 150K/year) relative to the terminal;
- lower primary memory cost;
- need for much more processing at the terminal and high bandwidth between the terminal and computer to get more productivity from expensive people;
- the introduction of the small floppy and now
- the small Winchester that can be packaged in the terminal.

Given that we sell a lot of dumb terminals, it is important for us to evolve them this way.

Tasks like editing require a great amount of computing power and very fast interrupt response time. It should also be noted that this kind of response is virtually impossible to deliver in very large, shared systems and gets even worse in very large computers. The issue is really latency versus throughput. There is some evidence to show that the cache miss rate goes up as the square of the processor speed. Also, the access time of large disks is not improving as rapidly as processing speed.

Just as there have been forces to establish the PC as an alternative to the dumb terminal using a terminal emulator program, the forces will continue to replace all the functions that the timeshared system provides by clustering the PC's and by having shared facilities using Ethernet. As we simply cluster the PCs, communication and file access among the machines is provided as long as all the computers are ALL turned on. This requirement leads back to asking for some shared facilities in addition to the communications link. Sharing occurs for two reasons: it is drastically cheaper or that it is necessary for communications. High performance or high quality printers, communications facilities, and large filing systems are examples of economic sharing; a filing system and communications link are examples of communications sharing. With sharing, there's also the need for privacy and higher overall reliability for shared parts.

EVOLUTION FROM TSS TO PC CLUSTERS AND NETWORKS
DEC developed Timesharing Systems (TSSs) so that everyone could "apparently" have their own computer which could be operated in an interactive, not batch fashion. We also built single user minis so everyone could have their own computer (e.g., LINC) as the first truly interactive, personal computers ... and then we put timesharing on the larger minis (e.g. TSS8, evolving to RSTS) to get the cost per terminal down. This era covers 1965 to 1980. 1980 to 1990 is likely to be a transition from the shared system to powerful PC's!

In 1977, with good microprocessors, low cost RAM, and small floppies, the Personal Computer (PC) entered the scene as an alternative to some TSS. By simply adding a terminal emulation program, a PC could operate as a dumb terminal (with some nice file access capability like the old Teletype ASR 33) and still be connected to a TSS. YET THE COST IS NOT MUCH MORE THAN A DUMB TERMINAL. WPS78 is a good example of a PC doing word processing (WP) and behaving as a terminal emulator. PC's that only stand alone and use terminal emulators will be a short lived phenomenon, covering only 1975 to 1985, because there is pressure to have PC Networks in order to minimize and localize shared facilities. This is analogous to the growth limits that departmental minis have placed on central mainframes. However, it is possible that PC's with terminal emulators could strengthen central mainframe computing and decrease departmental minis. PC's with terminal emulation and access to central systems will have wide scale home use!

PC Networks will form from economic pressure and sharing needs. Local area networks like Ethernet permit their formation. Thus, by proper design it appears that one can cover a much wider dynamic product range using this approach as compared to our TSS approach. Figure Evolve shows the evolution from Timesharing Systems to Personal Computers with dumb terminal emulation programs to PC Clusters and finally to networks of clusters PC Networks.

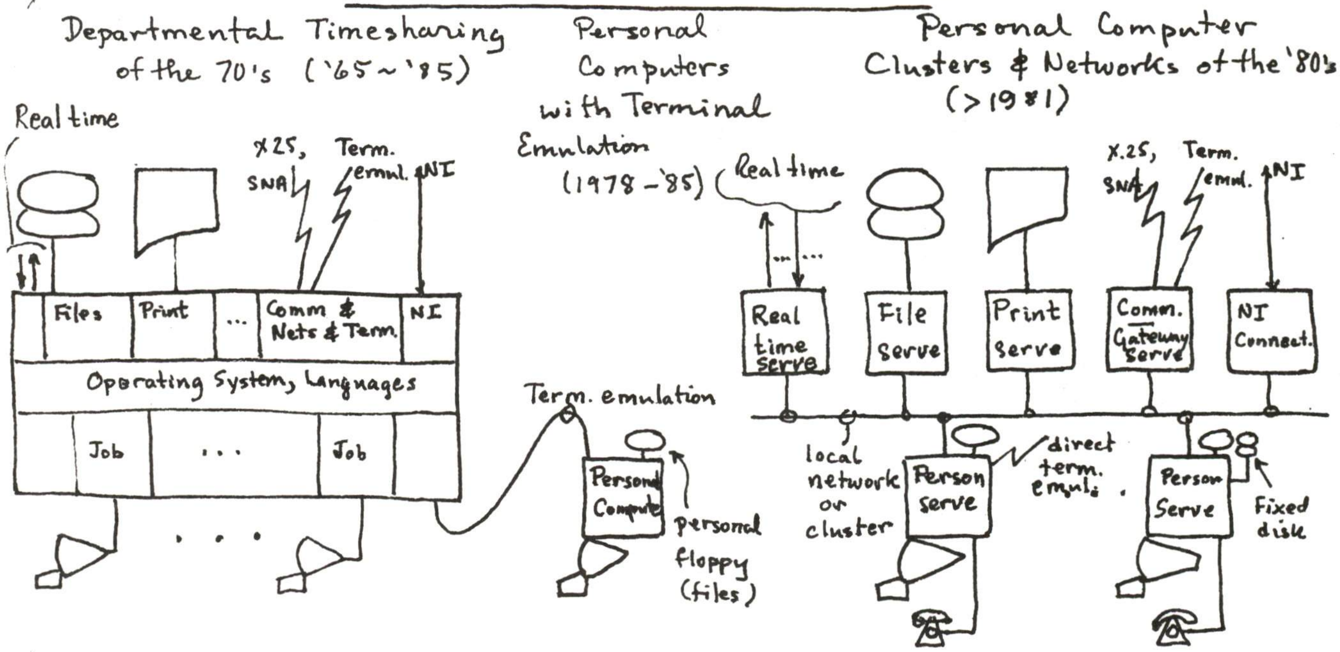
A TSS is composed of components that in principle can be broken apart and assigned to individual computers when forming a distributed PC cluster. A cluster is organized around the "distributed server" concept, where one or more computers reside on distinct processors and communicate with one another using a message passing mechanism via the fast, serial local area network link. The components include: the local area network link, the basic "person server", file service, print service (print queue), communications and network service. The scheduling and accounting programs, and of course, the jobs that exist for each person are distributed on the "person server" machines (i.e. the PCs ... which indeed must be capable of operating standalone!).

Each of the system structures provide alternative capabilities as shown in the following table.

TABLE: WHAT TSS, PC'S AND PC CLUSTERS OR NETWORKS PROVIDE

What	Timeshared System	Personal Computer	PC Cluster/ Net
processing	highest peak	lo-med, guaranteed	= PC
programs size	very high peak	small to medium	= PC
filing	large	small, guaranteed (+ off line)	= PC and TSS
communication	network	term. emulation	= PC and TSS
CRT	slow response "glass Teletype"	fast response, screen oriented	= PC = PC
cost	fixed, can go to lowest$/terminal	lowest entry	f(no. of PCs)
secure	shared, public access	totally private	contained/TSS
pros	explicit costs shared programs big jobs	low entry cost "owned" by indiv. security SW publishing = low cost	ability to expand shared facilities better match to org. structure
cons	shared poor response for terminals higher entry security	limited capability, but increasing	limited proc/prog. shared facilities

EVOLUTION FROM TIMESHARING



Estimated (G. Bell) Percentage (in # terminals) of Computer Use
Versus time (1950 – 1990)

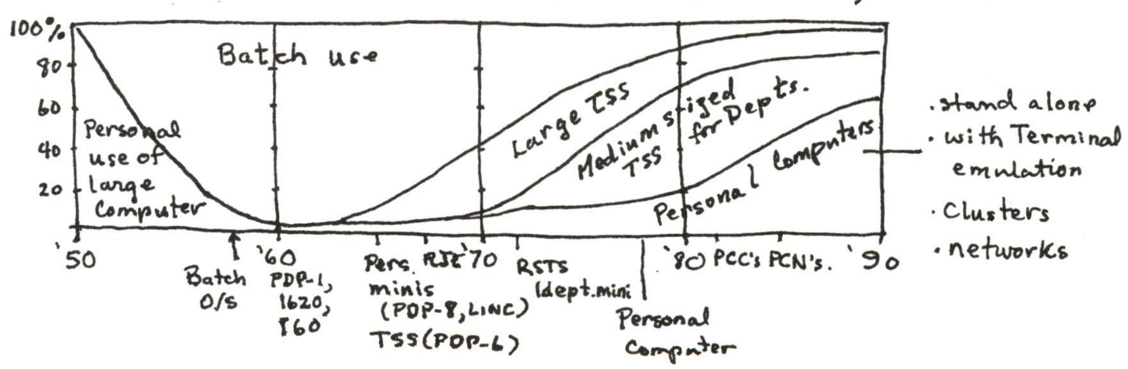


Fig. PC Evolution of COMPUTER Use 1950 – 1990 gB 3/8/81

THE PRODUCT STRATEGY

Provide a set of homogeneous distributed computing system products so a user can interface, store information and compute, without re-programming or extra work from the following computer system sizes and styles:

- as a single user, personal (micro) computer (PC) within a terminal, and evolving to PC Clusters and PC Networks;
- at a small, local shared, departmental (mini) computer system, and
- via a cluster of large central computer(s);
- with interfacing to other systems for real time processing; and
- all interconnected via NI.

VAX/VMS AND NETWORK BASE ENVIRONMENT
Achieve a single VAX-11/VMS, distributed computing architecture by 1985 (as measured by revenue) through:

- homogeneous distributed computing with varying computing styles including high availability and measured ease (economy) of use;
- building new 11 hardware to fill the product space below VAX; i.e. building a significant PC on the 11 with VAX-compatible files and languages so that user software investment is preserved when the ultimate transition from the 11 to VAX occurs;
- having a clear physical bus structure evolution and transition plan;
- and developing VAX, Personal 11, RSTS, M and M+ software for 11-VAX migration and 11 base protection.

Provide 10/20 systems that will co-exist with VAX/VMS through:

- building hardware that runs current 10 and 20 software;
- building VMS co-existence aids and using common components; and
- making market support and DEC-standard language enhancements.

Build and support the PDP-8 for WPS and small business applications until we get PC-11. Invest in application software that will be compatible with the strategy.

Ethernet (NI), which we call DECnet IV, is the backbone of our distributed processing. Aggressively breadboard; then develop it for gateways and concentrators. This forms the basis for the "server" model of computing for the network.

Provide essential IBM network interfaces and help set International standards. These include: Open-systems Interface, and page standards for text and mail.

APPLICATIONS
Provide general applications-level products that run on VMS and if possible layered on RSTS, M, 10 and 20, as a base for direct use, OEM and user programming including (in order):

- word processing, electronic mail, user typesetting and profession-based CRT-oriented calculators for the office and for professions;
- transaction processing, forms management, and data base query;
- management tools for various sized businesses; and
- general libraries, such as PERT, simulation, etc. aimed at many professions that cross many institutions (industry, government, education, home).

Provide specific profession (e.g., electronic engineering, actuarial statistician), industry (e.g., drug distributor, heavy manufacturer) and commercial products as needed by the Product Lines. Select from the wide range of possible languages a small subset for our own applications programming.

USER LEVEL COMPATIBILITY
Define, and make clear statements internally and to our users about programming for DEC distributed computing environment compatibility. Tighten DEC user interface standards for editors, forms management, application terminals, files and data bases, command languages, language dialects (e.g., BASIC), and applications languages.

DEC standards must be industry standards to get the software industry's maximum support.

HARDWARE COMPONENTS

Interconnection
Interconnection hierarchy with software compatibility:

- 0.3-19.2 Khz point to point communication line compatible for direct, dumb terminal;
- 10Mhz NI for interconnection at a site and the backbone of the distributed processing structure;
- 80 Mhz CI for interconnecting Hydra and 10/20/VAX Clusters (in a room).

Computer Systems
Thin out our basic computers by 11 to VAX transition and by

positioning CPU and Mass Storage systems (including PC's) to be a separated at least a factor of 2.5 apart in the price bands. A low cost, high performance processor either alone or in a multiprocessor configuration should cover a system range of up to 3 bands when combined with the appropriate mass storage configurations.

Memories
Cover the wide range of needs:

- solid state modules for low end software in terminals and PC;
- range of components for Personal Computers;
- removeable and low cost disk (Aztec, small Winchesters) for entry-level shared system;
- hi-volume, mid- and hi-end disks in (R80/R81) with (backup);
- high performance controllers;
  and HSC-50 controller for Hydra (evolving to file and data base service).

Computing Terminals
Terminals for everyone (in priority):

- office environment for quality printing, electronic mail, evolving ASAP for needs (and uniqueness); and
- professional using graphics (and/or color) evolving to handle images with target application software,
- low cost (dumb) but with ROM programmability for special use

NI and NI-Servers for Both Shared and PC Clusters
The NI and Personal Computers permit the evolution of two kinds of structures: Distributed Processing with functional servers for our central and departmental TSS's; and the basis of PC clusters (in order):

- intercommunication among all personal and shared systems;
- real time service for process and experimental equipment i/o;
- communications concentrators for dumb terminal interconnection to predominantly central sites;
- communications gateways to IBM, X25, and non-DEC NI nodes, all levels;
- file service at central and departmental sites for all levels, but predominantly PC's; and
- printer service at central and departmental sites for all levels, including PC's.

Specific Personal Computer Products

- aggressively build PC-11 for three environments:

    - support our past, conventional O/S's on the PC-11 hardware;
    - as part of the DEC architecture which starts standalone and evolves to a cluster; this system is compatible with a VAX subset for files and programs and implies a different, lower level interface to be successful. THE Terminal interface must evolve beyond our "glass teletype" to include multiple, concurrent windows and processes.

- establish a VAX environment for PC's (including servers) to envelope the PC-11, PC-VAX (i.e., SUVAX) and PC-VAX (Scorpio)
- build, ship, and test a SUVAX to establish PC-VAX and PCC-VAX and to begin to acquire the applications that only VAX can support; and
- aggressively schedule PC-VAX with a 2.5K - 6.25K cost (system with high resolution scope and mass storage) by 1985

Timeline of Critical Technologies
The figure on the next page describes the availability of technology and various systems versus time.

← PC's & PC Clusters now (5th gen.) → | ← Voice and Pictures (6th generation)

80 81 82 83 84 | 85 86 87 88 89 | 90

Technology Needs Versus Time for FIFTH Generation

		80–85	85–90	
Memory	ram	•64K (2 pages/chip)	•256K (8 pages) •1 Megabit (32 pages)	
	rom.			
	Secondary	•T/E ? low cost take away memory. •5~10 Mbyte Wini → evolution •Aztec •R81 •HSC50.		
	Videodisk	rom ram ?		
Pc's / C's.	chips/syst.	•C •T •N •Saras •J •Venus	•Scorpio •Nautilus. (Venus. II – Cray for 250K)	
	PC's	•CT120 •Portable II	•PVAX •capabilities to vax. ← vectors to VAX arch.	
	multi C	{ •Hydra. •HSC50 •Hq. } smP-VAX	•TMR VAX. •Self repairing C's. •Self diagnosis & user install/repair.	
Links		•NI first NI chip •CATV compat. NI •1 chip modems. •Combined voice/data for CT.	•Encryption required.	
Servers		?		
Transducers	VT200	•fullpage (text/graphics)	images. & objects to video output	
	input	•OCR •	low cost video input	
	hardcopy	LAZY Copier/printer	H/S print.	
	Voice	•Voice Commands •NI voice	•EMS Voicegrams. Continuous Speech recognition	
	Automata.	"Seeing"	robots.	
Programs		•3 level Homogenet.	•Secure VMS.	Users, OEMS, acquire SW.
		•CT120 •ADA avail.	•Begin "cottage" industry of ADA modules.	} SW publishing Industry (std. proced. lang.)
	•Visicalc.	•Visicalc II. •Parameterized SW.	•Visicalc III	
		•Dawn. •CT120 PC SW		} Users Do Applications (non-procedural language)
		•OFIS •EMS •Graphics/text.	•Voice WPS.	
		Knowledged engineered systems •Macsyma, Dendril, XCON.	•Bvax	Computers for Prof's. ≡ Knowledge Engineering •Ability to encode knowledge automatically with non-computer professional.

3/8/81 – GB.

THE FIFTH AND SIXTH COMPUTER TECHNOLOGY GENERATIONS

A computer generation is identified by four concurrent factors:

- the technology on which the machine (hardware and software) is based;
- the emergence of the machine itself;
- the intended need; and
- the actual use (market)...which may turn out to be a new machine (software) defined by users

The Table of Computing Generations lists various landmarks for these factors in both the future and past generations including the three pre-computing generations. Technology generations are now roughly seven years. These generations are driven mainly by semiconductors which evolve exponentially at yearly density factors of 1.6 - 2.0 and are used for processors and primary memory. Secondary memory in the form of magnetic disks evolve nearly as rapidly with factor changes of 1.4 per year. The seventh generation is fuzzy, so for our purposes, we can look at the next two generations 1980-87 and 1987- 1995.

The seven year period between generations will continue on into the future, based primarily on technology, and machines because:

1. Historically benchmark machines and/or computing styles have emerged each seven or eight years.

   The personal computer has emerged in the late fourth generation. With local area network communication, clusters and networks of PCs with specialized function servers (e.g. files, computation, communications) will create a drastically new, alternative distributed computer structure forming the fifth generation.

2. Seven years is roughly the time to get a factor of 100 in semiconductor memory density using Moore's law. (Semiconductor memories double in size every year; the number of bits/die = $2^{(t-1962)}$ for experimental circuits. Add 3 years for the circuit in production.) A more conservative model by Faggin has memory density growing at 1.6/year, thus a factor of 100 would take 10 years. The continued increase in density (at least at 1.6x) looks assured.

3. Seven years is roughly two product design and use generations for small systems. For higher cost machines (minis...super), the product periodicity is roughly seven years.

4. Every ten years drastically new use (and then product) segments occur, having at least a factor of ten lower cost. We assume the real cost reductions will continue at this 20%/year, independent of system size. (Faggin's projection is a factor of 10 cost reduction in 8 years or 25%/year. My 1975 model projected from 1972 used 21% and is given in the following table below, even though it might be appropriate to use a more rapidly decreasing rate (e.g., 25%).

TABLE OF COMPUTING GENERATIONS, WITH NEED, USE AND STRUCTURES

GENERATION	HIGH LEVEL NEED	SPECIFIC USE	COMPUTER STRUCTURE
Electro-mechanical 2 p.c. 1890	Mass production & census	Census & modern accounting	Comptometer, Electric calculator, Hollerith & accounting machines
Electronic (thermonic) 1 p.c. 1930	Power, highway & communication grids	Engineering calculations & cryptography	Network analyzer, Mark I, Bell Labs calculators, ENIAC, Collosus.
Electronic (magnetic) 1 c. 1945	Defense	War-machine control via tables & real time	EDVAC, EDSAC, IAS, Whirlwind, LGP30, IBM 650, 701, 709, UNIVAC.
Transistors 2 c. 1958	Space & science	Air defense & traffic control; Engineering & science education	TX-0, IBM 7090 Atlas, Stretch
Integrated Circuits 3 c. 1966	Transport flow control & welfare	Process control & social accounting, minis	PDP-8, B5000, PDP-6, IBM 360, CDC 6600
LSI 4 c. 1972	Economic models & r.t. control	Interactive computing, computers for logic	Intel 4004, 8008, PDP-11 (RSTS), Cray 1
VLSI 5 c. 1980	Productivity	Office (& home) personal computing	Personal Computer Clusters; VAX Homogenets; general purpose robots
ULSI 6 c. ~1987	Information & program overload, energy	Knowledge-based systems and video processing	Integration into standard communications
Electro-optical 7 c. ~1995	Arts, leisure, food & energy crisis.	Travel substitute & environmental management.	Global communication of video

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G Bell System Price Model (3/75)

System price ($) per byte of main memory

$$= 3 \times 5 \times 8 \times .005 \times .79^{t-1972} \times \text{no. of bytes}$$

$$= .6 \times .79^{t-1972} \times \text{no. of bytes}$$

where

3 is markup (roughly)
5 is fact that about 1/5 of system is primary memory
8 is 8 bits/byte
.005 is cost of a bit in 1972
.79 is 21% price decline per year for memory
1972 is base year

Some system prices at various time using the GB 3/75 model:

Bytes	Use	1978	1980	1982	Example
1		.146	.091	.057	
8K	Dedicated fixed	1.2K	745	467	TRS
65K (Qbus limit)	1 user interactive	9.6K	5.9K	3.7K	Apple II/III
256K (Ubus limit)	n user, 1 applic.	28.3K	23.9K	14.9K	11/23
1M	Small, gp. t/s	153K	95.4K	59.8K	Comet
2M (11/70 bus limit)	Mid, gp. t/s	306K	190.8K	119.5K	VAX 780
8M	Large, gp. t/s	1,225K		763K	478K

5. Breadboard structures have emerged in the early part of this fifth generation that can be mass produced to fuel the sixth generation. My guess is that this will take on the form of significantly better I/O, storage, and processing of both voice and 2-d images.

6. There is implicit faith that there's an infinite market. This is clearly substantiated using the five year market data projections. A paper, "Limits of Distributed Processing" describes our computing structure environment together with the factors that may limit computing. None of the following factors look insurmountable for continued exponential change.

- technology
- VLSI design and new ideas for designs

- too many standards, especially in communications/networks
- algorithms
- ability to define and supply useful systems
- lack of applications programs (programmers)...perhaps the most serious
- ability for users to get work from systems

DISTRIBUTED PROCESSING AND LIMITS TO ITS GROWTH

A fifth generation computer, can be fabricated on a very large scale integrated circuit (VLSI). Lower cost and increased use disperses computers in a manner analogous to the ubiquitous fractional horsepower motor. Distributed processing to interconnect dispersed computers is essential in order to avoid overloading people with information transmission and translation tasks.

The factors that affect and limit distributed processing are: physical technology and design complexity, ideas for new computer structures, basic tools to build applications, networking and other standards, useful applications, algorithms, and the human interface to the end user. A hierarchical, interconnecting model for distributing processing is based on established central and group level mini-computers, and evolving, personal computers.

DISTRIBUTED PROCESSING

Distributed processing matches computer systems to information processing needs (i.e. processing, memory, switching, transmission and transduction needs) on a geographical or organizational basis, and interconnects individual computers to form a single, integrated network so that related programs can share and transmit data among the computer nodes. The objectives are:

- to allow either local autonomy or central control of the various distributed parts;
- to provide an evolving open-ended system so that the development and installation of the parts can proceed in a quasi-independent fashion;
- to allow purchase and installation of hardware, taking advantage of timely, reduced hardware cost; and
- to build on and communicate with central systems, fully dispersed group-level mini-computer systems, and emerging personal computers.

Distributed processing is inherently hierarchical based on the principles that govern human organizational structures. In an organization, computers supplement their human, information processing counter-parts. As computers become better matched to people and organizations, and as people and organizations become more familiar with computers, an individual can interact directly with at least one computer and indirectly with group-level computers serving various functions of the organizational hierarchy. The opportunity of more egalitarian access to data provided by distributed processing may led to a change of the large organization from hierarchical to wider, functional matrix structures.

Large organizations need to interconnect the hierarchy of computers for:

- communication among computer with dumb and intelligent terminals using large, central computers;
- organization of central, group and individual sites; a functional activity such as word processing or order processing; and
- a specialized computer-based function such as archiving, typesetting, message switching, and electronic mail.

FORCES CREATING DISTRIBUTED PROCESSING
Rapid evolution of semiconductor and magnetic recording technologies have forced computers improvements along paths of:

1. constant cost, with increased performance and productivity for evolutionary use;
2. reduced cost, with constant performance permitting new uses commensurate with the lower cost; and
3. higher cost and performance structures permitting radically new applications.

Costs for nearly all other forms of information processing are because they are labor intensive. Traditional storage, processing, and transmission in libraries and postal systems are increasingly soaring. Simple word processing computers that replace typewriters save the time-consuming process of correcting errors. When groups associated with information processing start using computers a positive feedback, learning curve effect begins further increasing computer markets and uses, and lowering costs.

The industry groups supplying these products and services include:

- computers - mainframe, minicomputers, personal computers and computer services;
- semiconductors - nearly all LSI components are either memory or a computer processor;
- communications - conventional voice and data, new packet networks and associated services;
- television and cable TV - stand-alone use with TV sets (e.g. games, home computers) and as an alternative to conventional communication;
- office equipment - typewriters, copiers, and mechanical office equipment are increasingly electronic; and
- control - gears, cams and levers, and mechanisms for

control will become electronic, limited only by transducers and sensors.

LIMITS AND PROBLEM AREAS OF DISTRIBUTED PROCESSING

Ultimately all information processing will be computer based. Presently the speed of the evolution is limited by two factors: technical solutions to distributed processing problems and user assimilation.

Physical Technology

Semiconductors and magnetic recording technology provide the basis for cost and performance improvements. Although, extrapolations too far into the future are generally dangerous, the following technological rates of change, based on the past ten years, will continue for at least five years:

TECHNOLOGY (PERFORMANCE)	YEARLY-RATE OF CHANGE FACTOR
semiconductor memory density	2.Ø
semiconductors, random logic	1.4-1.6
core memory density improvement	1.3
magnetic disk recording density	1.3-1.4
magnetic tape data-rate	1.25
magnetic tape density	1.2

TECHNOLOGY (COST)	YEARLY-RATE OF CHANGE FACTOR
memory price reduction	Ø.7
computer system cost reduction	Ø.8
crt terminal cost reduction	Ø.85
communication cost/bit transmitted reduction	Ø.9
packaging (cost/vol.) and power (cost/watt)	1.Ø
communication line cost <u>increase</u>	1.12
paper cost <u>increase</u>	1.12

Semiconductor technology, shared among several buyers groups, eg. consumer, communications, computers, has a faster rate of improvement than other technologies. Slower evolution has occurred in magnetic recording density because there is only one user, the computer industry. Widely used, well developed technologies, such as CRT's, previously improved for the mass television market are scarcely affected by their increasing use in computers. Costs of paper and communication lines increase with inflation.

Physical transducers that sense temperature, pressure and control power flow are slow to evolve, limiting computer use in automotive applications. Even the most widely used computer equipment, such as keyboards, printing devices and communications devices, evolve slowly by comparison with semiconductors.

Complexity of Semiconductor Design

Gordon Moore of Intel, observed that the effort required to design semiconductors has doubled each 2-2/3 years since 1962, when a circuit only took 3 man months. 1979 circuits required 21 man years and 1982 circuits will take about 45 man years. While it is easy to conceive of organizing a team of 7 to complete a design in 3 years, the same time task by 15 people is difficult to imagine. Better management and design partitioning is required in order to avoid a drastic loss of productivity and quality that would increase the design effort even more. With one million circuits on a chip by 1982, new methodologies will be required to fully utilize VLSI's potential.

Because of the concern and numerous approaches being pursued, I am confident that it will only take another two semiconductor generations (six years) to solve the VLSI design complexity problem. Although we do not have a good measure of circuit complexity, a given circuit description is far less complex than the largest programs (e.g. a million bit, or 128 Kbyte program is not especially large).

Ideas About What to Build

New directions in computer structures are difficult to predict by simply looking at conventional machines. Current limiting factors point to needed innovations. Applications involving two dimensional signal processing for pictures appear to require a different processor design, and speech signal analysis requires vector processing. A general purpose processor could emerge from these alternatives for one-and two-dimensional arrays:

- arrays of conventional microprocessors;
- application specific, functional processors;
- bit array processors to operate directly on the array data structures, including arrays, or associative processing;
- processing associated with memory; and
- data flow architectures.

Basic Tools to Build Applications

Coupling knowledgeable user needs to machine development produces more capable, yet harder to understand systems: a paradox in the attempt to build highly capable and easy to use systems. The popularity of the Bell Labs UNIX System is a testimony to a single, consistent, easy to use language, that is described in a small manual. The popularity of APL and BASIC systems can be similarly explained. Although one would expect that additional capabilities (memory) would make the user interface simpler, few good examples are known. The time to build a given application using the multitude of systems/databases/languages is highly variable, indicating a continued lack of understanding of the design process.

Network and Other Standards

Because standards are evolving, the current situation of distributed processing among countries and vendor systems is a disaster. International protocol standards provided by manufacturers (Internets) and by various common carriers for Packetnets which are called by the same name, are fundamentally different and incompatible. Many standards mean no standards.

We must get beyond the simple standards required for Packetnets and Internets to define protocols for passing high level messages, such as electronic mail, among computers. Office based applications, centered around text processing, electronic mail, user typesetting, office processing, and electronic filing, all require significant user level standards. Using only lower level communications protocol standards will cause a combinational explosion of high level protocol changing gateways. This leads to added overhead, extra development, delay, incompatibility, and often, misinterpretation of messages.

In the low priority area of intra-computer architecture, the U. S. Government has standardized on the existing defacto standard, the IBM Channel, as the means of interconnecting mass storage to computers. Unfortunately this act of standardization will limit change into newer systems architectures.

Useful Applications and Distributing Them

Decisions to use the major applications centered around office automation are very complex. Justifying an application generally requires an understanding of both computer systems (beyond that provided by manufacturers) and the organizational structure of individuals and group users. Although electronic mail seems right, measurements of increased productivity, decreased paper flow, better decision-making, efficiency of communication, and the creation of excess communication are hard to make. To my knowledge, they don't exist.

Given that few measures exist to rationalize, simple stand-alone applications, justifying a distributed network becomes a work of art. Tools have only recently become available for a system manager or developer to distribute the database, processing, and intercommunications over several systems. In the specific case of distributed processing for electronic mail, the results are encouraging but a general solution has not yet emerged.

An underlying difficulty of building applications beyond the generic office automation described above exists because problems are solved by patch-work. Usually programmers with computer science (computer engineering) training and a representative of a particular discipline (eg. accounting, mechanical engineering) put a solution together to get something started. This results in sub-optimal designs. In order to use the computer as a component of systems they design, rather than as a simple tool for problem solving, computer science must take on a pure role, like physics, and each of the disciplines take the responsibility for training people and engineering the systems within its own discipline.

Algorithms

There are many cases of the adage: "It is better to work smarter rather than work harder". If always exponentially improving, technology will eventually permit solving a particular problem in a reasonable time, e.g. a 24 hour advanced weather forecast must be solved in less than 24 hours or an exponentially increasing machine population will be required. However, at a given time, algorithms limit when a problem can be solved and whether it is economically feasible.

Human Interface

The interface between the system and the final user is a barrier in the same way that a root system for building applications programs is a barrier to building applications. Adding more functions so that an application will perform better is generally accompanied by increased complexity requiring more documentation and training. The lack of standards at the user interface will limit getting the payoff inherent in a given system or set of systems, and may cause adverse user reaction. For example, word processing, electronic mail and user typesetting systems are all likely to have different syntax, semantics, manuals, training and procedures for dealing with the same text.

A DISTRIBUTED PROCESSING ENVIRONMENT
Proliferation of dispersed computing forces interconnection, hence distributed processing, so that human users don't have to become information carriers and translators between the different systems they use. Communication within and between organizations with common carrier networks is provided via an interconnected hierarchy.

Interconnecting the Components
The three types of computers in a given organization will be connected via high bandwidth links in what may appear to be a hierarchical structure. In addition, clusters may be connected on a fixed basis. The alternative interconnect possibilities are:

- ethernets or rings to interconnect all terminals and computers with specialized terminal concentrators;
- evolution of phone circuit switches using digital techniques for both voice and data;
- packetnet switching; and
- direct interconnection among the computers with routing through each computer.

Central Computers
The top most computers of the hierarchy will evolve from the current, highly central computation facilities. These machines store most of the data and do most of the computing in today's organizations. Given the difficulty of migrating files and work from these machines, the emphasis within the centers will be interconnection among the machines within each center, creating in the short run, even larger data bases. The tight interconnection among the central computers will also permit trade-offs among cost, reliability, performance, and evolving performance, for a given application or set of applications. In order to get the economy of scale required to support the large human organizations that attend central computers, their functions will have to be specialized (e.g. front ends for handling many communications lines, and back ending for databases and archiving).

Central computing facilities will continue to be operated by large staffs whose emphasis is on knowledge of the operating systems and getting work done using highly specialized facilities such as CODASYL Databases. The casual user will be dependent on the central systems through the applications. Cost will be high for everything except the storage of very large files, where hardware provides an economy of scale. Programming costs at the center have to be the highest, because the facilities are general purpose and applications are most remote from the ultimate user. The role of central facility will be to provide:

- communications among all the other computers within the organization including gateways between various computer and telecommunications vendors;
- archival file storage;
- unique, sharable facilities such as very high speed computers and printing devices;
- computational functions for the entire organization e.g. electronic mail;
- operation of historical programs and data bases; and
- relatively high cost computing by having to provide generality and service for the worst case.

Group Level Computers
Group level computers are based on the evolution of timeshared and real time minicomputers and cost roughly that of an additional person. Typically these machines support the single function of the group, (eg. order processing, engineering design and data base, laboratory data gathering and analysis, group word processing, single process control) running a single unattended program. Group level computers provide:

- relatively cost effective storage of the group data base;
- unique program(s) aligned with function of the group;
- relatively high performance processing; and
- cost-effective computing through sharing of a common function and specialization of work.

Personal Level Computers
Personal computers are emerging rapidly, and many believe that they will become the dominant form of computing. Since the only hardware technology for which economy of scale holds is mass storage, and given that all terminals already have embedded computers for control, it is easy to envision adding more primary memory and doing all the computation at the terminal instead of having computation done in any shared facility. A recent, Carnegie-Mellon University personal computer research proposal states:

> "The era of time-sharing is ending. Time-sharing evolved as a way to provide users with the power of a large interactive computer system at a time when such systems were too expensive to dedicate to a single

individual...Recent advances in hardware open up new possibilities...high resolution color graphics, 1 mip, 16 Kword, 1 Mbyte primary memory, 100 Mbyte secondary memory, special transducers,...We would expect that by the mid-1980's such systems could be priced around $10,000."

Personal computers provide:

- personal data bases and security;
- more, average computing power, with better response time than shared systems;
- needed processing for the computationally intensive tasks like editing, and speech i/o;
- a program creation environment; and
- relatively higher costs than group level computing, unless the task is very specific and well-matched to the system.

Although both the novice and experienced user relish the independence that the personal computer provides, communications and support by the other levels is equally necessary. Given that we are substantially far from such distributed systems, there are surely additional problems, limits, and opportunities that are yet to be forecast.

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CHAPTER II

ESSAYS ON THE CRITERIA FOR ALLOCATION OF ENGINEERING RESOURCES

OVERVIEW

Among the most critical decisions facing Digital each year is the allocation of our Engineering budget. What products and technologies should we invest in? Obviously, we want to maximize the long-term return to the Corporation. Chapter V contains financial and marketing metrics which are helpful. We must produce the products needed to meet the Corporation's business goals. Moreover, we believe that DEC is in a "technology inspired" market so that the first test of a proposed investment should be its contribution to the basic strategy described in Chapter I.

Unfortunately, there is no algorithm for translating the broad strategic framework into specific investment tactics. We are forced to study a huge space of feasible choices that lie within our resources (i.e., budget, capital equipment, and talent pool). Then we apply various heuristics to select among the better options.

There are three closely related areas of choice:

i) Products to build for the Company we want to be

ii) Technologies to own (i.e., engineering and manufacturing processes)

iii) Components to make vs buy

This Chapter contains several essays that provide some heuristics for selection in these areas:

1. <u>Heuristics for Building Great Products -- Revised 1982</u> by Gordon Bell

   The Group Vice-President for Engineering describes his rules for achieving winning products. This document has been revised to reflect recent experience.

2. <u>Proposed Resource Allocation Criteria</u> by Bruce Delagi

   Another global "take" at identifying investments that support the strategy. Five critical factors are discussed -- vision, winning, partnership, quality, and productivity/responsiveness.

3. DEC's Position in the VAN by Bruce Delagi

Computer products start with sand, fire, and water. They culminate in benefits delivered to end users. Different companies position themselves differently along the network of value-added contributors (VAN). This essay discusses a general philosphy of vertical integration and guidelines for selecting specific investment areas.

4. Buyout Philosophy/Process/Criteria
by Peter Van Roekens

Offers a recommended approach to the make versus buy decision as a part of the regular activities of our major programs.

5. Example of a "Make vs Buy" Analysis
by Gordon Bell and Grant Saviers

Actual "make versus buy" decisions can be very difficult. Two memos on high-end disk strategy provide a case study of the diversity of viewpoints and range of issues. Disks have a substantial leverage on profit since they represent the largest single component of systems cost. But if half the cost of current disks is electronics, perhaps semiconductor technology is more strategic since it impacts most of the components in a system.

6. Engineering Investment Sieve by Bruce Delagi

A short list of tests for the overall Engineering budget. It is a summary of issues considered at an Engineering Staff Strategy Woods.

Additional material of importance to this topic will be found in Chapter IV. It contains a report from Engineering's Technology Management Committee on the state of technology within Digital and the needs for investment.

This collection of essays presents a useful but incomplete set of criteria for the allocation of our Engineering resources. DEC is a large company with a diversity of on-going businesses. No single set of guidelines capture the complexity of the tradeoffs between our current business demands and our future opportunities. In the final analysis, the Engineering budget allocation must be a judgement call by our senior management. It has to be tested for consistency within itself and for consistency with our long-term Engineering strategy and our Corporate business plans.

HEURISTICS FOR BUILDING GREAT PRODUCTS

Product goodness is somewhat like pornography, it can't fully be described, but we're told people know it when they see it. If we can agree on heuristics about product goodness and how to achieve it - then we're clearly ahead. Five sets of dimensions for building good products need be attended to (roughly in order of importance):

- maintaining a responsible, productive and creative engineering group;
- understanding product metrics (competitiveness);
- understanding design goals and constraints;
- understanding when to create new directions, when to evolve products, and when to break with the past; and
- having the ability to get the product built and sold.

ENGINEERING GROUP

As a company whose management includes mostly engineers, we encourage engineering groups to form and design products. With this right of organizing, there are these management and engineering responsibilities:

- staffing with a chief designer/chief programmer who will formulate and lead the resolution of the problems encountered in the design; No matter how large the project, it must be lead from a "single head".
- having the skills on board to make the proposal so that we adhere to the cardinal rule of Digital, "He Who Proposes, Does"; Approving a plan, without the chief designer and sound team violates this! The plan must include the project organization.
- having management and a technical team who understand the product space and who have engineered successful products;
- understanding excellence and quality;
- understanding the performance and the learning curves that apply to design, design production processes, and manufacturing processes; The organization must be staffed with people who understand the product, the design process (CAD and management discipline) and the production introduction process. For complex projects employing more than a single design team (less than six engineers), a written design methodology must exist and include: all design processes as documents forming the design, design conventions, conflict resolution, criteria for task completion, the PERT structure, etc.
- having supporting skills and disciplines required in the relevant product areas, eg. ergonometrics, acoustics, radiation, microprogramming, data bases, security, reliability;
- being open by having external reviews, and clearly written descriptions of the product for inspection;
  For new product areas, we require breadboards in addition to the above heuristics. When the product gestation time equals the generation time, a full advanced development effort is most likely required to be successful.

- a group with no previous achievement must start small, be reviewed and grow when it has demonstrated success;
- continuous training to handle the increase in complexity that comes with technology.

PRODUCT AND DESIGN METRICS KNOWLEDGE

Engineering is responsible for knowing the product area:

- metrics (cost, cost of ownership, cost to operate and use); We have classic failures because a CPU cost has been minimized, only to find the total system cost has barely changed 10% and the total cost to the customer is only 5% lower!
- major competitor cost, performance and functions together with what they will introduce within 5 years;
- leading edge, innovative small company product introductions;
- reasons why the product will succeed against present and likely future competition; Sure success in the market is to introduce a needed function (eg. 32-bit address) by which all other products have to be measured.
- productivity, quality and design process metrics by which the project can be managed.

DESIGN GOALS AND CONSTRAINTS

- The most important heuristic about goals and constraints is that they be written down and updated from the day the project starts.

Virtually every product failure and period of product floundering is a result of no clear goals and constraints since everyone has a different idea of the product.
Design constraints are generally set as various kinds of standards. These are useful because they limit the choice of often trivial design decisions, and let us deal with the free choices. Goals are equally important. We should meet the standards unless they are unacceptable, and if so go about an orderly change. Standards can be grouped into four distinct sets:

- DEC Engineering Standards; These cover most physical structures and design practice for producibility, and assimilate critical external standards, such as UL, VDE, and FCC.
- official information processing and communications standards, from EIA, CBEMA, ANSI, ISO etc. such as Cobol '74, Codasyl, to IEEE 488;
- defacto industry wide information processing and communication standards such as IBM SNA, Visicalc;
- standards implied by the architecture of existing DEC products:
  - architecture of computers, terminals, mass store and communications links; These standards include 8, 11's, 10/20, VAX, 8048, 8080, 8086, 68000; VT52, VT100, keyboards, Regis; MCP; HDLC, CI, SI.
  - physical interconnect busses such as CT, Q, U, NI, CI, etc.

These insure that future system products can evolve from component or computer options.
. operating system interface, file commands, command language, human interface, calling sequence, screen/form management, keyboard, etc.

These standards insure our customer software investment is preserved.

. Products must be designed for easy translation into in any natural language since we are an international company.

In all cases, poor standards create to poor products, even though they may have made sense at one point of time. The historical English measures is a good case in point; Currently, the 19" rack and the metal boxes Digital makes to fit in them, and then ship on pallets to customers, act as constraints on building cost-effective PDP-11 Systems. This historical "mind set" standard is impeding the ability to produce products that meet the 20% cost decline.

All products must have the goal of customer installability and maintainability.
. Portability is an important goal. We must achieve this for all systems ASAP! Clearly all new personal computers must be portable.

WHEN TO CREATE AND WHEN TO EVOLVE
Given all the constraints, can we ever create a new product, or is everything just an evolutionary extension of the past? If revolutionary do we know or care where product ideas come from? The important aspect about product ideas is:

. Ideas must exist to have products! If we don't have innovative ideas to redefine or extend a market, then we should not bother building a product.

It is hard to determine whether something is an evolution or just an extension. The critically successful products all occur the second time around. Some examples: PDP 6,KA10,KI10,KL10,2080; Tops 10,Tenex,TOPS20; PDP5,8,8S,8I/L,8E/F/M; OS8-RT11; 11/20,40,34; RSX-A... M, M+; TSS-8,RSTS; various versions of Fortran, Cobol and Basic all follow this; LA30,36,120; VT05,50/52,100, 101 etc.; RK05,RL01/2.
. A product tree showing product roots, gestation time and product life should be maintained by each engineering group.

<u>Goodness</u>
All products whether they be revolutionary, creating a new base, or evolutionary, should:

. <u>offer at least a factor of two in terms of cost-effectiveness</u>

C O M P A N Y C O N F I D E N T I A L

over a current product; if each product is unique (not in competition with other products within the company), then we will have funds to build really good products.

- be based on an idea which will offer an attribute or set of attributes that no existing products have; For example, the goals and constraints for VAX included factor of two algorithm encoding and also offering ability to write a single program in multiple languages. VT100 got distinction by going to 132 columns and doing smooth scrolling.
- build in generality, and extensibility; Historically we have not been sufficiently able to predict how applications will evolve, hence generality and extensibility allow us and our customers to deal with changing needs. We have built several dead end products with the intent of lower product cost, only to find that no one wants the particular collection of options. In reality, even the $200 calculators offer a family of modular printer and mass storage options. For example, our 1-bit PDP-14 had no ability to do arithmetic or execute general purpose programs. As it began to be used, ad hoc extensions were installed to count, compare, etc. and it finally evolved into a really poor general purpose digital computer.
- be a complete system, not piece parts; The total system is what the user sees. A word processing system for example includes: mass storage, keyboard, tube, modems, cpu, documentation including how to unpack it, the programs, table (if there is one, if not then the method of using at the customer table), and shipping boxes.
- Good system products can only exist if we have good components. We should not depend on system markups and functionality to cover poor components and high overhead.
- We must carefully decide what components to make versus buy. It is very hard for an organization to be competitive without competing in the marketplace, hence unless we sell it, we should buy it.

Product Evolution

A product family evolution is described on page 10 of Computer Engineering along the paths of lower cost, and relatively constant performance; constant cost and higher performance; and higher cost and performance. In looking at our successful evolutions:

- lower cost products require additional functionality too, as in the VT100;
- constant cost, higher performance products are likely to be the most useful, as economics of use are already established and a more powerful system such as the LA120 will allow more work to get done (see Computer Engineering for the economics);

Revolutionary New Product Bases

- a new product base, such as a new ISP, physical interconnection specification, an Operating System, approach to building Office Products, must:

start a family tree from which significant evolution can occur; The investment for a point product is so high that the product is very likely not to payoff. In every case where we have successful evolutionary products, the successors are more successful than the first member of the family.

Product Termination

- A product evolution is likely to need termination after successive implementations, because new concepts in use have obsoleted its underlying structure. All structures decay with evolution, and the trick is to identify the last member of a family, such as the 132 column card, and then not build it. This holds for physical components, processors, terminals, mass storage, operating systems, languages and applications. Some of the signs of product obsolescence:
  - it has been extended at least once, and future extensions render it virtually unintelligible; (For example, PDP-8 was extended three times.)
  - significantly better products using other bases are available;

SELLING AND BUILDING THE PRODUCT

Buy in of the product can come at any time. However, if all the other rules are adhered to, there is no guarantee that it will be promoted, or that customers will find out about it and buy it. Some rules about selling it:

- it has to be producible and work; This, seemingly trivial rule is often overlooked when explaining a product's success.
- a business plan with orders and marketing plans from several marketing persons and groups needs to be in place; Just as it is unwise to depend on a single opinion in engineering for design and review, it is even more important that several different groups are intending to sell the product. Individual marketers Are just as fallible as unchecked engineers.
- never build a product for a single customer, although a particular customer may be used as an archetype user; Predicating a product on one sale is the one sure way to fail!
- it should be done in a timely fashion according to the committed schedule, at the committed price and with the committed functions;
- it must be understandable and easy to use. The small size, complete hardware books were the DEC trademark that established the minicomputer. We must revive these such that a particular user never need access more than one. Simplicity must be the rule for our documentation.

Now isn't it clear why building great products should be so easy?

Are there any heuristics that should be added? deleted? or need clarification?

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2/4/82 Thu 9:00

PROPOSED RESOURCES ALLOCATION CRITERIA
(MEETING STRATEGIC THREATS)

VISION
We want to be known for a uniquely productive style of computing as described by the Product Strategy in Chapter I. This requires us to be primarily a company that understands and satisfies the information system needs of our users and their machines. This criterion calls for a return to a clearer image of what we stand for in computing. Our perceived edge in user productivity with respect to IBM is slipping.

The call is in distinction to becoming a company primarily engaged in high volume manufacture of component-commodity subsystems. The intent is supply high volume needs by providing a product offering that is sufficiently broad, deep and interrelated that it presents an especially attractive foundation for others to build on.

We hope that our customers will view us as particularly capable of managing complex technologies - providing results in particularly simple and effective packages. This will take the form of the industry's broadest range of comfortable, interconnected computing facilities.

Highly productive computing makes effective use of the human contribution. We want to be known for leadership in the human interface to information systems. This requires an understanding of cognitive as well as classical human factors. It implies an investment in speech and image processing in order to couple more effectively with the user.

Leadership human interfaces are responsive, interactive human interfaces. To provide highly interactive systems, we need to support the cost-effective dispersal of processing to its point of use and use this processing power effectively in our terminals.

Increasing user productivity is measured against a given level of customer capital employed. Perceivably and measurable cost-effective user productivity is the goal.

We should strive to use our own products early so as to understand their effect on productivity.

WINNING

We will only enter or remain in a product area if we are playing to win. We will withdraw from a product area if we can't state clearly why we are going to win -or- won't dedicate ourselves appropriately to this goal.

Corollary: If we are already winning in a given product area, we will give first priority to maintaining this position: leveraging our installed base, existing products, and distribution channels.

We will not enter into later phases of product design without believable plans to generate high returns through product uniqueness and quality.

Exceptions: We will carefully review those occasional variations to this criterion required to meet specific bid requirements (c.f. IBM channels, DBMS) even though the product is not otherwise a critical (or profitable?) one.

PARTNERSHIP
Focus of our own resources and leveraging off the work of others must be a key premise of our strategy. We will invest to lead and sustain the industrialization of clear, efficient, effective human and machine interface standards over a broad product range.

We've been known historically as a company that makes products to which (and by which) others can easily provide complementary capabilities satisfying particular needs. We aim to continue in this position.

To avoid the time-delay otherwise implied in "partnership" marketing, we need clear long lived standards.

Our products are sold at several different levels of integration simultaneously through many kinds of channels. It's important that each product level stand on its own competitive merits.

The environment of the 1980's will almost certainly include a more intimate relationship between computing and communications. We will seek to cooperate in the development and application of standards tieing together these disciplines.

We will provide appropriate internal and external interfaces to tie our products to local and distributed, public and private communications switching systems supplied by a variety of carriers. We will invest to deal effectively with the integration of voice, data and video images because we believe this is critical to highly productive computing.

QUALITY
Investments we make will be complete enough to ensure the development of products that work as expected in worldwide markets.

The goal must be direct shipment via UPS, customer merge, installation and repair.

We seek to improve our responsiveness to manufacturing issues and provide sufficient co-location so that our engineers will get the necessary feedback to appropriately evolve product designs.

Together with manufacturing, we will seek automated methods that allow an increasingly higher level of consistently delivered quality.

We will invest in design aids that offer the promise of reducing design faults in shipped products.

At a systems level we will invest to provide user-tolerant, self-documenting products that rarely need service - and when service is required, do not involve skilled personnel.

We will invest to develop an increasing degree of data integrity in our products.

PRODUCTIVITY/RESPONSIVENESS
There is a strong possibility that the pace of change in our industry will increase. There are several strong new players in our game. Further, IBM is much less encumbered by its lease base than previously. We need a strategy for improving engineering responsiveness. Some key operating rules are emerging:

Make decisions that can stick (and stick by them);

Do advanced (standards) development so invention need not be incorporated in critical schedules;

Stick to standards (so invention is constrained to only what is critical for a product);

Provide tools for more productive design efforts and understand how our use of resources, especially computers, affect productivity.

Keep some slack resource so unanticipated events can be accommodated.

DEC'S POSITION IN THE VAN
(VALUED-ADDED-NETWORK OF SUPPLIERS AND CONSUMERS)

We have an industry position in "partnership" with those who provide end user services.

It is our assumption that we wish generally to increase partnership activities overall, limiting direct efforts to areas where we have particular competance and potential. In this, we balanced the benefits below:

LESS PARTNERSHIP (MORE DIRECT,...)	MORE PARTNERSHIP

. More market control as our suppliers forward integrate (potentially around us);
. More insite to end-user needs;
. Less dependence on OEM skills;
. Less vulnerability to economic cycles
. More danger of high investment levels in obsolete technologies
	. Less resource drain for end-user applications development;
	. More market breadth for products
	  . for higher product volume
	  . more opportunity to succeed in the absence of a complete, acceptable solution
	  . leverage off the ideas and investments of others;
	. Less possibility of getting caught in a saturated point market;
	. Clearer product feedback;
	. OEM test of our output at several integration levels

We seem to be in a "technologically inspired market". As a company we have a strength in distribution channels that we wish to emphasize.

Our policy on vertical integration (as follows) is consequent to this judgement and a consideration of the individual cases detailed later:

- Invest only in necessitites, not for incremental revenue or profit.

- Provide the productivity tools to encourage massive levels of applications development by others on our systems.

The criteria we will use in selecting areas for vertical investment are:

- First to ensure sources of supply, e.g. for disk supply that may dry up if controlled by a few large manufacturers. (This requires the test of clear and convincing evidence.)

- Then to get technology that is required for leadership proprietary function especially that which is visable to the user (e.g. personal computer terminals and these semiconductor processes and design tools to support leadership DEC products and proprietary architectures).

- Lastly, if ever, to internalize the base products needed for a large part of our revenues.

As a result of applying these policies/criteria we wish to allow the following corporate development.

B A C K W A R D   I N T E G R A T I O N

FORWARD INTEGRATION: % SERVICE	lo (% SELF-MANUFACTURE)	hi
lo	K-MART APPLE SEARS DEC '75 DEC '80	INTEL DEC '90 FUJITSU
hi	ADP Schlumberger	IBM AT&T

(This picture is probably too simplistic. It might be valuable to separate out, say, low-end high-end, computing vs. communications, ...)

WE WILL INVEST TO ACCOMPLISH SOMEWHAT MORE BACKWARD INTEGRATION TO:

- Increase security of supply: where this is critical to our business;
- Have better potential for leadership products by control of product definition;
- Maintain trade secret protection and the advantage of (unique) proprietary products
- Provide better internal responsiveness to our needs than outside suppliers would/will provide (and thus potentially shorter time-to-market for new products);

WE CHOOSE TO DEPEND LESS ON FORWARD INTEGRATION BECAUSE:

- DEC's success has been/will continue to be as a product company;
- Fundamentally we are better off if we provide products that don't need services to be useful;
- We project increasing difficulty in getting trained people: only products that don't need service don't need people.
- Cash looks better applied in providing better products than in providing more services. (This is due to expected productivity of capital assets vis-a-vis more direct labor);
- We project a crunch in service profit as a no-profit policy is played out by Fujitsu (and others).

This does not imply that we should not derive what profit we can from our service operations. As an engineering organization, however, we should provide products that to an increasing degree do not require service for maintenance, not for facilities management, not for custom installation, not for training, ...

We have some history with prior decisions to vertically integrate our supply. Some (e.g. terminals and "boards") we have chosen to sell on the open market. Some others (e.g. power supplies and most semiconductors) we have not. Recognizing the tradeoffs as detailed below, our overall policy is to subject vertical integration to the market test.

INTERNAL USE ONLY	OPEN MARKET SALES
Better responsiveness to internal demand shifts	More volume/scale
Retained focus on systems business	Clearer (economic) market feedback
More cooperation in fixing problems	Increased incentive/drive
Less management in dilution to work on market charter hassles,...	Better customer coupling
Reduced need for (complex) allocation schemes	More sensitivity to (cost) requirements
	Less chance of hanging on to an obsolete technical position
	Spreads DEC's name
	Develops new channels
	Value-added on DEC products by more people (leveraging ideas/assets)

For these reasons it is important when we indulge in vertical integration that we maintain a clear understanding of what we expect to get from the investment.

In terms of forward integration, the picture looks like this:

AREA	FUNDAMENTAL BENEFITS TO DEC	SUCCESS CRITERIA	INVESTMENT STRATEGY
Applications (Bill Johnson)	Elapsed time for customer implementation Broader markets (for growth?)	We establish the environment that most people build on ("code share")	Supply higher level tools Don't import systems software
Services (?)	Image as a manufacturer of high productivity (low hassle, high personal leverage) products	Make services unnecessary	Specific attention to methods reducing design faults. (design auto.) Repeatable processes than can be turned for lower product failure (process automation?) Failure tolerant systems (and subsystems) Self-instruction Self-repair Self-installation

AREA	KEY DEC BENEFIT	SUCCESS	SUPPLIERS/VENTURES	INVESTMENT
Power Supplies (H. Schalke)	Design-to-Fit Time to Market Potential Quality	Users seek to buy internally Meet MBTF specs	Look at Sanyo et al. for <50w and for low volume, high power	Design standard power pieces Minimize design
Physical Connect (Will Thompson)	Volume capacity at spec Cost/manufacturability Turn-around time Fewer mfg. test levels Integrate DEC/non-DEC parts	1 Wk. correctly stuffed bds. 200-300 pins/ sq. in. by '90 Suppliers cost	Fujitsu? Must develop outside suppliers	Fast turnaround manufacturability tools Up process density Integrate test philosophy
Disks (Grant Saviers)	Leadership systems image (quality, RAMP, cost/performance) Responsive system design (higher level file system opportunity) Volume capacity	Leadership cost Unique systems position Capacity supports revenue	J.V. w/HP and other systems competitors. Try Japan: Fujitsu, NEC (??), ... Buffer shrinking supplier base	Be ready to maintain supply position. Explore unique systems possibilities Buy commodities Build solid technical base/exploit broadly
Semi-conductors (Jim Cudmore)	Quaranteed supply of proprietary leadership function Turnaround time Control of base computing technology (cost/performance, density/speed/...)	Broad desire to use in design Use of only a few processes Turnaround in 5 days Code share on DEC standards	Commodities generally available. Harris Suppliers becoming or becoming owned by competitors	DEC Design System: tools & product architectures Education program Smart process selection Absorb outside technology
Terminals (Si Lyle/ Bill Picott)	Extension of DEC's name Development of new channels/markets Leadership systems image: packaging, graphics, color, voice, intelligence	Productivity leadership Dispersion of processing to DEC terminals Quality/MTBF	J.V. w/CRT suppliers Graphics equipment suppliers	Understand cognitive factors/ergonomics Distribute extended user interfaces to DEC terminals/ personal computers Stimulate code share

BUYOUT PHILOSOPHY/PROCESS/CRITERIA

BUYOUT PHILOSOPHY

Buyouts provide a mechanism which can give us significant leverage. We can utilize the work of others and focus our own resources on those issues which have the greatest strategic impact. The make/buy decision should always be supportive of our long term strategic plan. Where the issue is not covered or the decision is unclear given the criteria in the strategic plan, the specific decision is driven by the Program Manager at the appropriate level. (Refer to the attached flowchart for details.)

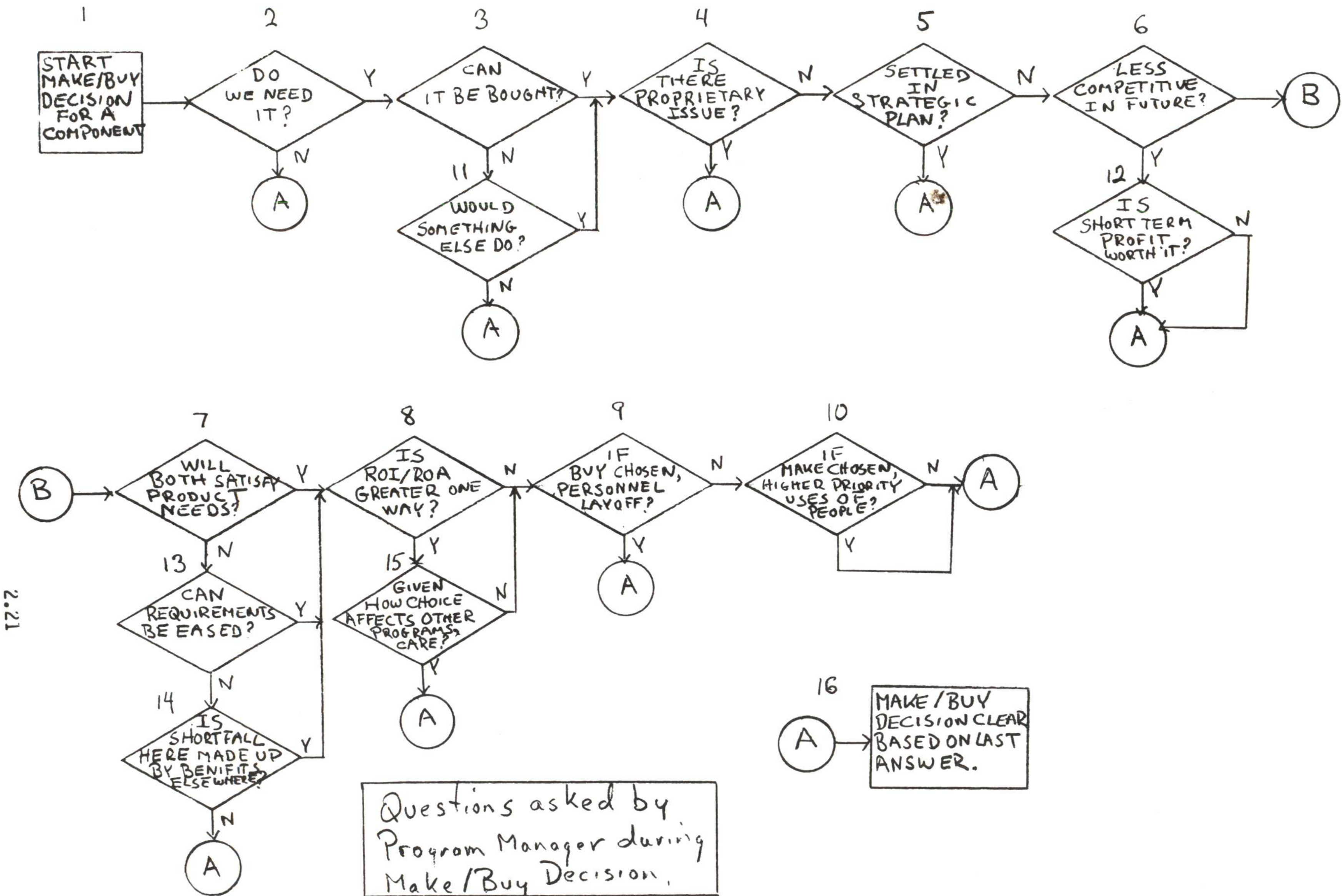
A general principle is to let the free market operate. In other words, unless otherwise specifically mandated in the strategic plan, the Program Manager should be able to purchase his components in the optimal way for his program. Further, the group producing the component should sell (or be able to sell) the component on the open market. This should insure that internal groups remain competitive with the outside suppliers. Obviously there are issues of proprietary products, sub-optimization and internal group startup that must be considered in the strategic plan.

PROCESS

In addition to the overall long term strategic plan, each program has its own strategic plan which is supportive of the long term plan and provides more details. Ideally, the Program Manager does not have line responsibility which might bias him towards make rather than buy. In the cases where he has line responsibility, (today most Program Managers do) it is critical that there be a strong advocate for the buy position. The Strategic Planning Manager provides a mechanism by which both the overall and the program specific strategic plans get created, reviewed, and/or modified. At the project level the Phase 0 Review requires a review of the alternative strategies including the make/buy decision. Finance should assist in the analysis of the numbers provided.

MEASUREMENT CRITERIA

Each of the program areas is working on developing output measurements. Clearly some revenue/cost equation provides one measure of a group's effectiveness. Also, in many cases it should be possible to do a retrospective review of the make/buy decision. eg. If we decided to make it, were the projected financials met? If it is available on the outside, how successful is the product? Is it replacing our offering in add on sales? etc. Finally, a very simple and clear test. If, at any time, the people doing the development state that that they have insufficient resources to build a winning product (however defined when the make decision was finalized), then we chose the wrong alternative!



Questions asked by Program Manager during Make/Buy Decision.

LEGEND: Number above each box corresponds to a more detailed question on the attached sheet.

PvR 3/2/81

REFERENCE NUMBERS FROM MAKE VS BUY FLOWCHART

1. The Program Manager asks a set of questions to determine the make/buy tradeoff.
2. Could we completely avoid the need for this component by utilizing some existing component and adjusting some other component or system requirement?
3. Is the component available on the outside?
4. Does the component represent a proprietary issue for DEC? (Not just a patent issue but also a marketing question).
5. Does the overall DEC Strategic Plan or the Program Level Strategic Plan require that this component be made or bought?
6. Will selection of either approach cause DEC to become less competitive in the future? eg. lack of suppliers, missing internal skills, or technology gap.
7. Can both make or buy options satisfy functionality, quality, transfer cost, and time to market requirements?
8. Is the ROI/ROA greater in one approach? eg. Plant loading, start up costs, etc.
9. If the buy approach is utilized, can adequate plans be developed to utilize the DEC people within this or other programs?
10. If the make approach is utilized, are there higher priority uses for the DEC people for which they are qualified?
11. Could we use what exists in the outside market by adjusting some other component or changing the system requirements?
12. Is the short term profit worth the long term loss?

13. Could one of the requirements be eased so that either approach would be acceptable?

14. Is the faulty element in either the make or buy approach compensated for by benifits to other programs? (This question must be answered jointly by all Program Managers and Finance.)

15. When the greater ROI/ROA is examined in the light of other programs is it still a factor?

16. END. Decision is clear.

EXAMPLE OF A "MAKE VS. BUY" ANALYSIS

This section presents the issue of high-end disk investment as a case study for "make vs. buy" analysis. The following memos illustrate the complexity of decisions about backward integration.

CURSORY THOUGHTS ON HIGH END DISKS by Gordon Bell

While I support investing in mass storage technology, I don't believe we should build higher end disks, because:

1. It stretches our range, and level of integration farther, and I believe it is too large for the money we are investing. I think we should try harder to cap our systems at $250K.

2. There are two low end threats to our traditional mid range business that are going to require resources: the personal computer involving both floppies and hard disks; and the small shared system is now sub-19" rack and will require hard disks.

3. We are biting off too much: floppies, Smaller winis, Aztec, Pinon, and evolving the R80, through the 81 and beyond. We're doing too much to get in manufacturing: T/E (2.5K), 5" wini (6.25K), Aztec (16K), Pinon (100K), R81/TU78 (>100K), and RP07 (in mfg.).

4. These disks take a disproportionate share of engineering resources for a disproportionate part of the revenue. Also, they are technically the most difficult to do. Given our limited engineering budget vis a vis the Japanese, HP, and IBM, I believe we have to select.

5. It is more important to have a better system range and to fund the important generic applications, such as the OFIS program than to backward integrate into this part of the system range.

6. We are not a dominant part of the market in terms of units, and hence we will not get the costs vis a vis the BCG learning curves. CDC (NPI), Fujitsu, Nippon

Peripherals, STC and IBM all cover us.

7. Maybe there is a joint venture that would be satisfactory such that the facility would get market share.

8. We are not a dominant supplier in this part of the business and hence will not get the volume to make the investment worthwhile. Note the small number of RP07s ordered.

9. If we ever start looking at roi/roa, there's no way to justify this investment. Buying out or joint ventures will be much better...provided we don't handle them to death in our multi-FAT sites.

10. We should get our better cost/megabyte by going after more aggressive mid-range system disks and then putting several of them on the larger systems.

11. Our successful products are those that go across both end user and OEMs. This would only go into the less profitable end user segment.

12. From a general direction standpoint, I think we should consolidate the range of products we have and invest in layered software together with the networking, while only manufacturing the parts where we make a dominant volume of the market needs, i.e. the mid range. This is the make criteria to be successful in the OEM business.

COMMENTS by Grant Saviers

1. It stretches our range: Our average 11/780 system is selling now for >$250K. Venus is certain to raise the ASP even higher. If Venus is to be a major system from a revenue viewpoint, we must have competitive, profitable disks. An alternative is to market Venus as a CPU, allowing others to integrate the systems and or sell the disks. This might be an acceptable strategy for a small market at the extreme of our range. Two major risks to this strategy are the willingness of customers to deal with multiple suppliers and lack of account control (sales and service).

2. Low end threats: We are expanding our range downwards with CT and agree that this extension is requiring additional disk products.

3. Biting off too much: We (development) believe that 25% to 30% year to year real growth is a realistic management limit. At current inflation rates this translates to 35% to 40% funding growth. The manufacturing growth rate has been 5% to 10% higher because of the rising percentage of NES in storage and continuing increase in the make/buy ratio.

4. Unfavorable ROI: Our large disk analysis indicated a favorable ROI. Our FY82 large disk only (no systems, controllers) NES is about $300M. Our current investment (fully loaded) is about $2M/year. It appears that any disproportionate investment is elsewhere.

5. Generic applications and systems breadth are more important integrations: It would seem that making what we know how to sell in high volume (large disks) has lower risks.

6. We have a small market share: We buy more disks than <u>any</u> other systems manufacturer in the world. IBM, CDC, Univac, Burroughs, NCR (via joint venture), HIS (via joint venture), Fujitsu, Hitachi, NEZ make their large disks. We will purchase about 8,000 large disks in FY81. This is more than MRX's or ISS/Univac production. It is about 3X Fujitsu's or Hitachi's production rate. CDC and STC produce about 10K-15K per year. IBM's 1980 annual report states "ten's of thousands of magnetic disk files... are being shipped to customers annually". Our large disk

usage has been growing at an annual unit rate in excess of 40%. If we produced our current products, we would be a major producer.

DEC's share of OEM shipments* (Non-captive)

1. Pack Drives (>100 MB)

	CY79	CY80	CY81	CY82	CY83
A. CDC	7500	13000	16500	18000	17000
B. MRX	5000	6500	6000	4500	2600
C. Other	800	6500	7400	7200	6500
D. Total (WW)	13300	26000	29900	29700	26100
E. Total DEC	3400	4300	6100	6100	5300
F. DEC % / WW	26%	17%	20%	21%	20%
2. Fixed Media (>200 MB)					
G. Total WW	100	900	3200	5400	7600
H. Total DEC	-	-	500	1700	2800
I. DEC % / WW	-	-	16%	32%	38%
3. Total DEC % / WW OEM Disks (>100 MB)					
J. WW Total	13400	26900	32100	35100	33700
K. DEC Total	3400	4300	6600	7800	8100
L. DEC %/WW Total	25%	16%	21%	22%	24%

* Source for Worldwide (WW) data 1980 Disk Trend Report + CDC input.

NOTE: IBM large disk products are typically about 30,000 units per year.

7. Joint venturing looks attractive: We have given this considerable thought and see the guidelines for joint venturing as:

Why we might be interested:

- We can't afford it, but need it
- Skill need beyond our abilities
- Acquisition of a technology base
- Political/tariff/government pressures
- Economical facility too large for DEC
- Only game in town

Hygenic factors:

- Our value added is elsewhere
- OK for competitor to have it
- We can work with the partners
- Adequate control of the results

- Partners contribute value

8. Small number of RP07's ordered: The Product Line requests are disappointingly low. We see this as a consequence of the earlier 300 MB cancellation, the RM05 introduction, large backlogs, and risk aversion.

9. Buy out or joint venture, don't FAT: Buyouts will always find the test of being competitively profitable unless we can market at 1.8X markup. 25% of the $150K and up systems costs (current large disks) could be shipped to customers from the volume factory (ours or suppliers). This should be done in any case.

10. Multiple mid-range disks to cover our large needs: This appears attractive and may be a viable solution. However, it requires a competitive technology base (hence investment). We are carefully examining this alternative as it may give us fewer better products.

11. Successfull products go OEM. Large disks "only go into the less profitable and user segment". We want to sell OEM and today have products that are saleable. We only build OEM competitive storage products. If end user is less profitable, why enphasize "generic applications" (#5)?

12. Invest in layered software and networking. Make only in the mid range. My view is to invest in a few key hardware technologies and leverage these technologies into products across our range. This should maximize ROI/ROA and establish adequate volume/market share to be competitive.

GB2.S4.6

ENGINEERING INVESTMENT SIEVE

1. Winning program for distributing processing over the range of departmental to personal computers.

   . Leadership to terminals since all terminals are computers (personal computers and terminals merge).

   . Provide a desireable base for multiple software vendors to independently build on - resulting in an integrated, effective offering.

   . Preeminance in local area nets: communications concentrators/ gateways, fileservers, person servers.

   . Be aggressive as possible on VAX.

   . Develop a much deeper competance in human i/o capabilities.

   . Understand role of integrated communications-and-computing competitors.

2. Get back on the leadership (small) systems curve(s).

   . Break thru cost limits imposed by conventional form factors.

   . Invest in the approaches to storage that maintain competitive systems position.

3. Manage complex technologies and provide them to our customers in simple, effective packages.

   . Be able to design (proprietary) systems products on silicon.

   . Learn how to manage/provide appropriate (CAD) tools to handle or hide complexity in the design process. Do it before the next major program.

   . Make service, installation and training unnecessary. (Product required services = 0)

CHAPTER III

ESSAYS ON STRATEGIC THREATS AND OPPORTUNITIES

OVERVIEW

As we look to DEC's future, we face a multitude of uncertainties in the external environment. We must anticipate the threats from aggressive competitors, government regulators, and an unstable world economy while exploiting the opportunities from advancing technology and the seemingly limitless demand for information processing. This Chapter is a collection of essays on the external environment.

1. <u>Strategic Threats</u> by Bruce Delagi

   A very brief, prioritized summary of key competitive threats as developed by the Engineering Staff at several Woods.

2. <u>Getting Organized in Engineering and Manufacturing to Face Our Future Competitors</u> by Gordon Bell

   A memo to the Group Vice-President of Manufacturing discussing competitive strengths and weaknesses.

3. <u>View of Competitors</u> by Gordon Bell

   Some additional commentary on IBM and other competitors.

4. <u>Telecommunications Environment</u> by Bruce Delagi

   A brief essay on the strategic implications of the joining of data processing, communications, and office automation.

5. <u>Competitive Strategy Exercise</u>

   Engineering conducted a competitive strategy exercise in December, 1981. The background material is printed here so readers can participate.

STRATEGIC THREATS
(INTEGRATED/FILTERED AND PRIORITIZED)

1. LOSS OF IMAGE AS (THE) LEADER IN EFFECTIVE COMPUTING STYLES

. high productivity terminals	(Apollo, 3Rivers, Convergent?)
. programmer productivity	(IBM System 38, INTEL 432 ADA "capabilities"
. relational data bases	(IBM System/R)
. dispersed processing	(Xerox, Apollo, Datapoint, servers, and intelligent you-name-its)

2. USER/INDUSTRY ACCEPTANCE OF THE "WRONG" STANDARDS

. SNA lockout/account control	(IBM)
. WPS "standardization"	(WANG)
. integrated comp/communications	(NEC, ROLM, EXXON, XEROX?)

3. POTENTIAL DEVELOPMENT OF AN IMAGE OF SECOND-RATE QUALITY

. doesn't fail	(Fujitsu, Tandem)
. data integrity	(IBM now, Future 432 file system?)

4. UNRESPONSIVENESS (IN COST OR FUNCTION) TO INCREASED RATES OF CHANGE

. lease base reduction	(IBM)
. entry of technology companies	(Fujitsu, NEC, Hitachi)
. entry of communications co's.	(NEC, AT&T?, Intelmatique)
. entry of office products co's.	(XEROX)

5. MARGIN/PRICE PRESSURES

. mass storage price/capacity	(Fujitsu, IBM?)
. non-profit service	(Fujitsu)
. vertically integrated competitors	
. long-term view of profit	(Hitachi, NEC, Fujitsu, MITI)

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TO: DICK CLAYTON
TED JOHNSON
MFG STAFF:
OOD:
JACK SMITH

DATE: THU 11 DEC 1980 10:16
FROM: GORDON BELL
DEPT: OOD
EXT: 223-2236
LOC/MAIL STOP: ML12-1/A51

SUBJECT: GETTING ORGANIZED IN ENGINEERING AND MANUFACTURING LIMITS TO FACE OUR FUTURE COMPETITORS [UPDATED FROM 10/26/79]

I'm still feeling good about our current and next few years of products; but I'm terrified about '83-'90 because I think we'll enter a more cost sensitive, commodity oriented market where emphasis is simultaneously cost AND quality. The challenge will be great in products-, process-, and manufacturing-engineering.

The four competitors of concern are IBM (everywhere), TI (only at low end and as a supplier), Intel (typifying the semiconductor revolution implicit in fifth and sixth generation computers of the early and late 80s) and the Japanese (Hitachi, Fujitsu, and NEC; also maybe others). Although each have some unique strengths and weaknesses, they have the following ordered strengths in common [our position is given []]:

1. Strong discipline in their engineering and manufacturing processes with relatively few, and aimed at volume. [Poor, lots with incremental evolution and freedom to define alternatives vs. use standard.]
2. High degree of plant automation. IBM may have the best understanding of robots and Japan is clearly the supplier! Also increased focus on productivity. Intel may not have this. [Poor, no activity outside of test. No automated material flow. Lower productivity per person.]

2a. Focussed factories with combined manufacturing and engineering industry process engineering [good in semis, part of disks. Poor in terminals, systems, cabinets, and power supplies.]

3. Very good internal source of semiconductors; all but IBM supply externally. [We only make a few of our needs.]
4. Very good disks (except TI who's now trying). Not Intel! [Need better mid/high end.]
5. Basic understanding of all kinds of materials. [Little or no work.]
6. Very large research groups, except Intel. All receive government grants for research! [Weak.

External R+D to couple to.]

7. Aggressive engineering and product positioning. [Ok; many products.]
8. Strong emphasis on quality (here, I exlcude TI). [Ok; improving.]
9. Willingness to change and move rapidly whether it be product, pricing, or market method (e.g. channel of distribution) and manufacturing. [We're strong; getting older and conservative?]
10. Understanding of learning curves, market share and use of forward pricing (including IBM). [Ok; except too many products?]
11. Low inventories and willingness to drop products at end of life.
12. Significant worldwide engineering and manufacturing, especially Japan.

There are selective strengths and weaknesses(-) no particular order:

IBM

1. Very strong CAD/CAM tools and effort.
2. Disciplined processes and engineers who use a small number of PCB, Backplane, and common semiprocesses rather than evolving every possibility to get slight gains.
3. An incredible customer base and sales force capable of devouring most of any product.
4. Highly automated assembly lines with independent test and production flow controls.
5. (-)Many competing architectures and problems to evolve networks.
6. Applicators programming knowledge.

Japan

0. Best overall technology understanding of semis, magnetics, speech, video, robotics, and comm.
1. Ability to quickly assimulate products or processes from others.
2. Experience with low cost products like TV sets that will be model for terminals, small business system, etc.
3. Strong concern for standards as a way to the market.
4. Large population of engineers, including manufacturing engineers.
5. (-)Channel of distribution.
6. (-)Programming. This is immaterial since software will be done by U.S. SW engineers in U.S.!

TI

1. Semiconductor strength.

2. Good terminal and low cost product base.
3. (-)Programming.

Our Strengths

1. The best general architecture/product position potential.
2. Product lines to focus on various users and channels of distribution.
3. Rapid turn-around, dedication of individuals to their plans. (Are we getting older and more lithargic?)
4. Strong Systems Programming to orient to generic, profession and other applications.

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VIEW OF COMPETITORS

HOW CAN WE WIN AGAINST IBM?
IBM has or will have: both constant and a decreasing cost a 360/370 line new in the $100 K to $10 M price range with lots of plug compatible competitors, several operating systems to support, a large backlog; the 8100 for Distributed Processing around the mainframe; RPG-based System 32/34/38 for Distributed Processing and as a Mainframe for small organizations; the aging Systems 3 to 15 for Distributed Processing; the System 1 for the would-be minicomputer buyer; the possibly defunct 5100-series Personal Computers for the scientist, engineer, analyst and small business; [the WPS computer] and several inevitable personal computer. All of these are incompatible, except for the fact that they speak some dialect of SNA and language standards. Products are relatively segmented to customer classes and different languages are used to enforce segmentation and hinder application mobility. Finally, they've sold via DPD, GSD, and Office Products.

The 8100 was a radical departure from IBM pricing as 0.5 Megabytes of primary memory and a 60 Megabyte disk are $ 29 K. Memories on all machines are similarly priced. We repriced as a result. The 8100 is exactly in the price range of the systems we sell and where we make most of our revenue. It is the second product in this price range within a year; the Series 1 minicomputer family patterned after the 11/04-11/34 was the first product. The 370 (via the 43xx series) is clearly either in or is coming into our space this go-around or next generation (1984). On the surface, the product is low priced, with lots of capability, but it also has a new communications structure (versus the one we have used substantially unchanged since 1961). This structure permits easy peripheral and terminal interfacing for both the office and factory environment. There is an extensive range of peripherals, terminals and communications to the 360/370. Since the product is sold by DPD, the strategy seems to keep account control and to make the money on software and the numerous locked-in, generally overpriced hard to emulate terminals.

SNA seems finally under control and we must be concerned because it has future built-in capability (e.g. word processing, typesetting, packetized voice). Their strategy seems to be to slowly unfold it, make it the standard, pay no attention to other standards and to make everyone follow their gyrations. A strategy based on being tightly coupled to them (e.g. with terminal emulation or fully compatible across the board) is really risky. We must interface to them "carefully" and be very, very aggressive in our own interconnect plans (both in performance and capabilities). We must collaborate with ATT and the international standards community to set standards.

We must watch how the System 38 is used vis a vis its 48-bit address because it can lock us out and cause others to generate many dead end architectures. It may be a E/H series follow-on breadboard.

HOW CAN WE WIN AGAINST OTHER COMPETITION?
There are established competitors too, such as DG, HP and Prime. DG and Prime have very simple, single architectures and have been most profitable and have grown most rapidly. HP is converging on a single architecture around the 3000, but it will have to be extended eventually. [The NOVA has been extended.] The large manufacturers (Univac, Honeywell and Burroughs) which operate with an established base are less profitable, have grown slowly and have multiple, poor architectures. Honeywell, with a simple, but adequate minicomputer architecture seems to be doing well by selling minis to its old line, mainframe base. There is no evidence that they're developing or pursuing the mainframe business actively.

There are probably more significant threats from the companies that can be easily founded to build systems into OEM Winchester disks by using the newly announced zero-processor-cost, microprocessors which have 22-bit address spaces and >11/45 performance. These architectures [are already] extended for multiprogramming and to handle larger virtual memories, but many point products, such as RSTS, can be built easily and cheaply and can quite possibly target a specific existing, trained user base. [UNIX could well be the standard that carries interactive computing in the 80s!]

There are also the Japanese and TI which can be lumped together because of their similar behavior. Both believe in targeted, high-volume products with forward pricing. Neither have an adequate architecture. TI is strictly limited to 16-bits with almost no escape and [except a new architecture ala VAX] the Japanese are aimed at the 360/370 using U.S. companies (e.g. Service Bureaus) to distribute hardware, and at high volume point products that will go into stores, no doubt.

[The strategy requires very high volumes for dumb terminals, evolving to down line loadable terminals for specific applications like TP.] [The market is requiring and evolving to programmable (intelligent) terminals [i.e. Personal Computers], and this requires using the 11 until VAX is appropriate in terms of price.] [The goal is PC-VAX with terminal, 5-10Mbytes of secondary memory, 512Kbytes of primary memory, processor, and NI connection.] In the mid and high priced minis, the strategy is compatibility and volume, phasing as appropriate from 11 to VAX [as dictated mostly by mass storage and customer need for VAX. We must recognize that virtually every application will evolve to outgrow the 11 and hence we should try to get our users to VAX ASAP, because the longer one can procrastinate a change, the more competitive the offerings will be!] For example, since there is not a high priced 11 after the 11/70 and the 11/44, there is a phasing to VAX (through Nebula).

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THE TELECOMMUNICATIONS ENVIRONMENT

A new industry is being formed from the joining of data processing, communications and office automation.

1. **"SERVICE"** - The front line of this industry is in providing information services - a data utility. The publishing and TV industries know how to package information. The telecommunications equipment suppliers know how to transmit and switch it. The service bureaus know how to process it. The common carriers know how to manage the transmission network that ties all this together.

   Our value added must be in our ability to store data cost-effectively and retrieve it flexibly along lines of access natural to untrained users.

2. **"HUMANISTIC"** - The crucially important part of this industry is its interface to workers whose job is the collection, rearrangement, and dissemination of data in ways that provide for better decisions. Vehicles for providing these services are (communicating) small business computers and office data management systems or pre-processing terminals off-loading central equipment.

   Our value added is in providing the most natural, most powerful methods to enhance the effectiveness of this work. Although productivity is key, there has been historical reluctance to capitalize such work and since this will remain a competitive field, cost of the tool providing such methods will continue to play an important part in purchase decisions.

3. **"CENTRALIZATION"** - The center of this industry will be the data switching and transmission network. Seeking incremental revenue on already committed capital equipment, the common carriers will press to extend their sphere of services. The PTT's will use the force of government regulations to assure their control of this sphere.

In such a situation, customer data storage and processing will be part of central office functions (hiearchically decentralized as needed to the customer site PABX's leased from the carrier). The common carriers will look to long established suppliers of central office equipment (for AT&T, there is Western Electric) to enhance their products to support this direction. These suppliers then will govern the market for computer equipment.

Our value added is on supplying a compatible line of processing equipment from chips (used directly in switching and transmission control) to very high availability shared central computer facilities. To generate revenue we will need to nurture our relationships with the dominant telecommunications equipment suppliers (Siemens, NEC, Western Electric, L.M. Erickson,...) and make a convincing case for them to buy ours rather than make their own computing equipment.

4. **"DIVERSITY"** - The breadth of opportunities available in this will favor start-up operations with novel approaches to previously latent demands. Private local, as well as independent city-wide cellular and global satellite communications networks will be an alternate to the previously establlished transmission monopolies. The regulating authorities will take the postion that competition will provide the most effective use of the available resources. Corporate headquarter operations will seek alternative forms of information services to avoid too close an embrace with any one vendor and to foster innovation through experimentation with novel approaches to the information problem.

   In this environment, our value added can be in providing the standards and critical components that allow special purpose equipment of many varieties supplied by many vendors to interact effectively. Many of the standards will take the form of open system network specifications at national or global levels and local area interconnects in more restricted geographies.

Our experience in distributed processing will allow us to establish a lead good enough for others to follow. Our indirect channels permit us to foster others innovation built on our standards and component pieces. Users seeking freedom from bureaucratic central data processing managers can get their needs satisfied with our equipment.

We offer an alternative to the single vendor approach supported by IBM.

COMPETITIVE STRATEGY EXERCISE

Understanding the resources and strategies of competitors is essential to the development of sound product strategy for Digital. In December, 1981, Engineering conducted an experiment. Senior Engineering managers and a few senior people from other groups such as Corporate Marketing and Product Groups got together to engage in a Competitive Strategy exercise. Teams were organized to represent five different competitors. Each team had to produce a set of scenarios for the years 1982, 86, and 90 describing the important product and marketing activities of their respective firms. Specifically, the teams defined processors, storage, communications, terminals, system software, application software, cost/price structure, service offerings, distribution channels, etc.

The exercise was administered by Bruce Delagi and a strategy task force that he gathered. Each task force member was assigned to one of the competitors and produced a straw horse scenario. These were given to the exercise teams in order to provide helpful background data and enough structure so the teams would not flounder.

The team participants found the competitive exercise enlightening. A second part of the December exercise which centered on alternative DEC strategies had less structure and proved less satisfying. It is being re-worked for the future.

Since the number of participants in these exercises is limited, we are publishing the original straw horse scenarios so that others can "play along at home". The scenarios have not been modified yet to reflect recent history (e.g., changes in anti-trust status for ATT and IBM) or a number of constructive suggestions from various experts within Digital. This should cause no problem since the straw horse scenarios are not the "answers", just a framework for thinking about the issues.

The five competitors in the December exercise were AT&T, Convergent Technology, Hewlett Packard, IBM, and NEC. They were selected either because they are major direct competitors or because they are good representatives of an important class of competitors.

Readers are encouraged to give the exercise a try for one or more of the competitors. If you have questions or would like to pariticipate in future exercises, contact Bruce Delagi.

AT&T FACTS

AT&T is the dominating supplier of communication services in this company. Although there has been some erosion in their mainstream markets (e.g. PBX's), they still dominate in wiring access to the home and within modern enterprises. To this point in time they have not been highly successful and moving from voice to data technology. They have been limited by a monopoly mindset, and by regulating legislation that requires lengthy amortization of equipment, preventing them tracking computer technology improvements.

Recently AT&T has aggressively moved to change their competitive posture. A modern marketing organization has been set in place. Effort has been expended to change the permited depreciation schedules. A non-regulated subsidiary seems sure.

The question at hand it clearly whether AT&T can break out of their historical mold and capitalize on their tremendous assets (interconnection is central to distributed computing) or whether they will be backed into a communication service position.

AT&T COMPETITIVE SCENERIO

During the decade of the 1980's, AT&T successfully used it's stature in communications to become a major computer service vendor. Their attack was based on these thrusts:

(1) Enhance PBX's to include significant computation and data processing capability. (This was aided by revision of the time period over which they could amortize capital investment permitting more rapid upgrading of exchanges). PBX's were produced that had extensive "message processing" services. In fact, they had full data management capabilities, and for all intents and purposes where commercial computers. Thus AT&T could offer an information processing solution as an upgrade to installed telephone switches. The key selling point was the use of the installed telephone wiring plant rather than the installation of new "local area networks."

(2) Improve terminal capability. AT&T aggressively developed "home terminals" which coupled to telephone delivered services, assumed a substantial percentage of the home computer market because of many adjunct services available through telephone distribution. AT&T also introduced professoinal workstations. The success in home computers was again based on leveraging the fact that all homes were wired into AT&T supported systems. AT&T was able to develop communication services (e.g. home retail purchasing, information access, etc.) and do software distribution via telephone. These improvements were significant steps in developing the home computer market, and AT&T won significant market share despite the fact that their products were off the leading edge.

(3) Encourge second-tier system vendors. AT&T encouraged smaller system and terminal vendors by providing attractive interconnection services and technical and marketing support. Thus AT&T significantly distrupted the success of computer vendor distributed processing efforts, by encouraging evolution using products from diverse vendors integrated by an AT&T interconnection system. AT&T not only permitted independent vendors to utilize their interconnect plant, but they actively solicited use by aggressively marketing the capability and by helping firms develop compatable equipment.

(4) Capture IBM interconnection business. AT&T actively develops and markets SNA interconnect capabilities thereby splitting IBM central and remote services and promoting the success of other vendors (including AT&T) in these systems. AT&T provides SNA services, and SNA protocol conversion capability. This coupled with the support of diverse system vendors disrupts IBM's attempts to provide one stop shopping and forces them to compete on a product for product basis, at which point their size and structure become a hinderance.

(5) Develop intra-enterprise data services. AT&T pioneered major new businesses serving multiple enterprises (e.g. supplier/consumer links; new forms of telephone/terminal retailing; major participant in compu-

ter banking ventures). This form of inter-enterprise application was the most significant market growth segment of the second half of the decade, after the flurry of personal and professional computers in the first half of the decade, and AT&T gained a leading share of this emerging and growing market.

Although AT&T continued to lag others in both base technology (the AT&T home computer was several years behind the leading competitors in features like graphics), and in marketing innovation, they were able to successfully exploit their dominating lead in communication technology, and develop a full computational alternative (a combination of capable terminals and PBX "computers", and gained significant business as communication and information access applications gained importance throughout the decade. Significantly, although Ethernet and other local area net technologies gained substantial use, in the end, adaptations of telephone technology based on distributed switch clusters interconnected by fiber optics locally and by satellite links remotely won the dominant market share, and AT&T held onto most of its share of this market.

How will they win? They will utilize their strength in communications, adding intelligent terminals and computer intensive PBX' to provide a full computational alternative, as well as various services for other modes of computer system design. They will excell at nuturing new forms of buiness, particularly intra-enterprise information services (e.g. intra-company ordering and accouting).

	1982	1984	1986
Processor	Diverse collection of Bell built and other vendor (e.g. VAX, 11/70) computers used	Home computer based on 68000 with buyout graphics chips	Introduction of "departmental" computer PBX based on Bell proprietary design, including SNA transfer (encrypted) services Introduction of"professional" workstation based on Bell CMOS 32-bit processor
Storage		Home computer features Bell produced bubble memory option	
Communications	X.25 data network developed.	Communication services enhanced to include SNA services, Bell introduces Local Area Network technology based on IEEE Standards	Significant satellite direct to building services offered
Terminals			
System Software			
Applications	Minimal network data services offered (e.g. message store and forward)	Substantial push in home computer applications. Aggressive joint marketing of professional applications from smaller companies that build AT&T communication services.	Home computer retailing services; expanded home information services
Cost/Prices		Bell products priced typically 25% above market price for same function without integrated communication services	
Services	Leading supplier of voice and data communications services	Offers distribution of home computer software and services via telecommunication	AT&T announces major home retailn effort growing on mail order successes but based on computer a telecommunication services
Market/Dist Channels		Computer services offered through expanded "Telephone" Stores	Major joint marketing announced w large retailers and service companies

	1988	1990
Processor		AT&T announces new architecture family with special features for image and voice processing
Storage	AT&T announces high density archival optical memory offering significant cost savings (20:1) over magnetic storage	
Communications	Multi-media (voice/data/image) communication services offered	
Terminals	Image and voice options are offered for professional workstations	Image features extendedto home computer terminals.
System Software		
Applications		Image/based retailing and entertainment services offered
Cost/Prices	AT&T offers advanced feature terminals at premium prices; communications prices are highly competitive	As market competitors catch up in technology and features, AT&T reduces prices toward market levels
Services		
Market/Dist Channels	"Telephone" stores offer wide variety of computer and application products	

Convergent Technologies
Fact Sheet

Convergent Technologies was founded in 1979 by Al Michels and two others from the INTEL Microcomputer Division. (Al Michels had worked at DEC for the 10 years before that, mostly in sales.) Their product set consists of several workstations based on the INTEL 8086 16 bit micro-processor. These workstations include a 15 inch medium resolution display (with RAM font memory), an electronics package, plus .5 megabyte floppies and/or 10 megabyte hard disks. There is some ability for OEMs to add hardware value, as there are 2-5 Multibus slots internally.

They believe that their primariy advantage today is their software. It consists of CTOS, an RSX11-M like operating system, that also supports communication between up to 16 workstations on a multi-drop line, running at about 300k baud. They have 5 languages that all run under the operating system (COBOL, FORTRAN, BASIC, PASCAL, and Assembler), and can share files. (It doesn't appear that programs in different languages can communicate directly by calling each other.) They also have a Forms facility, Sort/Merge, Word Processing, and IBM communication packages.

Nearly all sales of their products are through third parties. They have signed very large contracts with Burroughs, NCR, Savin and Thomson-CSF (in France). These contracts allow up to 10% equity investment (each) in CT, plus give manufacturing rights. CT has also signed up several very small OEMs that will add special software (and hardware in a few cases) and sell the systems. Service is always the responsibility of the OEM.

Convergent Technologies
Narrative of Events

1982

CT shipped 2000 stations this year, nearly all to about 20 OEMs, with about 100 units going to 30 potential new OEMs. Their products are well received, with the outside evaluators giving them high marks for the "human engineering" and overall system reliability (HW and SW).

They have spent the last 2 years primarily developing a high volume production line, with relatively little investment in new product development. They have announced several "fill the holes" software products, such as IBM SNA support and X.25. They have also announced that they will support some of the new disks that are available on the ANSI standard interface, and they will support the XEROX Ethernet.

There are no HW price reductions, although the price/performance of their systems improves as they introduce 64K memories and the new disks. The software license prices on some of the new software packages seem high, compared with the older software products.

1984

CT shipped 10000 stations, half to 4 large OEMs, including Ricoh (which was signed in 1983) for distribution in Japan. They also have about 200 active, small OEMs selling turnkey systems into a wide variety of applications. Their (OEM) customers are generally very pleased with the product, although there are constant requests for software features which they can't meet, and which in some cases, conflict.

CT has introduced a new version of the operating system that is much friendlier to both the programmer and the user, and is compatible with the newly specified "Friendly UNIX". This new OS is sold for significantly more money than the old one (which is still available), but CT successfully switches most of their customers by convincing them that the improved productivity of their programmers will more than offset the increased license fees.

They introduce new versions of their processor module: one has the INTEL 186, and reduces the cost of the basic workstation about $500; a second has the 286, which doubles the compute performace for the same price as the original 8086 product. They also announce a third version which has the 386, although they can't start shipping it, because it requires extensive changes to their operating system to support the extended addressing. CT starts discussing, under non-disclosure aggreements (but it shows up in the trade press anyway), their new high end workstation. It will include a very high resolution display, with a reasonably sophisticated graphics processor. The compute engine consists of an INTEL 486, giving it the power of the DEC VAX-11/780. This system will use new disk controllers, although it will still support the ANSI standard drive interface. A multibus is available as an extra cost option.

CT introduces a XEROX Ethernet connection, support for XEROX printers, and software that allows their workstations to interface to the "XEROX office". CT recommends that the Ethernet connection be made once from the cluster, instead of having a connection from each station, as the cluster interface costs 1/3 of the Ethernet connection, and there is rarely a performance penalty for using one of the workstations as the Ethernet gateway. CT also indicates it will support the IEEE 802 LAN, when the spec settles down sufficiently to allow an implementation.

They have added redundant communication to their clusters, plus support for journaling and automatic shadowing on the mass storage, and several OEMs are successfully selling into the "high availability" market. The greatest penetration is at the low end, since the product is somewhat cheaper than Tandems, and much, much cheaper than DECs.

1986

CT introduced its much touted high end workstation in 1985, although volume shipments didn't start until 1986, with about 1000 going out. It carries a premium price. In addition, they shipped 20000 of their midrange product. Most of their OEMs seem to believe that the midrange product will continue to be the high volume item, with a relatively small number applications for the high end system. They also deliver a "Telephone Management System" option, available on all the workstations, that allows voice store and forward.

Burroughs drops their OEM contract, so CT now has some additional manufacturing capacity available. They decide to enter the turnkey system market, selling products acquired from a few of their small OEMs that went out of business. They sell these systems through office supplies distributors. They also start selling directly to large end user accounts (Fortune 200) and are running into conflicts with their large OEMs that are selling basically the same product (but see below). They develop a small end user field sales force.

CT works with several major third party software publishers and software stores, and reachs agreements that the CT workstation will sold in software stores as the engine to run the applications. CT takes no responsibility for the software warranty, the software stores get somewhat better margins than the computer stores, and the software publishers get 3% of each hardware sale.

In addition, CT sets up a software publishing group to distribute SW written by third parties. They set pricing so their OEM customers total system prices are about the same as the sum-of-the-pieces prices (HW plus SW) from CT. Most customers continue to buy from the OEMs, since they take system responsibility. Several OEMs use the CT software distribution group as their manufacturing facility.

Service continues to be the responsibility of the OEMs. For the end user sales, CT develops a unique program of training the customers "key operators" (for no extra charge) to swap all the field replaceable units in the workstations, with a return-to-factory repair method. CT offers the spare modules for sale, or is willing to lease them in a more traditional "service contract" form, although either method is only about 1/3 the cost of the service contracts of their competitors. Their end user customers are somewhat wary of this service scheme, but a few do try it. Others contract with third party service companies. CTs OEM customers are pleased, as it gives them a clearly different product.

CT introduces new software that supports the high quality graphics on the new workstation, plus a "compatibility package" that allows a subset of the graphics to be supported on the original product. They provide many enhancements to their Friendly Operating system, but have not added any features to the original OS. They announce that support of the original OS will be dropped in 2 years. They also announce that they will offer a combination hardware/software secure communication option, that provides encription and other security features on all transactions between workstations.

CT needs additional financing to continue their growth, but isn't willing to go public (yet). They decide to offer non-voting stock to the public, and make an additional offering to all their large OEMs that increases each of their shares in the company to 12% to 15%.

1988

CT has made a major effort with direct sales into large accounts, and now has half a dozen of the Fortune 200 standardized on their workstations "for every desk". CT has purchased marketing rights to many of the software packages created by their OEMs, so now can offer a reasonably complete menu of applications for their systems. However, many of the applications don't integrate together well, and customers are somewhat frustrated by this.

They continue to sell turnkey systems through office supplies distributors, and also start using third party retail stores. The sales of workstations through the software stores has been quite successful, and is the faster growing distribuion channel.

CT total sales volume growth slows down as many of their small OEMs decide they can't compete, but their profit margins improve.

INTEL has introduced newer versions of the 86-family processors that tend to have increased levels of integration at a constant cost, but there are no major improvements in performance. CT uses these to get incremental cost reductions, along with the new disks and 256K memory chips. Margins improve as price reductions are not as great as the cost savings.

CT announces they will interface to the IEEE 8020 broadband/CATV local network, and support images (using the new digital TV standard), voice, and data. Product delivery is scheduled for 1989.

CT introduces a new version of their operating system that is a strick, but significant, superset of the UNIX standard. It is priced 50% higher than the previous version. The new system includes extensive security features, including data encription on the mass storage media. CT also raises the prices from their software publishing operation 20%; sales drop slightly, but the overall revenue and profit improve significantly.

The service method as been moderately successful, but about half of the end user customers have signed with outside third party service companies, and CT management feels that they are having trouble signing accounts because of the service problem. CT decides to use a dual strategy to solve the problem: for the large accounts, they offer to train in-house, full time repair people (customers employee), which the large accounts find much more acceptable. CT also contracts with outside third party service organizations, so that for small accounts, CT is responsible for the whole system. BMC rates are competitive. They still offer the "key operator" training.

CT and NCR announce a major extension of their contract through 1995. CT will continue to provide workstations; NCR will provide major new funding over the next 5 years for 20% ownership, and will get exclusive manufacturing rights (after CT).

1990

CT announces a new family of workstations. They are based on the new INTEL 32 bit architecture, the 96-family series. The 96-family architecture is culturally compatible with the 86, but does not run 86 machine language. CT announces a new operating system which has all the functionality of their 1988 release, but runs 2-3 times as fast. The new operating system provides a combined hardware/software simulation of the old CT environment, allowing (nearly) all software products to run, although there is no performance improvement in this mode. Nearly all the software is running in this mode, although there is a PASCAL compiler that runs in and produces code for "native" mode. The new PASCAL compiler cost 50% more than the old one.

The graphics processor is very impressive, including full 30 frame-per-second color animation (with limits on the rate of change of the picture). It is capable of interfacing to the IEEE 902 broadband network and displaying TV signals in windows on the screen.

CT has started developing a field service organization, as several of the third party service companies failed to deliver acceptable service, and CT ended up with several very unhappy customers (and a few lawsuits). The service rates on the old hardware remain unchanged, and for the new hardware are about half as much (per selling price). In addition, they guarantee that in a cluster of 10 or more stations, 90% will be up at least 98% of the time, including the return to factory turn-around that will always be less than a week from pickup to delivery. CT gets alot of praise from the trade press from the guaranteed overall availability this implies.

CONVERGENT TECHNOLOGIES

Key Strategies

- o They will be very creative applying "off-the-shelf" hardware technology, but will not develop any base hardware products. They will be a "system integrator".
- o They will write base software to generate competitive products and some uniquenss.
- o They will use outside high volume distribution channels that will not require extensive field sales or support organizations.
- o Over time, they will continue to use standard hardware, but integrate forward, selling directly to end users.

Convergent Technologies

NOTE: Pricing assumes constant value (1982) dollars.

	1982	1984	1986	1988	1990
Processor	8086 based workstation, with Multibus slots	186 and 286 based	386 based processor for original product; 486 for new high end, giving 11/780 perf	new versions that give incremental cost reductions	new "family" brought out (culturally compatible); still building old.
Storage	5" and 8" disks and floppies on industry standard interface	new disks as they become available, more memory available	Can mix various disks on either processor	Can use new disks as available, more memory (256k chip)	New family uses same disks as old
Communications	Proprietary network between units; CX style outside; SNA; X.25	Ethernet connection, IEEE 802 coming. Redundant comm.	IEEE 802 available. Encription between units.	IEEE 8020 broadband/CATV support announced	IEEE 8020 support
Terminals	character graphics with good resolution and RAM font memory	same as 1982	new high end graphics (with pointing device), supports images; telephone mngt system	same as 1986	full motion animation and TV support
System Software	unique RSX11-M like OS; some good function layered products, poor to fair performance	OS moving toward UNIX industry standard Some Hi-Avail tools available	Enhanced OS; graphics compatibility pkg; some security	Major unique enhancements to OS; "complete" security	New OS; culturally compatible; full compatibility mode, which everything uses.
Application Software	Word processing	Integration with the XEROX office	Selling some outside developed SW	Extensive menu of applications	Most applications run in compatibility mode
Costs and Prices	\$10K-\$20K/station HW; \$1K-\$4K/station/product SW	HW prices constant, new disks and memory give improved price/perf New SW about 20% more	New HW has premium price; old HW gets 10% reduction ("volumes up")	Aggressive pricing on turnkey products (-10%) Reduce HW 5%; add 20% to SW	Much better cost/perf on new family SW prices up 20%-50%
Service	provided by OEM	provided by OEM	"key operator" or 3rd party for direct sales; OEM for OEM sales	customer on-site repair person; CT contracts with 3rd party; OEM	small service organization; guaranteed availability
Channels	Volume thru 4 large OEMs, also some small OEMs and distributors; no direct sales	same	same, plus some end user sales to Fortune 200; software store engine; turnkey sales thru office supplies dist.	Salesforce for Fortune 200; office dist and stores for turnkey sys; OEM; SW store sales very successful	Extensive advertising on new products; available thru stores, catalog, distributors. Salesforce for Fortune 200.
Business Actions	Large OEM contracts with Burroughs, NCR, Savin, Thomson-CSF	Ricoh in Japan becomes OEM	Agreements with 3rd party SW publishers+stores Non-voting stock sold to public Lose Burroughs	6 Fortune 200 announce standardizing on the family on every desk Major extension of NCR contract	Public stock offering
Key Skills	Good human engineering; Marketing; manufacturing ramp-up	Good human engineering; quality SW; clever marketing; Quality/Volume mfg	same	same	same

8 December 1981 --- Strategic Planning Game

Your Name: DEFAULT Competitor: CONVERGENT TECH.

MARK EACH SCALE WITH
(1) AN "8" TO SHOW WHERE YOU THINK THE COMPETITOR IS IN 1980 AND WITH
(2) A "9" TO SHOW WHERE YOU THINK THEY WILL BE IN 1990

	1	2	3	4	5	6	7	8	9	10
Hardware Cost/Performance					8	9				
Cost of Ownership				8	9					
Existing Base / Reputation		8						9		
Unique Capabilities		9	8							
Programmer Productivity			8		9					
End User Productivity							8	9		
Availability of Third Party Software and Services				8				9		
Use of Industry (or other) standards							9	8		
Breadth of Offering			8		9					
Distribution Channels									9	8
------------------------(other)										

poor -> industry norm ->excellent

Total Information System and Services Market Share (% of total market) gained or lost during the decade of the 1980's expressed in "MILLIPOINTS" (1/1000 of one percent of share). In 1980 one millipoint corresponds to about $1 million of annual revenue.

1000 millipoints of share GAINED gained or lost

In recent months, a new name has appeared quite regularly in the small systems world. Convergent Technologies has contracted (or is in negotiations) with NCR, Thomson-CSF, Savin and most recently, Burroughs in pacts to supply systems which these major leaguers should have already had in their product lineups.

Factors for success were:

- o Excellent Products
- o OEM Only Strategy
- o Fortuitous Timing

Management has proven capable of having the right product at the right time. Now it must face the ultimate challenge of cost-effective volume production.

Convergent Technologies

Convergent Technologies (CT) was founded in August 1979 with the goal of becoming a leading OEM supplier of desktop minicomputer "integrated workstations." The company is still privately held, but if the numbers being discussed in the trade press are true, CT's 1980 revenues were about $1.5 million (first shipments were October 1980), and 1981 revenues might approach $50 million.

CT has combined the latest in hardware with a new distributed intelligence architecture and the necessary software to create an exciting new product:

1. The basic workstation engines are the Intel 8086 or 8088 16 bit chips. CT started its design concept based upon the needs of business applications. This concept was endorsed by IBM with the S/23 and 5150.

2. The storage concept includes large Winchester fixed disks along with smaller removable floppies for each workstation. This combination works very well with the 128K to 1M byte internal RAM memory. This insures that all the horsepower can be applied to the applications.

3. A high-speed local network capability for interconnecting workstations at speeds to 615KB/S (RS-422 compatible) allows creation of "distributed intelligence" systems on a modular basis. Workstations can operate as "stand-alones" or be interconnected.

4. A new realtime multitask operating system, CTOS, which supports applications programs written in BASIC, FORTRAN, COBOL and PASCAL, supports a complete file management

ELECTRONIC NEWS, MONDAY, DECEMBER 7, 1981

Convergent Technologies Offers Financial Package

SANTA CLARA, Calif. — Convergent Technologies has introduced a financial modeling and planning software package for its IWS and AWS workstation systems.

The company's Multiplan software package features financial and business planning, analysis, budgeting and forecasting routines and can operate in a network system. Convergent said the package lists for $2,000 on a full-support license plan.

ELECTRONIC NEWS, MONDAY, DECEMBER 14, 1981

Savin Introduces Convergent-Based Microcomputers

NEW YORK — Savin Corp. last week introduced its version of the Convergent Technologies AWS and IWS microcomputers, which it will market for word processing and data processing applications as the Savin Information Station 1000 and 2000.

As reported (EN, Nov. 30), Savin has established a $10 million "off balance sheet" financing entity known as Savin Associates to fund the project. Previously, the copier manufacturer had spent some $6 million developing a word/data processing system it originally planned to manufacture itself.

The Savin introduction follows by 3 weeks NCR's entry into the word processing market with Convergent-based equipment, but with April volume delivery schedules, Savin should beat both NCR — whose systems are to ship in June — and Burroughs to market with Convergent-based systems.

Although Savin has not taken an investment position in Convergent, it has advanced Convergent $1.25 million for start-up costs and provided another $200,000 to cover tooling for Savin's proprietary keyboard. In the Savin Associates prospectus, Savin warned investors that "In the event that CT, whether as a result of financial adversity, the over-commitment of its manufacturing capacity or otherwise, fails to supply Savin or the Partnership, on a timely basis, with the necessary quantity of hardware

Continued on Page 30

Business Sys. Offered by Savin

Continued From Page 27

components, Savin will endeavor to obtain alternate sources of supply"

Abe Ostrovsky, a Savin vice-president assigned to the new systems effort, said no such second source has been identified, but added that Savin has the option of manufacturing systems itself. According to the prospectus, Convergent currently has the capacity to produce 700 systems a month and in early 1982 should be up to 1,500 units per month. Savin is expecting unit shipments of 3,955 in 1982 and 8,137 in 1983.

The Savin Information Stations include both software and hardware additions to the Convergent products. A proprietary keyboard includes a touch panel with 30 function keys that can be altered for different programs with a series of overlays. The word processing software, which will eventually include four levels of functionality, was developed by Savin Corp. and sold to Savin Associates for $7 million. In addition, Savin has developed vertical market packages for distribution businesses and professional offices and will add other vertical products developed internally and by third-party software houses, company officials said.

The systems will be marketed immediately with word processing only, but will have general business applications and vertical packages available during the second quarter of 1982, Savin said. The basic word processing program, Savipak 1, is priced at $485 with an additional monthly license/update fee of $20. Savipak 2, which has not been priced, will follow in July and is expected to have list processing and other advanced functions. Savipak 3, scheduled for introduction in the fourth quarter, will add a spelling correction function, columnar math and spelling verification. In addition to Savipak 1, currently available software includes CT Basic, priced at $500.

The 1000 and 2000 each have four models. The basic Model 1001, based on the Convergent AWS 220, includes 192K bytes of memory and a single 5.25-inch floppy and lists for $7,000. The dual minifloppy 1002, with 128K bytes of RAM and based on the AWS 230, lists for $7,750, and the 1005 with a five-megabyte, 5.25-inch Winchester disk and 256K bytes of memory is $11,050. The 1000, a workstation with no mass storage, lists for $4,450. The 2000 series starts at $8,450 for the 2001, a single-floppy system with 192K bytes of RAM. The 2002, with 128K bytes of RAM and dual floppies, is $9,450. Two 256K-byte systems with 10 and 20 megabytes of 8-inch Winchester disk storage are also available at $16,750 and $18,750, respectively. A 45-cps Qume daisy wheel printer is available for $2,545, but Savin officials said other printers including high- and low-speed matrix printers will be offered.

Savin, which will provide marketing, service and support for Savin Associates on a fee basis, has established Savin Information Systems at its previous word processing manufacturing plant in Sunnyvale, Calif. There, customer service, quality control, spares stocking and software development will take place. Part of the Savin software effort will be to provide "custom" applications for users who answer a series of questions on a special disk and return it to Savin. The Sunnyvale facility will also have a toll free telephone number for customer questions and remote diagnostics.

Mr. Ostrovsky said Savin Corp. will add a high-speed nonimpact printer based on Savin copier technology for the Information Station line. He declined to predict when the system printer will be introduced.

C. Itoh to Enter U.S. Small Computer Market in 1982

IRVINE, Calif. — C. Itoh Electronics will enter the U.S. small computer market early next year through a new subsidiary, here, which will market systems built by Hitachi Ltd.

CIE Systems, Inc., was incorporated in October and capitalized with more than $7 million from C. Itoh Electronics, an American subsidiary of C. Itoh & Co. Ltd., a Japanese trading company with $50 billion in worldwide sales.

Jay L. Kear, a former General Automation vice-president and executive vice-president and general manager of CIE Systems, said the company will introduce systems ranging in retail price from $10,000 to $100,000 in late January or early February for shipment in mid-1982. The systems will be based on the Motorola 68000 microprocessor and will use the Versados operating system and Data Technical Analysts' Pro, a package which is said to enable non-programmers to write business applications. Mr. Kear said the systems will also be available with Unix in a later software release.

The CIE computers were designed by C. Itoh in the U.S. and will be built by Hitachi exclusively for C. Itoh. They are the result of a 3-year C. Itoh project which also produced a prototype stand-alone word processor, that was shown at the C. Itoh booth during the 1981 National Computer Conference as the X100, but was later abandoned. Mr. Kear said the company decided a range of small computers — developed under the name X4000 — would provide the company with a better entry into the U.S. computer market. He added that some features of the X100 will be incorporated into an intelligent workstation for the X4000 computers.

Mr. Kear said the company is aiming for a minimum of 40,000 to 50,000 unit shipments over the next 3 to 4 years and will market the computers to large OEM customers and systems houses which have the ability to add software, service and support. He said the company has two large orders pending, but declined to identify the customers.

He noted, however, that the large OEM prospects would include companies like NCR and Burroughs as well as traditional small computer companies seeking to enter the microcomputer market. C. Itoh Electronics president Mark M. Takeuchi said CIE systems will later add products to link office products such as copiers, computerized telephone systems and facsimile equipment into computer networks.

ELECTRONIC NEWS, MONDAY, DECEMBER 21, 1981

DATA TOPICS

In a move to bolster its office systems effort, **Prime Computer** is understood to be lining up an OEM supplier of standalone word processors. Those in the running are said to include **Syntrex, Inc.**, **Artelonics Corp.**, and the seemingly-ubiquitous-Convergent Technologies. At the same time, the company has cancelled plans to build its own terminals in Springfield, Mass., and will use land purchased there for another unspecified project.

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ELECTRONIC NEWS, MONDAY, JANUARY 4, 1982

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Another 16-bit-based microcomputer system will be unveiled this May when **Dynabyte Corp.** introduces a multi-user system internally code-named Monarch. The system will compete in the OEM market with computers from firms like **Convergent Technologies** and **Plexus** and will offer a variety of popular microcomputeroperating systems including CPM, MPM, Unix and Oásis. The Dynabyte system will accommodate 16 users and is expected to sell for well under $10,000.

ELECTRONIC NEWS, MONDAY, JANUARY 4, 1982

TRW to Distribute Convergent Gear

By JEFF MOAD

SANTA CLARA, Calif. — Convergent Technologies last week signed an overseas distribution contract with TRW Datacom, lining up what sources close to Convergent said is an agreement that could exceed the value of earlier OEM contracts with Burroughs, NCR, Thomson-CSF and Savin.

The agreement — which is understood to be non-exclusive — gives TRW a small computer system to replace the Datapoint products it distributed abroad in the past. Last year TRW sold its Datapoint distribution organization to Datapoint in a $102 million deal (EN, Aug. 10, 1981).

TRW has committed to purchase Convergent AWS and IWS series 16-bit systems for distribution everywhere outside the U.S. Sources last week estimated the deal to be in the same range as Convergent's previous contracts with Burroughs and NCR, which have been pegged at about $100 million. Sources close to Convergent said the contract could grow much larger, however, pointing out that TRW's business with Datapoint has been estimated at more than $150 million annually.

According to Convergent president Allen Michels, who confirmed the signing of the agreement, "It is our hope that this relationship will be at least as successful as that between TRW Datacom and Datapoint." Mr. Michels refused to comment further on the contract.

The agreement is not believed to include an option for TRW eventually to buy into Convergent. Some of Convergent's earlier major contracts, including Burroughs and NCR, include buy-in clauses that are tied to the number of systems purchased.

TRW is expected to market Convergent systems under the Convergent logo just as it had used the Datapoint name; however, the Convergent equipment is not operating system-compatible with Datapoint hardware.

HEWLETT PACKARD

Hewlett Packard is a 30 billion dollar a year corporation deriving approximately 50% of their revenue from the electronic data processing division. The Computer Systems Group has grown from a base of 375 thousand dollars in 1976 to a base of 1 and 1/2 billion in 1980. HP is a well known supplier of electronic instrumentation, digital calculators, computers, medical instruments and medical electronic equipment. HP is the third largest manufacturer of small computers after IBM and Digital Equipment Corporation when measured on dollar volume. HP's current product lines include the HP83 and 85 personal computers, the HP980 series desktop computer, HP250 and 300 small business computers, HP3000 - the companies larger business system, and the HP1000 - the general purpose mini-computer used primarily in scientific and industrial environments.

HP introduced several significant products in 1980 and 1981. In 1980 the expanded the top of the 3000 line into larger business systems and introduced new printing systems. Additionally, they announced personal computers with integrated terminal printers and cartridge tape drives. In 1981 HP introduced several new products to address the OFFICE market.

HP derives approximately half of their revenue from international sales with an overall net profit margin of 9%. HP has been able to achieve a 25% a year growth rate based on that 9% through outstanding asset management which has been improved over the years to currently allow a self financing growth of 31% a year.

HP over the years has focused significant resources on application software such that today HP is able to solve the problem of approximately 25% of their potential customers for computers in a manufacturing sector. HP offers significant third party software to compliment their own application capability.

Additionally, HP is focused on the quality and reliability of their computers. HP has the goal of reducing the failure rate on their products by 50%, as well as reduce the manufacturing costs by 15% for 1981. This quality is manifested in terms of HP's ability to guarantee a 99% up-time over a three month period for their computers.

HP has recently fabricated and tested a 32 bit micro-processor which is indicative of HP's committment to make a 32 bit product. Other product announcements include the CADCAM package called ADSAD 2000 for their HP 3000 series.

HP has a competitive cost to manufacture which in 1980 was 47% of their revenue (which compares to 55% cost to manufacture for Digital).

HP has long had the reputation of being a high quality company with concern for their employees in addition to product innovation and new product introduction. They have maintained an ability to be competitive in the marketplace with products that most people would consider to be less than a leader in technology, i.e. 16 bit HP3000 vs. VAX780

* d i g i t a l *
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TO: *BRUCE DELAGI

DATE: THU 3 DEC 1981 8:26 EDT
FROM: BUD HYLER
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EXT: 264-7369
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SUBJECT: HEWLETT PACKARD

Evolution of a Strategy - Hewlett Packard

Approaching 1982, HP has a fairly strong position in the computer industry, with computer sales of 1.5 billion, and a total company revenue of 3 billion. They are among the larger of the mini-computer manufacturers and have been experiencing significant growth for the past several years. HP is currently focussing on the manufacturing industry, to leverage both their internal manufacturing data processing experience, as well as their other engineering and technical oriented product lines.

They are considered to be a quality vendor with a full range of commercial and office systems.

One weakness in their product offering is the fact that their mini-computers are not 32 architecture, but HP is committed to address this weakness. So far product deficiency has not significantly impacted their growth or profitability.

In 1984, HP is replacing many of their older products and generally turning over the product line so that all their products are of 32-bit architecture. They will enhance their graphics capbility and the communications capabilites with other products that might be used in the manufacturing environment. Because of the range of products which they need to communicate with, HP has maintained a fairly open communications capability in terms of supporting many of the standard communications architectures. 1982 is the year for continued applications and system software growth following the introduction of the 32-bit architecture throughout their product line focussing on databases and application packages. Many of the application packages in the industry are not written for HP operating systems, but are written for other industry standards such as Unix. HP has decided that they will be better off by also offering to support the Unix operating system on their HP series to insure to their customers the availability of the widest range of application for solving their problems. In this respect, 1984 is a turning point for HP in which they realize that the real value added to their customer wasn't so much the unique capabilities of their software or hardware, but really the availability of applications and the experience to solve their problems.

1985 sees completion of all of HP product lines with the 32-bit architecture which gives them a fairly young product offering, extended communication support and a rounding out of their own operating system functionality and application set.

Additionally, there is a continuation and expansion of the strategy to offer applications, solutions, and general capabilities to their customer. HP has focussed their resources on solving the customer problems more than on the development of unique systems just as the primary differentiating factor. This philosophy and the re-evaluation of the make-buy decision for

processors and processor components has resulted in HP using a significant number of standardized "commodity" systems (68000,286) as components in the packaging of HP systems. Mini-computer vendors had been buying out disk tapes and printers for years, but this was really a breakthrough for HP in terms of buying out processor components. HP finds that, in terms of the

make-buy decision for systems capabilities, the buy decision offers dramatically much more price performance to their customers. HP dramatically reduced their internal systems development group to focus all their resources on the application of computing to address the customer problems.

In 1988, HP will be the leader in layered applications across a range of products, some of which were the traditional HP made

systems and some have been the more recent HP "buy" systems, all of which run a common layer to which HP can offer their unqiue software capability. HP begins focussing much more on offering "one stop shopping" capability for their customers and, as such, adds a robotics capability to their product line as well as supporting several industry standards in terms of systems

software and database managers. There is continued emphasis to merge the skills of computing capability into manufacturing tools and products, and focus on having all of the different elements in the manufacturing process work together so that there is a commonality of the HP layers and interfaces.

Computers have become part of the element that HP uses to solve the customer's manufacturing problem but representing a

decreasing component of that solution. Especially in the context of HP unique systems, although they do continue to support and sell HP unique products to their traditional installed base.

/bal

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In the beginning of the 1980's HP realized that as simply a manufacturer of computing systems they would lack the financial resources to compete with the emerging commodities enviornment being driven by Japan and IBM.

HP's skill historically had been one of competant engineering with excellence focused in the transition from the engineering group to manufacturing, enabling them to introduce new products through manufacturing which were of a high quality nature on a regular basis.

While this corporate skill was critical for HP's success in the embryonic computer industry, the skills necessary to succeed in the emerging competitive environment much more one of high volume manufacturing capabilities and financial assets for vertical integration.

HP saw the computer evolving from an embryonic/growth industry to a more mature industry in some areas, noteable the "mainframe" product area.

As a result of this maturing, the competitive strategies will begin to evolve from one of "new product introduction" to one of "industry standardization/low-cost commodity production".

COMPETITIVE STRATEGIES

```
New Product Introduction ( SYSTEM HOUSE )
                              / /   ¦ ¦    \ \
                             / /    ¦ ¦     \ \
                            / /     ¦ ¦      \ \
                           / /      ¦ ¦       \ \
                          / /       ¦ ¦        \ \
                         \/\/      \/ \/       \/ \/
```

low cost production of industry "standards" - 4300 architecture - 68000 - Intel 186	new product introduction	new competitive strategies: Trading company/ technology, product, boutiques

HP has decided to continue to compete on the basis of "new product introduction" as a systems house, but they realize that the basis of their value added will probably change dramatically.

As critical met mass built around industry standards, both hardware and software, it became increasingly difficult for HP to justify their uniqueness to perspective customers. The issues ved were ones of the availability of trained personnel, and easingly one of software availability. This impact was mpounded when the industry standardization provided significant everage to the top software producers which made it financially attractive for the software development talant of major corporations to go into business for themselves.

HP's survival, then, depended upon it's ability to maintain it's uniqueness and the value of that uniqueness to it's customer base. However, the source of that uniqueness had to evolve from one of manufactured systems and system software to one of application software and manufacturing experience.

The focal point for HP's competitive edge evolved from one of manufacturer of unique systems to one of unique capabilities in the utilization of standard systems to address manufacturing problems. This was provided through "one stop shopping", manufacturing experience, and a range of application software.

The effect of this transition was for HP to evolve from a competitor in the systems manufacturing environment to the number one "OEM" for the manufacturing community. By 1988 HP had captured over 35% of all computing system sales to the manufacturing areas of corporations.

HP

	1982	1984	1986	1988	1990
ARCHITECTURE	HP offers point solutions. Full range, well integrated commercial/office systems (low end workstations to 50 user systems); personal computer; new 32 bit architecture at high end; fair technical systems, low to mid range; very good I/O periph.	Some older office products replaced with new versions; mid and hi systems are 32 bits; images on hi end graphics; full range workstation products; new 32 bit tech. product Migration from 16 bit to 32 bit architecture.	Replacement products introduced so that no products are more than 3 years old; all are 32 bit based; maybe common 32 bit hardware.	Continuation of better cost/ performance products introduced; excellent "familiness."	
COMMUNICATIONS	Continued commitment to "open systems"; i.e. systems including equipment from multiple vendors. Layered comm. products. SNA/SDLC support.	Continued support for Ethernet/IEEE 802, SNA, ACS. Store & forward voice.	Support CATV/Broadband industry std; line of sight 5 mile network link; full PBX function.		
SYSTEM SOFTWARE	Good function, good performance, Layered product set quite complete for commercial applications. OS and files on 32 bit HW not compatible, but excellent conversion tools.	Incremental improvements in function and performance. Much improved DBMS. HP supports industry standard system software (ex. UNIX)	Significantly enhanced OS and some layered products introduced with much better "ease of use"; compatible subset user and program interface; conversion aids (when necessary) for migration. No commitment to HW arch., only SW. HP begins use of industry standard architecture as basis for system, disbands processor design engineering program.	Complete layered software move to new system; improved function and performance. HP systems sales reflect decrease in "HP unique" systems except to installed base.	Incremental improvements in function and performance.

APPLICATION SOFTWARE	Good automated office; electronic mail and filing; some generic applications packages. Total turnkey solution in manufacturing space (MRP+). Extensive 3rd party software.	Complete office, well integrated with DP; many turnkey commercial products, in well targeted vertical markets. Continue to add applications packages which grow out of installed base. Trend to add more financial packages like distribution and ordering to integrate the factory.	Complete office and extensive plans for applications support with new OS; several high quality turnkey application packages available.	With the addition of the Robotics Inc. acquisition, HP now offers complete "one" stop shopping" for the manufacturing industry.	
COSTS AND PRICES	Competitve pricing; most system software bundled with HW.	HW prices +5%, new SW not bundled.	HW prices constant; SW prices up 10%.	HW prices constant; SW prices up 10%.	HW prices constant; SW prices up 10'
FIELD SERVICE	High quality service at low cost, worldwide.	BMC reduced to .2% of price, 6 month warranty.	BMC .15% of price, one year warranty.	BMC .1% of price, one year warranty.	
MARKET/ DISTRIBUTION CHANNELS	Extensive salesforce, direct sales to large accts, many OEM sales. Industry specialists sell products. Strong push to sell their office automation products announced in October, 1981. 3rd party SW suppliers market programs to existing HP customers.	Applications brought in-house, through purchase; provide all but mainframe to large companies.	Very low product/cost-of-ownership; be viewed as very lost cost producer of high quality, computers.	Same. Retail store channel for personal computers. Backward integration especially in robotics area - put computers in robots to integrate into MRP package.	
BUSINESS ACTION	Major thrust into solution sell through applicaton software. HP will operate like an OEM company. Complete solution stressed into vertical markets, which are few but focused.				
COMPANY SKILLS	By 1988 competition will force HP to integrate computers and instruments business. At less than 1/2 DEC's size in computers, HP can best survive IBM/JAPAN competition by concentrating on natural strength of manufacturing.				

23 November 1981 --- Strategic Planning Game

Your Name: ____________________________ Competitor: HP

Hardware Cost/Performance

|-----|-----|-----|-----|-----|-----|-----|-----|-----|
1 2 3 4 5 6 7 8 9 10
Poor - - - - - - >average - - - - - - ->excellent

Cost of Ownership

|-----|-----|-----|-----|-----|-----|-----|-----|-----|
1 2 3 4 5 6 7 8 9 10

Existing Base / Reputation

|-----|-----|-----|-----|-----|-----|-----|-----|-----|
1 2 3 4 5 6 7 8 9 10

Unique Capabilities

|-----|-----|-----|-----|-----|-----|-----|-----|-----|
1 2 3 4 5 6 7 8 9 10

Programmer Productivity

|-----|-----|-----|-----|-----|-----|-----|-----|-----|
1 2 3 4 5 6 7 8 9 10

End User Productivity

|-----|-----|-----|-----|-----|-----|-----|-----|-----|
1 2 3 4 5 6 7 8 9 10

Availability of Third Party Software and Services

|-----|-----|-----|-----|-----|-----|-----|-----|-----|
1 2 3 4 5 6 7 8 9 10

Use of Industry (or other) standards

|-----|-----|-----|-----|-----|-----|-----|-----|-----|
1 2 3 4 5 6 7 8 9 10

Bredth of Offering

|-----|-----|-----|-----|-----|-----|-----|-----|-----|
1 2 3 4 5 6 7 8 9 10

Completeness of Solution Capabilities (other)

|-----|-----|-----|-----|-----|-----|-----|-----|-----|
1 2 3 4 5 6 7 8 9 10

TOTAL MARKET SHARE GAINED OR LOST: 10% gained

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$

— 1980

— 19..

R. Smart
4/23/81

********* C O M P A N Y   C O N F I D E N T I A L **********

HEWLETT PACKARD COMPETITIVE STRATEGY

RELATIVE POSITION IN MARKET SPACE

Geographic Dimension

HP has good international coverage with 52% of it's FY80 business outside USA. The international coverage was presumably developed on the basis of its Instrument business. Information on computer product revenues is not yet available by country. However, FY80 total HP revenues by geography are: USA 48%, Germany 8%, France 7%. UK 6%, Italy 4%, Other Europe 11%, Japan 4%, ANZ 2%, Canada plus Latin America 6%, Other Asia 3%, Africa 1%. Annual report date. (cf DEC).

Industry Dimension

HP is heavily biased towards manufacturers as end users. Compared with DEC's mix of end-user business, HP's mix has more concentration in manufacturing, while DEC is much stronger in education and research, as well as in EDP service business - all according to a mini/micro magazine survey published in April 1980. If DEC's OEM business is included, the manufacturing segment of our mix of business is closer to HP's mix.

Kind of Customer

HP's end user is presumably like DEC's - technical business rather than accounting oriented. They have targeted the F500 and stressed coexitence with the IBM central DP Site. They have excellent manufacturing management control applications offerings and can target this segment very comfortably. Long-term, we can expect direct overlap of end-user target markets. HP is less evident in communications-oriented applications, more so in industrial automation and medical instrumentation.

Channels

According to IDC, HP does 48% of its revenue via OEMs (surprisingly high to me).

Product/Application

HP's coverage of the price bands has a focus in the $100K-$250K segment with the HP 3000 and in the two bands 6.25K-16K-40K with emphasis at the lower end. The products are the HP 1000 Minicomputer and the Desktop 98xx. Computer products are now

50% of the total HP revenues and increasing.

As a subjective judgement, it is believed that HP have done a better job of providing applications software for the manufacturing end-user segment.

RELATIVE CAPABILITY

Financials

HP accelerated the growth rate of the computer segment significantly from 1975, to a 42% annual growth rate in 1979 and 1980. The computer segment profitability also increased in the last few years on a PBT percent basis. HP's ROA is close to DEC's, DEC having a better tax rate but HP doing better at asset management (especially inventories) and cost of goods and services. The computer segment is now HP's biggest and is more profitable than the corporate average but second to the slower growing electronic test and measurement segment. This latter segment performs the role of a cash source, which has meant that HP has not needed to look for outside financing.

Quality - Subjective Judgements

HP has a quality image as a company but a limited computer product offering. They are ahead in applications program offerings for manufacturing and seem to be good at marketing what they have. They do not have an integrated set of products and perhaps their structure tends to dull the forces for achieving better product synergy. Their customer interface (including administrative processes) is thought to be superior to DEC's at this time.

Organization

HP's business units are more independent than ours. Engineering, Manufacturing, as well as Sales/Marketing, is decentralized into these business segments.

R & D

HP in total spends more on Engineering than DEC does.

Summary

HP will be a competitor for the long term with primary market overlap occuring in the manufacturing segment. They have made the most (marketing, sales, administration) of quite limited product offerings. Probably the biggest trend to watch for is a turn around in their product engineering to support their financial and sales/marketing capability.

Hewlett Packard Company

Hewlett Packard (HP) is expected to announce at least 20 new products near the end of this week (October 29 is anticipated), which will clarify HP's strategies for office automation, software and networks in this decade.

In the automated office area, HP will be announcing a word processor which is expected to include a terminal that can be used for either word or data processing, depending on the software. HP is expected to introduce WP and text editing software which can run on all HP 3000 models, as well as on the new terminal. In addition, we expect to see software for automatic report generation. These new products, when used with HP's existing 3000 series, the new personal computer, the existing laser printer, and HP's interactive graphics capability, give the customer the tools for an almost completely automated environment. Unfortunately, electronic mail is (strangely) lacking, as are voice communications. However, HP for the most part will have caught up (and in many cases, surpassed) its competition.

HP should introduce both a new entry-level model 3000, which should be a real price/performance improvement, and a top-of-the-line machine with a 32-bit bus. All 3000s are expected to remain software-compatible.

Five new data communications capabilities are expected, including SNA compatibility, access to the packet-switched public data networks via the X.25 standard, and X.21 capability for access to digital circuit-switched data networks as well as for remote job entry communications to IBM and IBM-compatible systems. Also expected to be announced is fiber optic communications into local area networks via a new multiplexer. These capabilities will increase HP's flexibility for the future, as well as underline the company's strategy for a truly standard, integrated environment. It is eminently sensible, in our

IBM FACT SHEET

The Corporation is a well-known manufacturer of electronic equipment. Its annual sales today roughly equal one percent of the U.S. Gross National Product.

PROTOTYPE IBM SCENARIO
(NARRATIVE OF EVENTS)

BACKGROUND

IBM management in the late '70s was horrified by the implications of the Japanese competitive threat as first experienced through the "inconceivable" success of Amdahl in conservative IBM accounts. The Company found itself trapped by the huge investments that its own customers had made in 370 application programs. The market was so large that the commodity-oriented Japanese (and others) saw the opportunity to challenge based on price. But IBM could no longer use the standard ploy of migrating customers to a "future system" architecture since the plug-compatible vendors could win over many large IBM accounts with the promise that "we're more loyal to your 370 program investment than IBM."

At the same time, IBM had to admit that distributed computing and minicomputers would not go away. Fortune 500 companies continued buying DEC minicomputers even after Series/1 was introduced. The appearance of Apples with Visicalc in the offices of the Assistant to the Corporate Controller of many Fortune 500 companies was the last straw.

IBM needed to reassert account control in large organizations, protect itself against low-cost producers, and ensure that cheap computing (a consequence of microprocessors) would not disrupt its industry leadership.

Account control would be regained by unifying its product offering and providing large customers a single vendor solution to their information processing and communication needs. This meant reorganizing the sales force to eliminate the old DPD vs GSD conflicts, reducing the number of competing IBM architectures, and exploiting the synergy of IBM data processing gear, IBM office products, SBS communication, and the world's most respected service organization.

The best protection against low-cost producers in Japan was to ensure that IBM maintained the lowest costs. That meant mastery of basic technologies (such as disk and semiconductors) and aggressive hardware pricing to achieve volume efficiencies. Since it was almost impossible for anyone to compete with IBM for control of 370 system software, software prices would be increased to make up for declining hardware margins. Moreover, control of system software implied control of 370 architecture. Periodic "enhancements" would be used to keep the plug-compatible vendors in a visibly dependent role.

Finally, IBM could protect against cheap, microprocessor-based computing only by offering such products under its own logo. The cost of developing a myriad of application packages to compete with the thousands available for commodity architectures made little sense so IBM decided to implement home and small business computers on an Intel micro with "commodity" operating systems from outside suppliers. Thus, IBM became a supplier of commodity hardware (Intel micros and 370) with commodity software at the low-end and unique system software at the high-end.

1982

1982 proved to be a bad year for wine but a good year for IBM computers. Larger and smaller members of the high-end 370 H-Series (4 to 20 MIPS) were introduced at a price of $400K/MIP for basic CPU and memory. (VAX 11/780 is roughly equivalent to 1 MIP. The first H-Series machine, the 3081, was priced at $400K/MIP.) Two new families of 370 processors also were announced for shipment in 1983. G-Series (1.5 to 10 MIPS) was priced at $225K/MIP and the Olympia Series (0.2 to 2 MIPS) was priced at $175K/MIP. Olympia was the replacement for the old E-Series (4300's) which had been sold at $300K/MIP. The entry-level 370 system (0.2 MIPS, equivalent to 4321 or 4331-1) including minimum storage was $80K.

(Note that Grosch's Law had been reversed. The complexity and lower production volumes of high-end pipeline processors made them less cost-effective per MIP than the simpler, easily LSI-ed, high volume units in the mid-range.)

The troublesome 3380 (1.2GB/spindle) was shipping in volume finally and priced at $40/MB. A new streaming tape cartridge was introduced using an 18-track format at 20.5K bpi. It sold for $80K.

370 system software moved to greater compatibility among MVS, DOS/VSE, SSX, and their layered products. A comprehensive package of office automation software (mail, WPS, etc.) was announced.

The S/38 family had no major announcements but did expand somewhat both upward and downward in price and size. There were continued enhancements to software performance and better SNA interfaces. The product was sold to small businesses and departments in large organizations that insisted on a system that was much easier to use than the 370.

There were minor announcements in personal computers, but nothing very significant. IBM did announce a greatly enlarged library of third party applications. Also, new pricing and terms and conditions stimulated interest from third party software houses and OEMs.

In the area of communications, IBM released numerous enhancements to SNA performance and functionality. The Mirage front-end (370X replacement) was announced after what may have been the longest, most unsuccessful development project in computer history. IBM introduced two PBXs for sale in the U.S. They made a big splash in the press ("IBM vs ATT"), but they really were not very aggressive products.

IBM maintained an acceptable position in terminals - competitive functionality, nearly competitive prices. However, there was some reduction in the number of equivalent products as the old DPD/GSD split faded; and the Company did introduce terminals and 370 software with significantly improved business graphics. A $50K laser printer was announced for Olympia Series and System/38.

IBM continued its tradition of aggressive service pricing. This was viewed as an important strategic block to the Japanese. In addition, the Company reduced the risk of any serious competition on 370 system software by permitting plug-compatible hardware vendors to sell IBM software maintenance for their machines.

1984

Significant elements in IBM's new strategy became evident in 1984. The new Sierra series (6-40 MIPS) was shipped at $200K/MIP. Olympia was expanded, and the price of an entry-level 370 system fell to $60K. The new Palermo disk (double density 3380) with 2.6GB per spindle started shipping at $32/MB. Moreover, a database engine, available as a 370 back-end or SNA node, was introduced at $40/MB for storage plus $250K for engine and relational database software. It provided a factor of 3 improvement in retrieval access over IMS but was incompatible. Thus, customers generally put new applicatons on the product rather than instantly migrating old ones. The user and DB administrator interfaces borrowed heavily from the System/38. Indeed, it was becoming clear that IBM intended to migrate the improved human engineering from S/38 to the 370. Plans to introduce a S/38-like command language on the 370 were announced, but the process would be a slow evolution.

The S/38 itself was still being expanded. There was a high-end System/40. At the low-end, the System/36 covered the range from $30-160K. It supported more than 16 active users with typical storage in excess of 500MB. The software was becoming even more user-friendly and featured superior graphics. Nevertheless, rumors spread that these would be the last really aggressive extensions to the S/38 family. The system had fulfilled its purpose. It was a testbed for improved human engineering and an alternate product for those "oddballs" who would not accept a 370.

With the S/38 features migrating to the 370, IBM could not justify extensive investments in an alternate architecture. With its improvements in human engineering, the 370 was becoming clearly superior as a departmental machine. Remote operator control was available for all operating systems. This meant that a central host site could manage and operate a distributed network with minimal local staffing requirements. The product was good enough so that IBM retired the 8100. Although some customers were angry, there was no plug-compatible competition and IBM offered good migration aids.

IBM introduced a low-cost backup device for the fixed disks on the S/38 and Olympia. It was based on video recording technology.

1984 was the year when IBM answered the question of what it would do about the 16-bit address space of the Series/1. The solution was radical. Series/1 was maintained with minimal enhancements for existing accounts. Migration aids were provided for the new 32-bit Series/2. IBM concluded that its minicomputer business was coming primarily from its strong 370 accounts. It had not cracked the real-time market served by the traditional mini-vendors. Therefore, the decision was to base the Series/2 on Intel's iAPX-386, the 32-bit extension to the 8086. Intel's designers understood real-time better than IBM, and the 386 chip enabled them to introduce a powerful mini with 0.5 MIP performance (greater than 11/70) for less than $40K entry price. The new operating system, RSX-386, maintained substantial compatibility with its S/1 predecessors. The same was true for most of the layered software.

Even more stunning to the computer industry was IBM's decision to base a new line of personal computers on the same Intel chip. Two operating systems were supported - both from outside suppliers! One was UNIX-based and the other was Digital Research's compatible follow-on to CP/M. It featured multitasking, a good file system, and virtual memory.

The product represented a major unification of the IBM product family replacing the S/23 Datamaster, the Displaywriter, and the old 8088-based personal computers. There was a mini-floppy version for home and school priced from $1200-1500. A $6000 unit with 25 MB mini-Wini was available for small businesses. By this time, IBM's library of third party applications for CP\M and UNIX was huge. Several different levels of support - from no support through turnkey - were available depending on the particular application.

There were some sales of the personal computer to large organizations, but the volume was held down by persistent rumors of a 370-based personal computer in the works. IBM seemed to position the 386 personal computers as below the sophistication required for the Fortune 500. Of course, this did not stop IBM from building its word processing products out of the same basic hardware but different cabinets and IBM proprietary WP software.

Meanwhile, SBS was beginning to penetrate the Fortune 500 market with its rooftop satellite links. A new IBM digital PBX was introduced featuring convenient interconnection with SBS and SNA. It also offered voice mail capability. IBM's latest terminals provided a built-in telephone option. This permitted IBM customers to have a single unit on their desk to connect to IBM 370 data processing, 370 office automation, and telephone PBX. IBM told customers to commit to an "IBM desk". SNA communication and simple word processing was included in all but the cheapest Selectrics.

IBM continued to promote service by offering bundled maintenance for IBM hardware, software, and PBX. In addition, there was a major expansion of IBM's service bureau business.

The growth of the third party software business was creating noticable problems within IBM. The relatively small number of truly talented programmers saw progressively less barrier to achieving personal wealth by going into business for themselves. A similar, but more subtle, problem existed with talented VLSI engineers.

IBM was forced to respond with significantly enhances salary and reward mechanisms for its key employees.

Fear of possible changes in anti-trust philosophy led senior IBM executives to make substantial contributions to the Republican Presidential campaign.

<u>1986</u>

There were lots of rumors about replacements for Sierra and Olympia in 1986, but nothing happened. The Everest disk (3380 quadruple density) with 4.9GB per spindle was announced at $25/MB. Storage on the database engine was reduced to $32/MB.

The real action was at the low-end. IBM developed a single-chip 370 with 0.5 MIP performance. It was introduced in a personal computer priced from $12 to 20K. It ran a human-engineering-enhanced version of the old CMS operating system developed for VM/370. Thus, IBM finally had the "final solution" to time-sharing - eliminate it. With 370 personal computers gracefully coupled via SNA to MVS and DOS (SSX) hosts, IBM no longer had to struggle with time-sharing performance. VM/370 could be allowed to die, and IBM had achieved sharp differentiation between Fortune 500 personals (370 architecture at a premium price) and small business systems (Intel 386 architecture and a commodity price).

IBM refused to license or document the 370 chip so competing vendors had no idea what changes IBM might be able to make in CMS. Unlike the heavily-microcoded high-end machines, they could not risk selling 370 personals at a competitive price with a promise of long-term compatability.

A second generation of Intel 386 chips was available, and IBM introduced a new generation of personals in that architecture. The home and school product sold for $1K while the office version was $4500. At the same time, they used a new high-performance version of the 386 (4 MIPS) to bring out a new member in the minicomputer family at a $25K price.

SBS was making substantial penetration in the Fortune 1000. A complete rooftop installation was only $50K, and they were becoming as ubiquitous as television antennae were prior to cable TV. The voice mail in the IBM PBX was now integrated with the office automation running on 370 hosts and personals.

IBM terminals (including the 370 personal) added voice capability sufficient to implement voice menus. The laser printer family was extended down to $20K for an SNA node version.

With the introduction of the 370 personal computer, IBM encouraged the growth of an application software market with premium prices relative to the small business personal market. Although IBM's service bureau operation also provided application tools, it began to evolve more into an information library teletex service. IBM introduced a low-cost teletex terminal for users of this service and for customers selling their own teletex service based on IBM computers.

IBM's continuing evolution of system software led to a proposal from some customers and plug-compatible vendors to make MVS an ANSI standard (user and programming interfaces). IBM strongly resisted.

1988

The Summit series (12 - 80 MIPS) was introduced at the high-end of the 370 family. The prices were set at $100K/MIP. The rest of the mainframe area (less than 10 MIPS) was implemented with various multiprocessor configurations constructed from two VLSI implementations of the 370 architecture. There was a 4 MIP processor chip with a two-chip channel adapter and a single chip processor/channel rated at 0.5 MIPS. The base CPU and memory sold for $60K/MIP. The entry-level system was $30K.

Meanwhile, the S/38 family continued to be available in the $20 to 400K range. The rate of enhancement had slowed visibly. The new personal 370 (built from the slower VLSI chip) sold for $8 to 14K while the 386 personal had fallen to $900 for home and $4K for the office.

The database engine was available at $150K for hardware and software. Storage still cost $32/MB but performance was now 5 times the equivalent performance using IMS and regular disks.

Human engineering enhancements left JCL as a piece of nostalgia, supported only for backward compatibility. The effective and graceful distribution of function between 370 hosts and 370 personals improved with each new IBM release.

IBM's petition for admission to the United Nations was turned down.

SUMMARY OF IBM STRATEGY

1. Unify computing, communication, and service in order to provide a true, single vendor solution for most customers (uniqueness).

2. Reduce number of architectures using commodity microprocessors and software for low-end products.

3. Use VLSI to stay competitive in 370 architecture, deriving revenue and controlling the industry through continuing changes in system software.

4. Maintain leadership in critical technologies (e.g., disk, semiconductor) and price for volume in order to stay equal or better than Japanese on cost. Lead on service and quality.

5. Aggressively offer different business terms and conditions and products for every price band and market in order to achieve highest volumes possible for both components and systems.

/jdm
RC1.S5.42

IBM	1982	1984	1986	1988
PROCESSORS	• Larger and smaller H-Series at $400K/MIP • Olympia for 1983 $175K/MIP; 4321-class system at $80K	• Sierra Series (6-40 MIP) at $200K/MIP ships • Olympia expanded; entry price is $60K • S/40 and S/36 added to S/38 family • Mini based on Intel 386 and new real time OS announced • Intel 386 Personal Computers - home version at $1.2-1.5K; office at $6K	• New minis based on second generation Intel 386 (4 MIP) • 370 Personal Computer (0.5 MIP) at $12 to 20K • Second generation Intel 386 PCs; home at $1K and office at $4500	• Summit Series (12 to 80 MIP) at $100K/MIP • VLSI for <10 MIP mainframes at $60K/MIP and $30K entry • S/38 family from $20K to 400K • 370 PC from $8K to 14K • 386 PC at $0.9K for home and $4K for office
STORAGE	• Delivering 3380 in volume $40/MB • Del Oro streaming tape cartridge at 20.5Kbpi, 18-track, for $80K	• Start shipping Palermo fixed disk (double density 3380 with 2.6Gb/spindle at $32/MB • Database Engine introduced at factor of 3 retrieval perf. over IMS and $40/MB • Low cost fixed disk backup - video technology for low end systems	• Everest disk (3380 quadruple density with 4.9GB/spindle) at $25/MB • Database Engine at $32/MB	• Rumors of new disks coming • Database Engine at $32/MB and factor of 5 perf. over IMS
COMMUNICATIONS	• New PBX family, not too aggressive • Mirage (370X replacement) announced	• Some penetration of rooftop SBS in Fortune 500 • Digital PBX compatible with SBS, SNA, and voice mail • IBM sells teleconference facilities connected to SBS	• Substantial SBS penetration in Fortune 1000 • Low cost rooftop SBS system for $50K • PBX voice mail integrated with 370 office software	• IBM PBX managers voice, video, and data

IBM	1982	1984	1986	1988
TERMINALS	. Competitive functionality; approaching competitive prices . Better business graphics . $50K laser printer announced for 370 & S/38	. Terminals combined with telephone for "IBM desk" to IBM PBX . Laser printer family from $30K to $300K . Simple word processing and SNA communication in all but cheapest Selectric typewriters	. Support for voice menus . Laser printer family as SNA nodes from $20K . Introduce low cost teletex terminal	
SYSTEM SOFTWARE	. S/38 maintains ease-of-use leadership . Layered products move to compatibility on MVS, DOS, SSX . 370 Office Automation Software (OAS) introduced	. Good S/38 ease-of-use features (including command language) migrated to 370 . Superior Relational Database and query product for 370 with Database Engine. . Intel 386 PC has UNIX-like OS and CP/M compatible extension from Digital Research	. Graceful coupling of 370 host to 370 Personal "obsoletes" time-sharing . Graceful distribution of OA functions between host and personal 370	. JCL totally obsolete except for backward compatibility . Powerful application generators for 370
APPLICATIONS SOFTWARE	. IBM markets library of applications for its personal computers . New pricing and terms encourages 3rd party applications and OEMs	. Different support levels from IBM for 3rd party software . IBM claims largest library of applications	. Premium Price application market develops for 370 personal	
COST & PRICES	. Commitment to stay equal or ahead of Japan on costs . Aggressive pricing of commodity hardware for volume . Continuing increases in System Software pricing	. Commitment to products in every price band, every market	. Active oppostion to proposals to make MVS into ANSI standard	

IBM	1982	1984	1986	1988
SERVICES	• Low service pricing to block Japanese • Permit plug-compatible hardware manufacturers to sell IBM software maintenance service	• Total service package for PBX, computer hardware, and software		
CHANNELS	• Fortune 1000 - Direct Sales • Small Business - Direct	• Very small business - some retailers and IBM stores • Home - retailers		
BUSINESS ACTIONS	• Ever more aggressive variations of channels and terms and conditions to compete in all markets • Extensive investments in plant capacity for volume production	• Salary/reward mechanisms altered to hold key technical contributors • IBM active again in Service Bureau business • Heavy contributions to Republican Presidential campaign	• Service Bureau evolves to Information Library Teletex service	
KEY SKILLS	• Competitive primary technology (e.g., disk, semi, communication, etc.) • Break away from old IBM monolithic approach	• Utilize commodity products/architectures where most cost-effective	• Ability to manage huge organization in highly dynamic market • Keeping things simple for the overwhelmed users of the world	

8 December 1981 --- Strategic Planning Game

Your Name: 1980 (O)/1990 (X) Competitor: IBM

MARK EACH SCALE WITH
(1) AN "8" TO SHOW WHERE YOU THINK THE COMPETITOR IS IN 1980 AND WITH
(2) A "9" TO SHOW WHERE YOU THINK THEY WILL BE IN 1990

```
                                            O                   X
Hardware Cost/Performance          |---|---|---|---|---|---|---|---|---|---|
                                   1   2   3   4   5   6   7   8   9   10
                                   poor  -  > industry norm  ->excellent

                                                O                   X
Cost of Ownership                  |---|---|---|---|---|---|---|---|---|---|
                                   1   2   3   4   5   6   7   8   9   10

                                                                X   O
Existing Base / Reputation         |---|---|---|---|---|---|---|---|---|---|
                                   1   2   3   4   5   6   7   8   9   10

                                                        X       O
Unique Capabilities                |---|---|---|---|---|---|---|---|---|---|
                                   1   2   3   4   5   6   7   8   9   10

                                        O           X
Programmer Productivity            |---|---|---|---|---|---|---|---|---|---|
                                   1   2   3   4   5   6   7   8   9   10

                                                 O              X
End User Productivity              |---|---|---|---|---|---|---|---|---|---|
                                   1   2   3   4   5   6   7   8   9   10

                                                                     O X
Availability of Third Party        |---|---|---|---|---|---|---|---|---|---|
  Software and Services            1   2   3   4   5   6   7   8   9   10

                                                                O    X
Use of Industry (or other)         |---|---|---|---|---|---|---|---|---|---|
    standards                      1   2   3   4   5   6   7   8   9   10

                                                                    OX
Breadth of Offering                |---|---|---|---|---|---|---|---|---|---|
                                   1   2   3   4   5   6   7   8   9   10

                                                O               X
Distribution Channels              |---|---|---|---|---|---|---|---|---|---|
                                   1   2   3   4   5   6   7   8   9   10


-------------------------(other)   |---|---|---|---|---|---|---|---|---|---|
                                   1   2   3   4   5   6   7   8   9   10
```

Total Information System and Services Market Share (% of total market) gained or lost during the decade of the 1980's expressed in "MILLIPOINTS" (1/1000 of one percent of share). In 1980 one millipoint corresponds to about $1 million of annual revenue.

__________ millipoints of share __________ gained or lost

3.67

R. G. Smart
4/17/81

********** C O M P A N Y   C O N F I D E N T I A L **********

IBM STRATEGIC COMPETITIVE ANALYSIS

RELATIVE POSITION IN MARKET SPACE

Geographic Dimension

IBM is represented directly in almost every country of market significance. India and Nigeria are exceptions where local national ownership or other requirements have been enforced. IBM have distributed their Manufacturing and even their R&D activity geographically in order to maintain influence over nationalistic trends.

The geographic mix of business and profits had moved towards non-USA markets through the 70s. USA revenue share has (temporarily?) stabilized at 48%.

The following is the estimated 1979 geographic mix of sales. USA 48%, Germany 11.5%, France 6.8%, UK 3.1%, Italy 4.0%, Holland 1.8%, Belgium 1.6%, Spain 1.3%, Sweden 1.2%, Denmark 1.0%, Switzerland 1.4%, Other Europe/Africa 3.1% - Subtotal of Europe 36.8%.

Japan 6.9% (an increase over 1977), Canada 3.3%, ANZ 0.9%, Latin America (Brazil) 1.7%, Other Asia 2.9% - Subtotal "GIA" 15.7%.

These figures are derived from an analysis by Dean Witter Reynolds, dated March 1979. Country Planners can convert to projected IBM revenues for their country market, by noting IBM's 1979 world revenue was projected by Reynolds to be $24.6B. In fact it turned out to be only $22.9B of which $18.3B was from data processing.

IBM's EDP penetration of country GDPs in 1979 was approximately:

USA 0.37%, Germany 0.28%, France 0.22%, UK 0.14%, Italy 0.22%, Canada 0.28%, Japan 0.13%, Australia 0.13%, New Zealand 0.15%.

There was relatively little growth in penetration of major countries by IBM throughout the '70s.

Industry Dimension

IBM's industry distribution of EDP revenues is of course very close to the mix associated with all general purpose (mainframe) systems.

Only in the Federal Government market in IBM's mix unusually low, with CDC and UNIVAC together doing more Federal business than

IBM.

DEC's market mix of business by industry shows nearly twice the all mainframe average (much stronger than IBM) from the Federal Government. We are a little ahead of the average (and IBM) in Education and in Medical. The mix of our revenue in Manufacturing is slightly ahead of the mainframers average including IBMs, even at the end-user level. Our OEM business keeps our mix well above IBM's position in Manufacturing, although some of our OEM business ends up outside Manufacturing. We have great strength in Telecommunications mix (Western Electric, Bell Labs and the Telephone Operating Companies combined), relative to other vendors including IBM. Business Services is also exceptionally strong for DEC if the Channel Business is counted here. IBM seems to be growing strongly in this segment as well as in Manufacturing. Of course, in absolute size, IBM dominates any broadly defined segment.

In all other significant industry segments, DEC's position is well below the mainframer average, because of our choice of target markets: e.g., state and local governments, insurance, finance (excluding some specific banking segments), retail and wholesale (excluding channel business) all have a very low proportion of DEC business. Wherever we target, IBM is there even though some of the industry segments are a much bigger proportion of our business than of IBMs.

Kind of Customer

IBM has a very strong position in the large organizations. For example, in the F500 Industrials, IBM has a better than 76% market share of the mainframe business as against about 69% average for all kinds of customers in USA. There are very few F500 companies without an IBM presence in terms of some IBM equipment installed. IBM are expert at leveraging off their powerful market position in most accounts. Our "Kind of Customer" differentiation from IBM is primarily at the departmental and individual professional level, where the respective business/technical personalities of the two vendors can have some influence.

Channels

Most of IBM's business is via direct sales. There are signs that IBM is experimenting with the OEM channel. They are rumored to be planning to run on-customer-site service bureaus. They are also rumored to be developing retail channel (Sears, Penny's) for 51xx PCs.

Relative to DEC, IBM is far behind in the use of third-party channels. IBM's imperative towards direct account control and their attitude towards PCMs, imply a less than enthusiastic drive into third-party channels. This contrasts with DEC's channel attitude, experience and reputation.

In summary, DEC is substantially differentiated from IBM in the channel dimension of the market space. The one exception is in the use of third-party applications software. IBM may be ahead of us in the exploitation of this "channel". There is also a substantial third-party's systems software market on IBM's base, which IBM has tolerated.

It will be very important for us to accentuate the channel differentiation in our strategies and promotions. At the same time, we need to watch for substantial moves by IBM into the OEM market with S/1.

Product/Application

We are also substantially differentiated from IBM in the product/application dimension. Most of IBM's business is based on systems larger than $250K. The more successful IBM products are above $625K even today, except for S/38-5. The 4331 is weak as was 370/115 (bottom of the architecture range).

Below $250K, the 81xx products are constrained to be linkage products into large mainframes (no doubt deliberately, to channel work to the central DP site). System 3 pulled in a lot of revenue but these systems are ageing as is S/32. S/34 also went through its peak revenue years in 79/80. Series/1 is receiving a very strong marketing push which is bound to pull in business from IBM's captive accounts, of which there are very many. IBM has products all the way down to the PC level. IBM's systems below $250K do not at all equal the compatible range of general-purpose "small" systems that we have and for which we have built a substantial customer base. In these price bands, IBM's strength is in commercial applications e.g., COEM competition and decentralized commercial applications in the many IBM captive central DP sites.

IBM was almost as big as DEC in 1979 in the below $250K price bands and they will be pushing hard for a share of growth in this product space. We are probably becoming even more differentiated from IBM in terms of software compatibility across the small bands. We are differentiated in terms of applications: IBM volume is mostly commercial accounting applications while DEC is supporting a wide range of professional/technical and sophisticated "commercial" applications. The trend to watch for is in our respective attractiveness to the users (end-users, software houses or OEMs) who will be implementing the volume applications of the future - the approachability factor in hardware/software system design. S/38 seems to be a significant advance by IBM into an approachable software system (RPG-111). This indicates a very significant product trend towards our historical advantage of ease of use. Note however that so far, only the S/38 model 5 (above $250K) has any performance, the model 3 is a poor product.

RELATIVE CAPABILITY

Financials

IBM's financial strength is enormous and their manufacturing costs on a percentage basis much lower than ours. However, they have been maintaining high profits by selling off their depreciated base of rental sites. Profitability with high growth requires high productivity. IBM's and our productivity are closer together than are our ROAs given that DEC has been growing at more than twice IBM's rate. The other side of the growth adjusted profitability, is that IBM has invested heavily in Manufacturing as well as in bringing out a range of state-of-the-art products. Theoretically, they are ready to pour out a great stream of very attractive performance/price products relative to their historical position. Their internal pressure to increase revenue growth with their new capability will be enormous. Even if their products and channels don't overlap our own, we can expect powerful forces to be applied all over our market space. Being so much smaller than IBM financially, but approaching their market share at such a speed (even if from a distance) has got to attract considerable competitive attention which will require us to keep objective about our strengths, alert to breakthroughs into our market space and aggressive at building distance between ourselves and IBM in the whole market space.

Quality-Subjective Judgements

Subjective comparisons between IBM's performance and ours show our need for better administration of our customer interface especially in terms of order handling. Our business is probably more complex than IBM's (range of separate P/Gs, channel complexity, rate of growth, range of product options and complicated product mix forecasting). However, these are our problems not our customers'. We have to be good enough to manage our own complexity and growth rate or give them up and lose market share gracefully, if not graciously.

We have been incredibly flexible in managing manufacturing volume changes and in generally adapting to operational conditions which do not follow our "plans". This capability is squandered if we use it to save ourselves the trouble of getting better at our planning, especially of market demand for the various products. IBM may not be better at this than we are but there are enough competitors around for someone to pick the right product volumes if we don't. Note that IBM are very good at selling what they build, even when it isn't the best product/price available in the marketplace.

Producing quality products is becoming an important competitive capability. The Japanese hardware quality thrust will be amplified by IBM. In system software, we have a good edge except in large commercial data base support. The ease-of-use quality will be critical for future applications development. IBM are clearly recognized as the leader in commercial accounting software. However we have to exploit our software advantages in the more complex business applications (DDP and decision support?) and strongly coexist even in the many IBM accounts.

As a final subjective judgement, my relatively small sample of IBM people suggests that we have been much more exciting to work for and that we stimulate greater motivation in more of our people. Even if this was true, IBM's future will be more exciting to their employees than has the last few years. Consequently, we have the management challenge of clarifying the role satisfactions we want our people to strive for and of removing more of the obstacles to their achievement of those satisfactions.

Organization

Although IBM is reputed to have a highly centralized mangement philosophy, there are indications that their structure is anything but rigid. According to a Booz Allen study, IBM has no hesitation about establishing project-oriented structures and using communication channels which go right past the formal organization, in order to solve a technical/business/marketing problem. We can assume that the IBM organization will pursue established goals with considerable organizational momentum, but that they will be quite nimble in solving organizational obstacles to their success.

R & D

IBM has now restored itself as a technology-driven product-oriented Sales/Marketing company. A huge investment is made in R & D and the days of expensive mediocre products are over. Their focus has been on the high-performance mainframe products. While continuation of this emphasis is a natural extrapolation of IBM strategy, there is already a strong thrust into services (unbundled software) and networking to the departmental machine and to the intelligent terminal. The approach seems designed to maintain the role of the central DP facility and its associated software/hardware momentum.

IBM spends at least five times our dollar figure on Engineering.

DATE: TUE 8 DEC 1981 11:13 EDT

THIS EMS IS FROM ROGER BISBO, DTN 264-6777.

The current issue of Business Week (12/14/81) is devoted to "Japan's Strategy for the '80's" (pp. 39-120). One article (starting on p. 65) specifically discusses Japan's worldwide strategy for the computer market. Japan has set a national goal of winning 18% of the U.S. and 30% of the global computer business by 1990. The key Japanese tactic for reaching this goal is the production of IBM-compatible mainframes (i.e. S/370 look-alikes). Since IBM dominates both the U.S. and global markets, any Japanese expansion will be at IBM's expense.

Concentrating on plug-compatible mainframes allows the Japanese to capitalize on their strength in highly productive manufacturing while avoiding their weakness in software engineering. However, it leaves them extremely vulnerable if IBM switches to a new computer architecture and/or operating system. The Japanese are hedging their bets by launching a massive effort to build intelligent, Fifth Generation systems. Unfortunately, this is a long-term strategy which provides little safety in the short to medium-term.

Business Week believes that IBM may already be poised to switch architectures and operating systems (see "An Ace in the Hole," p. 74). The new architecture will be System/38. BW notes that IBM's reorganization will allow the entire IBM salesforce to sell all products. They state that John R. Opel, IBM's President, has indicated that IBM customers would be willing to render obsolete their software investments for a radically new, and better, computer. This was also the consensus of a panel of experts convened by Datamation magazine to discuss usability problems of IBM's mainframe operating systems (see "Renovating Dinosaurs," Datamation, 10/81).

It is highly unlikely that Business Week would have published such a dramatic statement without substantiation. BW did not credit their data to a source outside IBM. Apparently IBM has divulged to BW certain, previously confidential, information. It could be that IBM has floated a "trial balloon" via BW to gauge their customers' reaction to, what would certainly be, the most significant product change since the announcement of the System/360.

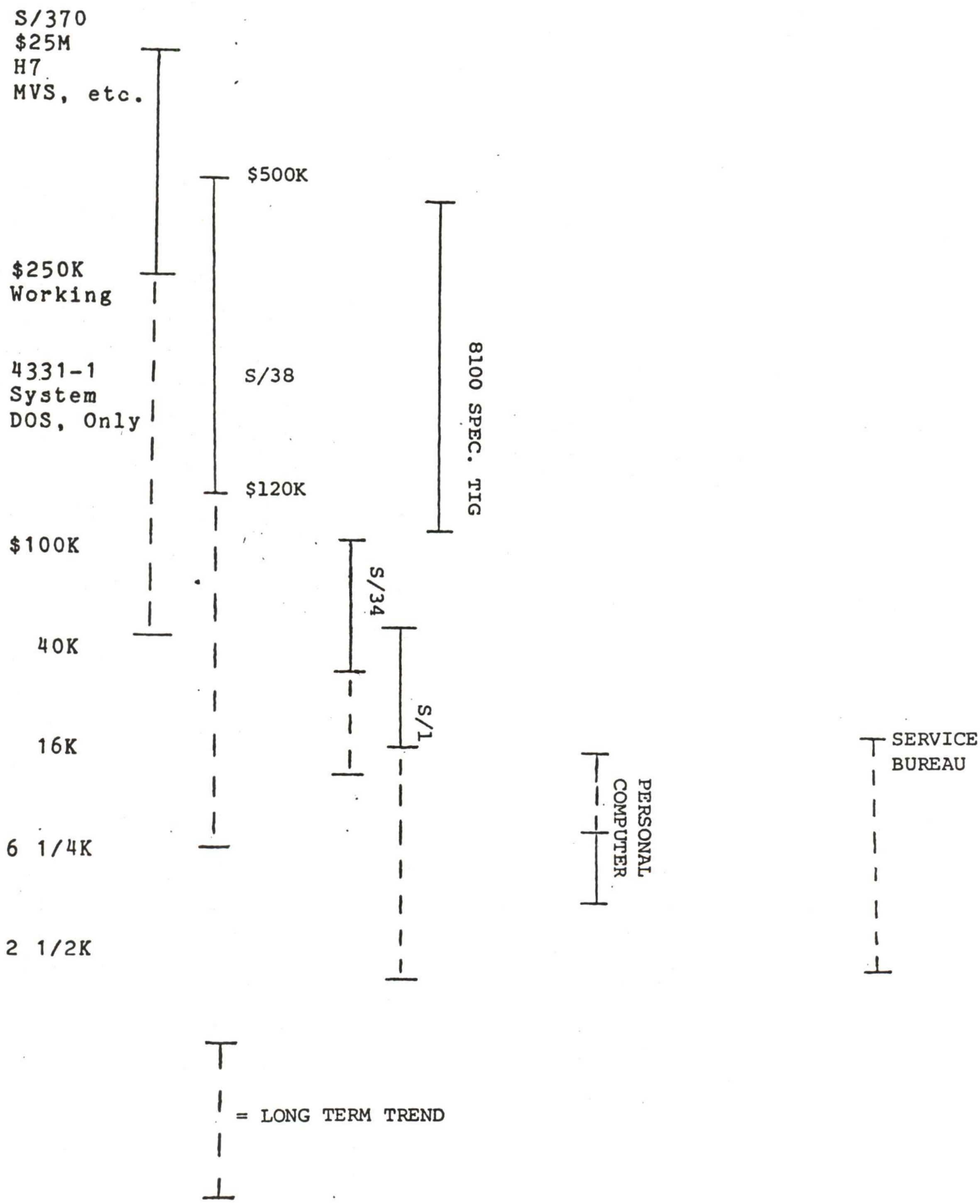
There is a book, published in 1978, which presents the scenario of IBM changing to a new architecture. "The Waves of Change" was written by Charles Lecht after extensive research involving the Telex vs. IBM trial. IBM was forced to divulge a considerable amount of confidential information during this legal proceeding. Lecht's System/80, discussed in his book, could very well be System/38.

It would be extremely difficult, if not impossible, to produce a plug-compatible System/38. IBM has buried most of the operating system in proprietary microcode. Considering the present state of software engineering in Japan, it would appear that the Japanese are, indeed, at risk if IBM does successfully switch their mainframe customers to a compatible family of System/38's encompassing small, medium, and large processors.

08-DEC-81 17:18:55 S 26628 EMMK

09-DEC-81 06:24:27 S 31414 FLIN

EVOLUTION OF IBM PRODUCT FAMILIES



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INTEROFFICE MEMORANDUM

TO: Bud Hyler

CC: Dave Fernald
Bob Perry

DATE: 13 November 1981
FROM: Roger Bisbo
Rick Case
Joanne MacMullen
Don McGinnis
DEPT: Commercial Marketing
EXT: 264-6777/7307/4477/5375
LOC/MAIL STOP: MK1-2/N38

SUBJECT: IBM BUSINESSES IN THE 1980'S

The attachments represent our best efforts, in the half day allocated. This exercise deserves much deeper study. If time permits that study, we may require gross changes to the attachments.

We disagree (on strong technical grounds) that the 4300 can be driven into a commodity. A 4300 is its software; and compatibility/history precludes "4300-Apples." The System/38 could be made into a commodity over time.

We don't think IBM can grow the volumes it wants without significantly changing the nature of its business. IBM major strategic moves show this change. Our speculation as to the nature of this change derives from conversations with Phil Cosgrove.

The analysis is not limited to the topics you sketched, as we project more signficant changes by IBM.

dw
Attachments

THE IBM BUSINESS IN THE 1980'S

	1982	1984	1986	1988	1990
ARCHITECTURE	No unification through 1984.		Begin unification o S370 ? o CPF (S/38) o RTOS (S/1 & PC)	----------	----------
(CPU)	MIPS will continue to improve/price				
(DISK)	Better 8" New 5 1/4"	IBM will continue to be industry leader Only Japan, Inc. will be in race		----------	----------
(TERM)	Unify on 3101 base	Color & Graphics (TRY FOR MARKET LEADERSHIP)	Flat screen Touch screen		Functionality to home
COMMUNICATIONS	LOCAL AREA NETWORK	S.B.S. (PABX (US)!) (OFIS)	Cable TV View data Telephones	Cable TV network broadcasting Electronic publishing (Encyclopedia)	Home entertainment ---------- Value added publishing
SYST SW	App'l generators------	Specialized---------- BIG REVENUE SOURCE	----------	----------	----------
APP'L SW	LOTS	Video Disk BIG REVENUE SOURCE			
COST/PRICE	CRT 1/2-2/3				
FIELD SERVICE		RAPID DECREASE IN HW & SW MAINTENANCE			No HW maint. $100K system. Major Ed. Serv.
MARKETS/ CHANNELS	Distributors Joint ventures Wholesalers	Catalogue Office Prod. suppliers		Pure retailing Mostly indirect	---------- View data ordering
BUSINESS ACTIONS		Buy major publisher Buy cable TV co. Buy view data co.	Buy cable TV network Buy encyclopedia	Buy news service	Debt = equity

PRODUCTS/SERVICES OF THE IBM BUSINESSES

(Systems Integration)

Trading Co.	Systems House	Commodity
View Data	4300	S/34 Short Range
Cable TV	S/38	S/1 Short Range
Networks	S/34	S/38 Long Range
Phones	8100	3310 Disk, 5 1/4" Disk
PC	Service Bureau	3101
SBS		PC (Series/1)
Home Entertainment		3101 AS:
		3270, 5251 Short Range
		DW, PC

NEC FACT SHEET

Nippon Electric Co. is a member of the Sumitomo group. This is a relatively tight knit group and commanded (in 1972) the greatest financial resources of the Japanese zaibatsu. It includes Sumitomo Mutual Life Insurance, Sumitomo Bank, and Sumitomo Trust. These last two are the leading loan source for over 120 major companies in Japan. The group also includes Meidensha Electric (facotry computer applications) and Sanyo (consumer electronics). Sumitomo maintains close ties with C. Itoh trading company which does the bulk of its banking with Sumitomo Bank. (But C. Itoh also has affliations with Dai-Ichi and thus with the looser group of which Fujitsu - through Furukawa - is a member.) Sumitomo also has its own trading company, Sumitomo Shoji Kaisha, which though only the sixth largest in Japan, is the most profitable. Matsushita Electric Industrial Co. is loosely allied with the Sumitomo group.

NEC started out in 1899 as a communications company and is now the largest supplier in Japan of semiconductors and personal computers. They are currently third in the production of general purpose (other than personal) computers in Japan, but have the highest growth rate (20%) and in JFY81 (ending March, 1981) sold $1.0B of such equipment, about 25% of their total business in that year. The other pieces of NEC's business include 20% in semiconductors, which grew 40% in JFY81, 15% in consumer electronics, with the remaining 40% in (wired and wireless) telecommunications systems. NEC has publically articulated a strategy of "integrating computing and communications" but there's little evidence of what exactly they intend this to mean.

NEC exports about 30% of what they make (up from 24% the year before) and sell another 30% of what they make to the government of Japan and NTT (which is forbidden, by law, to do its own manufacture). They are spending about $200-250M a year (6% of sales) in R&D but this, of course, excludes the work done by (and with) NTT which is the foundation for the equipment designed for NTT purchase - and, perhaps, other ends.

NEC employs about 60K people (4K in R&D). They use about half again as many assets per employee as we do and generate about half again as much revenue per employee. Profit performance is in the 2% area (after taxes levied at roughly a 50% rate). Dividend payout is about a third of what they net. They have heavy debt expenses with net profits only about 1.3X their debt service expenses. About 25% of their stock is held by Sumitomo banking interests. ITT owns 13 percent of NEC and is represented on its board of directors. In all, 30% of NEC's equity is in foreign hands.

NEC's products include microcomputers and 256Kb (350ns cycle 190 X 340mil) RAM's (they do some offshore assembly of 64Kb parts in Lexington, Massachusetts) supplying both W.E. and IBM with 16Kb and 64Kb dynamic RAM's. NEC will also produce 64Kb parts next year in San Mateo. Product volume of the 64Kb parts will be boosted from the current 300K units/month to 1000K units/month by next March. Since 1975, they've had production use of a fully automated pattern recognition based wire bonder of their design. They recently reported a mask-pattern driven logic simulator used successfully on 10,000 transistor control circuit at about a 70,000 to 1 rate. They have developed a 25ns 16Kbit static RAM chip using metal plus 2 layer poly (with poly loads). The same technology in a 1.5 micron design, yielded a 64Kb 150ns access time static RAM in a 150 X 300 mil chip. In the bipolar area, NEC has lab samples of 1 X 3 micron emitter regions providing 290ps, 1.5mw (450fj) gates. Current lab results in production automation include a precision measuring system for optical fiber array pitch using an air bearing linear guide system with a laser interferometer and a new CCD camera. The camera had a 350nm/bit resolution yielding an overall accuracy of 800nanometers over a 50mm span in the measurement system.

NEC is the largest manufacturer of personal computers in Japan selling 50K units ($200M) in the year ending March 1981 and taking first position over from Sharp. Their December 1981 capacity in personal computers is planned to be 25K units/month (up from 10K units currently) - about twice that of Sharp. Total Japanese output for the current fiscal year (ending March '82) is estimated at 500K units. Japanese domestic demand, however, is estimated to be only 200K-300K units per year compared to 400K units ($2B) per year on the U.S. market. NEC has just introduced two new models bracketing their first PC entry. The new high-end product features modular construction and provides several storage and display options as well as an IEEE 488 bus interface and a 60 word (discrete, trained) speech recognition unit. NEC has a network of consumer appliance (e.g. TV) stores and a new family of 60 computer outlets in Japan.

In the area of computing systems, NEC's reported research results tend to be in the area of (distributed) databases, file systems, and query languages. Nippon Electric sells office automation equipment including office computers, but principally seems to come at the office from the perspective of the communications supplier: facsimile, PBX's, and a promise of teleconferencing. They are putting in place $15M of (internal?) communications circuits linking computers, FAX, terminals and teleconferencing to promote office automation (and their role in it).

NEC has reported a video "subscriber set" providing moving image video: 1/10 second per 100 X 100 frame over a 64Kb/s line using CCD and SAW based real-time signal bandwidth compression techniques. They claim to to be marketing 100 word continuous speech voice recognition equipment and developed a digital video effects system. They have lab demonstrations of a single chip 384 X 490 element CCD sensor in a prototype color camera. Together with NTT, they have produced an amorphous silicon image sensor intended for use in a facsimile system. NEC reports the development and commercial production of a 23 inch, 4 color (red/orange/yellow/green), 1500 line monitor using beam accelleration voltage to control the color. Their IC graphics display controller provides graphics drawing capability of 800ns/dot plus a flexible scheme for zooming, panning and scrolling of a 4 plane 1024 X 1024 display without cpu intervention. NEC has also developed a digital video effects system.

NEC's traditional telecommunications business includes installation of country wide networks (in Libya and Saudi Abrabia), telephone exchanges, (PBX and central office) and mobile radio - including digital cellular radio - systems. Digital signal processing for (digital) TV networking, optical fiber connector/transmission systems, semiconductor lasers and very high speed GaAs IC's (50-100ps/gate) are active research areas in support of this mission.

There is, of course, keen interest at NEC for integrated digital networks and integrated service networks.

NEC's business also includes complete systems - an example is the radar target detection air traffic control system for approach control at Singapore's Changi International airport.

SOURCES: NEC Annual Reports
Japan Economic Journal
Abstracts of reports submitted by NEC authors to various technical journals and trade magazines.
1972 Handbook of Japanese Financial/Industrial Combines.

NIPPON ELECTRIC COMPANY

THEMES FOR THE EIGHTIES

- COMPUTERS AND COMMUNICATIONS - IN THE OFFICE

  PENETRATION OF THE OFFICE ENVIRONMENT THROUGH BROAD CAPABILITIES IN TELECOMMUNICATIONS.

- SEMICONDUCTOR AND PERSONAL COMPUTER VOLUMES FOR WORKSTATIONS

  VOLUME DOMINANCE: HIGH PERFORMANCE FOR PROFESSIONALS, MANAGERS AND SMALL BUSINESSMEN

- WIDELY ACCEPTED COMMODITY FOUNDATIONS

  FOR AVAILABILITY OF MUCH VALUE-ADDED SPECIFIC APPLICATIONS SUPPORT: UNIX 68000 AND 386, SNA

- JOINT VENTURE WITH PRIME COMPUTER

  FOR NORTH AMERICAN APPLICATIONS/CHANNELS/SERVICES AND FOR MID-RANGE COMPUTER SYSTEMS DEVELOPMENT

- CLOSE OEM RELATIONSHIP (AND A BIT MORE) WITH A SUPPLIER OF FACTORY AUTOMATION EQUIPMENT

PROTOTYPE NEC SCENARIO

(Narrative of Events)

IN 1982 NEC concluded a multiple source agreement with Motorola for the 68000. NEC's semiconductor business continued to grow in this year but the worldwide capacity for memory chip production impacted its profitability. The mid-range and hi-end computer system business seemed to grow faster at Fujitsu and Hitachi. The bright spots at NEC were the lower priced computer systems, personal computers, and more specialized semiconductors: graphics display controllers, speech processors and high performance microprocessors. The bright spots at NEC were the lower priced computer systems, personal computers, and more specialized semiconductors: graphics display controllers, speech processors and high performance microprocessors. NTT's announcement of a significant capital plans for an upgrade of the Japanese telecommunications plant showed promise for NEC's extensive communications business.

In this year, NEC completed the installation of experimental advanced office communications network for Sumitomo Bank, Asahi Breweries, and Meidensha Electric Manufacturing Co's (all members of the Sumitomo Group). These integrated digital services nets provided electronic mail, primative voice-store-and-forward, and facsimile network facilities within the (extended) local area defined by a contiguous group of buildings. The building PBX was the center of these facilities and linked through NTT operated (NEC designed) central office switches to other building clusters in Tokyo and Osaka. Links between multiple PBX's within a facility was via fiber optic communications. The offices of top management in all these firms could communicate with each other through the teleconferencing terminals on their desks. Existing building wire pairs provided the requisite 64Kb/sec and the PBX's used arrays of high performance 68000s in a non-stop redundant configuration to control switch matrix.

IN 1984 NEC announced a high performance UNIX 68000 based professional workstation. It provided a floating point processor using the IEEE standard formats and auxilliary processors for backward compatibility with CP/M 8085 programs. It included links to the integrated digital services network installed experimentally in 1982. An inexpensive hi-resolution, 4-color display, advanced display controllers, 256Kbit memories, an amorphous silicon "facsimile plate" and simple local area network connection to shared departmental laser beam printers and data storage facilities were brought together to provide the foundation for cost effective professional (and business) computing. The choice of UNIX and the 68000 (and backward compatibility with CP/M) provided NEC's customers with a variety of popular application packages that were coupled effectively together through the UNIX "pipes" facility. UNIX's relatively unfriendly user interface was sufficiently well masked so that many managers and clerical workers accommodated themselves to the product in spite of some rough edges. NEC established an apparently unassailable dominance in professional and high end personal computers in Japan and a significant, perhaps overpowering presence elsewhere. It amazed U.S. manufacturers to see the volume increases NEC delivered from relatively fixed costs.

In this year also, NEC's mid-range and high end computer systems business continued to lose momentum hitched as it was to an increasingly unfamiliar (Honeywell) architecture. The market did not see much benefit in deviation from comfortable, de-facto standards at the lower integration levels of computer and information systems. The comfort and security of purchasing known MVS 370 and UNIX 68000 foundations were of increasing importance. In this environment DEC continued to base its development on VAX VMS (and its subsets). In general DEC had interesting products that, however, were increasingly not in the mainstream of computer developments since, to a greater and greater degree, most added-value in computer systems was available on the UNIX 68000 or MVS 370 base. NEC executives approached DEC to discuss this issue and to see if DEC wished to engage in joint developments to reverse this trend or, even better, capitalize on it. DEC debated the question internally for six months and NEC withdrew the offer.

NEC than concluded a joint venture agreement with Prime Computer. The details were not clear but it appeared Prime would manufacture mid-scale computer systems for NEC-Prime and do applications development for professional, small business, and office information systems.

IN 1986 NEC-Prime announced a parallel processor 68000 isp departmental machine in the 10-25 Mips range; each processor individually was a 4 Mips machine. NEC gate arrays, a custom CMOS 68000 processor, and 1Mbit memories were brought together with a redo of the UNIX internals to provide the computation engine that the NEC office-information-system needed. Prime provided all the standard language processors and in particular, a very highly optimizing FORTRAN compiler for this system. NEC announced that its PBX products could be connected to the NEC-Prime System to allow all the workstations served by a PBX to access these central computation facilities as easily as they accessed each other. Simple local area nets could still be used where high performance links to other departmental resources were needed.

Personal/professional computer sales continued to grow as new UNIX 68000 applications were generated by many independent software publishers and integrated together by the engineers at Prime into a cohesive package more suitable for North American and European users by the engineers at Prime. VLSI CAD tools sparked by the Fifth Generation Computer Project and retrofitted to an upgraded NEC Professional Workstation were made available to the Prime hardware designers.

NEC also announced, however, that to better serve its customers and allow them better linkage between their workstations and central edp systems, NEC would provide a network upgrade service. Customers would then be able to use an SNA backbone for direct connection to IBM and Fujitsu mainframes. In order to demonstrate its committment to its customers and this market, NEC did this for purely a nominal charge. NEC-Prime announced the SNA Total Information Network. It linked together Prime computation servers and NEC workstations, PBX's, and local area nets. Only in France and Italy was permission denied for NEC to install its own network-control PBX's. In Japan, an experimental central office exchange was built to allow NTT customers in separate buildings to exchange electronic mail, and do invoicing, billing, and payables between their firms.

In this year, NEC's semiconductor business continued to flourish, focusing increasingly for profit on the unique capabilities NEC had developed in speech and image processing. The volume operations in memory and stock microprocessors were increasingly run for the incremental revenue they bought in on a relatively fixed asset base. The principal value of the semiconductor capability was the volume base on which rested many significant custom VLSI designs for highly capable but cost effective workstations.

NEC opened its new $500M semiconductor facility in Tsukuba, Japan. It produced 5 million packaged chips a month in any mix of part designs. Mask and test tooling were variable on a die-by-die basis. It was run by just a few people but more importantly it provided very quick turnaround for new designs. With a fixed asset cost structure of this magnitude in place, Sumitomo Bank encouraged NEC to price for incremental volume. Sanyo designs were "cast" by this NEC foundry.

Also in 1988 NEC Telecommunications promised to build a personal computer manufacturing and process engineering plant in Brazil. In return Brazil awarded NEC a $600M contract to wire Brazil nationwide for the advanced telecommunication facilities first experimented with within the Sumitomo Group in 1984.

Sanyo used this capability very effectively with its family of dependent subcontractors. International Telephone & Telegraph (ITT) promoted the system in South America and in those parts of Europe where it had influence.

In the meantime, of course, NEC's capabilities in speech and image recognition had moved forward quickly (thanks in part to their collaboration with NTT research efforts). The store-and-forward systems were encoded but still preserved original quality of speech and identity of the speaker. Speaker identification, in fact, was central to the security and authentication system that was used in the network. An experimental speech to text system yielded results equivalent to typical shorthand transcription accuracy and thus met wide acceptance.

Meidensha Electric Co. announced that in a joint effort with NEC and Prime Computer that they had built a fully automated facility for small to medium sized electronic and electromechancial assembly operations. (NEC videoprocessors and vision systems were crucial in this accomplishment.) The facility could be "programmed" to build new parts with a combination of standard NC tooling tapes and assembly robots "instruction". These robots were capable of efficient generalization from a series of mimicked hand driven assembly actions.

IN 1990 DG filed for reorganization under Chapter II and a week later had a fire sale in Southboro but NEC-Prime saved the governor of Massachusetts from certain electoral defeat by installing a second copy of its automated IC production facility in the Natick-Framingham area. The facility was complemented by a general assembly facility built for Prime by Meidensha. Meidensha went into the robotic factory business on worldwide basis. Prime agreed to market NEC and Meidensha robotics equipment for those companies that wanted to do their own factory system integration. Design skills at NEC and Prime kept their factories busy producing products and systems with new capabilities for information processing centering around speech and picture understanding. NEC was rumored to be looking for a site in Hudson, MA.

Prime announced a small business information system that by an automated interviewing process could construct the forms, data flows, and control procedures appropriate to the business operations of each given (client) firm. This was provided as a superstructure to the NEC Workstation/PBX/Computation Server Area Net. (There were hints of extending this to the control and data interchange needs between corporations in North America). In this system, voice recognition was used to access databases and "sign" authorizations as well as do simple form fill-ins.

IN 1990,NEC was one of the few firms left in the Personal Computer business. The low end of the market (for homes and education and simple accounting) had been captured by consumer electronic companies - which, however, did not have foundation in computer systems needed to provide effective office and professional systems. NEC's concentration on the needs for communication, information interchange, and business control flow had established it in the higher margin sectors of the personal computer markets.

The match with Prime had provided sorely needed North American outlets as well as an applications design center around a fundamentally solid manufacturing capability. The choice of SNA, UNIX and the 68000 allowed many U.S. firms to add value to NEC-Prime products. NEC's advanced semiconductor, speech and vision capabilities, and worldwide telecommunications base coupled with Prime's computer system integration design skills and Meidensha's insight into industrial automation had together provided products and services that proved to be both highly valued and difficult to imitate. Combined (deflated) profits of Meidensha-NEC-Prime were 18% after taxes. But more importantly, the ROA reached 35%, 15 points above the no-risk interest rate. The Wednesday Club of the Sumitomo group was very pleased.

NEC	1982	1984	1986	1988
PROCESSOR	. 68000 @ 8MHz (&8088/8086)	. 68000 @ 15MHz w/mem. mgt.	. Parallel processor 10-25Mips 68000 departmental machine (Prime)	. Special speech and image processors
STORAGE	. 256Kbit memory . 5" Winchester, 5MB (buyout)	Simple file server	1Mbit memories	?
COMMUNICATIONS	. Teleconferencing net, 68000 based digital PBX, 64Kb/s desk interface	. Simple and limited local area net . Fiber optics for inter LAN's	Departmental PBX links to computation server and SNA net	Experimental Osaka Commercial Information System
TERMINALS	. 600X400 pixel color terminal . 64Kb/s limited teleconferencing terminal . Graphics display chip	. 4 color 1500 line UNIX 68000 based workstation . Facsimile xfer plate . 300dpi laser beam-printer (buyout)	. VLSI CAD tools . Speaker identification voice encoding, Medium quality speech to text . Special purpose display/speech processors	. Speech and image understanding
SYSTEM SOFTWARE	. UNIX, DINA net	. User Friendly Facade (for UNIX)	. Parallel processor UNIX . Integrated applications interface fo UNIX	Final LAN design with extension to external nets
APPLICATIONS SOFTWARE	. Electronic mail, Voice store and forward, facsimile network	Add UNIX 68000 applications avail. thru third parties	. Information flow control (Prime) . Factory automation (Meidensha)	. Automated Business Information System Design
COSTS & PRICES	. Generally to maximize volume on fixed costs	. Driving for volume dominance in workstations	. Incremental costing in standard prices . Value pricing in unique equipment	. Premium for unique value in products and services
SERVICES	. Generally site and store return/exchange for computer terminals	. North American service (Prime)	. Information Network installation and maintenance (NEC telecommunications)	. Client business operations analysis (Prime)
CHANNELS	. Computer stores in Japan . Direct sales of communication systems	. Direct in North America (PRIME)	. IT&T and other telecommunications vendors	?
BUSINESS ACTIONS	. Experimental company nets in Sumitomo test sites	. Joint venture with PRIME	. Fully automated VLSI semiconductor facility . Brazilian factory . Joint marketing with Meidensha	. Natick Ass'y and IC Automated Production . Prime markets robotics
KEY SKILLS	. Volume semiconductor and terminal manufacture . Communications, Graphics, and Semiconductor design	. Information System design	. Factory automation . Information network service	

How will they win? They will use the production capabilities in personal computers and semiconductors and their design knowledge of telecommunications and display electronics to form PBX - centered professional/small business workstation networks to form a commodity - foundation for applications developments by themselves, PRIME and many software publishers. They will complement this position in the office with a position in factory automation won in concert with their robotics OEM's.

```
23 November 1981 --- Strategic Planning Game
Your Name:__1980 (O)/1990 (X)__________Competitor: Prototype NEC__________

Hardware Cost/Performance
                              O                 X
                   |-----|-----|-----|-----|-----|-----|-----|-----|-----|
                   1     2     3     4     5     6     7     8     9     10
                   poor - - - - - >1990 Industry - - - ->excellent
                                        norm
Cost of Ownership
                                                    O     X
                   |-----|-----|-----|-----|-----|-----|-----|-----|-----|
                   1     2     3     4     5     6     7     8     9     10

Existing Base / Reputation
                         O                 X
                   |-----|-----|-----|-----|-----|-----|-----|-----|-----|
                   1     2     3     4     5     6     7     8     9     10

Uniquely Useful Capabilities
                               O           X
                   |-----|-----|-----|-----|-----|-----|-----|-----|-----|
                   1     2     3     4     5     6     7     8     9     10

Programmer Productivity
                         O           X
                   |-----|-----|-----|-----|-----|-----|-----|-----|-----|
                   1     2     3     4     5     6     7     8     9     10

End User Productivity
                   O                 X
                   |-----|-----|-----|-----|-----|-----|-----|-----|-----|
                   1     2     3     4     5     6     7     8     9     10

Availability of Third Party Software and Services
                   O                                         X
                   |-----|-----|-----|-----|-----|-----|-----|-----|-----|
                   1     2     3     4     5     6     7     8     9     10

Use of Industry (or other) standards
                         O                                   X
                   |-----|-----|-----|-----|-----|-----|-----|-----|-----|
                   1     2     3     4     5     6     7     8     9     10

Breadth of Offering
                                     O                 X
                   |-----|-----|-----|-----|-----|-----|-----|-----|-----|
                   1     2     3     4     5     6     7     8     9     10

Effective Distribution Channels
                               O                       X
                   |-----|-----|-----|-----|-----|-----|-----|-----|-----|
                   1     2     3     4     5     6     7     8     9     10

______________________(Other)
                   |-----|-----|-----|-----|-----|-----|-----|-----|-----|
                   1     2     3     4     5     6     7     8     9     10

TOTAL MARKET SHARE GAINED OR LOST (Information Systems/Services)
(Consider "P&G", "BOEING", "M&P BOATS", "IRVING TRUST", "GE REFRIGERATORS")
     ______  ________  __________  ___________  _______________
      SHARE
     OVERALL CHANGE  (+ OR -)_______________MILLIPOINTS              3.90
(Each market share millipoint is worth $1M in 1980)
```

d i g i t a l

INTEROFFICE MEMORANDUM

SUBJ: TMC - CHAPTER 4 PART OF ESO DOCUMENT

TO: DISTRIBUTION

Date: 4 FEB 82
From: Eli Glazer
Dept: Corp. Product Management
Ext: 223-4434
Loc: ML12-B/T61

Chapter 4 of the ESO document is a draft submission of the Technology Management Committee (TMC). TMC is comprised of all the Advanced Development Managers from each of the Engineering organizations. The goal of TMC is a corporate advanced development plan. The (Chapter 4) TMC document requires further integration and rationalization leading towards a revised verison in May. Please direct feedback on this chpater to Nancy Neale, Corporate Research, HL2-3/N04, DTN 225-5867.

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* D I G I T A L *
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INTEROFFICE MEMORANDUM

DATE: 2/2/82
FROM: NANCY NEALE NN
DEPT: Corporate Research
EXT.: 225-5867
LOC.: HL2-3/N04

SUBJ: ESO TECHNOLOGY SECTION DRAFT

The enclosed document represents the current TMC draft of the ESO Technology Section. This collection is subdivided into the following nine major technology areas:

ESO TECHNOLOGY SECTION

1.	Summary	Bruce Delagi
2.	Semiconductors	Bob Supnik
3.	Storage	George Hitz
4.	Communications/Nets	Tony Lauck
5.	Power and Packaging	Henk Schalke Joe Chenail
6.	Computing Systems: PSD MSD LSG	Don Gaubatz Peter Jessel Roy Rezac
7.	Human Factors	Russ Doane
8.	Terminals/Workstations	Walt Tetschner
9.	Software	Bill Keating
10.	Applications in Computing	Russ Doane Bill Keating
11.	Appendix	Listing of Technologies

The Listing of Technologies (Appendix) provides background detail on technologies considered in this review.

Each of the nine technology areas is outlined according to the following format:

ESO TECHNOLOGY SECTION FORMAT

I. Strategic Assumptions

. critical assumptions for particular technology area

II. Key Parameters

. critical technology measurements for area

II. Doane Metrics

. ratios of the preceeding key parameters

IV. Competition

. ranked on a 0 to 10 scale according to Doane metrics

V. Investment Imperatives

. key decision rules for DEC

VI. Investment Priorities

. technologies prioritized for DEC

This draft of the ESO Technology Section received preliminary evaluation by TMC and PEG at the January 22, 1982 Non Product budget review. It will be further integrated by TMC against in depth review of the Research/Advanced Development/Tools/Processes program plans in each of the nine major technology areas during February and March.

The ESO Technology Section draft is considered a working document; critical feedback is welcomed.

TMC
4.2

SUMMARY

BRUCE DELAGI

DEMAND ASSUMPTIONS

(priority ordered values)

- Fundamental cost performance is highly valued

  (simple metics first - proprietary only viable if competitive)

- Products must be "immediately" useful and work as expected

  ("obvious" function; lots of helps; few failures)

- Increasingly less reliance on central edp - or other experts

- Communications and computing must be integrated

  (the need is for office/factory information systems)

  - Ultimate user desire is to ignore the net

  - Terminal/Workstations need to be simple and effective points of entry, to the computing/information services provided by a variety of vendors.

> OUR SYSTEMS MUST DEAL EFFECTIVELY WITH IBM AND COMMODITY SOFTWARE APPLICATIONS & IBM./PTT/AT&T AND DOCUMENT INTERCHANGE STANDARDS.

TMC
3:44

SUPPLY ASSUMPTIONS

(technology, regulation, industry)

- SEMICONDUCTORS ARE BASIC - and may be the foundation for radical change.

- RATIOS OF COST/PERFORMANCE TRENDS LEADS TO "SERVERS" COMPUTE STYLE

  (built around electro-mechanical givens)

- NATURAL IMAGE DISPLAY/PROCESSING COST EFFECTIVE BY '88

  (available in volume terminals - and industrial/office building broadband capacity will be in place to handle it)

- BUILDING WIRING CONNECTS TO PBX'S AND ISDN'S 56-64Kb

  (Europe: mid '80's; North America: late '80's; Japan:?)

- GOVERMENT REGULATION WILL DICTATE ERGONOMICS/SECURITY

  (and they'll be inconsistent/subject to interpretaion)

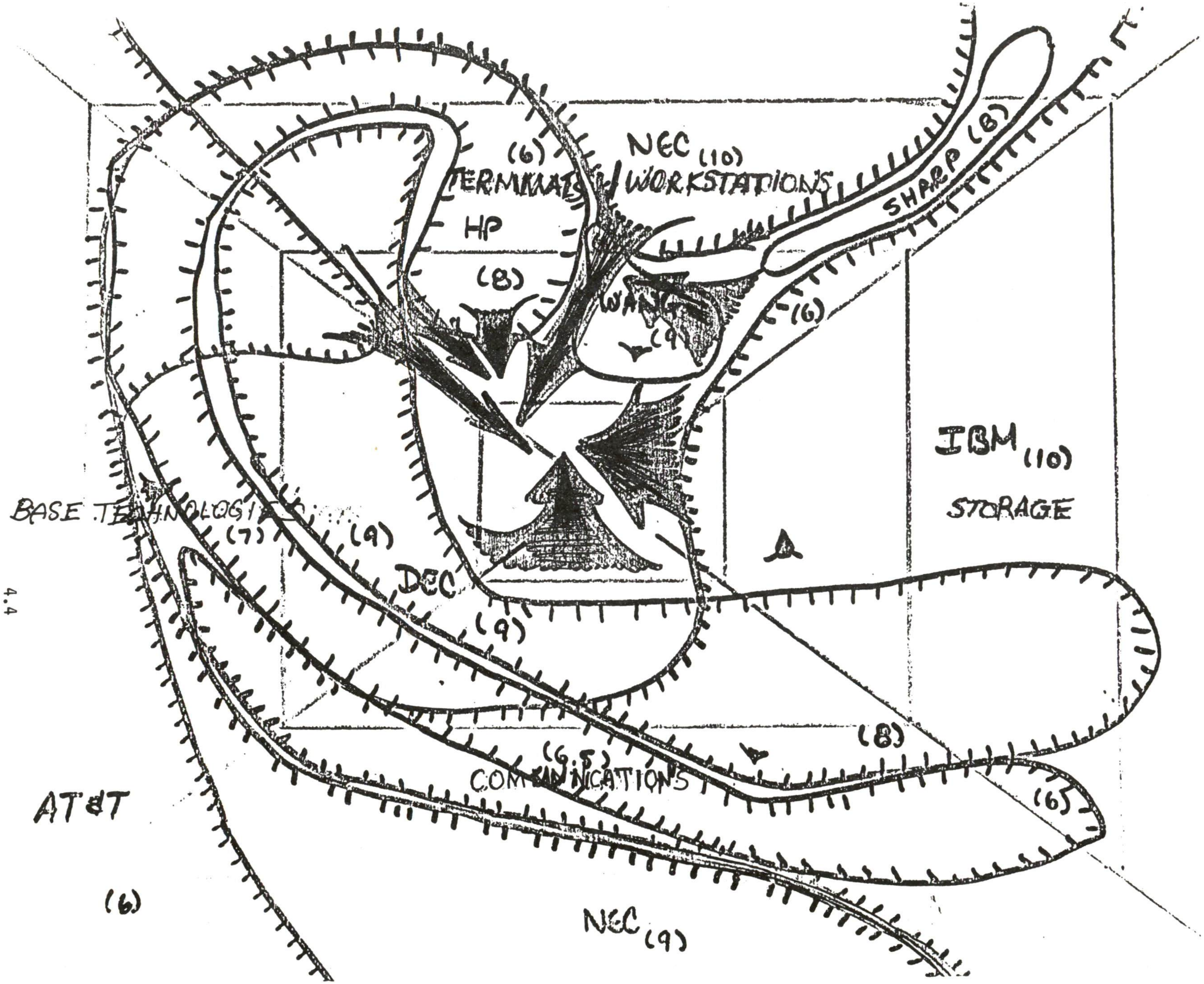
- DISK STORAGE 25% -> 30% OF SYSTEM EQUIPMENT COST

  BUT EQUIPMENT COST DECREASING AS A PROPORTION OF THE COST OF EFFECTIVE USE

- TARGETING OUR MAJOR EFFORTS ON ONE SINGLE OS INTERFACE IS THE MOST ECONOMICAL WAY TO PROVIDE EFFECTIVE USE

- REMEDIAL SUPPORT OF DESIGN FAULTS WILL DOMINATE SERVICE

TMC 3:45


NEC (10)
(6)
TERMINALS / WORKSTATIONS
SHARP (8)
HP
(8)
WANG
(6)
IBM (10)
STORAGE
BASE TECHNOLOGIES
(7)
(9)
DEC
(9)
(8)
(6.5)
COMMUNICATIONS
(6)
AT&T
(6)
NEC (9)

SEMICONDUCTORS

I. ASSUMPTIONS

- SEMICONDUCTORS ARE <u>THE</u> BASE TECHNOLOGY OF LOGIC AND MEMORY

- MEMORY IS HANDLED BY A LARGE NUMBER OF AGGRESIVE (VORACIOUS?) COMMODITY SUPPLIERS.

- THEREFORE, DEC'S SEMICONDUCTOR TECHNOLOGY FOCUSES ON LOGIC.

- THE ULTIMATE METRIC IS COST PER FUNCTION (E.G. GENERAL PURPOSE MIPS PER DOLLAR) VERSUS YEAR: <u>IT IS DECLINING.</u>

- ANY DEC PROPRIETARY HARDWARE STANDARD WHICH DOES NOT FOLLOW THIS METRIC WILL ULTIMATELY LOSE IN THE MARKETPLACE.

- THE SEMICONDUCTOR INDUSTRY WILL NOT PROVIDE DEC WITH THE STATE-OF-THE-ART TECHNOLOGY, METHODS, AND DESIGNS NEEDED TO KEEP OUR HARDWARE COMPETITIVE.

- NOR CAN DEC SUCCEED SOLELY AS A PACKAGER OF INDUSTRY COMMODITY PARTS.

- SEMICONDUCTORS HAVE THE POTENTIAL FOR REVOLUTIONARY CHANGES IN COMPUTER STRUCTURES, COSTS, AND USAGE.

- THEREFORE, DEC MUST OWN THE KEY SEMICONDUCTOR TECHNOLOGIES (PROCESS, DESIGN METHODS, SILICON ARCHITECTURE) THAT CAN MAKE (OR BREAK) ITS BUSINESS.

III. METRICS

- NORMALIZED DEVICE DENSITY VERSUS YEAR OF INTRODUCTION

- GATE PERFORMANCE/GATE POWER VERSUS YEAR OF INTRODUCTION

- TOTAL DEVELOPMENT TIME AT DIFFERING COMPLEXITY LEVELS VERSUS YEAR OF INTRODUCTION

- ARCHITECTURAL INNOVATIONS/CAPABILITIES VERSUS YEAR OF INTRODUCTION

BOB SUPNIK

IV. THE COMPETITION

0--10

IGNORES/	FOLLOWS/	IN THE PACK/	LEADS/

NORMALIZED DEVICE DENSITY (MOS):

WANG	DEC --->	HP	[INTEL]
	AT & T	IBM	NEC
		SHARP	

NORMALIZED DEVICE PERFORMANCE (BIPOLAR):

HP	<--- DEC	[TI]	IBM
WANG	[SIGNETICS]	[MOTOROLA]	NEC
SHARP	AT & T	[FAIRCHILD]	[FUJITSU]

TOTAL DEVELOPMENT TIME (MOS):

WANG	HP	DEC --->	NEC
	IBM	SHARP	[INTEL]
			AT & T

ARCHITECTURAL INNOVATIVENESS:

WANG	DEC --->	AT & T	HP
	SHARP	IBM	[INTEL]
		NEC	

BOB SUPNIK
7-JAN-82

V. INVESTMENT IMPERATIVES

1. BE A LEADER IN MOS PROCESSES FOR LOGIC

   - BY COMPLETING A 2 MICRON, DOUBLE METAL NMOS PROCESS
   - BY DEVELOPING A 1.5 MICRON, DOUBLE METAL CMOS PROCESS
   - BY DEVELOPING BASE TECHNOLOGY IN OPTICAL AND NON-OPTICAL LITHOGRAPHY, METALIZATION, ETCH, DIELECTRICS

2. BE A LEADER IN DESIGN METHODS FOR HIGHER ENGINEERING PRODUCTIVITY, FASTER DESIGN TIME, AND LOWER COST

   - BY IMPROVING DESIGNER PRODUCTIVITY
   - BY REDUCING TOTAL DESIGN TIME
   - BY REUSING (SHRINKING) EXISTING DESIGNS
   - BY TRAINING NEW VLSI DESIGN ENGINEERS

3. PROPAGATE VLSI DESIGN THROUGH DEC

   - BY DEVELOPING COMPONENTS FOR LOW-COST 32 BIT SYSTEMS
   - BY EXPLORING ALTERNATIVE ARCHITECTURES BASED ON SILICON-UNIQUE CAPABILITIES

4. ARCHITECT LEADERSHIP PRODUCTS IN VLSI

VI. INVESTMENT PRIORITIES

TECHNOLOGY AREA	HI PRIORITY	<------------->	LOW PRIORITY
A. PROCESSES	CMOS NMOS		ECL
B. PROCESS TECHNOLOGY	OPT LITH, DIELECTRICS, DRY ETCH, SILICIDES, METALS, NON OPTLITH	LASERS, DWW	SOI
C. PROCESS SUPPORT	DEV MODEL, RELIABILITY	(PROC MODEL), SURFACE ANAL	
D. DESIGN TECHNIQUES	HANDCRAFTED, SHRINKS	(POLYCELL)	(GATE ARRAY)
E. ARCHITECTURE	NEW CHIPS, TESTABILITY	REDUNDANCY, NON VON NEU	(SELF-TIME)
F. TOOLS AND TEST	CHIP SIMUL, CHIP DATA BASE, CHIP VERIF	SYNTHESIS, (ATG)	(AI DESIGN)

SCENARIO A- <——

SCENARIO A <——

SCENARIO B OR C <——

STORAGE

GEORGE HITZ

STORAGE SYSTEMS

I. ASSUMPTIONS

- Storage strategy needs to be consistent with DEC systems strategy
- Storage products are high impact (>40% NES Now, trending to >50% by FY85) i.e., collectively they must be competitive. CPU leadership cannot carry substandard storage
- Buyout storage products in general are not sufficiently competitive (some exceptions, e.g. MOS RAM's). Some of the vendor base is weakening. High NES products need to be internally developed.
- Technology evolution is rapid. Disk density is increasing at 32%/year, tape density at about 25%/year, MOS RAM density at about 60%/year.
- Technology evolution is expected to continue for a decade or more without much change in pace
- Meeting environmewntal and people induced constraints of an office environment is required, especially for low-end storage
- Meeting governmental constraints is a necessity
- Data integrity, data security, and reliability will continue to grow in importance over the next decade.
- LSI will continue to invade magnetic storage products until electronics costs become small relative to total product cost.
- Optical storage will eventually service some storage applications.

George Hitz

II. KEY PARAMETERS

- Cost
- Capacity (Megabytes)
- Total Fetch Time
- Hard Error Rate
- MTBF
- Size

II PRIORITIZED METRICS

- Cost/Megabyte
- Requests/Second/Megabyte
- Megabytes/Cubic Foot

IV. MAJOR COMPETITORS (Leaders in Order)

- Disk Cost/Megabyte - IBM, Fujitsu and DEC
- Disk Requests/Second/Megabyte - IBM. Fujitsu, DEC
- Disk Megabytes/Cubic Foot - DEC, Fujitsu, IBM
- Tape Cost/Megabyte - IBM & STC
- Tape Requests/Second/Megabyte - STC, IBM
- Tape Magabytes/Cubic Foot - IBM and STC
- MOS RAM Cost/Megabyte - TI, Hitachi, NEC

V. INVESTMENT IMPERATIVES

- O PUSH TECHNOLOGY OF HIGHEST IMPACT PRODUCTS (HIGHEST NES COUPLED WITH WEAKNESS OF VENDORS)
  - IMPLIES - NEED FOR COMPETITIVE DEC DISKS
    - MAXIMUM DISK LAG OF ONE YEAR BY FY'85-'86
    - NEED TO REBUILD TAPE CAPABILITY
- O CAPITALIZE ON DEC STRENGTHS - (CONTINUE INVESTMENT)
  - STRENGTHS - BEST SUB-SYSTEMS STRATEGIES
    - BEST CODES, READ/WRITE SYSTEM AND SERVO STRATEGIES
    - GOOD HEAD START ON PLATED MEDIA
    - STRONG THIN FILM HEAD TEAM ASSEMBLED
- O MAINTAIN, USE AND SUPPORT STRONG MOS VENDOR BASE.
- O PUSH LSI HARDER TO IMPROVE OUR WEAK COST, RELIABILITY POSITION.
- O CONTINUE MONITORING AND INGESTING (AS APPROPRIATE) EMERGING TECHNOLOGIE
  - IMPLIES - NEED TO UNDERSTAND HOW TO USE OPTICAL TECHNOLOGIES
    - HOW BEST TO APPLY SOLID STATE MEMORY

VI. INVESTMENT PRIORITIES

	HIGH 1 (ALL A-)	PRIORITY 2	3 (ALL C)	LOW 4 (C)
GENERAL TECHNOLOGY	R/W & CODES SERVO DRIVE LOGIC MECHANICAL SYSTEMS LSI THIN FILM HEAD VERT RECORDING ADV. TESTERS	DATA BASE SYSTEMS-C VERTICAL FLEX MEDIA-C	FURTHER ACCELERATION OF 60MB/IN.	
DISK EXCLUSIVE	THIN FILM MEDIA LOW FLY HEAD		VERT RECORDING IN FUTURE PRODUCT	
TAPE EXCLUSIVE			VERTICAL RECORDING IN FUTURE PROD.	
S.S. MEMORIES		APPL. TECH. A,B		
TICAL DISKS		VIDEO, AUDIO A,B	WRITE-ONCE	MAGNETO-OPTI

COMMUNICATIONS/NETS

TONY LAUCK

TONY LAUCK
13 JAN 82

COMMUNICATIONS/NETWORKS

I Specific Strategic Assumptions

- Ultimate user desire is that he doesn't notice the network
- Coping with diversity will be a service customers will want vendors to provide
- Network policy and infrastructure was decided on before customer decided on DEC
- Most corporate networks are SNA based
- Security and Encryption will pop up greatly in customer values
- Selling the terminal on the customer's desk will be the key to success in the commercial marketplace
- Multiple technologies will coexist for local and long-haul networks due to technical and political considerations
- New industrial and office buildings are now being wired for broadband transmission
- Almost all building wiring today connects to PBX's
- Ma Bell will provide ISDN in the late 80's <56Kbps at desk>
- ISDN's will be pervasive via European PTT's by 1986
- International standardization of network protocols will be accomplished by mid-late 80's
- DEC's current strength in department computing is and will be highly valued
- DEC will continue to sell stand-alone timesharing systems
- DEC must increase its emphasis on the low-end of its product spectrum for personal computers and workstations, both stand-alone and connected to local networks
- Ethernet is the only "standard" we'll be able to drive

II KEY PARAMETERS

- O NUMBER OF NODES IN NETWORK
- O NET GOOD BITS PER SECOND (THROUGHPUT)
- O DELAY THROUGH THE NETWORK IN SECONDS (RESPONSIVENESS)
- O PRICE INCLUDES TRANSMISSION COST, HARDWARE COST, SOFTWARE COST, SUPPORT COST, AND COST OF CPU CYCLES CONSUMED BY SOFTWARE
- O NETWORK APPLICATION INVESTMENT TO MAKE THE NETWORK INVISIBLE
- O INVESTMENT TO ADD N+1ST NODE ON A NETWORK, INCLUDING COST OF "SYSTEM ANALYSIS" AND "NETWORK DESIGN"
- O UNDETECTED BIT ERROR RATE
- O FRACTION OF TIME A TERMINAL USER PERCEIVES THE NETWORK IS "UP"
- O NUMBER OF TERMINALS SUPPORTED ON A TIMESHARED SYSTEM

III DOANE METRICS

1. (NETWORK APPLICATIONS INVESTMENT TO MAKE NETWORK TRANSPARENT)
   o (-LOG BIT ERROR RATE)
2. (THROUGHPUT) ÷ (PRICE)
3. (PRICE) ÷ (NUMBER OF TIMESHARING TERMINALS)
4. (INVESTMENT TO ADD NODE) ÷ (FRACTION OF TIME USERS PERCEIVE THE NETWORK UP)

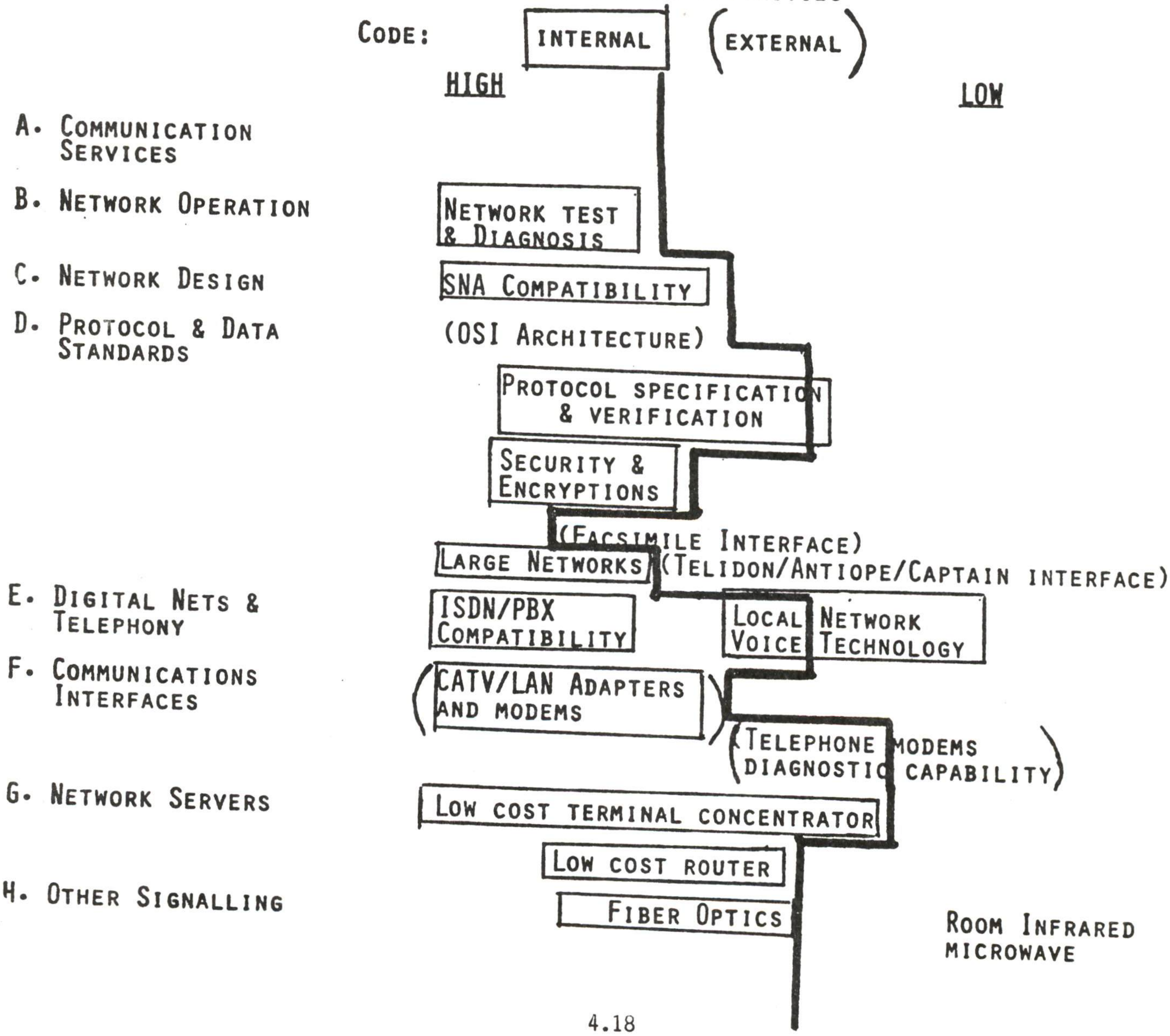
IV Competitive Position

	Ignores (0–1)	Follows (2–3)	Keeps Pace (4–6)	Leads (7–8)	Excells (9–10)
1. Network Applications Investment	ATT, PTT's NEC, Olivetti SHARP	WANG	DG IBM	Prime HP DEC Tandem	
2. Throughput/price	SHARP	ATT WANG	IBM Tandem PTT HP NEC	Prime DEC Tandem DG	
3. Price/number of terminals	SHARP, NEC ATT, Olivetti	IBM WANG PTT's HP	Tandem DEC	Prime DG Able	
4. Investment to add Node/fraction of time up	SHARP NEC Olivetti ATT	ATT WANG IBM	DG Prime PTT HP		DEC Tandem

V Investment Imperatives

1. Regain leadership in price/performance connection of terminals to computer systems
2. Protect our strength in invisible networking by supporting fast-evolving infrastructure
3. Significantly reduce the cost of operating our networked systems (RAMP)
4. Enable our customers to purchase as much integrity (security, availability) as they need

VI R & AD Investment Priorities



POWER AND PACKAGING

HENK SCHALKE
JOE CHENAIL

HENK SCHALKE
20 JAN 82

POWER AND PACKAGING

I SPECIFIC STRATEGIC ASSUMPTIONS

* DEPARTMENTAL MACHINES WILL CONTINUE TO FORM THE CENTER OF OUR PRODUCT OFFERING, WITH CONTINUED REQUIREMENTS FOR MODULAR PACKAGING FOR THE OEM-MARKET.
* SMALL SYSTEMS, PERSONAL COMPUTERS AND WORKSTATIONS WILL FIND THEIR WAY INTO THE OFFICE AND LAB ENVIRONMENT AND WILL REQUIRE SYSTEMS PACKAGING APPROACHES.
* SERVER BASED ARCHITECTURES WILL NOT APPRECIABLY CHANGE PACKAGING REQUIREMENTS.
* THE COST OF PACKAGING MATERIALS CONTINUE TO INCREASE.
* INCREASING POWER DENSITY TREND AT THE MODULE LEVEL.
* POWER SUPPLY DENSITY NEEDS WILL DOUBLE IN THE NEXT FIVE YEARS.
* CUSTOMER EXPECTATIONS ARE CHANGING:
  - MIGRATION TO THE OFFICE ENVIRONMENT WILL MAKE PRODUCT ACOUSTICS A MAJOR MARKET ISSUE BY THE MID 80'S.
  - DISTRIBUTION CHANNELS WILL BE CHANGING TO COMMON CARRIER SHIPPING.
  - INCREASE PRODUCT RELIABILITY.
  - WIDER RANGE OF OPERATING ENVIRONMENTS.
  - CUSTOMER MAINTAINABILITY/INSTALLABILITY.
  - INCREASING ERGONOMICS FOCUS.
* INCREASING COMPETITION WILL FORCE IMPROVED POWER AND PACKAGING PRODUCT QUALITY AND VALUE.
* REGULATORY REQUIREMENTS WILL HAVE AN INCREASING COST IMPACT.
  - PRODUCT SAFETY REGULATION (MECHANICAL - ELECTRICAL).
  - ERGONOMIC REQUIREMENTS.
  - ACOUSTICS REGULATION.
  - POWER POLLUTION PROTECTION REQUIREMENTS.
  - ENVIRONMENTAL PROTECTION REGULATION.
  - ENERGY EFFICIENCY REQUIREMENTS.
  - EMI REGULATION.

II KEY PARAMETERS

- O PACKAGING COST AND WEIGHT
- O POWER SUPPLY SIZE, WEIGHT, COST
- O FOOTPRINT
- O ACOUSTIC NOISE POWER EMISSION LEVEL
- O POWER UTILITY SERVICE LINE REQUIREMENTS (LEVEL, DISTORTION)
- O NET POWER DISSIPATION LEVEL (WATTS)
- O ELECTRICAL POWER EMISSION LEVEL (RFI/EMI)
- O RELIABILITY: (MTBF) PERFORMANCE DEGRADATION, ENVIRONMENTAL TOLERANCE
- O SERVICABILITY: (MTTR)
- O INSTALLIBILITY

III DOANE METRICS

1 LIFE CYCLE COST/PRODUCT WATT

    PACKAGING COST/WATT

    POWER COST/WATT

    CABLE COST/SYSTEM SIZE

    SHIPPING COST/SYSTEM WEIGHT

2 ACOUSTIC NOISE POWER EMISSION LEVEL/PRODUCT

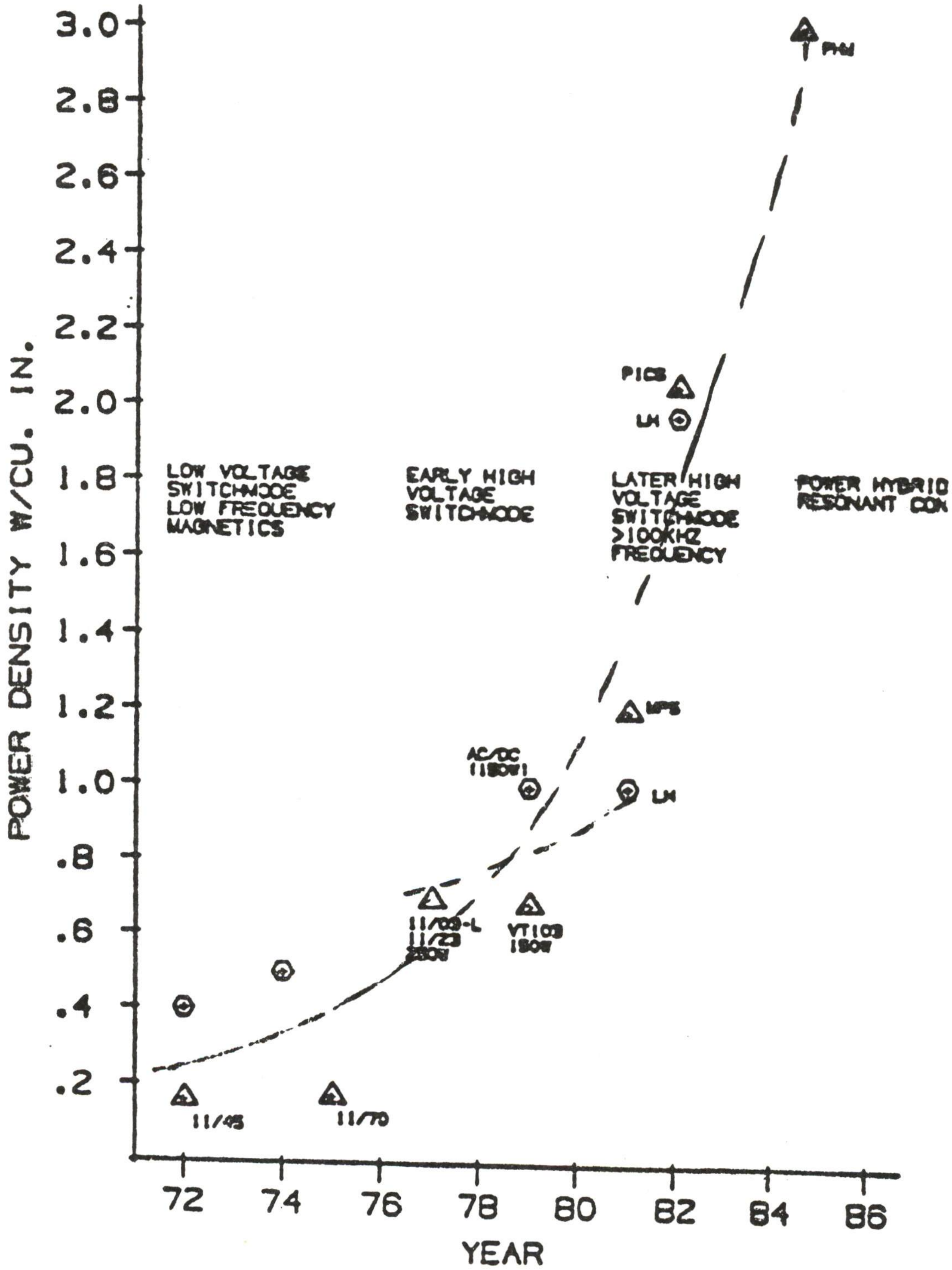
3 ELECTRICAL POWER EMISSION LEVEL/PRODUCT

4 SQ.FT./PRODUCT

5 POWER DENSITY WATTS/CU.IN

SCHALKE 2

POWER DENSITY



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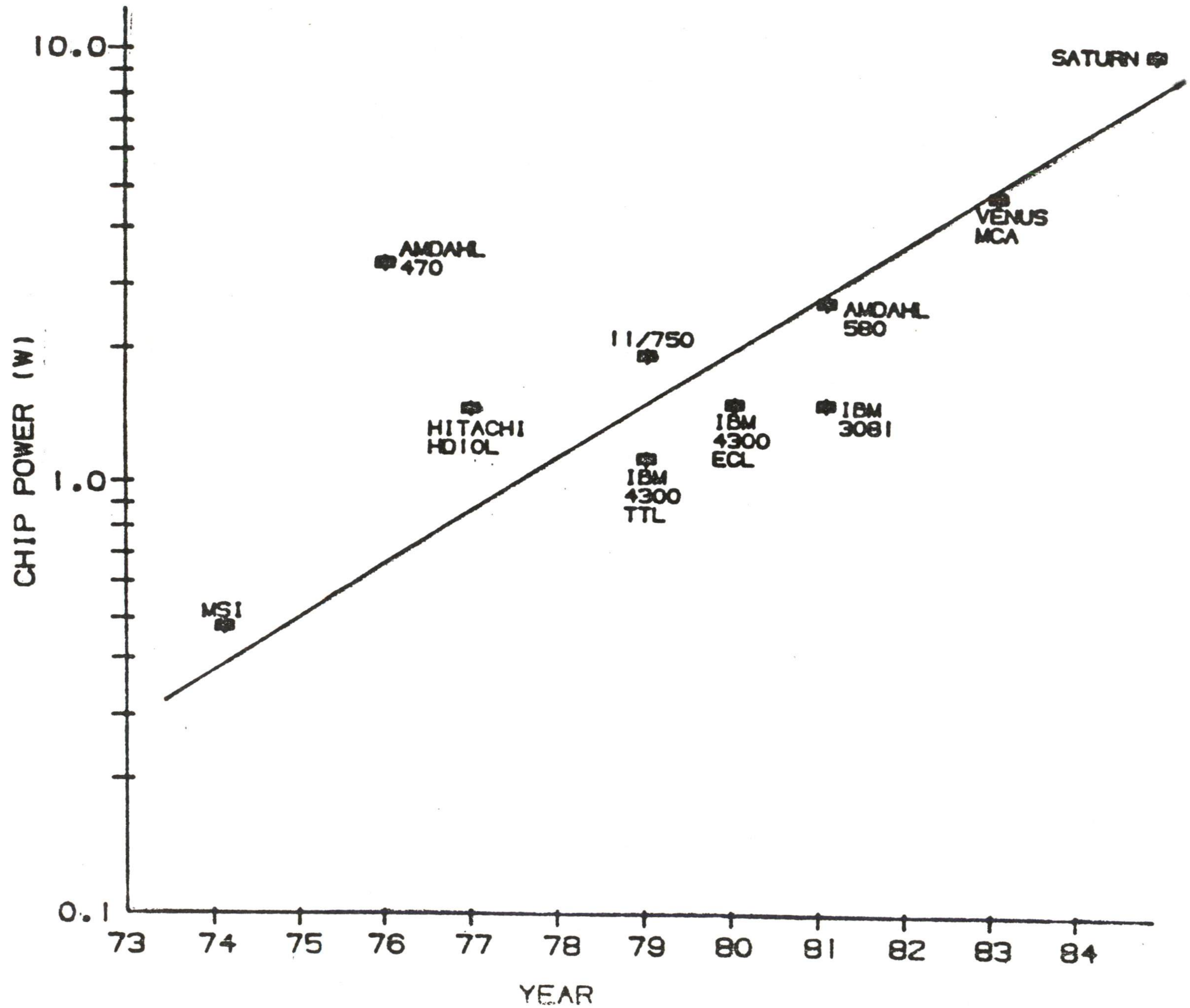
CHIP POWER DISSIPATION



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IV COMPETITIVE POSITION

	IGNORES (0–2)	FOLLOWS (2–4)	KEEPS PACE (4–6)	LEADS (6–8)	EXCELLS (8–10)
Scale	0 1	2 3	4 5	6 7	8 9 10
ELECTRONIC PKG COST/PERFORMANCE			WANG, APPLE DG AT&T, DEC	HP IBM	
THERMAL PERFORMANCE		DG HP	DEC	AT&T IBM	
PRODUCT ACOUSTICS POWER EMISSION LEVEL/ PRODUCT		DG, TI, WANG	(STC) HP	DEC (CDC), IBM (JAPAN, INC)	
POWER SUPPLY DENSITY		APPLE	(JAPAN INC) IBM DEC WANG (AC/DC (LH)	HP AT&T	
ELECTRICAL POWER EMMISION LEVEL/ PRODUCT (EMI/RFI)			DEC DG	IBM HP	

SCHALKE 3

V INVESTMENT IMPERATIVES

1. POSITION THE POWER AND PACKAGING TECHNOLOGIES TO FACILITATE THE CHANGING MARKET NEEDS OF:

   - THE OFFICE ENVIRONMENT
   - DISTRIBUTED SYSTEMS
   - OEM MARKET

2. ENABLE A GRACEFULL INTRODUCTION OF REGULATORY REQUIREMENTS INTO PRODUCTS AND PROCESS

3. INVEST IN THE DEVELOPMENT OF TOOLS AND CAPITAL EQUIPMENT FOR ENGINEERIING AND MANUFACTURING PRODUCTIVITY IMPROVEMENT AND FOR DESIGN INTEGRITY AND PRODUCT QUALITY.

VI R & AD INVESTMENT PRIORITIES

HIGH — LOW

A. POWER TECHNOLOGY

[ANALYSIS TOOLS] (POWER COMPONENTS TECHNOLOGY)

[POWER HYBRIDS TECHNOLOGY] [EMI COMPATIBILITY]

B. POWER PROCESS TECHNOLOGY

[POWER SUPPLY TEST TECHNOLOGY] [RELIABILITY MODELING]

(NEW INSPECTION TESTERS)

C. THERMAL DESIGN

[ANALYSIS TOOLS] (FAN & BLOWER DESIGN)

[COOLING TECHNOLOGIES]

D. ACOUSTIC DESIGN

[LEADERSHIP & STDS] [ACTIVE ATTENUATORS]

(FAN BLADE DESIGN) [ANALYSIS TOOLS]

E. SIGNAL INTEGRITY

[EMI/RFI COMPATIBILITY]

[TRANSMISSION MEDIA & CIRCUITS]

F. ELECTRONIC PACKAGING

[ADVANCE PACKAGING] (EMI GASKETING & MATERIALS)

G. MATERIAL ENGINEERING

(PLASTICS) (MECHANICAL PROCESSES)

H. OTHER

[ENVIRONMENTAL TEST]

[STRUCTURAL ANALYSIS]

PHYSICAL INTERCONNECT

I. ASSUMPTIONS

- LSI Technology and Product Trends Will Be As Outlined By The LSI Group's LRP.

- During The Foreseeable Future Single Chip Design Solution Will At Best Cover Only The Bottom End Of The Product Spectrum.

- By The Late 80's Many Of The VLSI Chips We Use To Build Computer Systems Will Have I/O Between 100 & 300 Pins, And Power Dissipation In Excess Of Five Watts.

- Multichip Packaging Will Be Pursued For Performance And Economy Because Package Cost Will Equal Or Exceed Chip Cost.

- Test Processes Need To Be Developed For Probe Testing VLSI Chips To A Very High Certainty Of Goodness.

- System Manufacturers Cannot Rely On Semiconductor Vendors To Offer Solutions For These Chip Assembly And Interconnect Requirements.

- It Will Take The Combination of Improved Signal Density PWB Processes And Continuously Improved CAD Layout Tools To Maintain A Quick Turnaround Module Prototype Process.

- Establishing Like Capability for Multichip Assemblies Will Be Equally as Important.

- Design and Manufacturing Processes For Electronic Packaging And Interconnect At All Levels Will Be Further Complicated By Requirements For Impedance Control, Thermal Cooling, And Replacement And Repairability.

JOE CHENAIL

II. KEY PARAMETERS

ENGINEERING PARTNERS

Design Cost
Design Time
Prototype Tooling Cost
Prototype Turnaround Time
State-of-the Art Technology

- o Risk
- o Density
- o Capacitive Loading
- o Signal Prop Delay
- o Power Dissipation
- o Test Coverage

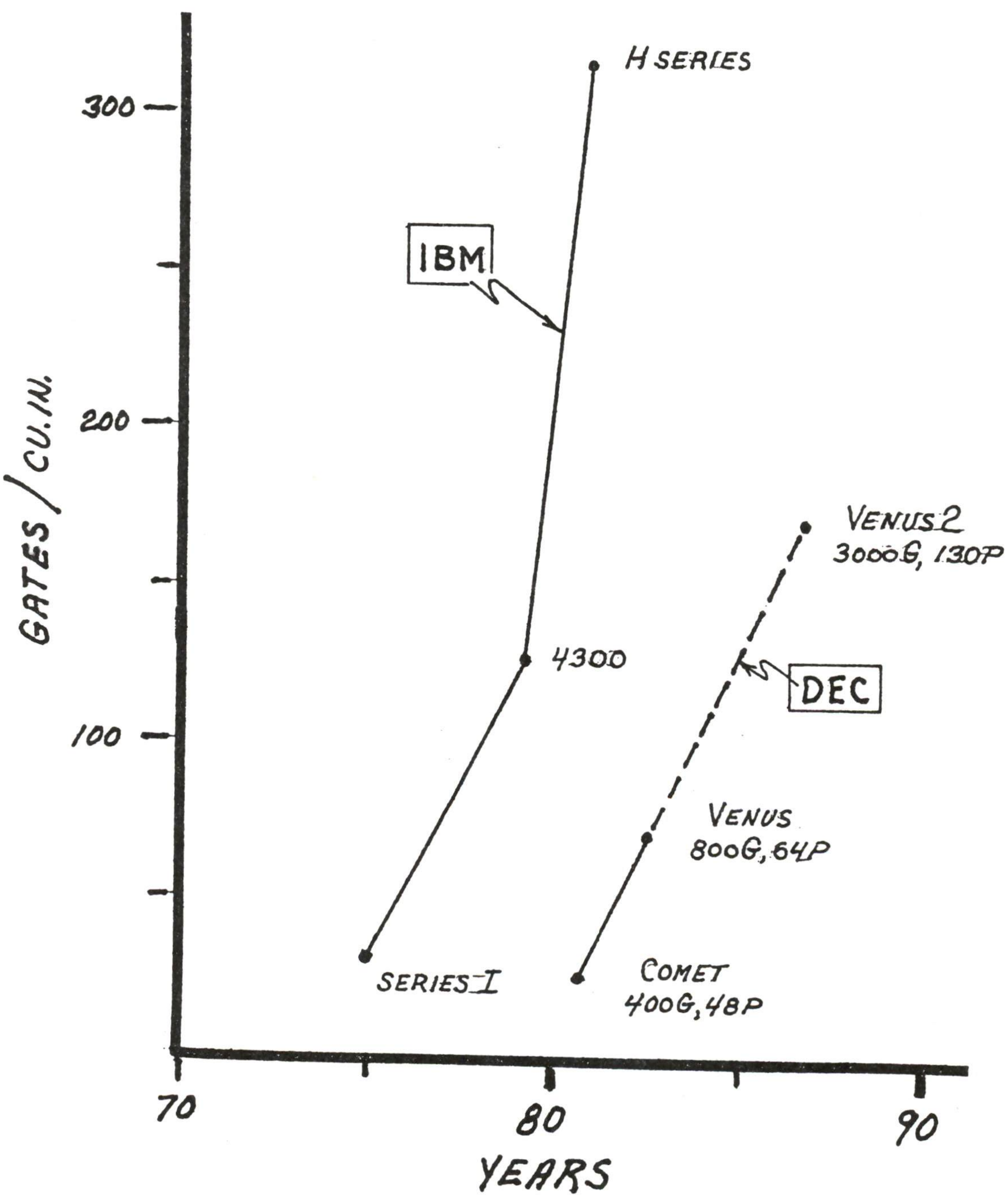
MANUFACTURING PARTNERS

Impact on Current Mfg Base (Impact on Inventory Turns)
Capital Investment
Workforce Impacts
Controllable Fabrication Process
High Fresh Lot Yield
Quick Diagnosis & Repair
Stable Design
Adequate Raw Material Sources
Quantifiable Process Parameters

FIELD SERVICE PARTNERS

Good Diagnosability
Ease Of Replacement And Repair
Socketed Component Assembly
High MTBF

CPU GATE DENSITY



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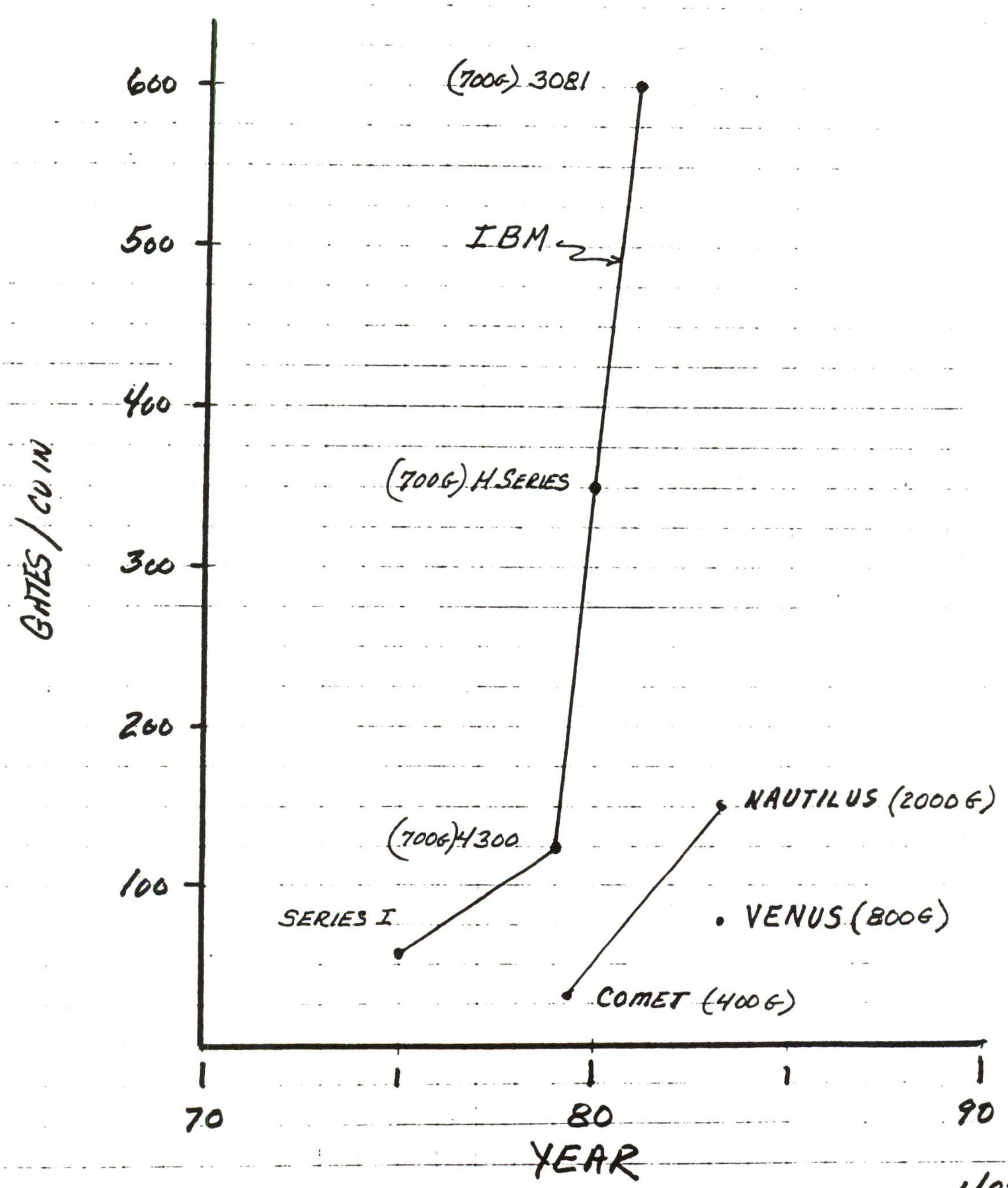
CPU GATE DENSITY



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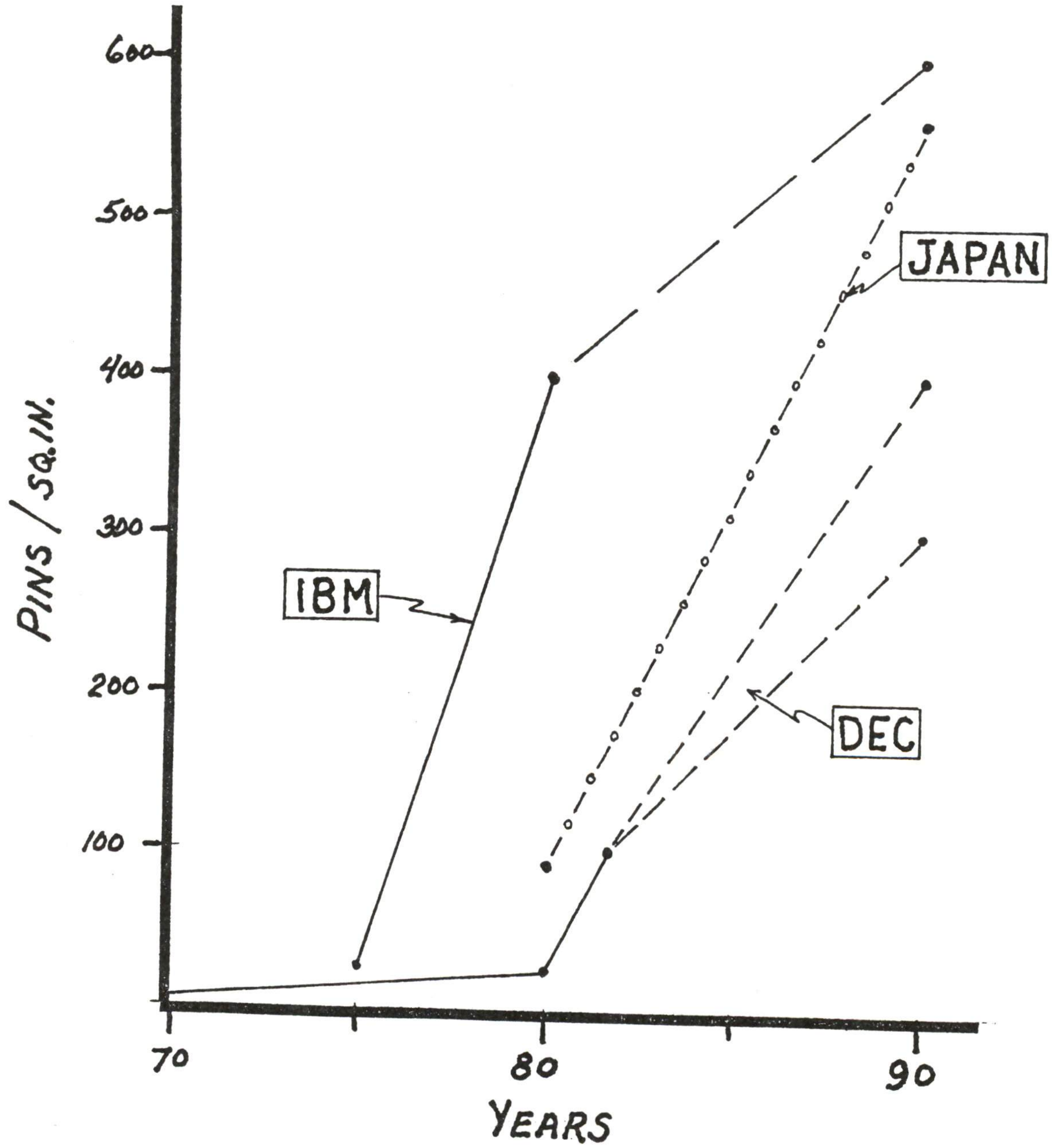
INTERCONNECT DENSITY



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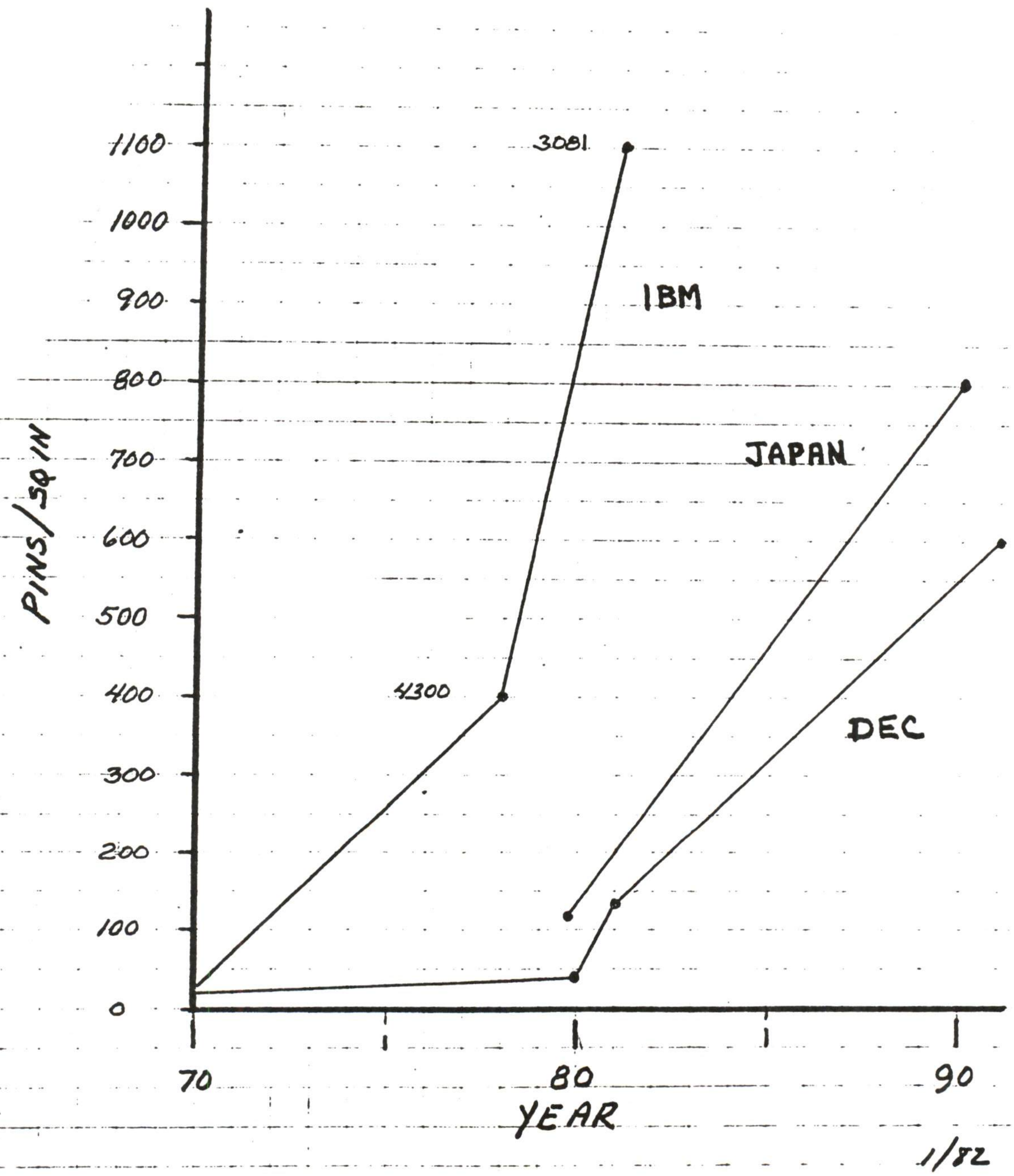
INTERCONNECT DENSITY



IV. COMPETITIVE POSITION

	FOLLOWING					KEEPS PACE					LEADING
	0	1	2	3	4	5	6	7	8	9	10
INTERCONNECT DENSITY			INTEL			DEC	H-P	FUJITSU HITACHI NEC			IBM
MULTI-LAYER			INTEL			DEC	H-P	FUJITSU HITACHI NEC			IBM
PRODUCT TESTABILITY					DEC INTEL	WANG HONEYWELL		FUJITSU HITACHI NEC			IBM

1/20/82

INVESTMENT IMPERATIVES

83 84 85 86 87

1. MICRO PACKAGING	CAD DESIGN TOOLS
	MULTI LAYER SUBSTRATE
	BUMP & TAB ASSEMBLY PROCESS
	THERMAL COOLING
	CHIP PROBE TEST
2. MSL PRINTED	CAD DESIGN TOOLS
	H2D PROCESS
	H3D PROCESS
	CONTROLLED Z PROCESS
3. SIGNAL INTEGRITY	CHARACTERIZATION & DESIGN RULES

VI. INVESTMENT PRIORITIES

PHYSICAL INTERCONNECT
KEY PROGRAM & ACTIVITIES

1/20/82

TECHNOLOGY DOMAIN	82	83	84	85	86
MULTICHIP MICRO PACKAGING	MULTICHIP FEASIBILITY	BUMPS, TABS, & CERAMICS BREADBOARDS	PROCESS IMPLEMENTATION	PROTOTYPES	VOLUME MFG.
PRINTED WIRING BOARDS (MSL)		MSL DESIGN RULES			
	MSL CAD DEVELOPMENT				
	H2D MSL DEVELOPMENT		H2D MSL MFG.		
		H3D PROCESS DEV.	H3D MFG.		
	CONTROLLED Z PROCESS DVELOPMENT		CONTROLLED Z MFG.		
STRUCTURED TESTABILITY		EVALUATION OF SET SCAN & SELF TESTING TECHNIQUES; DESIGN RULES & SOFTWARE	PROTOTYPE	TECHNIQUES IN PRODUCT DESIGN AND MFG.	

COMPUTING SYSTEMS

OVERVIEW

COMMON STRATEGIES
(ALL SYSTEM PRODUCTS)

- o ASSUMPTIONS: (ALL AGREE WITH B. DELAGI SET WITH UNIQUE ADDITIONS)
- o METRICS: COMMON
- o DIFFERENT PRIORITIES TO SATISFY CONSTRAINTS OF DIFFERENT DESIGN CENTERS

FOCUS/DESIGN CENTER OF ADVANCED DEVELOPMENT

GROUP	KEY METRIC	SEMICOND.	PKG./LEVEL OF INTEGR.	PROC. ARCH.	TOOLS
PSD	COST	3 CUSTOM CHIP	1 SINGLE BOARD	4 LIMITED PARALLELISM	2 -MGE EFFICIENCY .MECHANICAL PACKAGE
MSD	COST/ PERF.	4 GATE ARRAY. (CMOS)	2 INTEGRATED SYSTEMS PACKAGING	3 DRIVE FOR MAX. PERF. AT UNDER $100K	1 -MGE COMPLEXITY TO GET TIME TO MARKET .PERF MODEL. .MICRO SW .CAD
LSG	PERF	3 ECL: -GATE ARRAY -CUSTOM GaAs	2 -VERY DENSE PKG -NON AMBIENT COOLING	4 -HEAVY PIPELINE -VECTORS	1 -MGE COMPLEXITY TO GET TIME TO MARKET .HIER.DESIGN .PERF MODEL. .CAD FOR CUSTOM LSI

PRIORITIES SHOWN AS #

COMPUTING SYSTEMS

I. ADDITIONAL STRATEGIC ASSUMPTIONS

- COMPUTING SYSTEMS ARE EXPECTED TO BE

  INCREASINGLY RELIABLE
  INCREASINGLY AVAILABLE
  INCREASINGLY SECURE

- CUSTOMERS (USERS) WILL WISH TO DEAL WITH COMPUTING SYSTEMS AT LEVELS ABOVE INSTRUCTIONS SETS AND OPERATING SYSTEMS

  WISH TO INCORPORATE INDUSTRY STANDARD (NON-DEC) OPERATING SYSTEMS, LANGUAGES, APPLICATIONS, MICROPROCESSORS TO THEIR EXISTING DEC (AND IBM) COMPUTING FACILITIES

- CUSTOMERS (USERS) WILL WISH TO SOLVE PROBLEMS WHICH ARE

  SYMBOLIC RATHER THAN NUMERIC
  PARALLEL RATHER THAN SEQUENTIAL

- VLSI LOGIC AND STORAGE DENSITIES ARE LEADING TO HARDWARE COMPUTING STRUCTURES WHICH INTEGRATE THE "CPU" AND "STORAGE" (PRI. & SEC.)

- SEMICONDUCTOR COST PERFORMANCE TRENDS AS COMPARED TO ELECTROMECHANICAL, POWER, PACKAGING LEAD TO "SERVERS" BUILT AROUND ELECTROMECHANICAL UNITS

- EQUIPMENT COST WILL BE A DECREASING PROPORTION OF THE COST OF EFFECTIVE USE

- REMEDIAL SUPPORT OF DESIGN FAULTS WILL DOMINATE SERVICE COSTS

II. KEY PARAMETERS (CONCENTRATED ON CUSTOMER VALUES)

1. $\$_E$ - COST OF EQUIPMENT
   $\$_O$ - COST OF OWNERSHIP
   $\$_A$ - COST TO EFFECTIVELY APPLY THE COMPUTING SYSTEM
   P_D - WANTS DISSIPATED PER CUBIC METER
   - P_{DT} - THERMAL
   - P_{DA} - ACOUSTIC

   A - AVAILABILITY OF INSTALLED COMPUTING SYSTEM
   C_I - INSTRUCTIONS PER SECOND
   C_D - DATA STRUCTURE SEARCH AND UPDATES PER SECOND
   I_P - ILLIGITIMATE DATA STRUCTURE ACCESS RATIO
   T_D - DEVELOPMENT TIME

III. PRIORITIZED METRICS

1. $\$_A$ $(\text{LOG } I_P)/C_D$: APPLIED SYSTEM COST PER SAFE UPDATE CAPACITY
2. $\$_O/A$: COST PPER AVAILABILITY YIELDED
3. $\$_E/C_I$: CLASSICAL COST PER COMPUTING CAPACITY

COMPUTING SYSTEMS

PSD

DON GAUBATZ

I. ASSUMPTIONS

1. PDP-11 SYSTEMS REVENUE WILL NOT PEAK UNTIL FY84

2. PDP-11 SYSTEMS WILL FACE INCREASING PRICE AND PERFORMANCE PRESSURE FROM COMMODITY-DERIVED SYSTEMS PRODUCTS.

3. CMOS J-11, TO BE DELIVERED BY SEG IN FY84, IS LAST PDP-11 CPU FOR CORPORATION?

II. KEY PARAMETERS (CONCENTRATED ON CUSTOMER VALUES)

1. $\$_E$ - COST OF EQUIPMENT

   $\$_O$ - COST OF OWNERSHIP

   \$A - COST OF EFFECTIVELY APPLY THE COMPUTING SYSTEM

   P_D - WANTS DISSIPATED PER CUBIC METER
   P_{DT} - THERMAL
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   A - AVAILABILITY OF INSTALLED COMPUTING SYSTEM

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   C_D - DATA STRUCTURE SEARCH AND UPDATES PER SECOND

   I_P - ILLIGITIMATE DATA STRUCTURE ACCESS RATIO

   T_D - DEVELOPMENT TIME

III. PRIORITIZED METRICS

1. $\$_A$ (LOG I_P)/C_D: APPLIED SYSTEM COST PER SAFE UPDATE CAPACITY

2. $\$_O$/A: COST PPER AVAILABILITY YIELDED

3. $\$_E/C_I$ CLASSICAL COST PER COMPUTING CAPACITY

DON GAUBATZ

IV. COMPETITIVE POSITION

	IGNORES			FELLOWS		KEEPS PACE		LEADS		EXCELLS	
	0	1	2	3	4	5	6	7	8	9	10
$u(logIp)Cd	sharp		AT&T	NEC	WANG	HP	IBM	DEC			
$0/A	sharp		AT&T	WANG	NEC	IBM	HP		DEC		
$c/Ci	sharp		AT&T		WANG	HP	IBM	NEC	DEC		

V. INVESTMENT IMPERATIVES

1. INCREASE CONTRIBUTION TO SYSTEM FUNCTIONALITY PER BOARD
   - REDUCES NUMBER OF BOARDS PER SYSTEM
   - LOW END ACHIEVES SINGLE BOARD MULTIUSER SYSTEM

2. ENHANCE FACILITIES FOR DEVELOPING MECHANICAL SYSTEM PACKAGES
   - ALLOWS RAPID EVALUATION OF ALTERNATIVES
   - ACHIEVE FASTER TIME TO MARKET

3. INCREASE UTILIZATION OF GATE ARRAY AND CUSTOM CHIPS IN LOW END SYSTEMS
   - REDUCES NUMBER OF BOARDS, COST PER BOARD, COST OF SYSTEM
   - (RE)TRAINS DESIGN COMMUNITY

4. OPTIMIZE CPU'S CONTRIBUTION TO SYSTEM PERFORMANCE AND FUNCTIONALITY
   - REDUCES NUMBER OF BOARDS, COST PER BOARD, COST OF SYSTEM
   - NOTE: J-11 PRODUCT DEVELOPMENT MADE IN S E G

R & AD INVESTMENT PRIORITIES:

INTERNAL, (EXTERNAL), SURPRISES

INCREASE FUNCTIONALITY REDUCE BOARD COUNT	SINGLE BOARD COMPUTER SYST.	MULTI SINGLE BOARD COMP.	VAX/PDP HYBRID
MECHANICAL, SYSTEMS CAD			
USE GATE ARRAYS CUSTOM MOS		QBUS LSI	SINGLE CHIP SYSTEM
MAXIMIZE CPUs CONTRIB.TO SYSTEM	SHARED TERMINAL CONTROLLER	PERFORM.RANGE MULTIPROCESSING	SOFTWARE FPP ADVDEV 68000S
		A AND A+ SCENARIO	

COMPUTING SYSTEMS

MSD

Peter Jessel

I STRATEGIC ASSUMPTIONS

- BASIC VAX ARCHITECTURE WILL REMAIN VIABLE OVER THE PERIOD; ALL CHANGES WILL BE EVOLUTIONARY
- DESIGN FOR SERVICE/MANUFACTURE WILL BE A REQUIREMENT
- SYSTEM COST/PERFORMANCE WILL CONTINUE TO DOMINATE MID-RANGE SELECTION CRITERIA
- COMPLEXITY OF DESIGN WILL OUTSTRIP TRADITIONAL DESIGN APPROACHES NECESSITATING THAT A HIGHER PERCENTAGE OF INVESTMENT DOLLARS BE DEVOTED TO TOOL BUILDING
- THE HIGH COST OF PRODUCT INTRODUCTION AND SUPPORT WILL PRECLUDE THE DEVELOPMENT OF "SPECIALTY MACHINES": HENCE RELIABILITY AND SECURITY MUST BE BUILT INTO THE BASIC SYSTEM
- MULTIPROCESSING WILL BE AN INTEGRAL PART OF ALL NEW SYSTEM DESIGNS
- SEMICONDUCTOR TECHNOLOGY WILL DRIVE 32-BIT DESIGN
- SEG/EXTERNAL SUPPLIERS WILL SATISFY 32-BIT SEMICONDUCTOR DEVICE REQUIREMENTS, BUT THE SYSTEMS GROUP WILL BE RESPONSIBLE FOR DESIGN

P. JESSEL
1/19/82 1.5

II. KEY PARAMETERS

1. $\$_E$ - COST OF EQUIPMENT
   $\$_O$ - COST OF OWNERSHIP
   $\$_A$ - COST TO EFFECTIVELY APPLY THE COMPUTING SYSTEM
   P_D - WANTS DISSIPATED PER CUBIC METER
   - P_{DT} - THERMAL
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   C_D - DATA STRUCTURE SEARCH AND UPDATES PER SECOND
   I_P - ILLIGITIMATE DATA STRUCTURE ACCESS RATIO
   T_D - DEVELOPMENT TIME

III. PRIORITIZED METRICS

1. COST/PERFORMANCE
2. COST/OWNERSHIP
3. TOTAL DEVELOPMENT TIME AT DIFFERING COMPLEXITY LEVELS VS. YEAR OF INTRODUCTION
4. ARCHITECTURAL INNOVATIONS/CAPABILITIES VS. YEAR OF INTRODUCTION
5. COST PER AVAILABILITY YIELDED

P. JESSEL
1/19/82 1.5

IV. COMPETITIVE POSITION

	IGNORES (0 1)	FOLLOWS (2 3 4)	KEEPS PACE (5 6)	LEADS (7 8)	EXCELS (9 10)
1. COST/PERF	SHARP	WANG ATT[2]	IBM[1] TANDEM	DEC HP	
2. COST/OWNERSHIP	SHARP	WANG ATT[2]	TANDEM IBM	HP DEC	
3. DEVEL. TIME	SHARP	ATT IBM	HP TANDEM DEC WANG		
4. ARCH. INNOV.	SHARP	IBM HP ATT	TANDEM WANG DEC		
5. COST PER AVAIL.	SHARP	HP WANG DEC	IBM	TANDEM ATT	

[1] IBM (ONLY MID-RANGE)

[2] ATT (3B PROC. ONLY; NO FAMILYNESS)

P. JESSEL
1/19/82 1.5

V. INVESTMENT IMPERATIVES

1. MAINTAIN DIGITAL'S COST/PERFORMANCE LEADERSHIP IN DEPARTMENTAL COMPUTING

2. DEVELOP AN INTEGRATED SET OF DESIGN AND MODELING TOOLS TO SUPPORT CPU AND SYSTEM DEVELOPMENT FOR ALL OF 32-BIT SYSTEMS

3. DESIGN LOW COST, LOW POWER, BUT HIGHLY PARALLEL PROCESSOR STRUCTURES WHICH MAXIMIZE SYSTEM PERFORMANCE

4. PRODUCE NEW SYSTEM ARCHITECTURES WHICH INTEGRATE COMPONENTS AT THE BOX LEVEL AND MINIMIZE CONTROLLERS, POWER SUPPLIES, BACKPLANES & OTHER INTERCONNECT, PACKAGING, ETC.

5. INTRODUCE NEW TECHNOLOGIES TO SUPPORT EMERGING MARKETS

P. JESSEL
1/19/82 1.5

VI. 32-BIT SYSTEMS ADVANCED DEVELOPMENT INVESTMENT PRIORITIES

	HIGH <----------------------------------> LOW			
	(A-)	A	B	C
TOOLS	V-SYSTEM			
	PRODUCTION DRIVEN GATE ARRAY TOOLS			
		VLSI DESIGN		
BASE TECHNOLOGY	(SEMICONDUCTOR TECHNOLOGY): CMOS			
	PARALLEL STRUCTURES			
		SERVER SYSTEMS		
INTEGRATED SYSTEMS PACKAGE	CONTROLLERLESS SYSTEMS (POWER SUPPLIES) (PACKAGING) INTERCONNECT SELF TEST MULTIPROCESSING			
NEW TECHNOLOGY	FIBER OPTICS			
		VOICE		

COMPUTING SYSTEMS

LSG

ROY REZAC

LARGE SYSTEM GROUP

RESEARCH AND ADVANCED DEVELOPMENT

I. STRATEGIC ASSUMPTIONS

A. LSG SPECIFIC

1. USERS WILL PAY A PREMIUM PER COMPUTE FOR HIGH PERFORMANCE MACHINES:

   o TIMELY PROCESSING ON LARGE PROBLEMS
   o APPLICATION GROWTH
   o GENERAL PURPOSE CAPITAL INVESTMENT RATHER THAN SPECIFIC CAPITAL INVESTMENTS

2. PROBLEM OF HAVING A SEQUENTIAL PROGRAM AUTOMATICALLY RUN ON SEVERAL COMPUTERS IN PARALLEL WILL NOT BE SOLVED IN THE 1980'S

3. CONCEPT OF "HIGH PERFORMANCE" IS IN A STEEP CURVE

4. HIGH PERFORMANCE MACHINES WILL NEED TO BE COST EFFECTIVE IN THE ROLES AS COMPUTE PERIPHERALS, SERVERS FOR MASS STORAGE/ ELECTRO-MECHANICAL UNITS/PERSONAL COMPUTER, NETWORK CONTROLLERS, ETC.

5. DIGITAL WANTS TO BE IN THIS BUSINESS

   o KEEP CUSTOMER BASE
   o MARGIN

ROY R. REZAC
18 JAN 82

II. KEY PARAMETERS

1. $\$_E$ - COST OF THE EQUIPMENT
   $\$_O$ - COST OF OWNERSHIP
   $\$_A$ - COST TO EFFECTIVELY APPLY THE COMPUTING SYSTEM
   P_D - WANTS DISSIPATED PER CUBIC METER
   P_{DT} - THERMAL
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   A - AVAILABILITY OF INSTALLED COMPUTING SYSTEM
   C_I - INSTRUCTIONS PER SECOND
   C_D - DATA STRUCTURE SEARCH AND UPDATES PER SECOND
   I_P - ILLIGITIMATE DATA STRUCTURE ACCESS RATIO

III. PRIORITIZED METRICS

1. $\$_O/C_I$ - COST OF OWNERSHIP PER COMPUTING CAPACITY
2. $-\$_A\,(\mathrm{LOG}\ I_P)/C_D$ - APPLIED SYSTEM COST PER UPDATE CAPACITY
3. $\$_{O/A}$ - COST PER AVAILABILITY YIELDED

IV. COMPETITIVE POSITION

	IGNORE	FOLLOWS	KEEPS PACE	LEADS	EXCELLS
	0 1 2	3 4	5 6	7 8	9 10
$\$_O/C_I$	SHARP AT&T	WANG	HP IBM NEC	DEC HITACHI	
$\$_A(\mathrm{LOG}I_P)/C_D$	SHARP AT&T	WANG NEC	HP IBM	DEC	
$\$_O/A$	SHARP AT&T	WANG	HP IBM NEC	DEC	

ROY R. REZAC
18 JAN 82

LARGE SYSTEMS GROUP

V. INVESTMENTS IMPERATIVES

1. IMPROVE ENGINEERING PROCESS/DESIGN METHODOLOGY SO THAT PRODUCTS CAN BE DELIVERED IN A TIMELY AND PREDICTABLE MANNER
   - ANALYTICAL CAPABILITY
2. PUT A CAD SYSTEM IN PLACE
   - HIERARCHICAL DESIGN
   - SIMULATION
   - GATE ARRAY AND CUSTOM CHIPS - GaAs
   - TIMING VERIFICATION
   - SCAN DESIGN/AUTOMATIC TEST GENERATION
3. OBTAIN SEMI-CONDUCTOR, PHYSICAL INTERCONNECT, AND PACKAGING TECHNOLOGY WHICH ARE NEEDED FOR HIGH PERFORMANCE MACHINES (E.G., 40 X 11/780)
4. EXPAND ON THE WORK OF CANE & ORBITZ TO EVOLVE PROCESSOR STRUCTURES

VI. R & AD INVESTMENT PRIORITIES

	HI-------------	-------------	-------------LO
A. MODELING	DESIGN PROCESS	PERFORMANCE	
B. CAD SYSTEMS	(HIERARCHICAL DESIGN. TIMING VERIF.)	CHROMA SIMULATION SCAN DESIGN	
C. PHYSICAL TECHNOLOGY	(SEMI-CONDUCTOR) PACKAGING PHYSICAL INTERCONNECT		POWER SUPPLY
D. PROCESSOR STRUCTURES	PIPELINE MODELS		
E. OTHER		SERVER SOFTWARE	COMPUTING SYSTEMS

ROY R. REZAC
18 JAN 82

HUMAN FACTORS

RUSS DOANE

HUMAN FACTORS

I. ASSUMPTIONS

- An UNEXPLOITED KNOWLEDGE-BASE exists:
    - Anthropometrics
    - Perception
    - Learning
    - Psycholinguistics
- Human Factors are BASIC HARDWARE AND SOFTWARE DESIGN
- DEC Products are increasingly being introduced to users with:
    - LESS FAMILIARITY with engineering & programming
    - LESS FREEDOM to escape into non-electronic tasks
    - LESS TOLERANCE for difficult-to-use products
    - RISING EXPECTATIONS for performance and help
    - GOVERNMENT REGULATIONS to protect their health & safety while at the same time continuing to be used ad-hoc

II. PARAMETERS

A. INSTALLATION/STARTUP/LEARNING PARAMETERS

- Number of SENSES utilized; size of CHUNKS for each
- Number of STATES in the User-Interface State-Diagram
- Number of CONCEPTS invoked in User Interfacing
- Number and narrowness of RULES; tolerance for USER VARIATIONS
- Fright Factor (see terminals parameters)
- METAPHORS & SIMILES vs. manual methods & expectable habits:
    - Sequence in which things must be done
    - Entry
    - Access
    - Mathematics
    - Relations/Translations
    - Relocations/Communications
- Compatibility with EXPECTATIONS of target population
    - Changes from DEC products
    - Changes from Industry Standard products
- Number of UN-NEEDED CHOICES presented to novices
- Documentation READABILITY
    - Jargon & Abbreviation avoided where practical
    - Percentage of Jargon & Abbreviations that appear in Index
    - "Fog index" grade level: see definition attached
    - Pictures per 1000 words
    - Fraction of Rules and Concepts illustrated by Example
    - Presentation by System as appropriate while using

RUSS DOANE

B. USING PARAMETERS

- STATES TRAVERSED in state diagram for often-used features
- VISUAL INDICATION of user-interface current state
- ERRORS:
  - User Variations, Omissions, Comissions tolerated amicably
  - Keystrokes Required to Recover when product is intolerant
  - Suggestive Diagnostics provided (vs mere factual un-help)
- RESPONSE TIME:
  - Consistency of Cursor Time Delay
  - Cursor Delay
  - Cursor Velocity
  - System Response Time
- DUALITY between CRT image and printout
- PHYSICAL DEMANDS
  - Non- Touch-typable keys
  - Eye motions
  - Eye accomodations
  - Gross Hand motions
  - Eye-Hand coordinations; eye-hand-ear coordinations
  - Character size/subtended angle
  - Near-focus distance demanded (vs. farsightedness)
- MENTAL DEMANDS
  - Unexplained Abbreviations (mis-mnemers)
  - Invisible Alternatives, available only if remembered
  - Unconventionality vs. users' everday experiences
- SECURITY: Digital Acceptance (Writing? Voice? Fingerprint?)

C. ENVIRONMENTAL

- User Preferences on Attitude Surveys:
  - Absolute
  - Relative to Other Products (color, shape, height, etc.)
- Physical
  - Deskspace, Floorspace occupied; furniture compatibility
  - Adjustability to user's body dimensions
  - Compatibility with Personal and Work-Related Accessories
  - Acoustic emissions (acoustic tolerance, for voice input)
  - Watts dissipated; warm air velocity & direction
  - Weight/portability/movability
  - Lighting Conditions producing Tolerable Glare/Contrast
- User installation/User Servicing
- Avoidance/Pre-emption of government, union, etc. Standards

III. PRIORITIZED METRICS

1	STATE-DIAGRAM STATES invoked PER CHARACTER SUCCESSFULLY ENTERED
1	STATE-DIAGRAM STATES invoked PER RANDOM ACCESS
1	CURSOR MANIPULATION TIME PER RANDOM ACCESS ON CRT SCREEN
1	PERCENTAGE OF ATTITUDE-SURVEY PREFERENCES SATISFIED per $$
2	SYSTEM RESPONSE TIME PER COMMAND
2	TIME TO FIRST USER BENEFIT for naieve user (study & startup)
2	Duality, CRT DISPLAY vs. PRINTOUT
3	TIME PER RANDOM ACCESS including both local and network access
3.	TIME TO UNPACK, INSTALL, AND ADAPT TO LOCAL NEEDS

IV. COMPETITION

IGNORE	FOLLOWERS	IN THE PACK	LEADERS
Sinclair	IBM sys. software	DEC, Prime, DG,	Xerox Star, HP (hw)
	Apple, TRS-80	Burroughs, NCR	Wang (office only)
	Commodore	Sharp, Seiko	TI voice, TOPS-20
		UNIX, VMS	IBM Displaywriter
		HP Software	Small Terminal Cos.
			AT&T, Sony, Nixdorf
			Siemens
			Phippips

3

V. INVESTMENT IMPERATIVES

1 Objective Testing is a necessity. "Gut feel" won't hack it for competitive Human Factors in the '8Øs.

2 Hardware, Firmware, Software, and Documentation must be seen as a System, not viewed as if they were independent.

3 Anthropometrics, Perception, Learning, and Psycholinguistics knowledge and skill must be brought to bear in a balanced way.

4 Target customer population(s) must be identified and described well enough to insure relevance.

5 Low End products deserve priority because they more often encounter low-skill, low-motivation, and/or infrequent users.

VI. HUMAN FACTORS R & AD INVESTMENT PRIORITIES:

← HIGH - - - - - - - - - - - - - - - LOW →

Sales Communications

Installation

Self-Evidence vs.
Opacity & Ambiguity:
Tutelage

Tolerance for
User Variability

Recovery from
Intolerance ("error")

Key:
Boxed $\boxed{\text{internal}}$; parenthises (external); Upper-case SURPRISE

TERMINALS AND WORKSTATIONS

WALT TETSCHNER

TERMINALS AND WORKSTATIONS

I. SPECIFIC ASSUMPTIONS

- IMPACT MATRIX PRINTERS WILL SATISFY THE BULK OF LOW END "LETTER QUALITY" PRINTING REQUIREMENTS.
- ERGONOMIC REGULATIONS WILL DOMINATE THE BUSINESS ENVIRONMENT.
- PUBLIC DATA NETWORKS WILL BE MAJOR FACTORS BY 1985.
- VIDEOTEX SERVICES WILL BE A SIGNIFICANT FACTOR BY 1985 AND TWO DISTINCT SERVICES WILL EXIST.
- TELETEX WILL BECOME THE DOMINANT INTERNATIONAL EMS AND BECOME THE PLP STANDARD FOR TEXT COMMUNICATIONS.
- ELECTRO-PHOTOGRAPHIC PRINTERS WILL SHOW A COST IMPROVEMENT OF 3X BY 1985.
- A MAJOR % OF THE TERMINALS AND WORKSTATIONS WILL CONNECT TO DEC HOSTS.
- OUR EMPHASIS WILL BE ON HIGH-VOLUME PRODUCTS.

WALT TETSCHNER

SPECIFIC ASSUMPTIONS

(CONTINUED)

- o LOW-VOLUME PRODUCTS WILL BE PURSUED SELECTIVELY
  - o UNIQUE/INNOVATIVE SYSTEM CAPABILITY.
  - o SPECIFIC P.L. DRIVEN
- o DISPLAY/PROCESSING OF NATURAL IMAGES WILL BE A MAJOR FACTOR BY 1987.
- o COMPUTER GENERATED GRAPHICS WILL BE A MAJOR FACTOR BY 1984.
- o PORTABLE/HAND-HELD TERMINALS WILL BE A MAJOR MARKET AREA BY 1984.
- o ADDRESSING THE FAR-EAST MARKET WILL BE A SURVIVAL ISSUE BY 1983.
- o FAR-EAST MANUFACTURING FOR THE BULK OF TERMINALS AND WORKSTATIONS PRODUCTS WILL OCCUR BY 1984.
- o TELEPHONE-TERMINALS WILL BE A MAJOR MARKET BY 1986.

TERMINALS AND WORKSTATIONS

II. KEY PARAMETERS

* HUMAN INTERFACE
    * KEYBOARDS
    * DISPLAYS
    * SPATIAL I/O
    * VOICE
    * COGNITIVE
* MULTI-USE, MULTI-ENVIRONMENT TERMINALS
    * TRANSPORT PROTOCOLS, PLPs, ...
    * TELETEX, VIDEOTEX, ...
    * GRAPHICS, WORD-PROCESSING, TIME-SHARING,...
    * TELEPHONE TERMINAL
    * BROAD COST RANGE

COMPATIBILITY

* BETWEEN TERMINAL GENERATIONS
* BETWEEN SOFT AND HARD COPY

SERVICE COST

III. DOANE METRICS

1. PRINTER $\dfrac{\text{(NO. OF CHAR/LINE @ SUSTAINED RATE) (CHAR. QUAL)}}{\text{COST}}$

2. VIDEO $\dfrac{\text{PIXELS/DISPLAY}}{\text{(NO. OF FILL CHARACTERS @ SUSTAINED RATE) (COST)}}$

3. WORKSTATIONS $\dfrac{\text{EASE OF USE}}{\text{COST}}$

PRIORITIZED METRICS OR EASE OF USE

STATE-DIAGRAM STATES INVOKED PER CHARACTER SUCCESSFULLY ENTERED
STATE-DIAGRAM STATES INVOKED PER RANDOM ACCESS.
CURSOR MANIPULATION TIME PER RANDOM ACCESS ON CRT SCREEN
PERCENTAGE OF ATTITUDE-SURVEY PREFERENCES SATISFIED PER $$

SYSTEM RESPONSE TIME PER COMMAND
TIME TO FIRST USER BENEFIT FOR NAIEVE USER (STUDY AND PRACTICE)
DUALITY, CRT DISPLAY VS PRINTOUT

TIME PER RANDOM ACCESS INCLUDING BOTH LOCAL AND NETWORK ACCESS
TIME TO UNPACK, INSTALL, AND ADAPT TO LOCAL NEEDS

IV. MAJOR COMPETITORS

1--10

IGNORE	FOLLOWS	IN THE PACK	LEADS	
	IBM ATT HP	WANG SHARP	NEC	DEC
	IBM ATT DEC	WANG HP	SHARP	NEC
	NEC SHARP	DEC HP WANG	IBM	ATT

TERMINALS AND WORKSTATIONS

V. INVESTMENT IMPERATIVES

1. HUMAN FACTORS AND EASE OF USE - BE THE STANDARD SETTER BY HAVING TERMINALS AND WORKSTATIONS PRODUCTS KNOWN FOR HAVING SUPERIOR HUMAN FACTORS.

2. INTEGRATED AND COMPATIBLE FAMILY OF TERMINALS AND WORKSTATIONS WHICH SATISFY A BROAD RANGE OF REQUIREMENTS AND PROVIDE A GRACEFUL GROWTH PATH TO LARGER SYSTEMS/SERVICES.

3. USE OF NEW TECHNOLOGIES CONSISTENT WITH HIGH VOLUME MANUFACTURING AND SERVICING ABILITIES.

WALT TETSCHNER
JANUARY 1982

VI. ADVANCED DEVELOPMENT INVESTMENT PRIORITIES

HIGH <-----------------------------------> LOW

A. VOICE
- (Text to Speech)
- Store and Forward Waveform Encoded
- Word Recognition
- (Store & Forward Parametric encoded)
- (Speaker Recognition)

B. PRINTERS
- Electrophotographic Printer
- Color
- Hi-resolution Impact Matrix
- Document Scanner
- (Alternate Print Technol.)

C. MECHANISMS
- Sheet Feeders
- (Scanners) (Motors)
- (Photoconductors) (Encoders)
- Ribbons
- (Toners)
- Print Heads
- (Fusers)

D. KEYBOARDS
- Elastomer
- (Capacitive)

E. SPATIAL I/O
- Cursor Positioner
- (Graphic Input)

F. DISPLAYS
- Monochromatic 25 --> 72 lines
- (Flat Panel) LCD
- Color 25 --> 72 lines

G. TERMINAL CONTROLLERS
- Custom Video LSI
- Custom Printer LSI

H. NATURAL IMAGE PROCESSORS
- Display of Natural Images, Text, and
- Frame Grabber

I. DATA COMM
- TMS
- LNA
- Intelligent PBX Interface
- Synch. Comm X.21, HDLC
- Value Added Links Teletex Videotex

J. TERMINAL SYSTEM ARCHITECTURE
- Backward Compatibility
- Print Server
- Host Migration of Functions

A SCENARIO

SOFTWARE

BILL KEATING

SOFTWARE

I. Specific Assumptions

- Customers will be growing and evolving rather then seeking a revolution of system capability. Customer's main life cycle cost will be in programming, installing, and maintaining his system(s). This will be done at all levels of organization. DEC's Software is good for Top End Departmental User and this is a valid base to grow from.

- Average sophistication of a computer user is dropping. End-users will be looking for systems that are more complete solutions to their problems. This will mean stepped-up application package development in target markets. Turn-key systems. Transparent failure/recovery.

- Average number of users per computer system is dropping. However, everything will be connected to everything else creating an immense challenge of developing, installing, managing and evolving in a complex, distributed and heterogeneous environment.

- A major problem will be packaging, documentation, installation and management of very complex system(s) offerings.

- Transparent Distribution of Functions/Applications/Data will be expected to provide capability where needed, as needed.

- We must live with and cooperate well with IBM systems and link with AT&T.

- Software installation/development/use/maintenance/evolution costs are the single most significant factor in the customer's life-cycle costs.

- Software development/use/maintenance/evolution is skilled-people intensive. The demand of software professionals is (and will continue to) outstrip the supply thru the mid 1980's. Qualilty/Productivity improvement are essential.

- By targeting our major effort on a single architecture, we can move faster in providing customer capabilities. Operating System Interface is key here.

- IBM is our chief volume competitor across-the-board. However, there is competitive exposure to small companies that can devote their entire resources to introducing new technology - without the inertia of supporting an existing customer base and associated software.

- Standards will be forthcoming which will have to be understood and properly influence future Software.

- Software is the main deliverable most of our users become intimately aware of.

Bill Keating

II. Key Parameters (Software)

- Contribution to Organizational Productivity through effective and productive utilization of Customer Total Information Flow.
- Contribution to Control and Productive use of Information Resource throughout organization including delivery, maintenance, and security of Information.
- Cost of integration and cooperation of various systems and links chosen based on Customer history, environment and emerging needs.
- Cost of delivery of appropriate capabilities to Professionals, Ad Hoc Users, Managers, End Users.
- Cost of Application Programming for System and network of Systems.
- Effective Functionality/Documentation/Training/Support.
- Reliability (as measured in cost of failures to user) and competitive Cost Performance.
- Flexibility of customer choice (High Availability, Security, Personal Convenience, etc.). Get what you need at a price.

III. Software Metrics

All current software products are measured on the following metrics:

1. Functionality
2. Publication/Documentation
3. Installability/Packaging
4. Ease-of-use/Human Factors
5. Reliability/Availability
6. Performance
7. Maintainability
8. Maintenance Services
9. Compatibility
10. Evolvability
11. Cost
12. Timeliness

Goals are established and measurements gained in field test and after release. This is a first step toward metrics which reflect true Customer Cost of Ownership of Systems and Nets of Systems. Against IBM (our prime target).

IV. Competition

Costs of	General	Exception
Application Development	DEC over IBM	TP & System 38
Install New System Mode	DEC over IBM	SNA is net mode
S/W Migration within Vendor	DEC over IBM	--
Information Management	IBM over DEC	VIA moving fast
Managing Complex of Systems	Unclear at this point	--
Startup for new user	DEC over IBM	System 38

V. Investment Imperatives

- Continue to Improve Software Engineering Productivity and Quality of our products.
- Develop High Level Tools for Distributed Data Processing.
- Learn how to Package/Integrate/Sell Tools we have as Total Information Systems.
- Provide "End User" Capabilities. Query <---> Programming.
- Improve Customer Application Productivity. (Professionals and Specialists - i.e. A/I)
- Move effectively to Intelligent Work Stations, Servers, etc.
- Improved integration of Layered Products among themselves.
- Human Factors considerations in all products.
- New (to DEC) Capabilities (Graphics, Security, Voice, etc.)
- Develop Low End 32 bit software.

Another concern: The Japanese are behind us today in Software. However, good Software engineering is characterized by hard meticulous work. The Japanese will be outstanding in this, watch out!

VI Investment Priorities

Technology Areas For Software

Hi <---------------------> Lo

Methodology

Hi		Lo
Architecture Design Implementation Verification Maintainability Documentation Packaging Consistency Performance	Management Metrics Standards	(Design/Arch. Tools) (Proof of Correctness)

Surprises: Errorless Prog., Embedded Doc
New way of Delivery

Operating Sys.

Human Factors Hi Reliability Addressing Security Hi Availability Performance Recovery Distribution of Funcitons	Data Integrity Realtime Special Purpose Servers.	Object Based Systems	(Provably Secure Sys)

Surprises: Fully Dist. O.S.

Languages

Compiler Design Lang. Environment Integration (other DEC products)	A/I Languages Language Design Cognitive Factors	(Languages)

Hi <-----------------------> Lo

Data Base	Data Integrity Distributed Data Relational DB Addressing	Query/Access Languages Integrated Text/Data/Voice Security/Cryptology (New Approaches)
Application Tools	Transaction Proc Forms Mgmt. Graphics Development Tools Application Packaging	Distribution of these (New Developments)
Office	Human/Cognitive Factors Text Management Office Graphics Integration with DP Video Disc - App.	Voice Image Compatibility with DEC Software
	(Video, Electro Optics, FAX, Digital PBX, Cable TV, Voice Digitizers)	
Dist. Data Processing	Dist Functions Dist Applications Dist Data Network Naming Management/Installation	Foreign (IBM) Cooperation Servicing (Standards)

APPLICATIONS

IN

COMPUTING

RUSS DOANE
BILL KEATING

R Doane
4feb82

COMPUTER-INTEGRATED MANUFACTURING

BASIC ASSUMPTION

We want to get computers to perform or at least discipline the routine things. People should be freed up to improve quality, productivity, asset utilization, and responsiveness.

ASSUMPTIONS ABOUT QUALITY / PRODUCTIVITY

Inspection and test would ideally be eliminated altogether and replaced by excellent process control, so things are right the first time. Every touch costs money and threatens quality.

If defects are few and information is current and believable then materials and the whole mfg. process can be made to flow smoothly. Smooth mfg. takes less people, space, equipment, $$, and less WIP.

When a plant operates with low WIP, problems surface fast. People can focus on improving the process, not on mounds of bad product.

ASSUMPTION ABOUT THE INFLUENCE OF GOOD INFORMATION ON ASSETS

Our $1B inventory is largely a stand-in for Believable Information.

The only BELIEVABLE information is On-Line, Real-Time information.

ASSUMPTIONS ABOUT RESPONSIVENESS

When Cycle Time approaches 2 times the "ideal" process time (with appropriate buffers for predictable interruptions), manufacturing is responsive.

Good information, low WIP/short cycle, and low inventory allow such quick response that manufacturing becomes a competitive weapon.

AUTOMATION PRIORITIES

Where eliminating inspection and test is impractical, we should push it upstream. And we should automate it where we can.

Dirty, hyper-clean, or hazardous jobs should be automated first.

Scarce-skill work (e. g. welding) should be automated.

PARAMETERS that have relevance and could conceivably be measured are listed below just as a resource, so that when we later select a few metrics we aren't making that selection with blinders on.

This list is supposed to be complete, but it is the product of an intentionally out-of-control "brainstorm" process. Nobody is proposing to take all of these items seriously: it's just a list.

THREATS TO BELIEVABILITY of "information" GATHERED WITHIN a plant

- Length of Incoming Inspection Queue (mat'l of unknown usability)
- Length of In-process Inspection / Test Queues (same issue)
- % of Quality Data Automatically Sensed (avoids inputting errors)

- Percentage of Material Moves Automatically Sensed in real-time
- Percentage of Non-Sensed moves Manually Keyed in real-time
- Absence of manual information-changing
- Paper (human writing gives errors both in writing and reading; can't be automatically checked for reasonableness):
  - Number of paper forms
  - Number of paper documents
  - Number of people on the floor who ever write anything down

- Number of information-collecting formats (confusion factor)

- WIP as percentage of actual process time (WIP may hide problems)

TIMELINESS of "information" INPUT TO a plant

- Hours from DEC Booking to effect on Component Vendor Orders

- Planning Pulse Rate (on-demand, hourly, daily, weekly, etc.):
  - Request / Commit
  - Parts Explosions
  - MRP
  - Vendor Orders
    (weekly deliveries may require hourly control!)

SMOOTHNES OF MATERIAL FLOW

- Material Move Pulse Rate (on-demand, hourly, daily, weekly, etc):
  - Vendor Deliveries
  - Kitting
  - Intra-process
  - Inter-process
  - Inter-Plant Deliveries
  - To Remote Distribution Centers
  - Customer Shipments

GRANULARITY (if coarse, leads to big lots: raises WIP)

- Number of units produced during time of one setup/tooling change
- Minimum economical lot size

- Average Diagnosis Time (size of bad-pile when process found bad)
- Diagnosis Time within which 95% of faults are identified
- Percent Defective exceeded by 5% of lots or on 5% of days

- Min. number of workers req'd to put one unit of work thru process
- Versatility: % of plant's jobs that median worker is skilled for

- Range of product complexity within economical process capability ("complexity": no. of ICs, no. of boards, BOM line items, VOP)
- Range of product type within economical process capability ("type": component, board, cable, mech. assy., box/unit, system)

UTILIZATION (production work vs. non-production work or costs)

- ECO value added
- Rework "value"

- Machine uptime (% of regular production hours)

- Data collection time (writing, keying, walking, talking)
- Data processing time (reading, calculating, graphing)
- Waiting time (waiting for information, supervision, material)
- Learning time

- Floorspace dedicated to WIP
- Walking time caused by obstructions
- Energy consumed (HVAC; products; equipment)

AUTOMATION FOCUS

- Percentage of Assemblies analyzed by GroupTechnology

- Percentage of jobs requiring workers to wear:
  - Dirt-protection (aprons, boots, etc.)
  - Cleanroom garb (bunnysuits, etc.)
  - Hazard protection (masks, gloves, etc.)

- Pixels (area scanned, divided by minimum just-tolerable flaw) inspected by eye
- Precision req'd in assembly

- Number of unique line items req'd (not common to other products)

- Percentage of skilled jobs open more than 3 months

4

PRIORITIZED METRICS (selected ratios involving Parameters above)

1 Paper In divided by Value Added (reams per $1M)
1 3 Sigma bracket width on Daily Shipment Value

2 Employees per $1M of Value Added
2 Assets per $1M of Value Added

3 Cycle Time divided by Process Time
3 WIP (hours)

4 Special-garb workers per $1M Value Added
4 Pixels inspected by eye per $1M Value Added

5 % Upside capacity increment avail. in 13 weeks
5 % Capacity conversion (complexity and/or type) avail. in 13 wks

COMPETITIVE POSITION; where we are Today vs. DEC competitors:

IGNORE	FOLLOWER	IN-THE-PACK	LEADER
Convergent Systems	DEC FA&(not T), Prime, D. G.	HP, DEC Terminals, NEC, Oki DEC Storage (mid-range)	Sharp, IBM, Hitachi, Epson/Sieko, DEC T (notFA), 2-stage mfg., Fujitsu

INVESTMENT IMPERATIVES

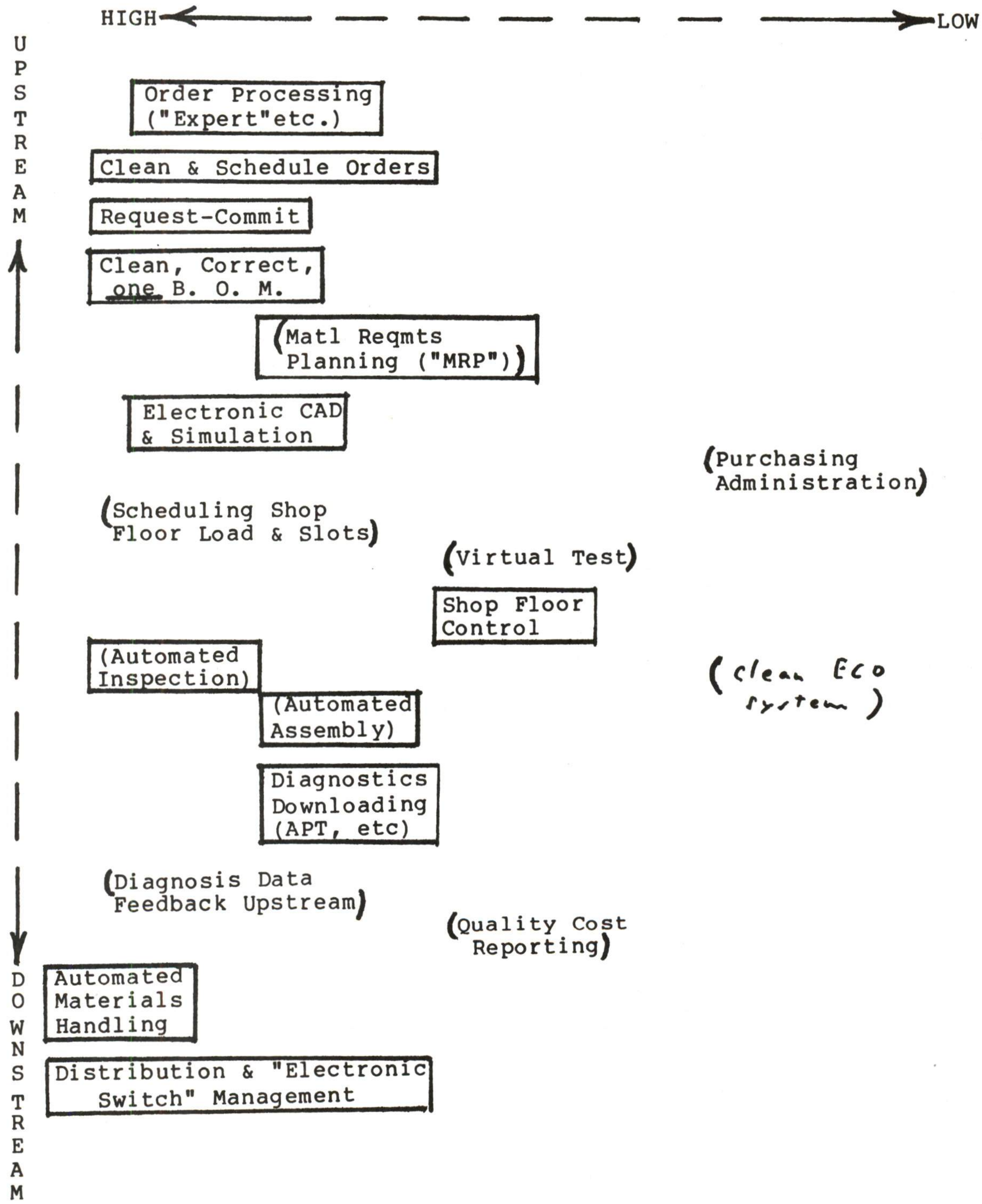
1 Speed up the information pulserate so NO category of routine Mfg. data flow happens less frequently than Weekly, including:
   - Orders Booked information
   - Inter-plant scheduling (request-commit, etc.)
   - Intra-plant scheduling (MRP etc.)
   - Purchasing releases to vendors
   - Shipping info to Sales & Customers
   - Labor Reports
   - Quality Cost information

2 Training / teaching / experiencing a "headset" that Knowledge and Inventory are to a large extent interchangeable; and that Knowledge is nearly always better than Inventory for quality, productivity, and responsiveness.
(Credible, automated knowledge generates trust.)

3 Exploiting design simulation and manufacturing automation to motivate a thorough, disciplined approach to an entire system (eg design, specs, diagnosis)

4 Inter / Intra Plant interlocking real-time MIS business system

R & AD INVESTMENT PRIORITIES



Key:
Boxed internal; parentheses (external). Upper-case SURPRISE
Perentheses within box means BOTH internal and external

LISTING OF TECHNOLOGIES - Background Information

CODING:

INTERNAL: Critical technologies to be developed internally

EXTERNAL: Necessary technologies to stimulate through external funding

SURPRISES: Technologies having potential of substantiall shifting industry direction

OTHERS: Technologies to be watched and/or ignored

1. SEMICONDUCTOR TECHNOLOGIES (Bob Supnik)

A. Processes

Internal: NMOS (till FY84) CMOS
External: (none)
Surprises: ECL, GaAs
Others: MNOS, TTL, CML, Josephson Junction, HEMT, InP, EEPROM, IG FET, DNA logic (!)

B. Process Technology

Internal: (buy): Optical Lithography, Ebeam/Xray Lithography, dry etch, resist, annealing, silicides, metalization, dielectrics, beam processing
External: (none)
Surprises: insulating substrates
Others: metal customization of buyout layers

C. Process Support
Internal: (buy):Surface analysis, device modeling, device reliability analysis
External: Process modeling
Surprises: Materials analysis, manufacturability analysis
Others: (none)

D. Design Techniques

Internal: Hierarchical Handcrafted
Internal: (buy): gate arrays, polycell
External: (none)
Surprises: (none)
Others: random

E. Silicon Architecture

Internal: Redundancy, testability, architectural transforms, silicon unique structures
External: Self-timed systems
Surprises: (none)
Other: Analog, linear, multilevel logic

F. Tools and testing

Internal: Hierarchical chip simulation including fault insertion, integrated chip data base, total chip verification, partial then total chip synthesis, design for test
Buy-out: Automatic test generation, testers
External: AI-based design and test techniques
Surprise: Leadless probe (SEM test)
Others: Microcode compiler, automated combinational logic design, LSSD, in circuit test, transmission modeling

STORAGE SYSTEMS TECHNOLOGIES (GEORGE HITZ)

EXTERNAL ALSO INCLUDES PURCHASED COMPONENTS AND GIVING VENDOR DIRECTION IN PRODUCT DEFINITION

1. GENERAL TECHNOLOGIES

INTERNAL: READ/WRITE & CODES, SERVO & DRIVE LOGIC, MECHANICS, LSI, HEADS, SYSTEMS, ARCHITECTURE

EXTERNAL: LSI FAB, COMMODITY LSI, CUSTOM LSI, PACKAGING, POWER SUPPLIES

SURPRISES:

OTHER:

2. FLOPPY DISK STORAGE

INTERNAL: HEADS

EXTERNAL: FLEXIBLE MEDIA, HEADS

SURPRISES:

OTHER:

3. MAGNETIC DISK STORAGE

INTERNAL: HEADS, RIGID MEDIA

EXTERNAL:

SURPRISES:

OTHER:

4. MAGNETIC TAPE STORAGE

INTERNAL: HEADS

EXTERNAL: HEADS

SURPRISES:

OTHER: MEDIA

5. OPTICAL DISK STORAGE

INTERNAL:

EXTERNAL: MEDIA, DRIVES FOR WRITE ONCE, LASER REFLECTIVE VIDEO/AUDIO DISK

SURPRISES: MAGNETO-OPTIC

OTHER:

6. SOLID STATE MEMORY

INTERNAL:

EXTERNAL: DYNAMIC, STATIC, NON-VOLATILE RAM, ROM SERIAL "RAM", BUBBLE

SURPRISES:

OTHER:

3. COMMUNICATIONS/NETS (Tony Lauck)

A. Communication Services

Internal: (none)
External: (none)
Surprises: (none)
Other: Teleconferencing, Videotex

B. Network Operations

Internal: Network test and diagnosis
External: (none)
Surprises: (none)
Other: (none)

C. Network Design

Internal: SNA compatibility
External: Open systems architecture
Surprises: (none)
Other: (none)

D. Protocol and Data Representation Standards

Internal: (none)
External: Telidon, Antiope Prestel, Teletex, Bildshormtex, Captain, FAX
Surprises: (none)
Other: (none)

E. Digital Networks & Telephone Switching

Internal: Compatibility with integrated digital service nets and PBX's
External: (none)
Surprises: (none)
Other: (none)

F. Communications Interfaces

Internal: Local area interconnect adaptors, cable television(adapters), telephone modems, broadband modems
External: Codecs (?)
Surprises: (none)
Other: (none)

G. Microwave Communications

Internal: (none)
External: (none)
Surprises: (none)
Other: digital radios, satellite, communication links, cellular radio

H. Optical Communicatons

Internal: Infrared transceiver links (within a room)
External: cross-building infrared transceiver links
Surprises: fiber optics (internal buy)
Other: (none)

I. Signalling

Internal: (none)
External: (ECC)
Surprises: (none)
Other: Signal integrity, signal processors, signal detectors, modulation techniques,

J. Optical Components

Internal: (none)
External: (none)
Surprises: (none)
Other: Integrated optics, semiconductor laser, optical fiber material technology

4. POWER AND PACKAGING (Henk Schalke, Joe Chenail)

A. Interconnects

Internal: bumps, passive & active slabs, conformal spiders
External: (none)
Surprises: (none)
Other: RC chips or wedges, traditional TAB, wafer scale integration, co-fired and thick film ceramics

B. Printed Circuits

Internal: Impedance control, multiwire, blind vias surface mount
External: (none)
Surprises: laser enhanced etching
Other: Additive processing, flexprint, metal core, polymide

C. Packaging & Cooling

Internal: Hostile environments, acoustics, EMI/EMC (use optical and magnetic components, aesthetics, local heat pipes, air flow modeling, 5W/chip
External: (none)
Surprises: (none)
Other: Free air optical signalling,liquid cooling/plumbing, cooling functions, plastics, critical materials, (gold, siler, tantalium, cobalt, chromium) dangerous materials (e.g. berylium, cadmium)

D. Power Conditioning

Internal: Local regulation, 2 volt power, power hybrids
External: (none)
Surprises: (none)
Other: glassy metals, active rectifiers, ferrites, optical power transmission, distribution drops (power factor correction)

5. COMPUTING SYSTEMS (Don Gaubatz, Peter Jessel, Roy Rezac)

A. Computer Architecture

Internal: Capability-based machines, non-numeric computation
External: HLL-restricted machines
Surprises: Floating point standard
Other: Theory of computation, automata theory

B. Parallel Processing

Internal: VLSI processor arrays, pipeline machines
External: (none)
Surprises: inference engines, dataflow machines, non-vonNeumann architectures
Other: FFT engine, Vector processor, processing by optical effects

C. Computer Performance

Internal: End user productivity/performance (product positioning), network measurement and analysis tools, load drivers for end user and network environments
External: Modeling tools
Surprises: (none)
Other: (none)

6. HUMAN FACTORS (Russ Doane)

A. Physical Factors

Internal: Front design, flicker (visual) fatigue, ergonomics, ergonomic standards (radiation, health, safety)

External: (character) intelligibility

Surprises: (none)

Other: (none)

B. Cognitive Factors

Internal: self-training systems, limited training interfaces, user-installability (modular packaging)

External: (none)

Surprises: (none)

Other: (none)

7. TERMINALS AND WORKSTATIONS(Walt Tetschner)

A. Voice

Internal:	(buy): Phonetic recoding & smoothing algorithms Text-to-speech subsystems, digital telephone voice messaging (waveform encoding), Voice messaging (parametric encoding).
External:	Word recognition (speaker dependent & independent)
Surprises:	Speaker recognition
Other:	Speaker recognition, voice response (canned)

B. Printers

Internal:	Impact matrix, Electro-photographic
External:	Band
Surprises:	(none)
Other:	Thermal, electrosensitive, electrostatic, electromagnetic, daisy wheel, band, drum, thermal transfer, piezoelectric...

C. Mechanisms/Electromechanical

Internal:	Sheet feeding, shuttle, re-inking ribbons, films ribbons, color ribbons, stored energy print heads
External:	Stepper motors, DC servo motors, disc encoders, linear motors, Galvo scanner, acousto-Optic scanner, photoconductor, toners, fusers, illuminators
Surprises:	(none)
Other:	(none)

D. Scanners

Internal:	Bar code/graphic input on impact matrix printers, Group III Facsimile on Electrophotographic printers
External:	CCITT standards
Surprises:	(none)
Other:	Wand

E. Keyboards

Internal:	Typewriter style mechanical, soft labels, low profile
External:	ANSI keyboard standards
Surprises:	(none)
Other:	Touch panel, LED Magnetic, elastomer...

F. Spatial I/O

Internal: Cursor positioning devices
External: (none)
Surprises: (none)
Other: Touch Screen, tablets, mouse...

G. Terminal Controllers

Internal: Video custom VLSI, Printer custom VLSI
External: (none)
Surprises: (none)
Other: (none)

H. Softcopy displays

Internal: Monochromatic CRT's (240-960 lines, 12"-17"), Color Crt's (480 lines, 15")
External: Color CRT's (480 lines, 19") LCD message panels, LCD 1/4 page displays
Surprises: Home TV high resolution displays
Other: Plasma, electroluminescent, LED, Fluorescent, Ferroceramic, electrochromism, electrophoresis, incandescent...

I. Natural Image Processing

Internal: Frame grabbers, display of natural images. text & computer graphics
External: Videodisc. CATV, TV camera
Surprises: (none)
Other: (none)

J. Terminal System Architecture

Internal: Backwards compatibility, host/terminal function migration
External: (none)
Surprises: (none)
Other: (none)

8. SOFTWARE (Bill Keating)

A. Software Process & Methodology

Internal:	Architecture, design, implementation, management, metrics, verification/validation, maintainability, documentation, packaging standards, consistency-over-products, performance
External:	Design & architectural tools, proof of correctness
Surprises:	Error free programming, embedded (in software) documentation, new package/delivery of software
Other:	(none)

B. Operating Systems

Internal:	Human Factors, Hi reliability/recovery, security, Hi availability, addressing, performance, data integrity, realtime, distribution of functions, special purpose servers & systems, object based systems
External:	Provably secure systems, (monitor)
Surprises:	Fully distributed OS
Other:	(none)

C. Languages

Internal:	Compiler design, integrated language environment, A/I languages, language design (for end-user, and high productivity professionals), cognitive factors, integration with D & E
External:	Languages (probably special purpose) (monitor)
Surprises:	New breakthough man/machine programming interface
Other:	(none)

D. Database Management

Internal:	Data/information integrity, distributed data management, relational data bases, query/access languages, information management, integrated text/data/voice, addressing, security/cryptology
External:	New data base approaches (monitor)
Surprises:	Hardware assisted data management
Other:	(none)

E. Application Tools

Internal:	Transaction processing, forms management, graphics, software development and management tools, distribution of these
External:	Monitor above areas for new developments
Surprises:	New breakthroughs
Other:	(none)

F. Office Tools

Internal: Human/Cognitive factors, text management, office graphics, voice, image, integration with DP, compatibility with DEC traditional SW Architectures
External: Video
Surprises: New breakthrough in man/machine dialogue
Other: (none)

G. Distributed Data Processing

Internal: Distributed functions, distributed application, distributed data, network (Local & dist) management/installation, servicing, network addressing, foreign (especially IBM) communication/cooperation, evolving Nets for customer
External: Standards (formal & ad hoc)
Surprises: Revolutionary approach

I have not covered several other Software Areas which are critical to the success of the above (Networking and Intelligent Terminals). I assume these will be covered elsewhere.

CHAPTER V

QUANTITATIVE MEASURES

A) DIGITAL'S ENGINEERING INVESTMENT
   1) LRP numbers and Engineering Budget
   2) Competitive Engineering Investment - no lag
      - 2 yr lag
      - Growth to investment correlation graph

B) PRODUCT POSITIONING
   - Benchmark Systems: Price vs Time at 20% decline chart
   - Price Band Charts: 16-B, 32-B, 36-B, Terminals, Printers, Storage
   - System Positioning Charts, Gestation Chart

C) CE BUDGET OVERVIEW - FY82-86
   - Expense by organization
   - Expense by activity

D) TESTS OF BUDGET ALLOCATION
   - NOR by price band and architecture (Oct 81 Data)
   - NOR by price band and architecture (Nov 80 Data)
   - Comparison of Oct 81 data with Nov 80 data (2 pgs.)
   - Revenue shift over time by architecture
   - Products in each price band
   - Revenue/Investment comparison by architecture
   - Revenue/investment comparison by price band

E) MARKET SIZE
   - Segmentation, size, growth rate, shares
   - IBM revenues by System type, price band

F) FINANCIAL METRICS OF BUSINESS PLANS
   - Cash breakeven charts
   - NOR vs IRR - Systems
     - Storage
     - Terminals

G) P.G. ENGINEERING EXPENDITURES - FY83-86

D. CLINTON
2/3/82

A) DIGITAL'S ENGINEERING INVESTMENT

ENGINEERING INVESTMENT
LRP

	ACT 80	ACT 81	LRP 82	LRP 83	LRP 84	LRP 85	LRP 86
MLP ($B)	2.2	2.9	3.6	4.6	6.0	7.7	9.9
NES ($B)(LRP IS APPX.)	1.8	2.4	2.9	3.7	4.9	6.2	8.0
NOR ($B)	2.4	3.2	4.0	5.1	6.8	9.0	11.8
CENTRAL ENGINEERING ($M)	133	178	254	347	446	579	753
% NOR	5.6%	5.6%	6.4%	6.8%	6.6%	6.4%	6.4%
P/L ENGINEERING ($M)	45	58	73	85	107	144	186
MANUFACTURING ENGINEERING ($M)	9	16	21	33	43	55	71
ALL ENGINEERING % NOR	7.9 %	7.9 %	8.7 %	9.1 %	8.8 %	8.6 %	8.6 %

OBSERVATION: Central Engineering is expected to increase its historical spending proportions of NOR.

SOURCE:
1) Corporate LRP dated December 1981.
2) Central Engineering expense from Engineering Budget as of January 1981 for FY82,83,84. Fy85,86 grown 30% on FY84 base.

D. CLINTON
2/1/82

A) DIGITAL'S ENGINEERING INVESTMENT

COMPETITIVE ENGINEERING INVESTMENT
--2 YEAR LAG--

Key Competitors in Box

	ENG % NOR (2 YEAR LAG)	EST/REAL ENG EXP 3 YEARS 1979-1981 ($ MILLION)	EST NOR 3 YEARS 1981-1983 ($ BILLION)
FUJITSU	7.2%	$640	$ 8.8
DG	7.2%	192*	2.7
HP	6.0%	839	13.9
DEC	4.7	576	12.3
IBM	4.5	4580	102.9
PRIME	4.3%	65	1.4
NEC	3.4%	563	16.3
WANG	3.2%	121	3.7
HITACHI	2.9	1475	51.6
TANDEM	2.3%	32	1.4

*D.G.: "Real investment is probably $160M or 5.9%

D. CLINTON
2/2/82

A) DIGITAL'S ENGINEERING INVESTMENT

COMPETITIVE ENGINEERING INVESTMENT NO LAG

Key Competitors in Box

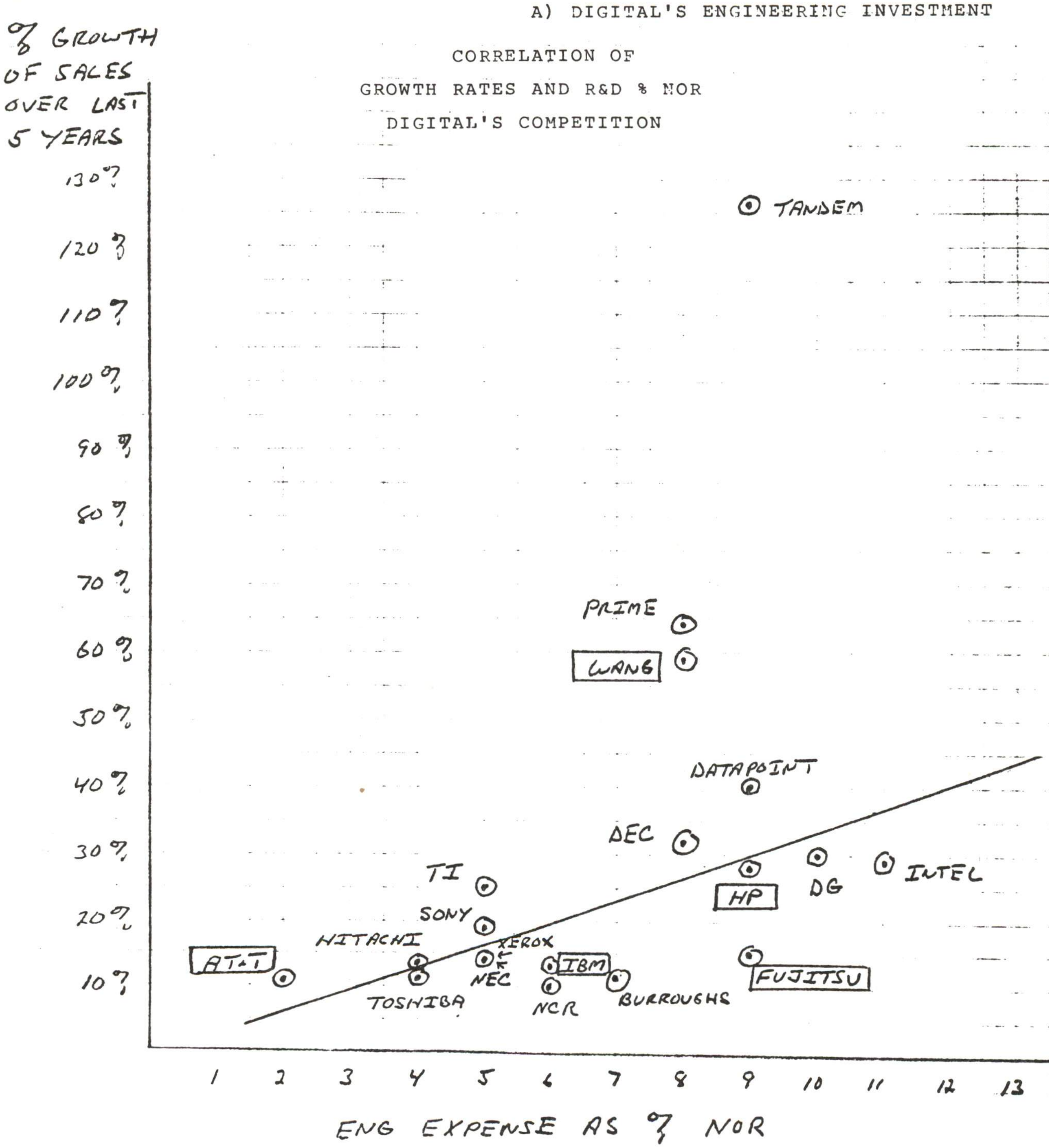
	ENG EXP AS A % OF NOR	APPX ANNUAL SALES GROWTH OVER PAST 5 YRS
DG	10 %	30 %
¦FUJITSU¦	9	15
¦HP¦	9	27
DATAPOINT	9	40
TANDEM	9	126
¦DEC	8	32
¦WANG¦	8	59
PRIME	8	64
BURROUGHS	7	12
NCR	6	10
¦IBM¦	6	13
XEROX	5	14
SONY	5	18
NEC	5	14
TI	5	25
HITACHI	4	13
TOSHIBA	4	12
AT&T	2	11

SOURCE: FY81 OR FY80 ANNUAL REPORTS OR 10K OR FY81 EARNINGS ANNOUNCEMENTS

D. CLINTON
2/2/82

A) DIGITAL'S ENGINEERING INVESTMENT

CORRELATION OF
GROWTH RATES AND R&D % NOR
DIGITAL'S COMPETITION

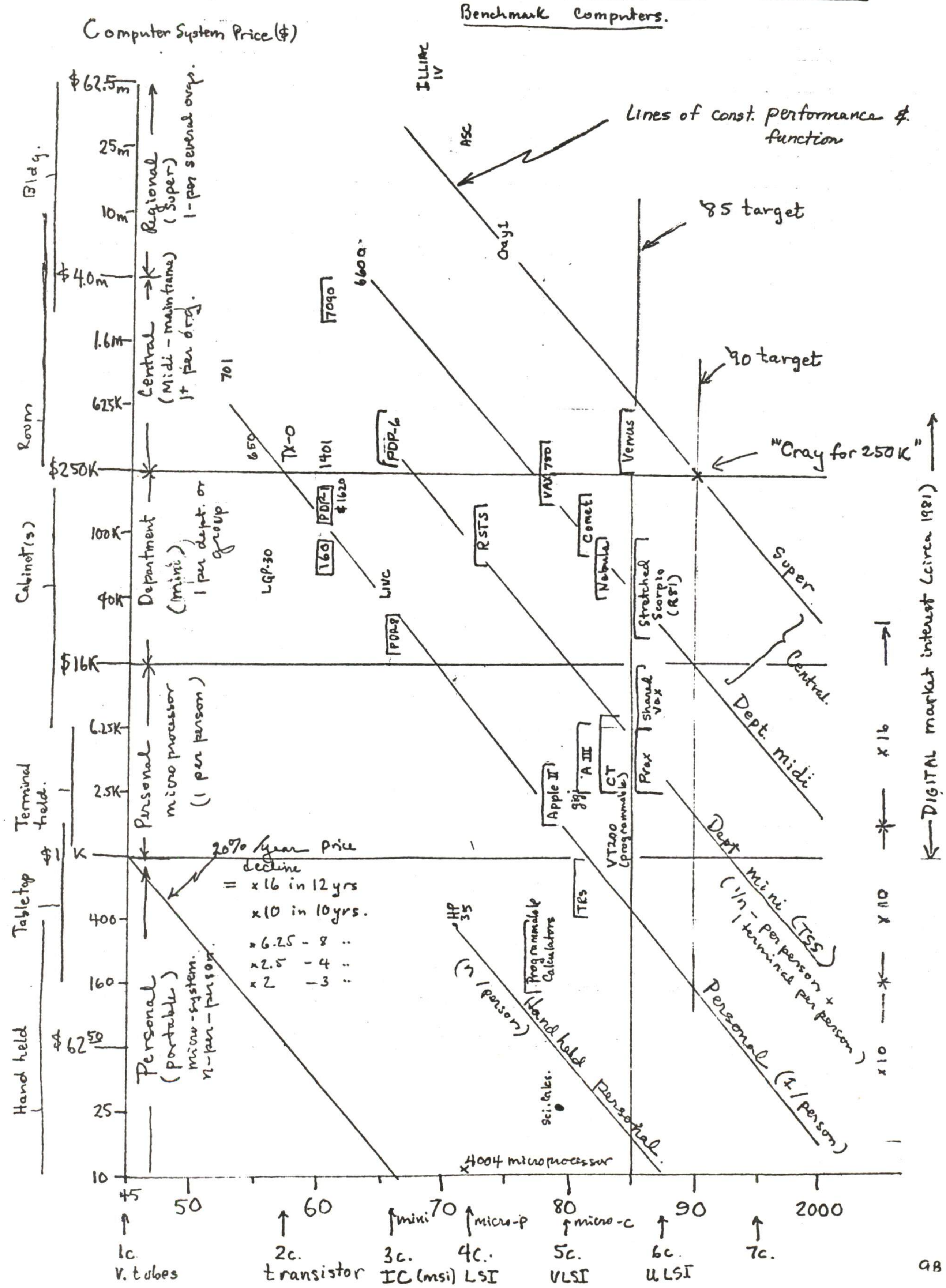


OBSERVATIONS:

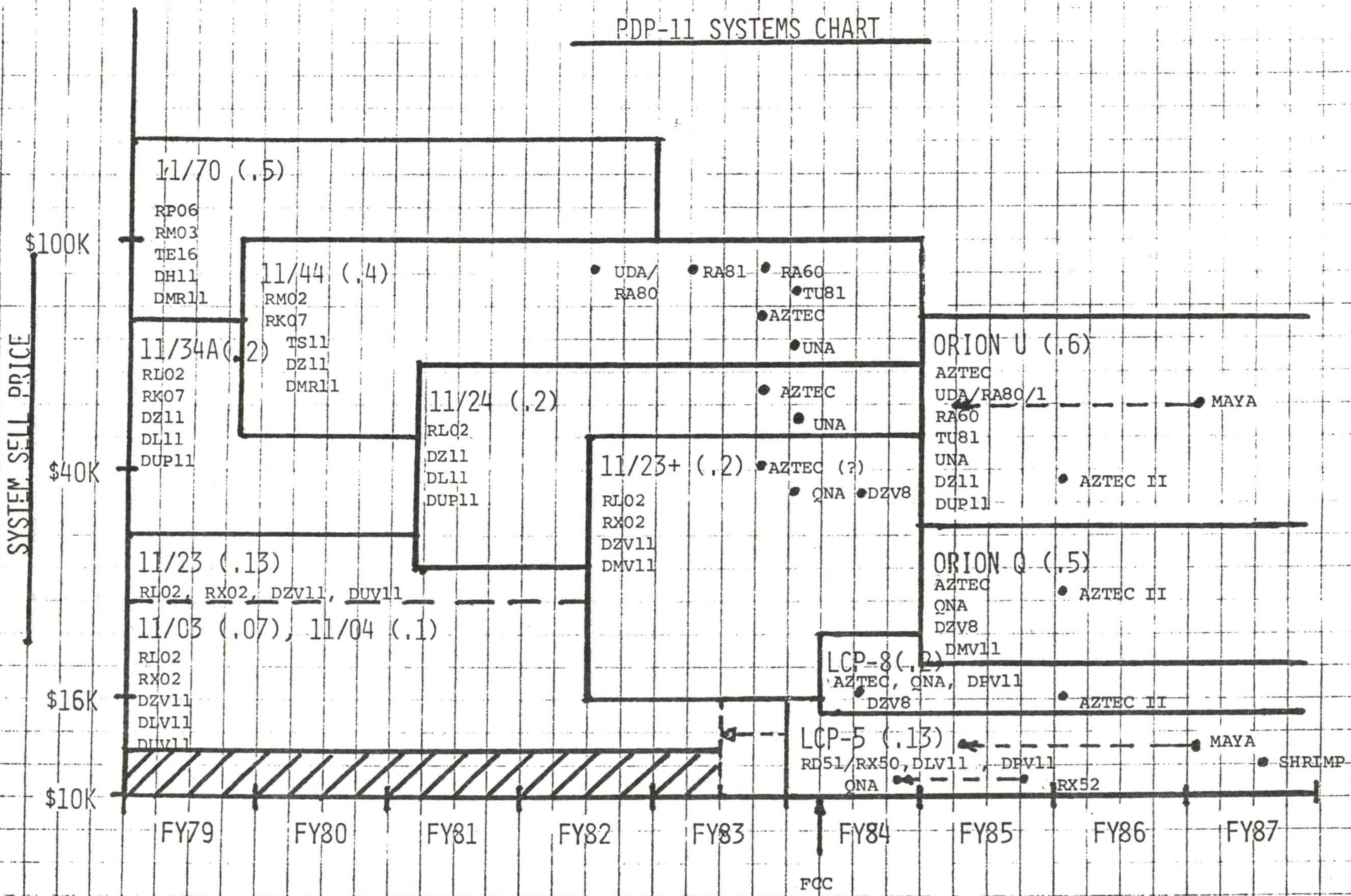
1) For the Computer Industry, there is a positive correlation between growth and size of R&D investment.
2) Of the competitors above the trend line, WANG and PRIME have very focused product offerings. In contrast, IBM and FUJITSU, although much larger, have procducts across a very broad range. Clear product focus may correlate with higher growth.

SOURCE: CORPORATE ANNUAL REPORT

Fig. GC Computer System Price Versus Time for Various Benchmark Computers.



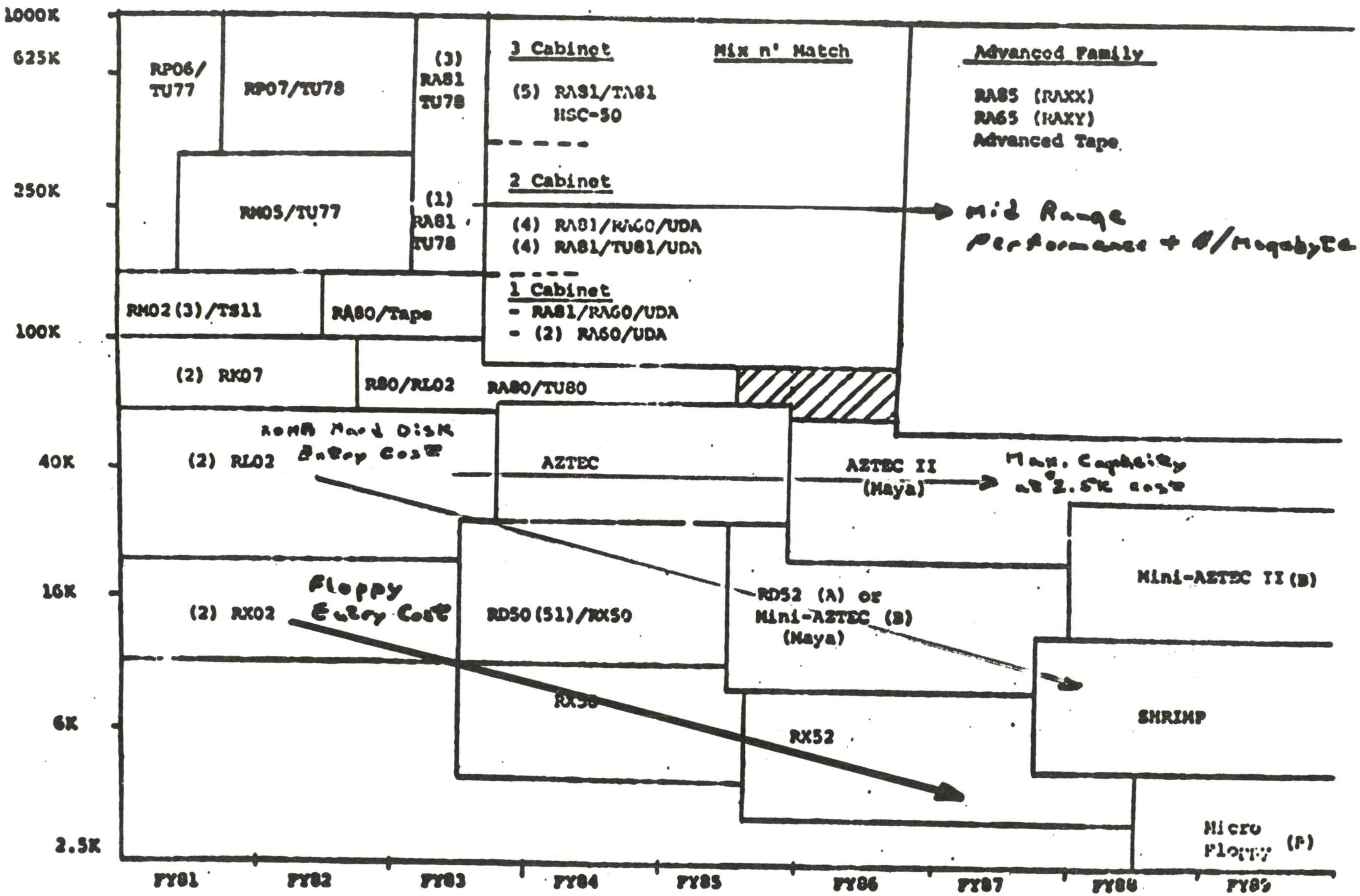
PDP-11 SYSTEMS CHART

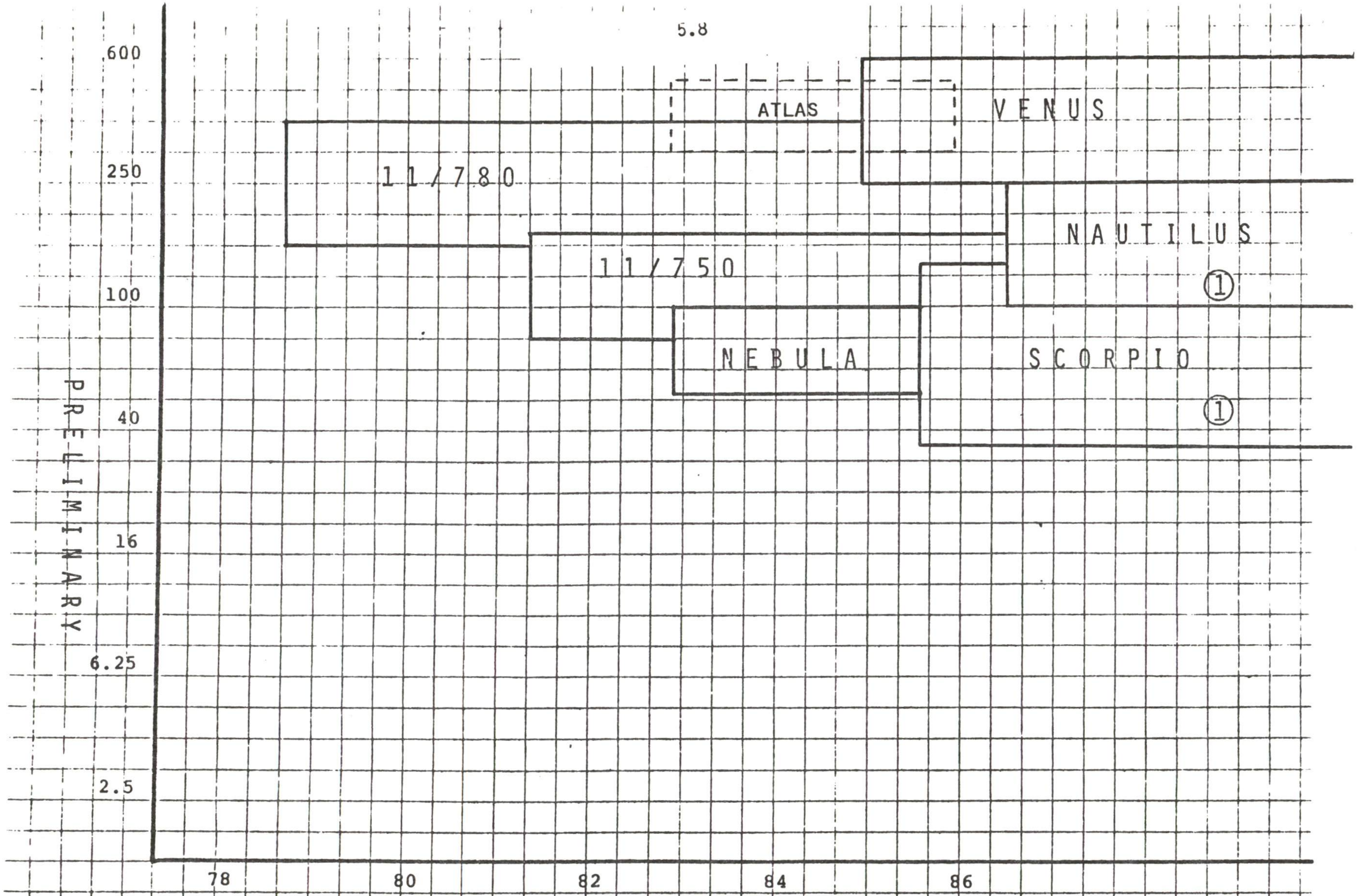


( ) = PERFORMANCE RELATIVE TO 11/780 = 1

1/82

STORAGE SUBSYSTEM PLAN (SCENARIO A,B) - 12/81



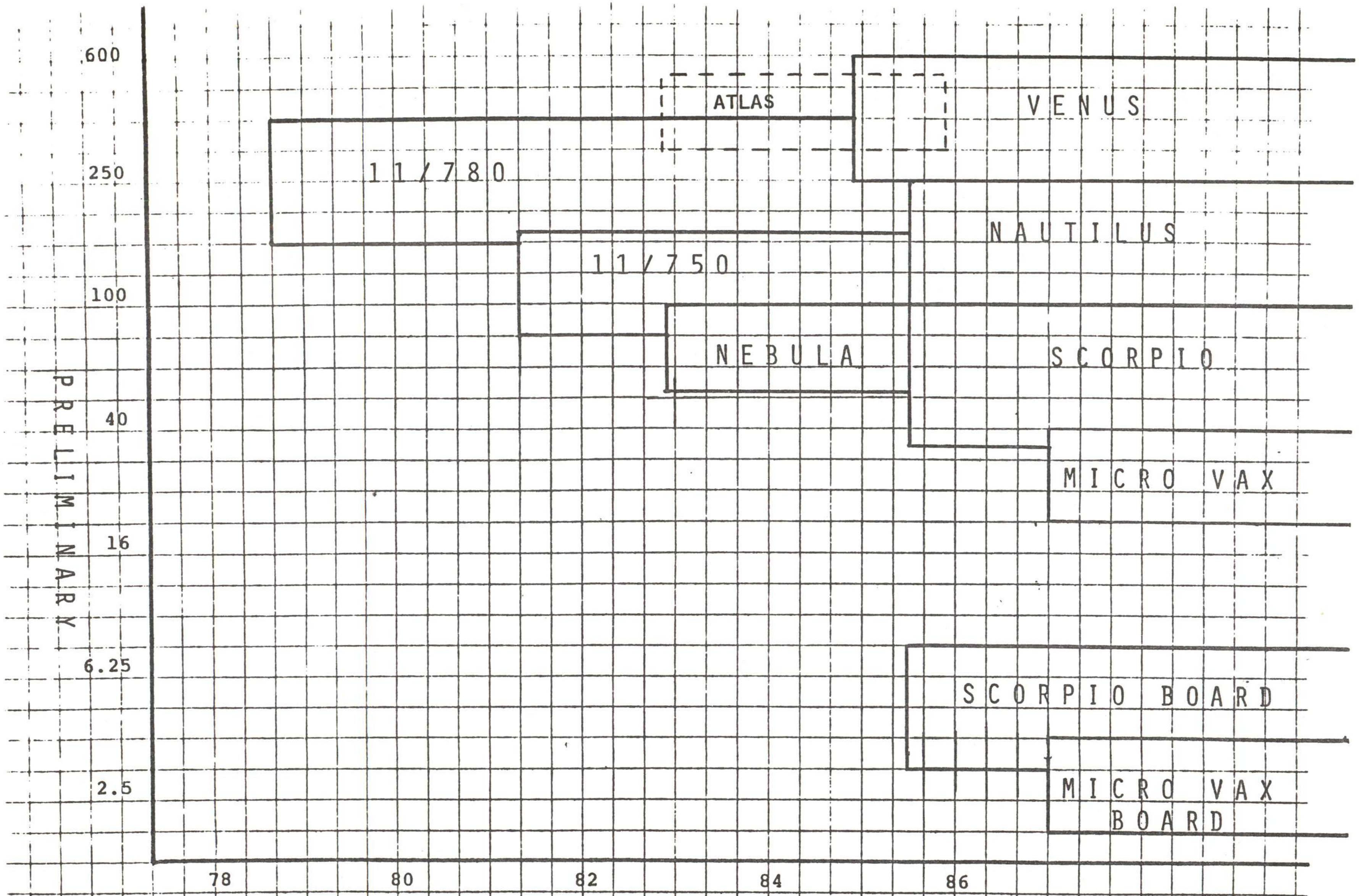


A SCENARIO

1/14/82

1 NON BI, NO PKG.

12/4/81

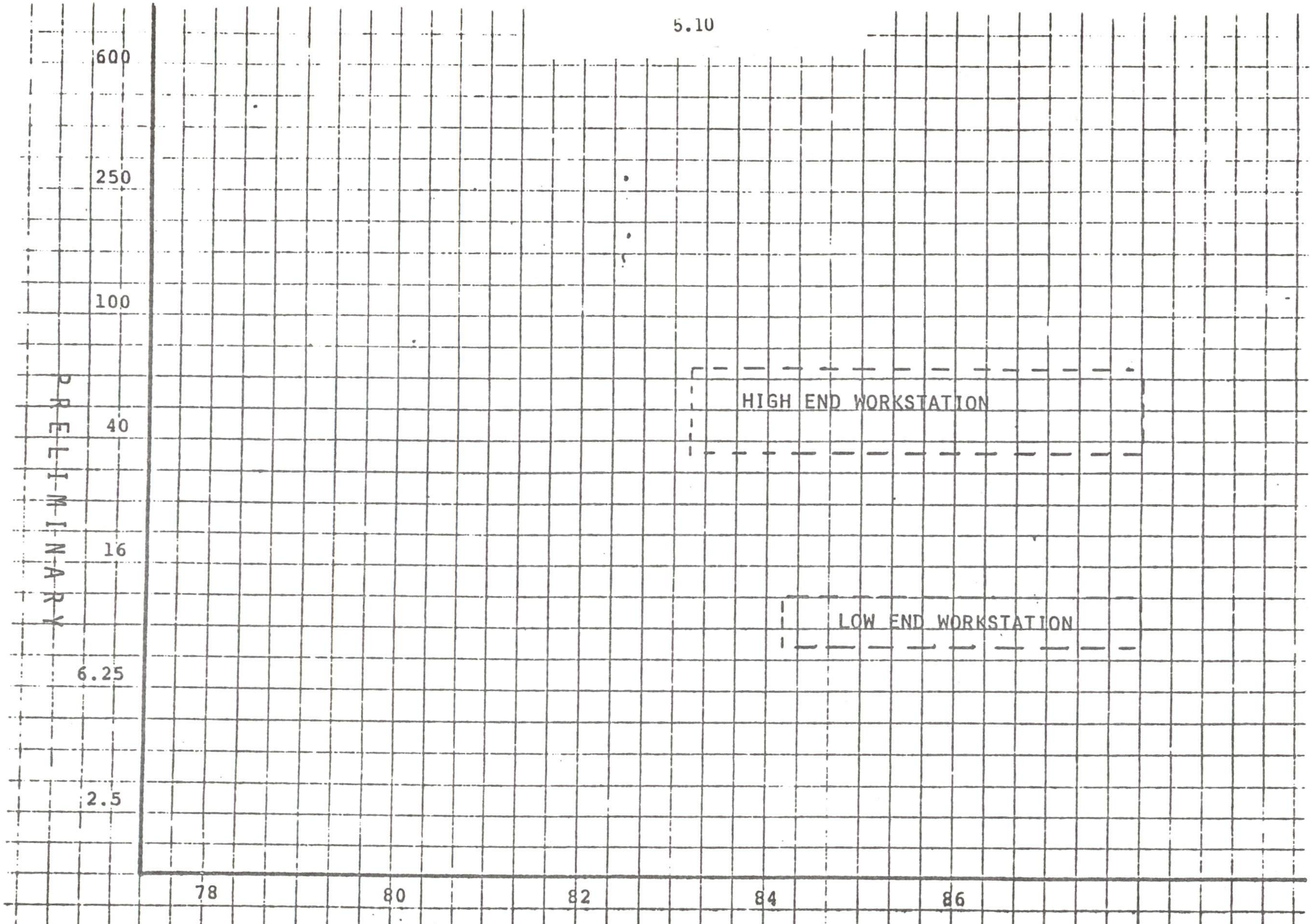


B SCENARIO (for reference only)

5.9

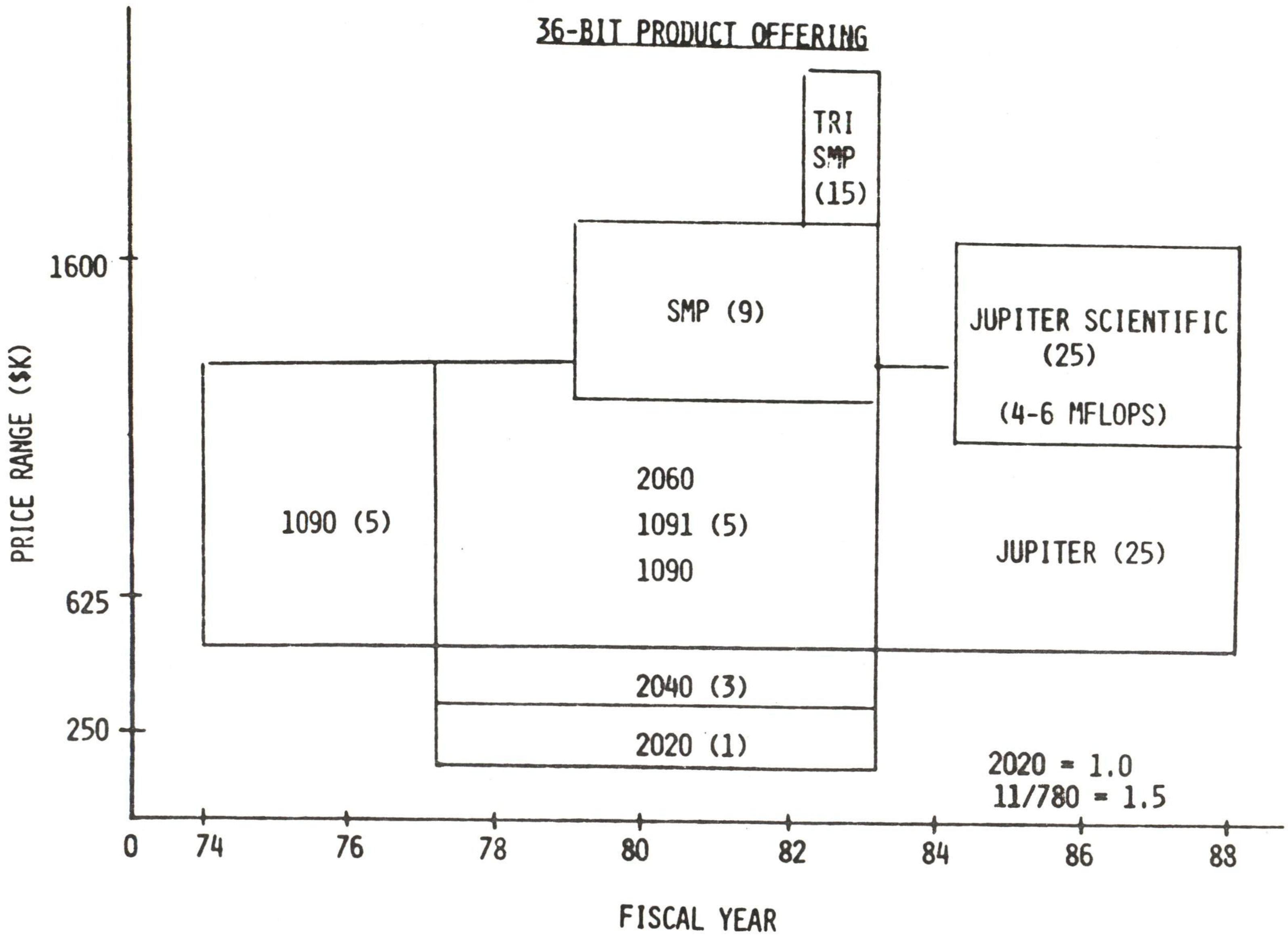
1/14/82

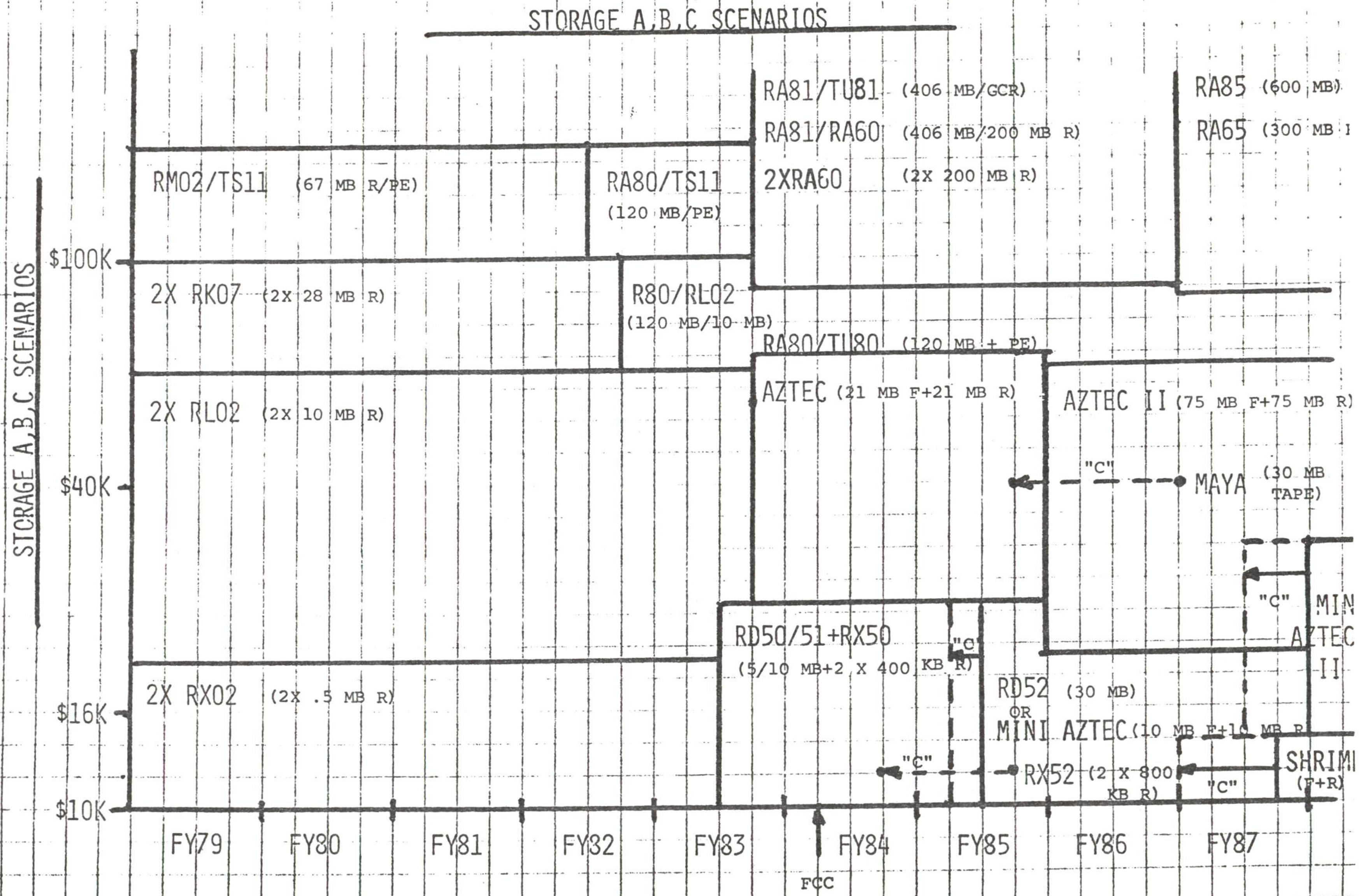
12/4/81

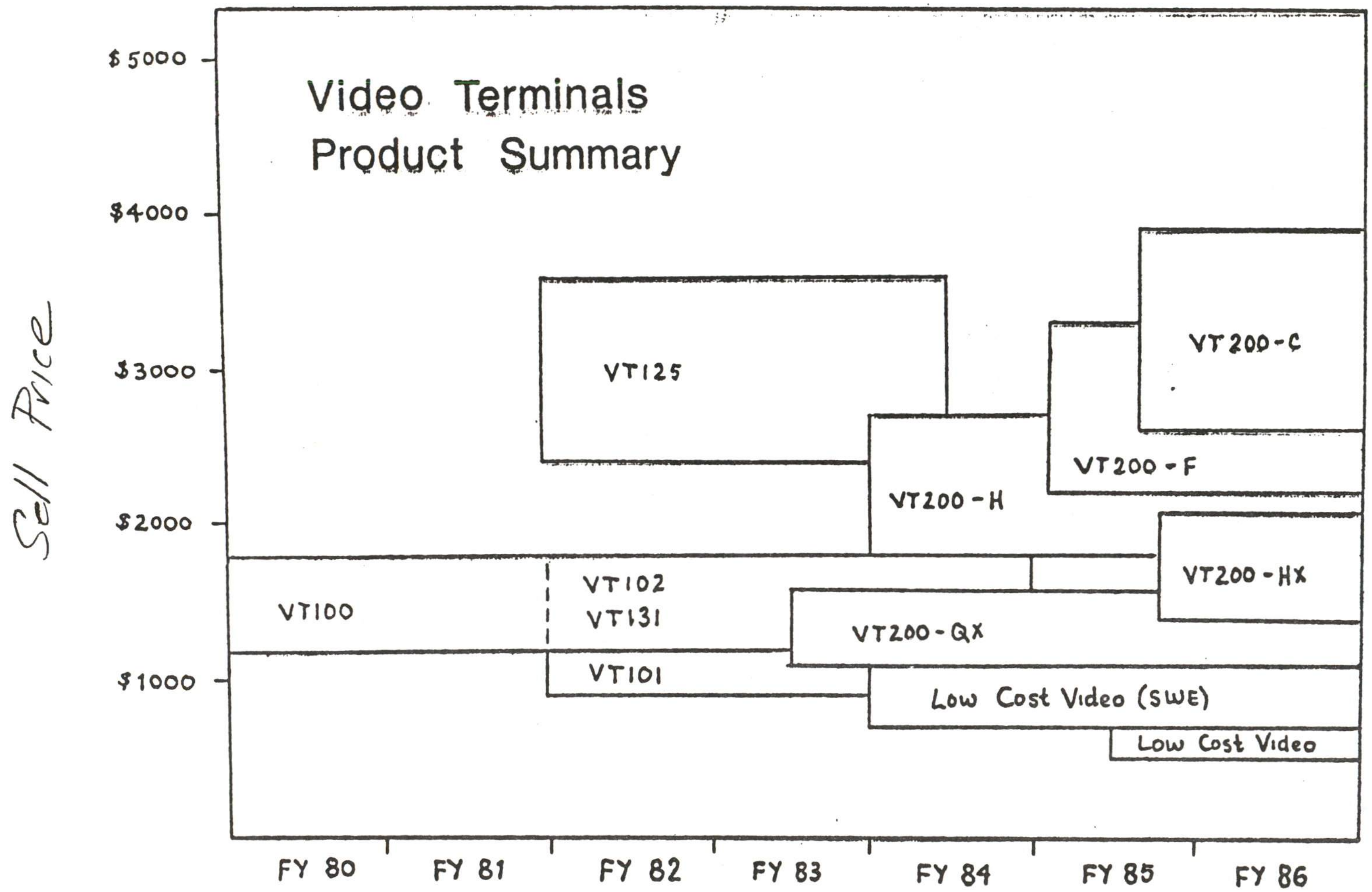


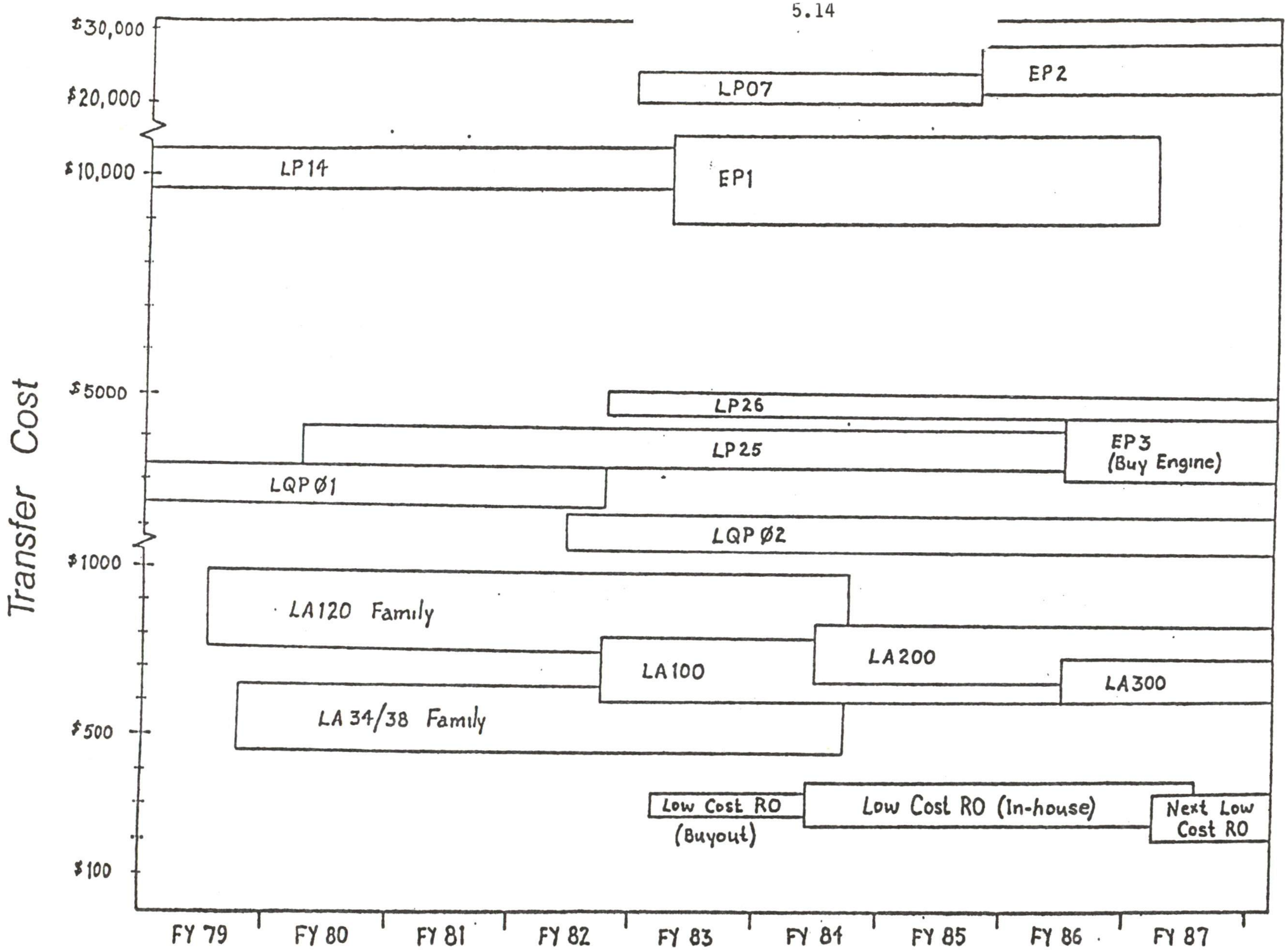
B AND C SCENARIO (for reference only) 12/4/81

36-BIT PRODUCT OFFERING



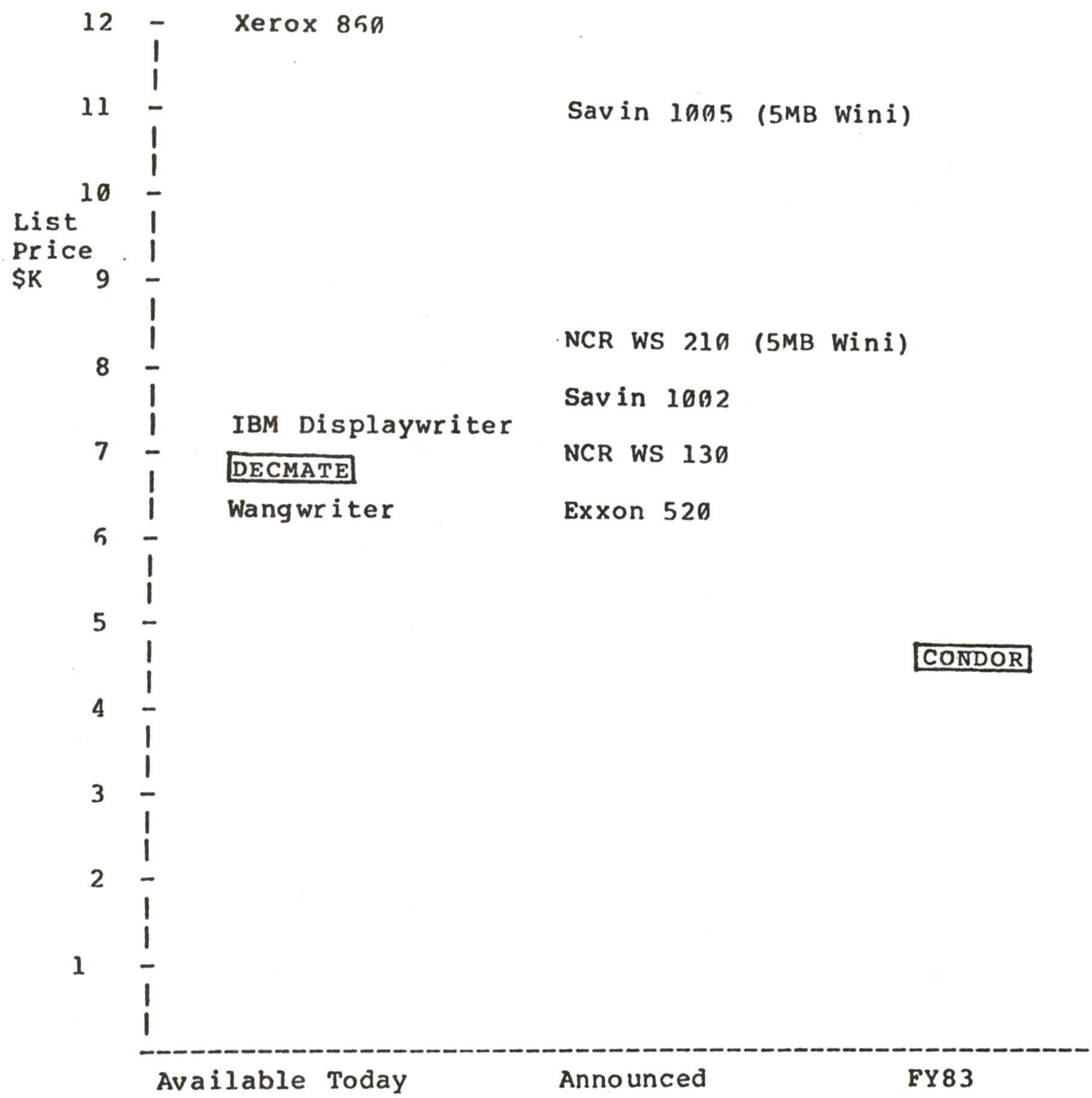

STORAGE A,B,C SCENARIOS
STORAGE A,B,C SCENARIOS
$100K
$40K
$16K
$10K
RM02/TS11 (67 MB R/PE)
RA80/TS11 (120 MB/PE)
RA81/TU81 (406 MB/GCR)
RA81/RA60 (406 MB/200 MB R)
2XRA60 (2X 200 MB R)
RA85 (600 MB)
RA65 (300 MB
2X RK07 (2X 28 MB R)
R80/RL02 (120 MB/10 MB)
RA80/TU80 (120 MB + PE)
2X RL02 (2X 10 MB R)
AZTEC (21 MB F+21 MB R)
AZTEC II (75 MB F+75 MB R)
"C"
MAYA (30 MB TAPE)
"C"
MIN AZTEC II
RD50/51+RX50 (5/10 MB+2 X 400 KB R)
"C"
2X RX02 (2X .5 MB R)
RD52 (30 MB) OR MINI AZTEC (10 MB F+10 MB R
"C"
RX52 (2 X 800 KB R)
"C"
SHRIM (F+R)
FY79
FY80
FY81
FY32
FY83
FY84
FY85
FY86
FY87
FCC


Video Terminals
Product Summary
Sell Price
$5000
$4000
$3000
$2000
$1000
VT125
VT200-C
VT200-F
VT200-H
VT100
VT102
VT131
VT200-HX
VT200-QX
VT101
Low Cost Video (SWE)
Low Cost Video
FY 80
FY 81
FY 82
FY 83
FY 84
FY 85
FY 86


$30,000
$20,000
$10,000
$5000
$1000
$500
$100
Transfer Cost
EP2
LP07
LP14
EP1
LP26
EP3
(Buy Engine)
LP25
LQPØ1
LQPØ2
LA120 Family
LA200
LA100
LA300
LA 34/38 Family
Low Cost RO
(Buyout)
Low Cost RO (In-house)
Next Low
Cost RO
FY 79
FY 80
FY 81
FY 82
FY 83
FY 84
FY 85
FY 86
FY 87

Hardcopy I/O

WORD PROCESSING SYSTEMS



Configurations exclude printers and application software, are dual floppy-based or Winchester/floppy-based (Wini capacity is stated), with memory necessary to run target applications.

NCR and Savin systems are based on Convergent Technology's AWS system family. The Exxon 52Ø is based on a CompuCorp. System.

SMALL BUSINESS COMPUTERS

List Price $K

12 – DG Enterprise 3000 (12.5MB Wini)

11 –

10 – D315 IBM Datamaster

9 – Fortune 32:16 (10MB Wini)

8 – TRS 80-II (8.3MB Wini)
Vector 3005 (5MB Wini)
CT150 10MB Wini

7 – DG Enterprise
Apple III (5MB Wini)

6 –

5 –

4 –

3 –

2 –

1 –

Available Today | Announced | FY83

Configurations exclude printers and application software, are dual floppy-based or Winchester/floppy-based (Wini capacity is stated), with memory necessary to run target applications.

PROFESSIONAL COMPUTER WORKSTATIONS

List Price $K	Available Today	Announced	FY83
40			Nebula (20MB and up)
30	Apollo Domain (33MB Wini) Three Rivers Perq (12MB Wini)		
20	Convergent IWS 2200 (10MB Wini) Xerox Star (10MB Wini)		
10		Convergent AWS 240 (5MB Wini) Fortune 32:16 (10MB Wini)	
9			
8			CT150 (10MB Wini)
7	DG Enterprise HP 125	Convergent AWS 230	
6			
5			CT120
4	IBM PC	Convergent AWS 210 (No Mass Storage)	CT25 CAT
3			
2			
1			

Configurations exclude printers and application software, are dual floppy-based or Winchester/floppy-based (Wini capacity is stated), with memory necessary to run target applications. COMPANY CONFIDENTIAL

DIGITAL PRODUCT SPACE ANALYSIS

The enclosed figures examine product group characteristics from a composite price-performance-time point of view as follows:

Figure 1 groups our products along lines of constant performance. The 11/03, 11/34, 11/44, 11/70, 11/780 and 11/782 serve as pivots for the different Iso-performance curves.

Figure 2 positions our products per the $1K-2.5K-6.25K-40K-100K-250K-625K Iso-price-bands lines.

Figure 3 breakes the product space by three major "vintage periods": The 1975-1976, 1980-1982, and 1984-1985 (introduction year) periods. Products introduced in other years are depicted as well; their relative "goodness" is measured by their proximity to the aforementioned period lines.

Figure 4 depicts our products' excellence (in terms of price/performance merit index) versus machine size class. Contrary to the intuitive expectation, diseconomies of scale seem to be indicated.

In all four figures arrows are used to denote (hypothetical) product adjustment to their "appropriate" lines.

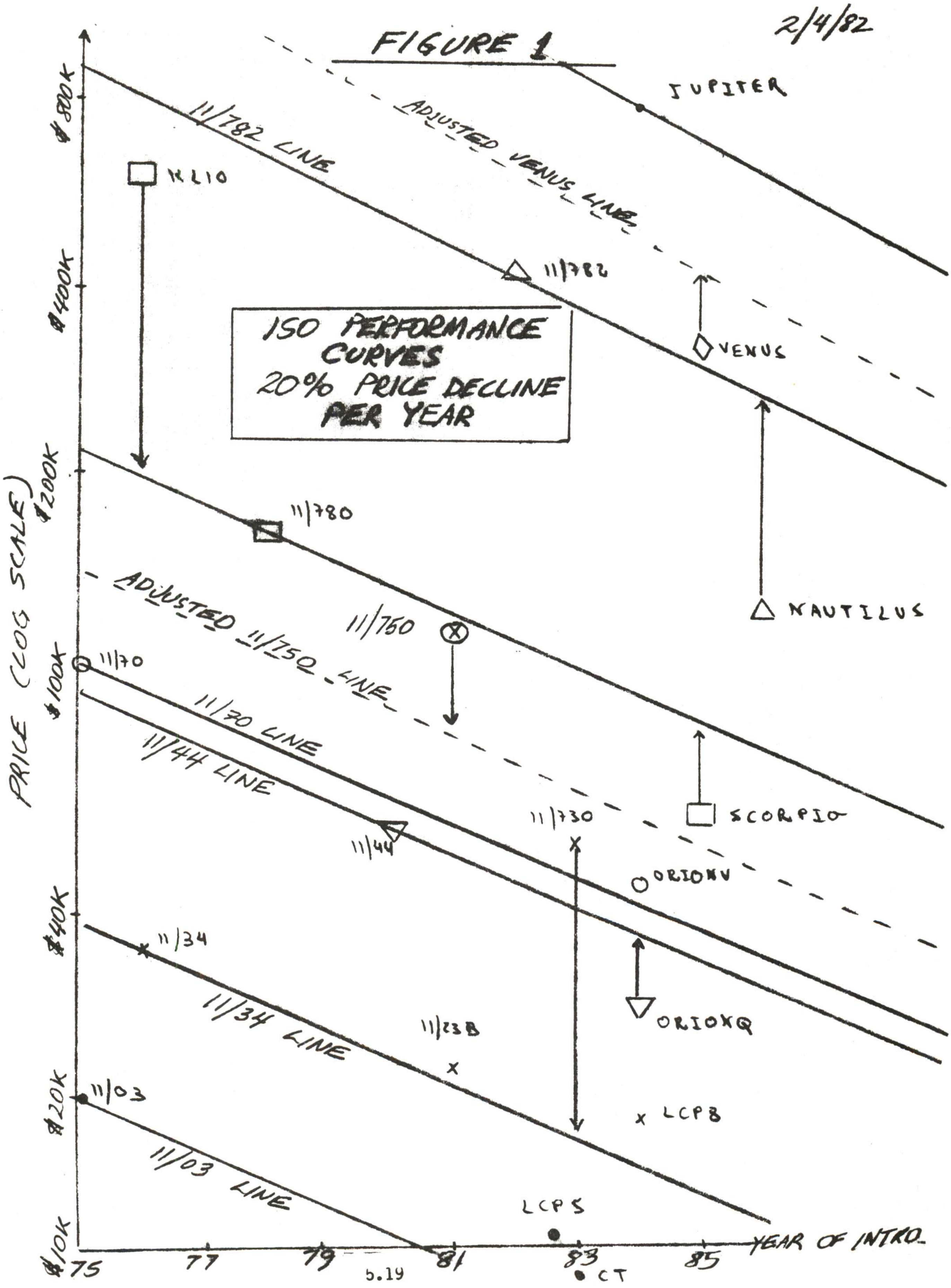
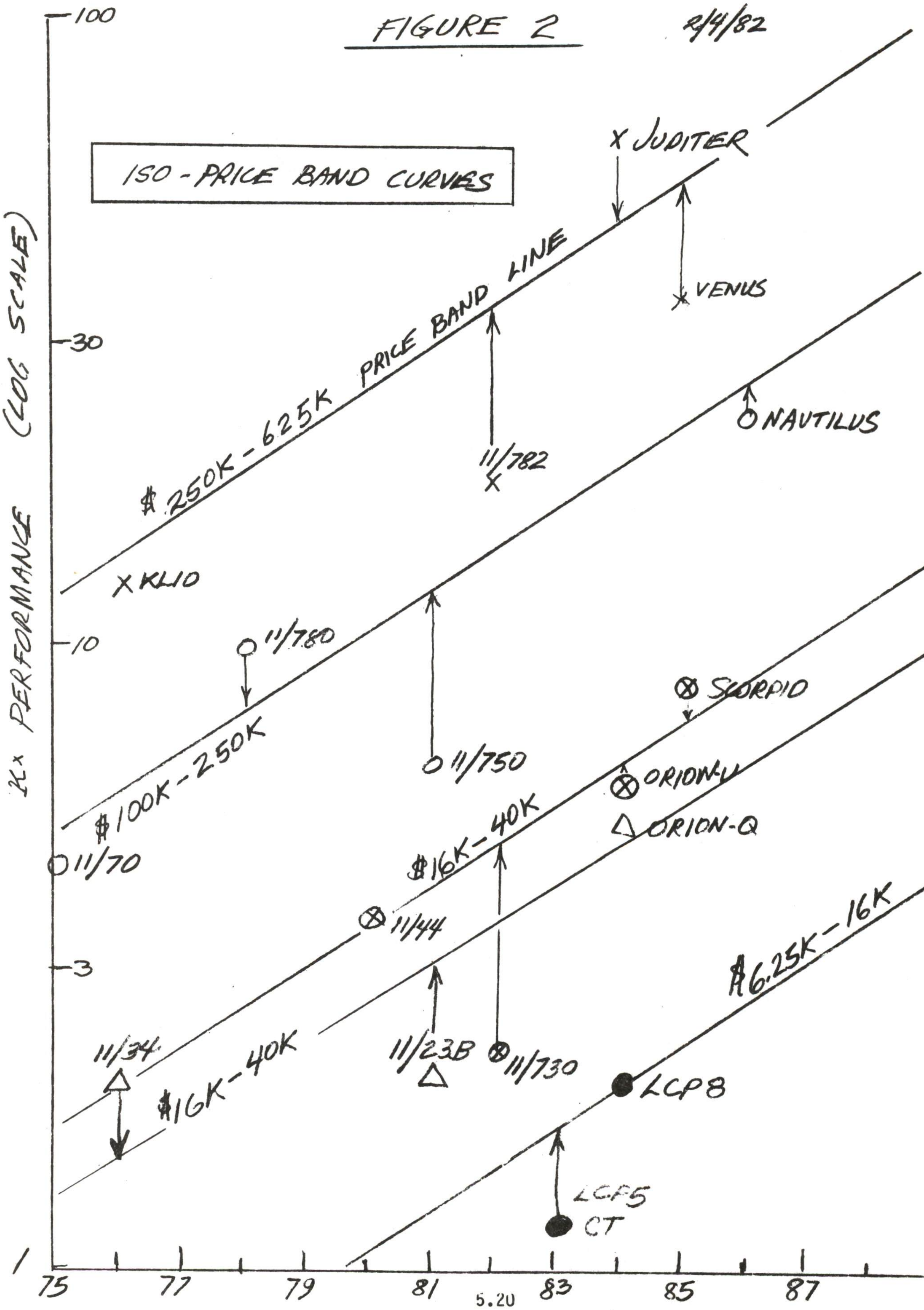


FIGURE 1
2/4/82
ISO PERFORMANCE CURVES
20% PRICE DECLINE PER YEAR
PRICE (LOG SCALE)
YEAR OF INTRO.
$800K
$400K
$200K
$100K
$40K
$20K
$10K
75
77
79
81
83
85
JUPITER
ADJUSTED VENUS LINE
11/782 LINE
KL10
11/782
VENUS
11/780
NAUTILUS
ADJUSTED 11/750 LINE
11/750
11/70
11/70 LINE
11/44 LINE
11/44
11/730
SCORPIO
ORIONV
11/34
11/34 LINE
ORIONQ
11/23B
11/03
LCP8
11/03 LINE
LCPS
CT

FIGURE 2

2/4/82



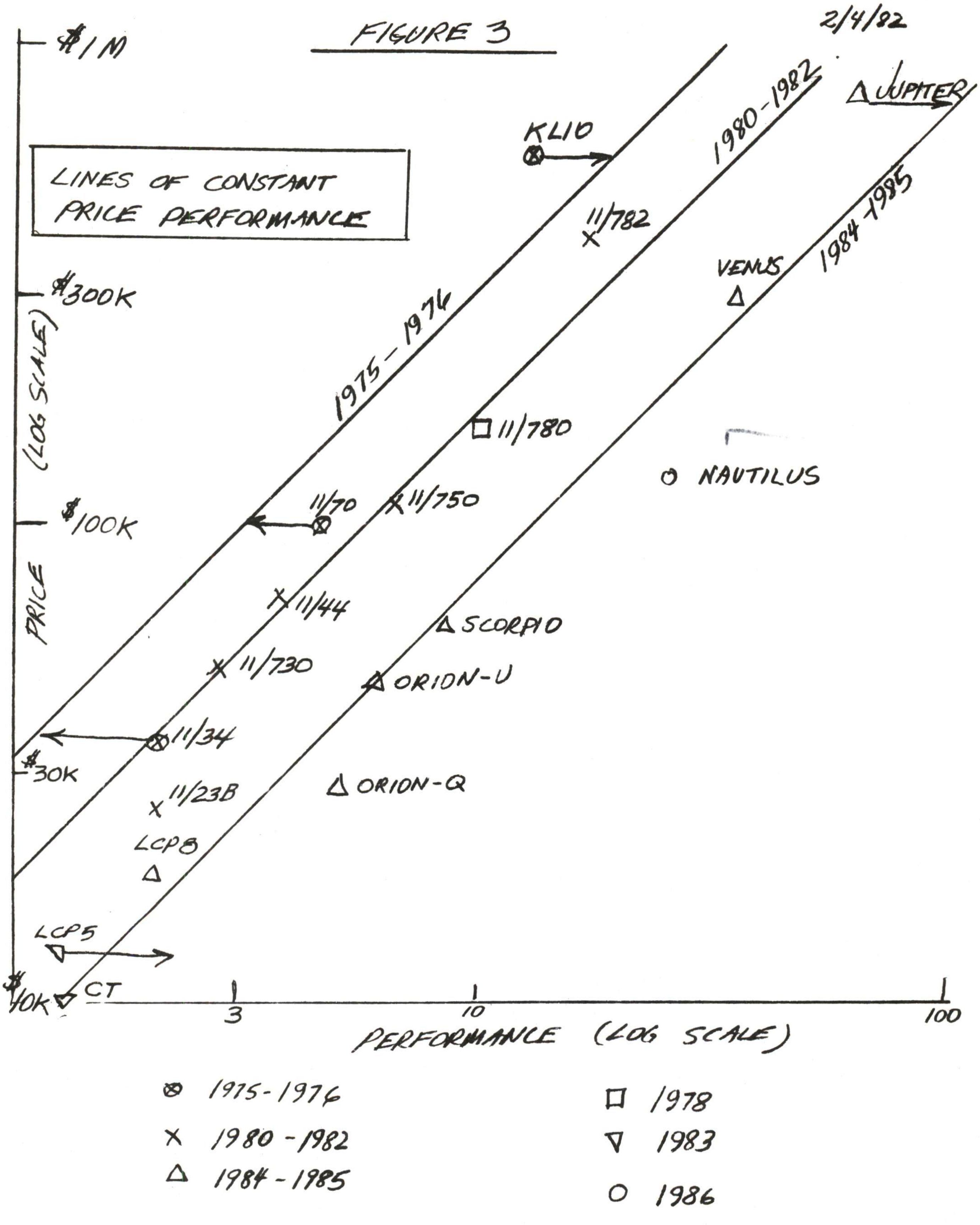


FIGURE 3
2/4/82
LINES OF CONSTANT PRICE PERFORMANCE
$1M
$300K
$100K
$30K
$10K
PRICE (LOG SCALE)
PERFORMANCE (LOG SCALE)
3
10
100
1975-1976
1980-1982
1984-1985
KLIO
11/782
JUPITER
VENUS
11/780
NAUTILUS
11/70
11/750
11/44
SCORPIO
11/730
ORION-U
11/34
11/23B
ORION-Q
LCP8
LCP5
CT
1975-1976
1980-1982
1984-1985
1978
1983
1986

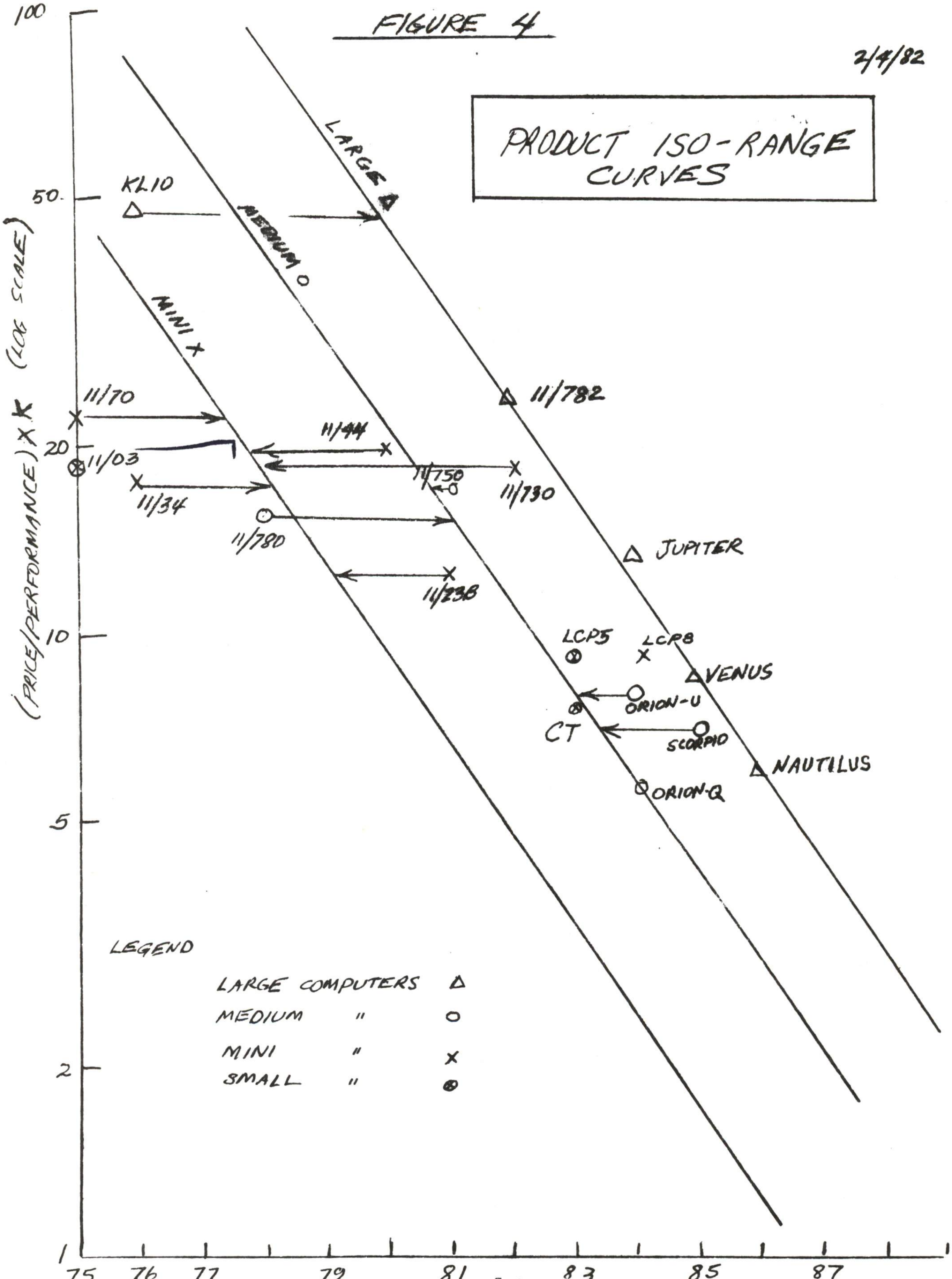
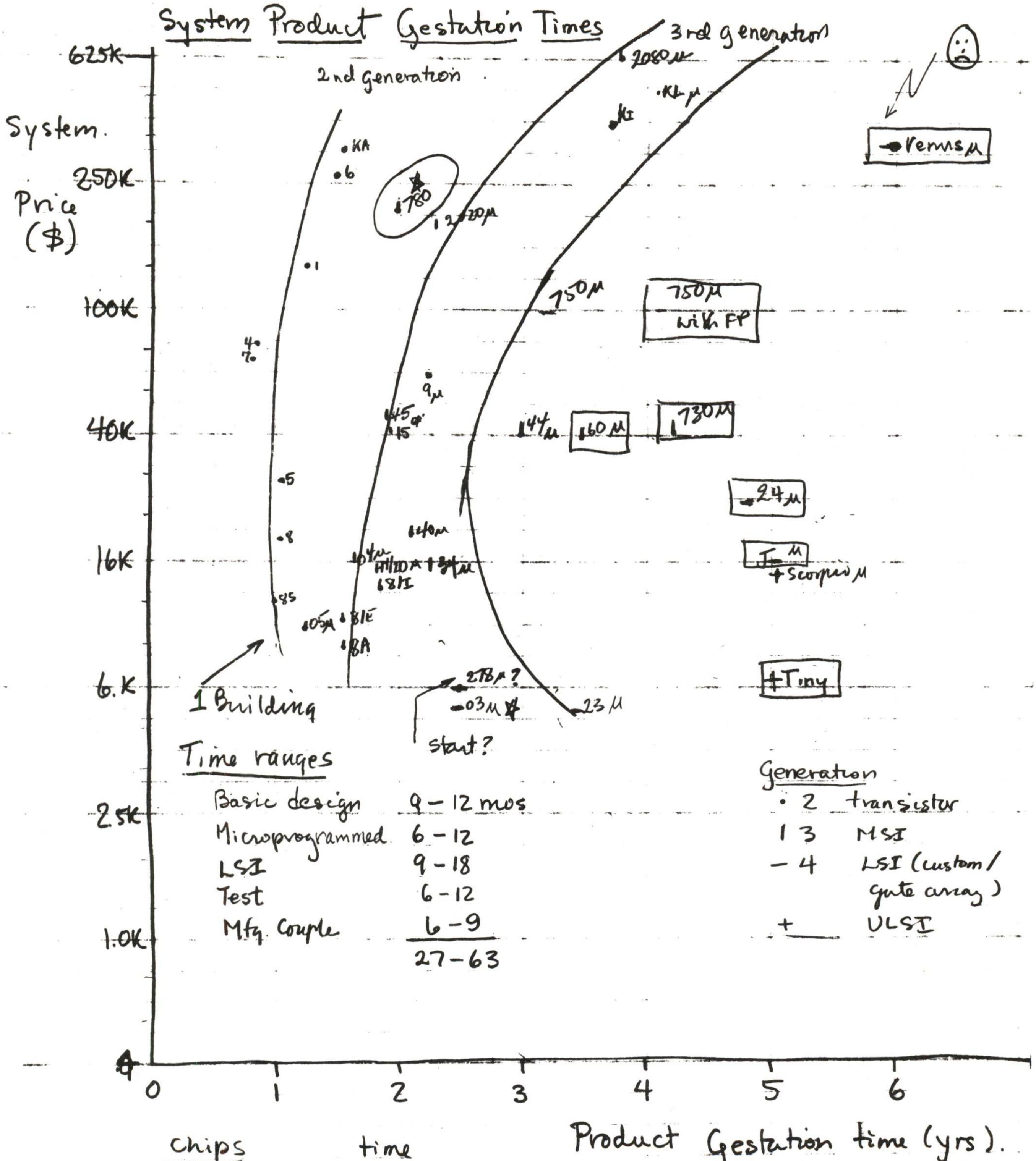


FIGURE 4
2/4/82
PRODUCT ISO-RANGE CURVES
LARGE △
MEDIUM ○
MINI ×
KL10
11/782
11/70
11/44
11/03
11/750
11/730
11/34
11/780
JUPITER
11/23B
LCP5
LCP8
VENUS
ORION-U
CT
SCORPIO
NAUTILUS
ORION-Q
(PRICE/PERFORMANCE) × K (LOG SCALE)
100
50
20
10
5
2
1
75
76
77
79
81
83
85
87
LEGEND
LARGE COMPUTERS △
MEDIUM " ○
MINI " ×
SMALL " ⊗

System Product Gestation Times



Time ranges

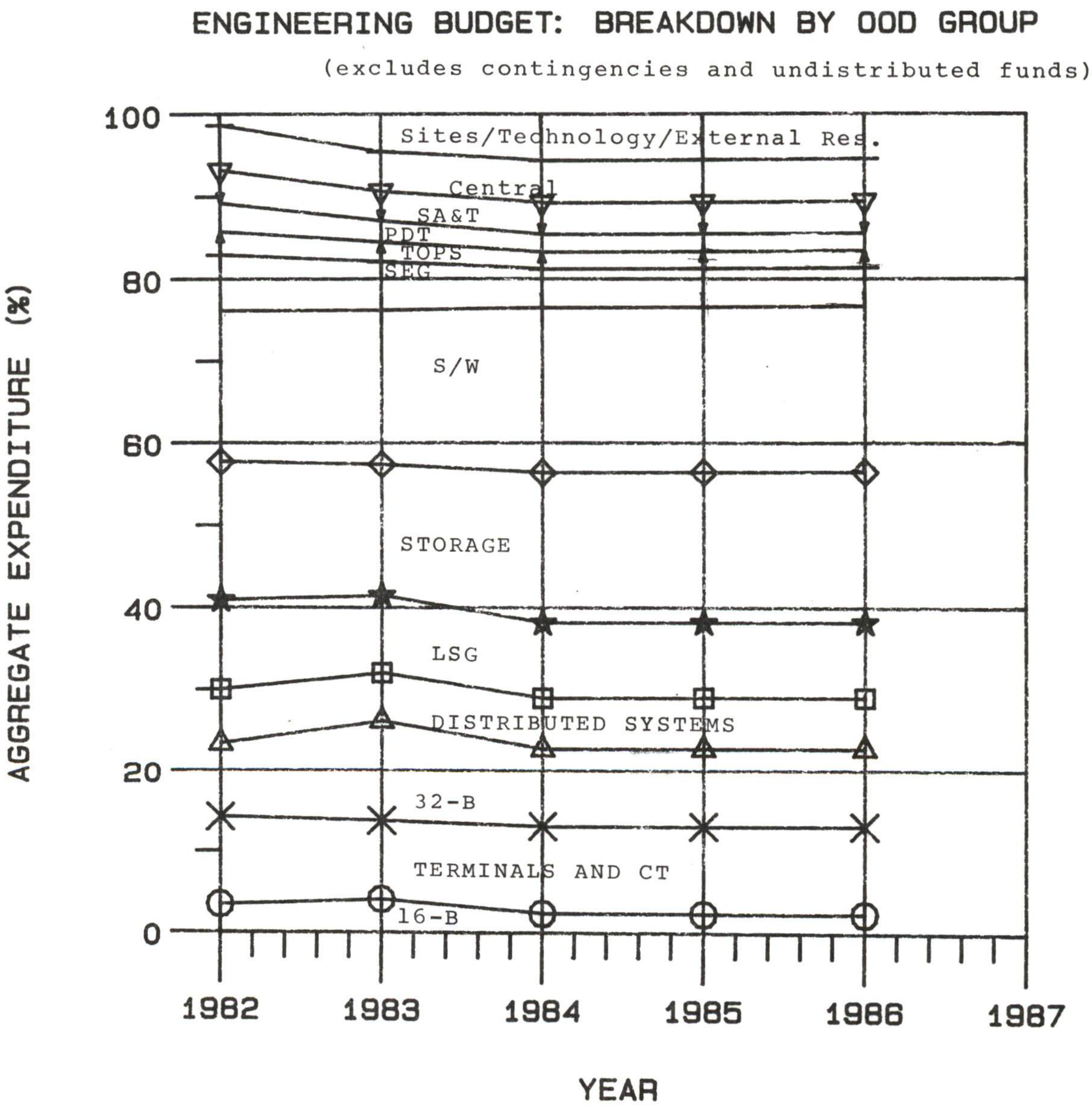
Basic design	9 – 12 mos
Microprogrammed	6 – 12
LSI	9 – 18
Test	6 – 12
Mfg. Couple	6 – 9
	27 – 63

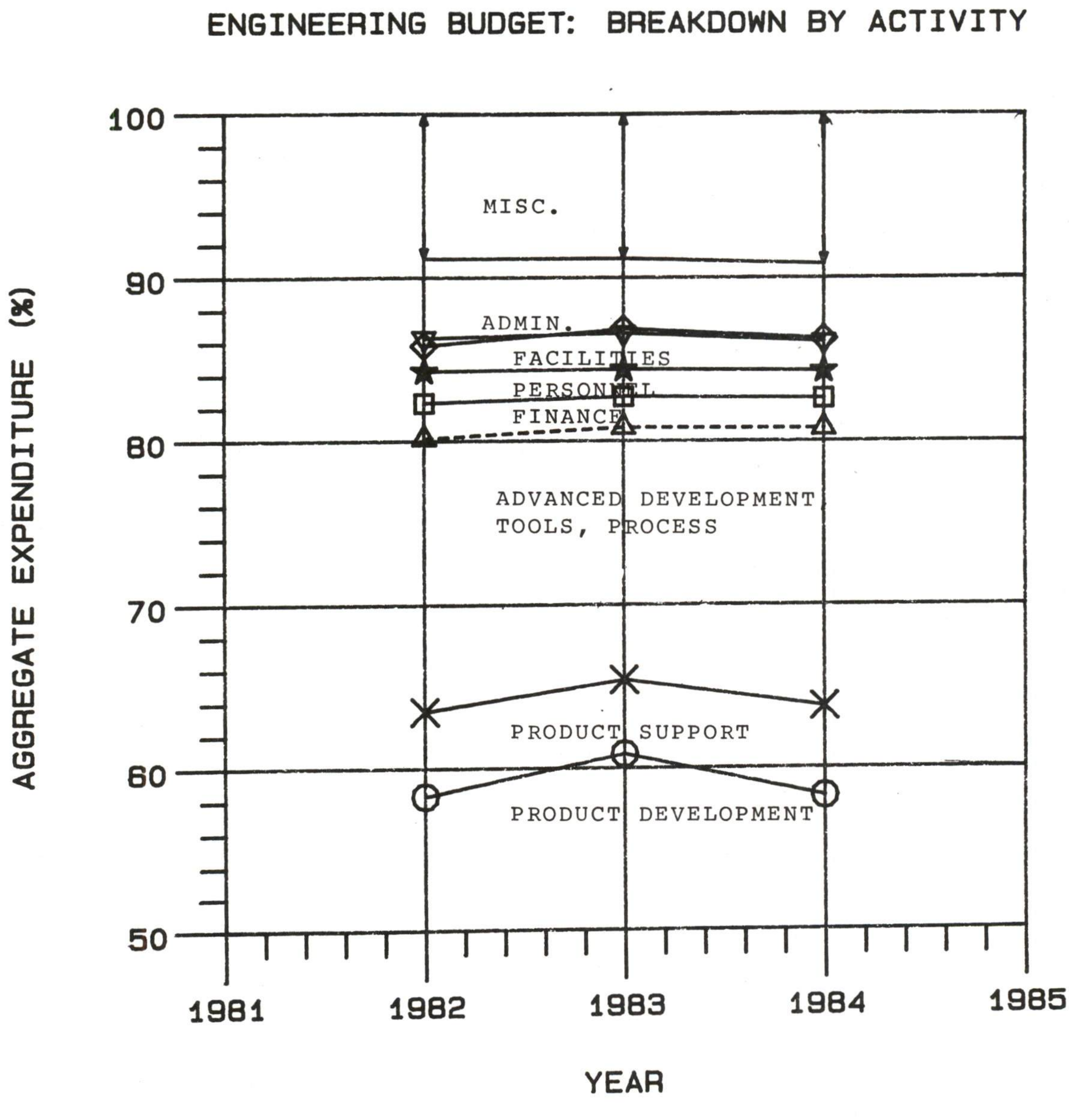
Generation

•	2	transistor
|	3	MSI
–	4	LSI (custom / gate array)
+		ULSI

cgb 2/3/82.

Chips	time
LSI-11	31 mos
F-11	43
T-11	63
J-11	59 (est)
V-11	59 (est)


ENGINEERING BUDGET: BREAKDOWN BY OOD GROUP
(excludes contingencies and undistributed funds)
Sites/Technology/External Res.
Central
SA&T
PDT
TOPS
SEG
S/W
STORAGE
LSG
DISTRIBUTED SYSTEMS
32-B
TERMINALS AND CT
16-B
AGGREGATE EXPENDITURE (%)
100
80
60
40
20
0
1982
1983
1984
1985
1986
1987
YEAR


ENGINEERING BUDGET: BREAKDOWN BY ACTIVITY
AGGREGATE EXPENDITURE (%)
100
90
80
70
60
50
MISC.
ADMIN.
FACILITIES
PERSONNEL
FINANCE
ADVANCED DEVELOPMENT,
TOOLS, PROCESS
PRODUCT SUPPORT
PRODUCT DEVELOPMENT
1981
1982
1983
1984
1985
YEAR

TESTS OF BUDGET ALLOCATION

Notes and comments on the comparison of FY83 Central Engineering spending versus FY82 through FY86 cumulative NOR:

The revenue data was derived from Product Group submissions of LRP shipment plans as part of this year's planning process. The data was submitted in October 1981.

The allocation of Engineering investments was made by the following general rules:

1. Gutman, Avery and Demmer's entire organizational (direct engineering) budget was allocated to 16B, Terminals/Workstations, and 32B respectively.

2. Fagerquist's budget was distributed between 32B and 36B as defined by the line items. Support, Advanced Development and Overhead, etc, were allocated in proportion to the development monies in 32B and 36B.

3. Software expenditures (Johnson) were allocated to 16B and 32B by line item project with the rest distributed in proportion to the development monies in 16B and 32B.

4. Storage (Saviers) was allocated between 16B and 32B after certain line items specifically earmarked for Workstations were assigned to that program.

5. Communications (Lacroute) was proportional to the spending by Gutman, Demmer and Fagerquist 32Bit projects.

6. Semiconductor Engineering was proportioned among all except the 36B program according to the spending by Gutman, Demmer, Fagerquist and Avery.

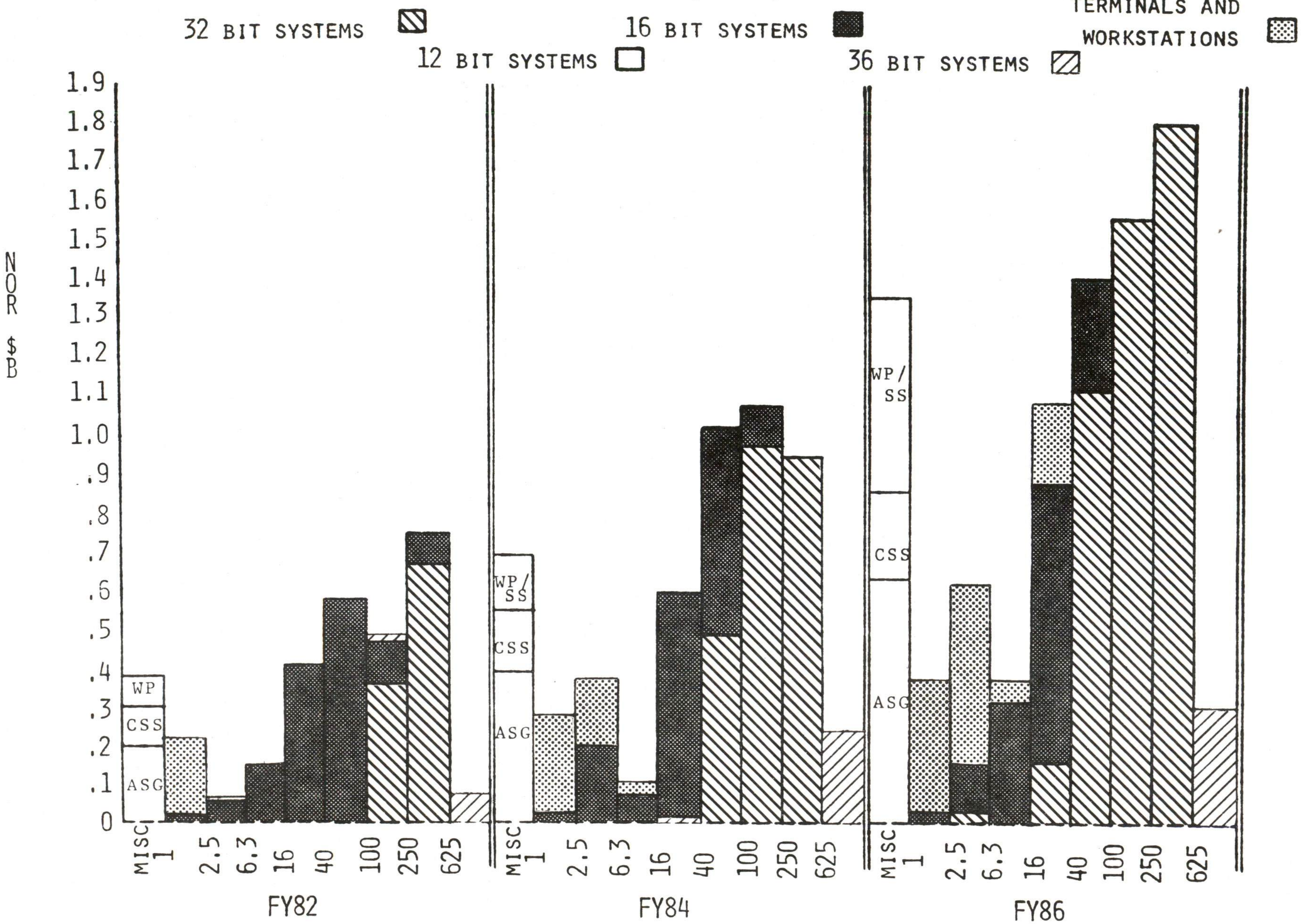
The "back of envelope" analysis is meant to be an overall sanity check of spending versus revenue. Allocation algorithims, time value of near versus longer term revenue etc are all part of the fuzziness of the data. Most if not all investment decisions are made on a more pragmatic basis of meeting competition, exploiting creativity and new technology and satisfying perceived customer needs.

EG:kr3.29

Eli Glazer 2/3/82

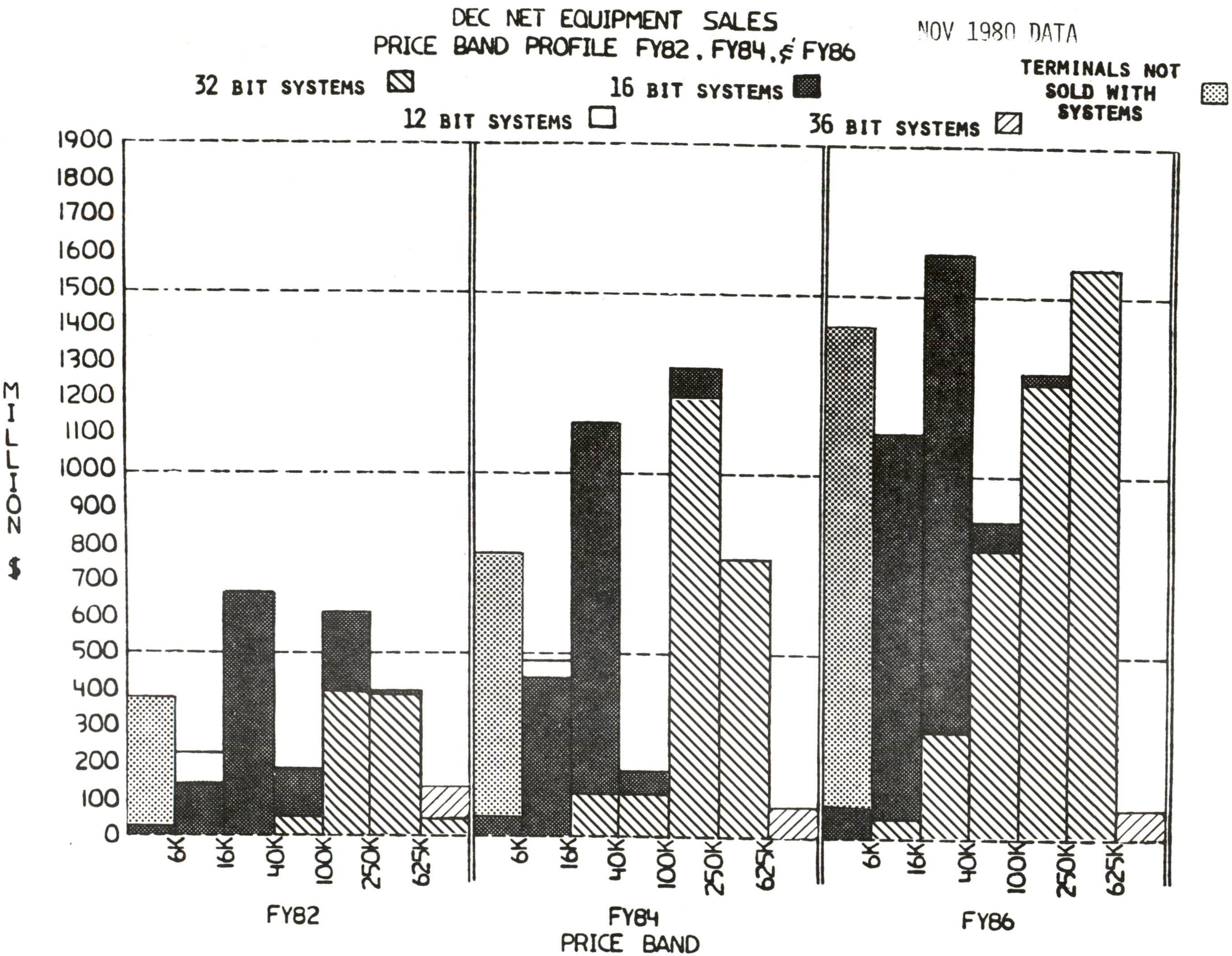
NET OPERATING REVENUE
PRICE BAND PROFILE FY82, FY84, & FY86

OCT 1981 PLAN



CPU AND TERMINAL PRODUCTS BY PRICE BAND
INCLUDED IN THE OCT 1981 PLAN

	FY82	FY84	FY86
1 - 2.5K	TERMINALS VT18X	TERMINALS, VT18X, SBC 11/21	TERMINALS, CT120, J-11, SBC, SBC 11/21
2.5 - 6.3K	PDT SBC 11/21	VT180, CT120, LSI 11/2, LSI 11/23	VT180, CT120, CT200, BOARD SETS
6.3 - 16K	11/03, 11/23	CT150, VT103, 11/03, J-11 (BOARD SET), GEMINI (BOARDS)	CT150, CT120, CT250 VT103, 11/23B, GEMINI (BOARDS
16 - 40K	11/03, 11/04, 11/23, 11/23B, MINC, 11/24, 11/34	11/2XJ, 11/23B, MINC, 11/75Q, 11/24, 11/75U, 11/34,	CT-SCORP, SUVAX, TWS, 11/2XJ, 11/75U, 11/24, 11/75Q, 11/34, SCORPIO, SCORPIO (BOARDS)
40 - 100K	11/24, 11/34 11/60, 11/44 11/730, 11/750	11/24, 11/2XJ, 11/34, GEMINI, 11/730, 11/750	11/24J, 11/24, 11/2XJ, SCORPIO, 11/730
100 - 250K	11/70, 11/750 KS10,	11/44, 11/70, 11/750, KS10, ATHENA, NAUTILUS, ATLAS	11/70, NAUTILUS, 11/750, 11/730, ATHENA
250 - 625K	11/780	11/780, VENUS,	11/780, VENUS,
625K - 1.6M	KL10	2080, KL10	2080



DEC NET EQUIPMENT SALES
PRICE BAND PROFILE FY82, FY84, & FY86
NOV 1980 DATA
32 BIT SYSTEMS
16 BIT SYSTEMS
TERMINALS NOT SOLD WITH SYSTEMS
12 BIT SYSTEMS
36 BIT SYSTEMS
MILLION $
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
6K
16K
40K
100K
250K
625K
FY82
FY84
FY86
PRICE BAND

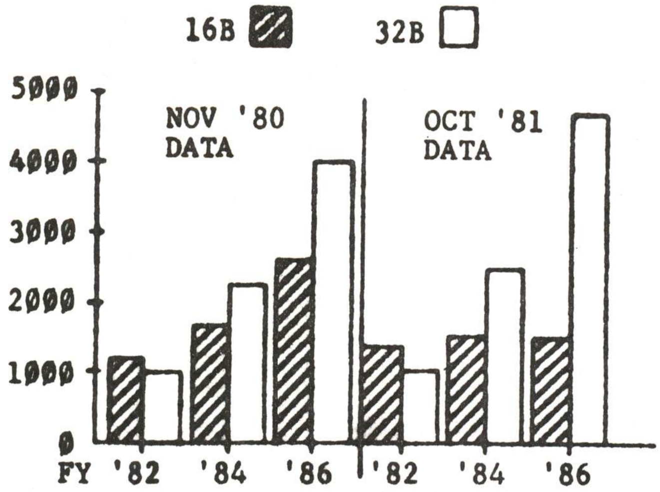
5.29

COMPANY CONFIDENTIAL

CPU AND TERMINAL PRODUCTS AVAILABLE BY PRICE BAND
NOV 1980 - DATA

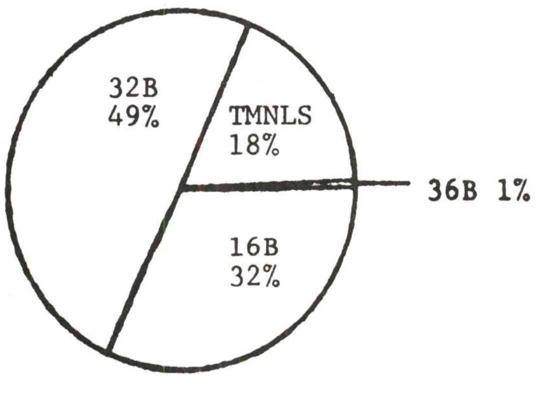
	FY82	FY84	FY86
0 - 6K	Terminals (LA VT, VK) BOARD SETS	Terminals (LA, VT, VK), CT FAMILY, BOARD SETS	Terminals (LA, VT, VK), CT FAMILY, BOARD SETS
6 - 16K	12b Systems, 11/03, 11/23, 11/24 (box)	12b Systems, 11/03, 11/23, 11/23B, 11/24 (box) 11/24J (box), CT/MU, CT150	11/23B (box), 11/24 (box), 11/24J (box), CT/MU Scorpio (box) CT250
16 - 40K	11/23, 11/24 11/34A, MINC	11/24, 11/23B, 11/24J, 11/34A	11/23B, 11/24J, 11/34A?, Scorpio, 11/730 (box)
40 - 100K	11/44, 11/34, 11/23B, 11//24, 11/750	11/44, 11/70, 11/750, 11/730	11/24J, 11/44, 11/750, 11/730
100 - 250K	11/70, 11/44, 11/780, 11/750	11/70, 11/44, 11/780, 11/750	11/70, 11/44, 11/780, 11/750
250 - 625K	11/780, KS10	11/780, Venus	11/780, Venus
625K +	KL10	Jupiter	Jupiter

16B VS. 32B OLD AND NEW DATA

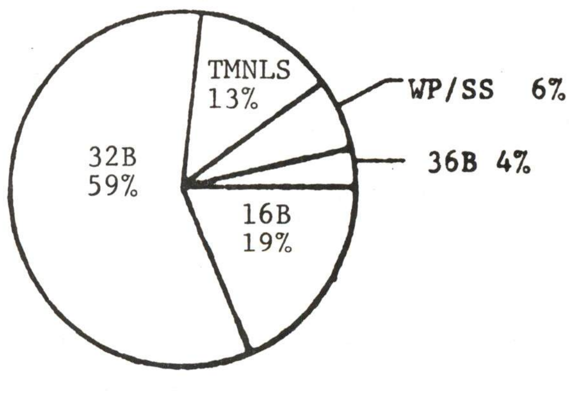


The current plan shows the 16B architecture family to have relatively flat growth compared to the plan developed one year ago.

NOV 80 DATA FY86



OCT 81 DATA FY86



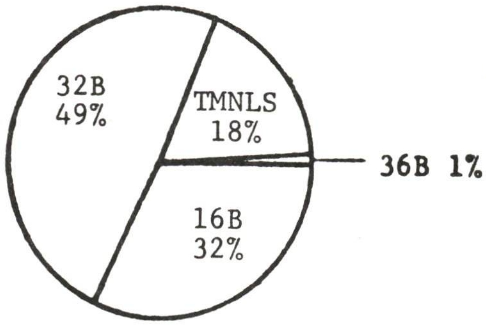
The 32B family growth plan, as of October 1981, resulted in that family representing 59% of equipment sales.

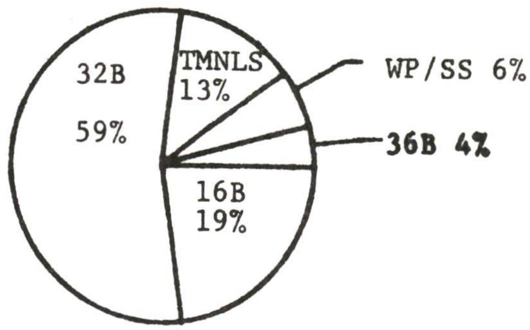
The November 1980 terminal data included the WP and Retail projections.

The 36B family has a significantly larger % of the equipment sales in the current plan compared to the older plan.

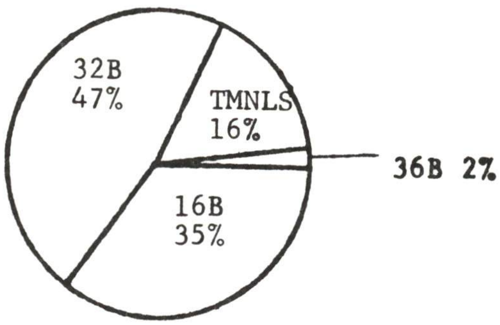
NOV 1980
DATA

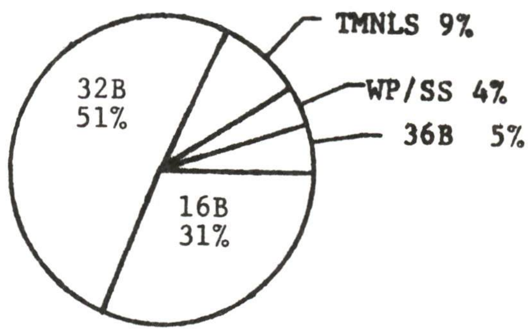
OCT 1981
PLAN



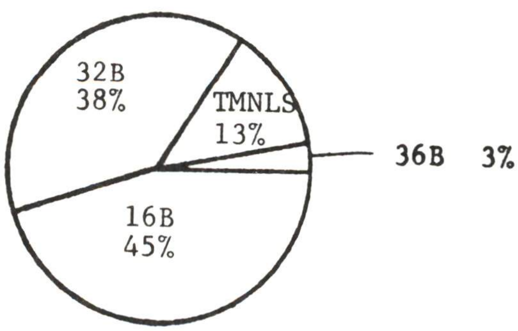


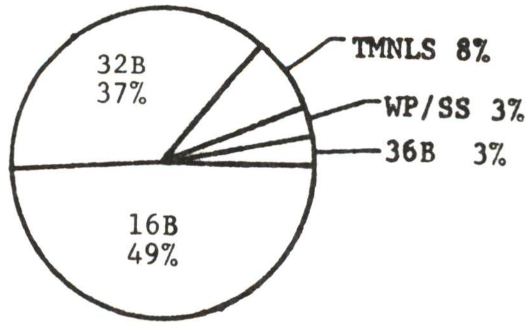
FY86





FY84



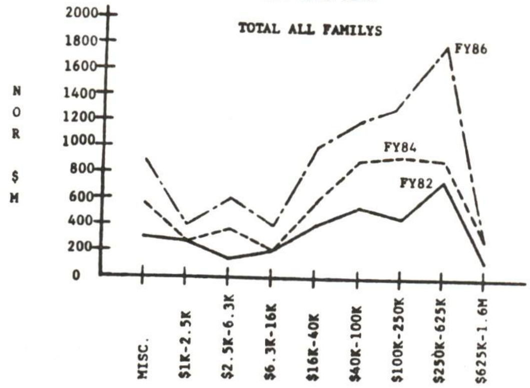


FY82

PRODUCT FAMILY FOR FY82, FY84, FY86 IN THE NOVEMBER 1980 DATA.

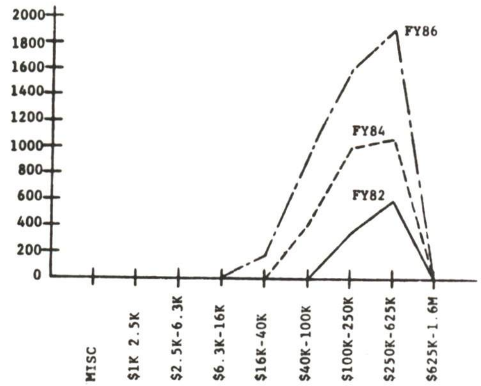
PRODUCT FAMILY FOR FY82, FY84, FY86 IN THE OCTOBER 1981 DATA.

OCT 1981 PLAN



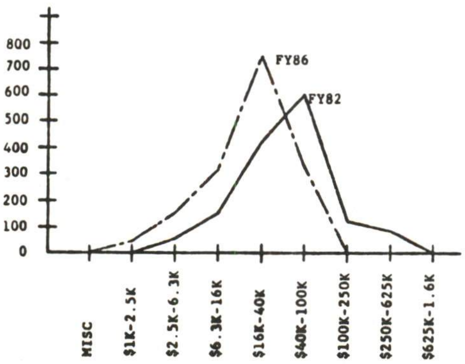
THE PRICE BAND PROFILE CHANGE FROM FY82 TO FY86 SHOWS THAT THE BULK OF THE BUSINESS REMAINS IN THE PRICE RANGE ABOVE $16K. THE TWO BANDS THAT HAVE THE MOST SIGNIFICANT GROWTHRELATIVE TO THE REST OF THE BANDS ARE THE 2.5K TO 6.3K BAND (TERMINALS AND CT) AND THE 250K TO 625K (VENUS).

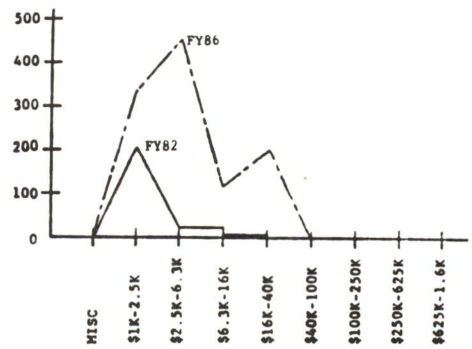
OCT 1981 PLAN
32B NOR BY PRICE BAND



THE BREADTH OF THE 32B FAMILY REMAINS LARGELY IN THE $40K AND UP IN FY86.

TOTAL 32B
16B PRICE BAND SHIFT / OCT81 DATA





TERMS/WS

PRICE BAND SHIFTS FROM FY82 TO FY86 FOR 16B AND TERMINALS/WORKSTATIONS.

"BACK OF ENVELOPE"
FY83 CENTRAL ENGINEERING INVESTMENT
COMPARISON WITH FY82 THROUGH FY86 CUMULATIVE REVENUE

PROGRAM	FY83 ENGINEERING	CUMULATIVE (UNDISCOUNTED) NOR FY82 THRU FY86
16BIT	19%	30%
32BIT	72%	54%
36BIT	5%	4%
TERMINALS & WORKSTATIONS	16%	11%

FIGURE 1
EG:kr3.29.1

"BACK OF ENVELOPE"
FY83 CENTRAL ENGINEERING INVESTMENT
BREAKDOWN BY PROGRAM
$M

SYSTEM PROGRAM / ENG ORGANIZATION	16B	32B	36B	TERMINALS & WORKSTATIONS
GUTMAN	12.3			
AVERY				34.5
DEMMER		44.0		
FAGERQUIST		19.0	12.5	
SUBTOTAL	12.3	63.0	12.5	34.5
LACROUTE (DP) [1]	3.4	17.6		
JOHNSON (SW) [2]	19.4	44.5		
SAVIERS (SSD) [3]	8.6	45.7		4.0
TEICHER (SEG) [4]	5.1	9.2		2.1
TOTAL %	48.8 19.4%	180.0 71.5%	40.6 5%	251.9 100%

NOTE 1: Allocated in proportion to 16B and 32B Engineering Expense.
NOTE 2: Allocated according to projects within SW Engineering.
NOTE 3: Allocated according to primary program office 16B, 32B Engineering Expense, except for identifed Terminals & Workstations projects.
NOTE 4: Allocated in proportion to primary program office investment in 16B, 32B and Terminals & Workstations.
NOTE 5: The remaining part of the Engineering expense for FY83 is treated as overall support for the programs.

FIGURE 2

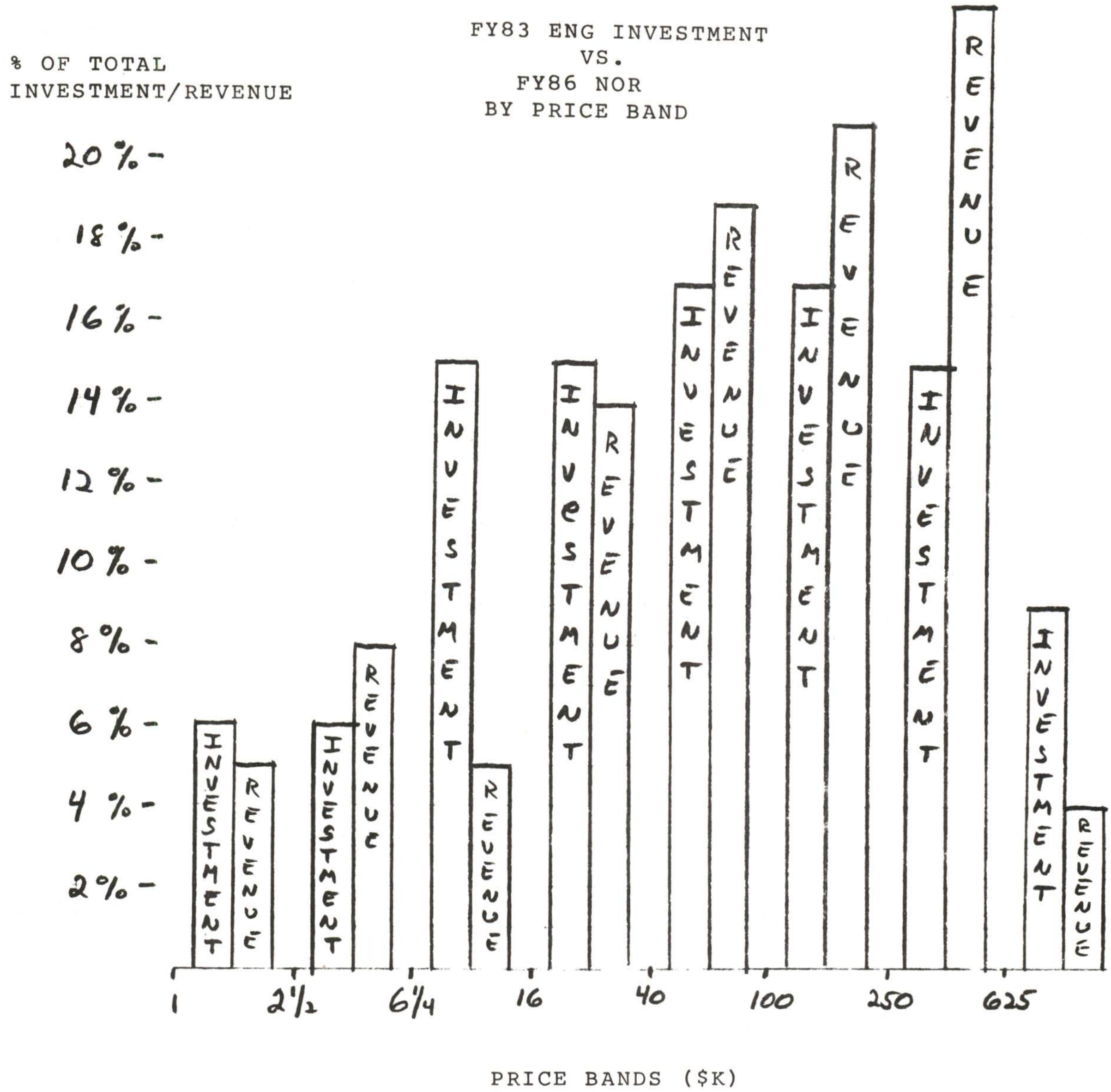
FY82 - FY86 OCT 81 SHIP PLAN NOR
$B

PROGRAM	FY82	FY83[6]	FY84	FY85[7]	FY86	CUMULATIVE (UNDISCOUNTED) NOR FY82 TO FY86	%
16BIT	1.4	1.5	1.5	1.5	1.5	7.4	30%
32BIT	1.0	1.8	2.5	3.6	4.7	13.5	54%
36BIT	.1	.2	.2	.3	.3	1.0	4%
TERMINALS & WORKSTATIONS	.2	.3	.4	.7	1.0	2.7	11%
OVERALL TOTAL						24.6	100%

NOTE 6: FY83 data is 1/2FY82 and 1/2FY84.
NOTE 7: FY85 data is 1/2FY84 and 1/2FY86.

FIGURE 3

FY83 ENG INVESTMENT
VS.
FY86 NOR
BY PRICE BAND



DEFINITIONS

1. System Components

   The products sold to third parties who build and resell systems. The segment shown is for minicomputer boards, boxes and systems. Below this space are the semiconductor components.

2. Technical/Professional

   Engineers, scientists, planners, consultants and other professionals and departments buying products to use for various Technical/Professional purposes.

3. Management Decision-Making

   This is a new segment, as yet not well defined. Much of the Technical/Professional computation is done in support of management. However, the new segment is intended to imply the new computer tools which are specifically intended to make organizational management more productive.

4. Office

   This is primarily Word Processing, the market for office automation.

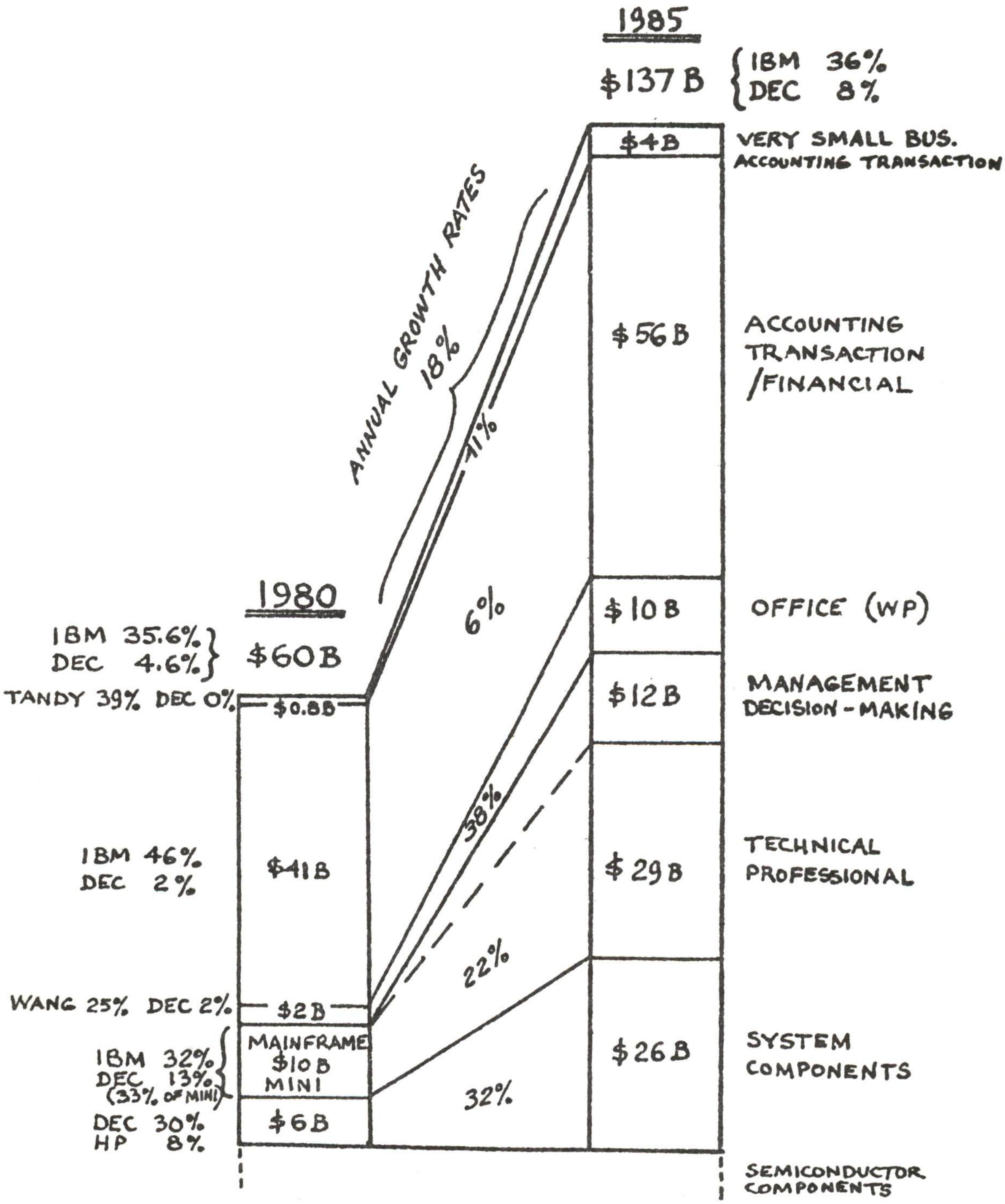
5. Accounting Transactions/Financial

   This segment is the routine processing of accounting and financial transactions.

6. Very Small Business

   A subset of (5) in very small businesses.

MARKET SEGMENTS
SIZE, GROWTH RATES, SHARES



SMART/MCGINNIS

IBM REVENUE ESTIMATE*

BY SYSTEM TYPE

	77	78	79	80	81	82	83	84	85
H&S SERIES	0	0	0	0	1,308	5,925	8,690	10,398	9,192
3033	0	2,448	5,141	6,248	4,411	940	0	0	0
3032	0	864	2,331	0	0	0	0	0	0
3031	0	1,078	2,770	23	0	0	0	0	0
4341	0	0	71	1,510	3,666	3,842	1,945	0	0
4331	0	0	210	3,062	900	568	90	0	0
O&C SERIES	0	0	0	0	0	307	2,515	3,101	4,446
370/148	2,301	2,608	0	0	0	0	0	0	0
370/138	1,976	1,760	52	0	0	0	0	0	0
S/38	0	0	0	1,400	1,936	2,583	3,357	4,373	5,576
S/34	0	625	875	992	983	970	1,210	1,700	2,200
S/32	412	63	0	0	0	0	0	0	0
S/1	65	104	280	344	422	519	637	800	1,000
PERS. COM.	0	0	0	0	60	1,000	1,500	2,250	3,175
OTHER	4,706	1,716	131	0	0	0	0	0	0
TOTAL	9,460	11,266	11,861	12,579	13,686	16,654	18,944	22,622	25,589

NOTE THE SIGNIFICANT GROWTH OF S/38 AND PERSONAL COMPUTERS

* ON "IF-SOLD" BASIS

SOURCE: DON MCGINNIS
FEB 1982

IBM REVENUE ESTIMATE*
BY PRICE BAND

	77	78	79	80	81	82	83	84	85
OVER $25M	0	0	0	0	0	56	175	288	102
$10-25M	485	432	379	1,670	1,278	2,016	3,027	4,664	5,374
$4-10M	2,378	4,033	6,494	4,765	3,087	3,335	3,629	4,089	3,442
$1.6-4M	1,470	2,360	3,470	684	1,387	1,719	2,571	1,714	470
$625K-1.6M	3,510	3,498	76	1,222	3,137	4,112	1,871	1,580	1,436
$250-625K	123	78	275	2,600	1,984	1,260	1,840	2,265	3,391
$100-250K	816	119	113	503	1,424	1,687	2,458	3,302	4,399
$40-100K	399	635	968	929	980	890	1,090	1,500	1,950
$16-40K	279	111	186	224	440	600	760	1,000	1,250
$6.25-16K	0	0	0	0	10	409	524	750	1,660
$2.5-6.25K	0	0	0	0	60	670	1,000	1,500	2,115
$1-2.5K	NO TRUE SYSTEMS - NOW OR ANTICIPATED				NO TRUE SYSTEMS - NOW OR ANTICIPATED				
TOTAL	9,460	11,266	11,961	12,597	13,787	16,754	18,945	22,652	25,589

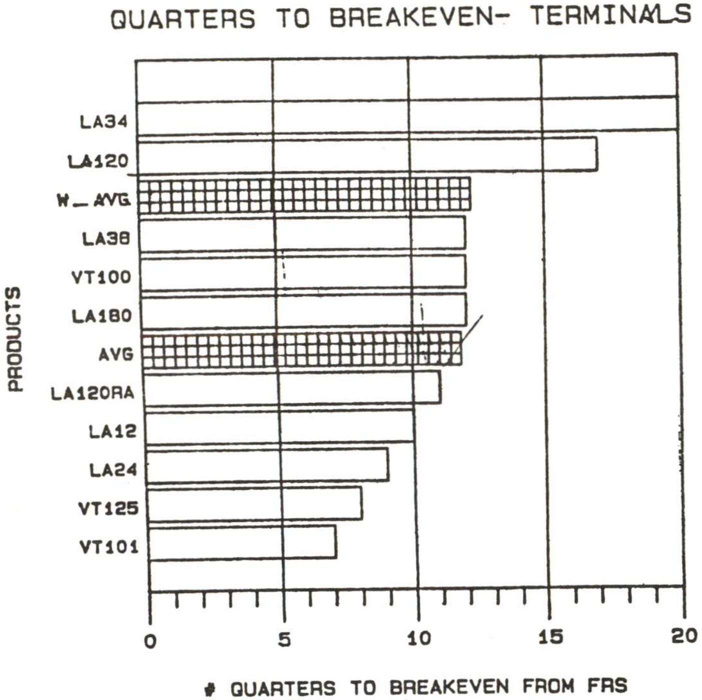
NOTE THE HIGH EXPECTED GROWTH OF THE $2.5-$6.25K BAND, AS WELL AS THE MID-RANGE BANDS OF DIGITAL'S TRADITIONAL STRENGTH.

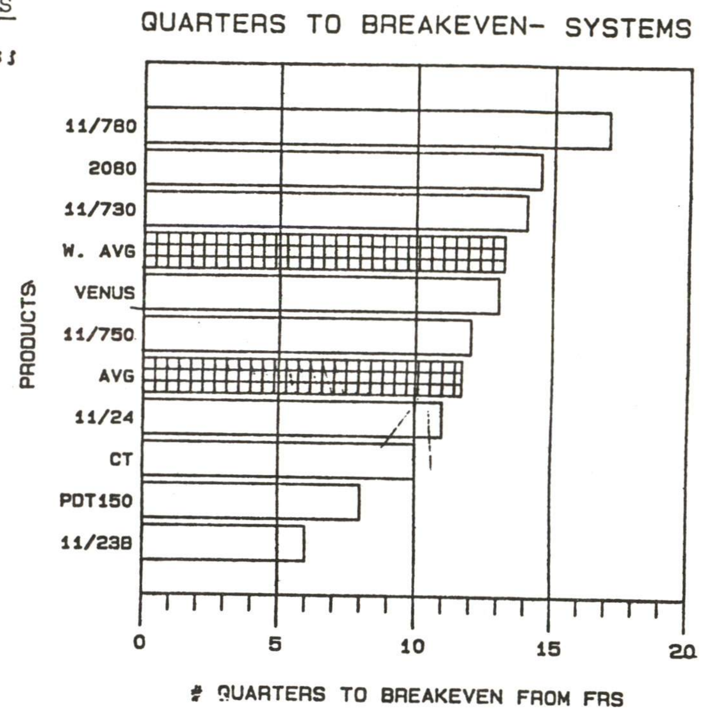
*ON "IF-SOLD" BASIS

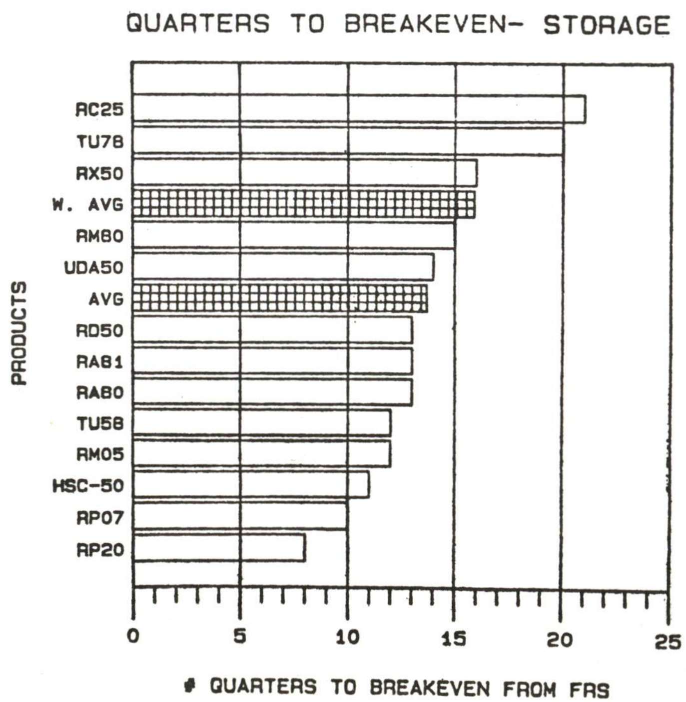
SOURCE: DON MCGINNIS
FEB 1982

CASH BREAKEVEN CHARTS

Source: Product Business Plans

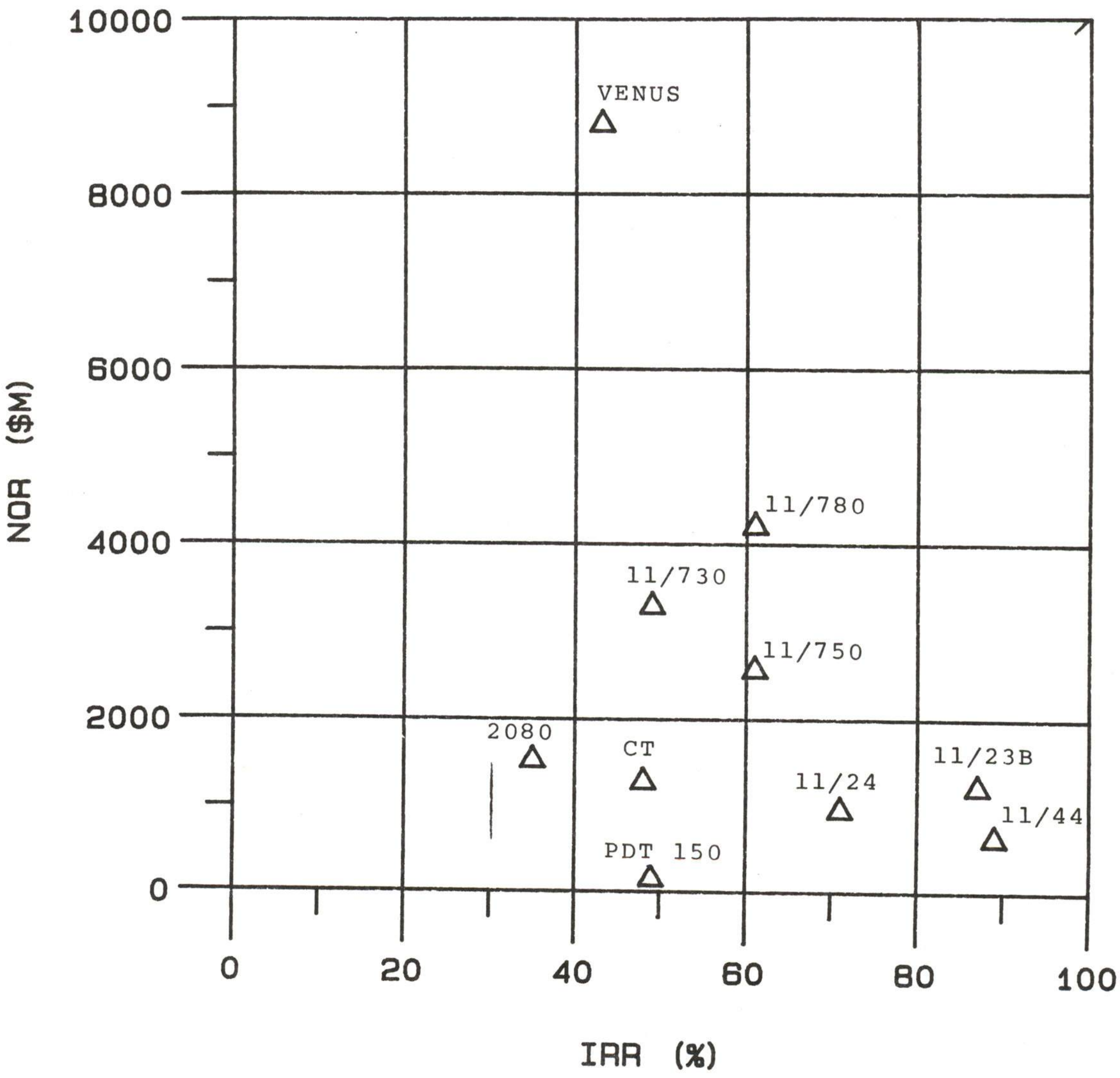






Financial Metrics
—
Business Plans

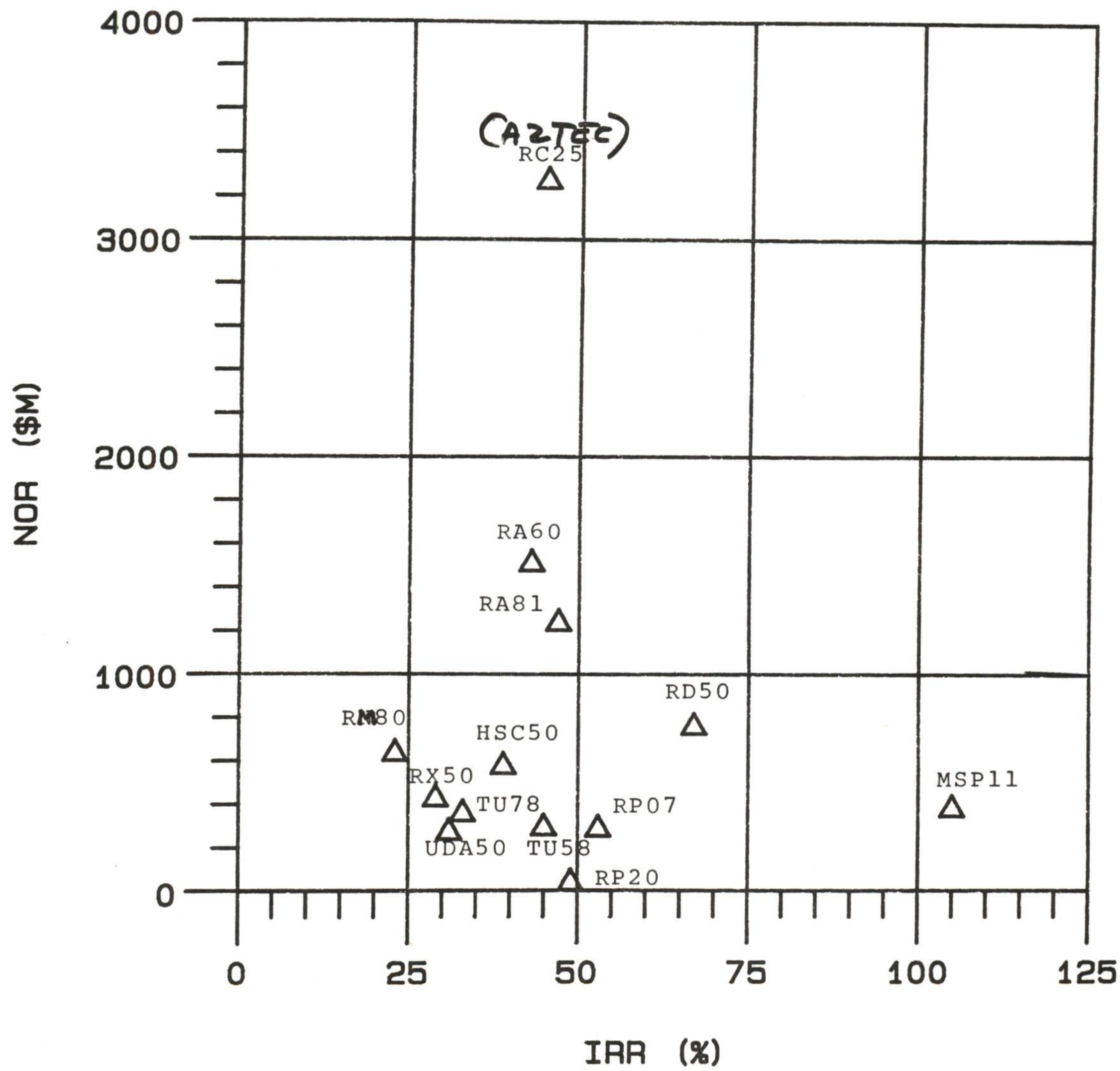
NOR VS. IRR- SYSTEMS



IRRSYS.RNO 29-JAN-82

SOURCE: PRODUCT BUSINESS PLANS (BURP)

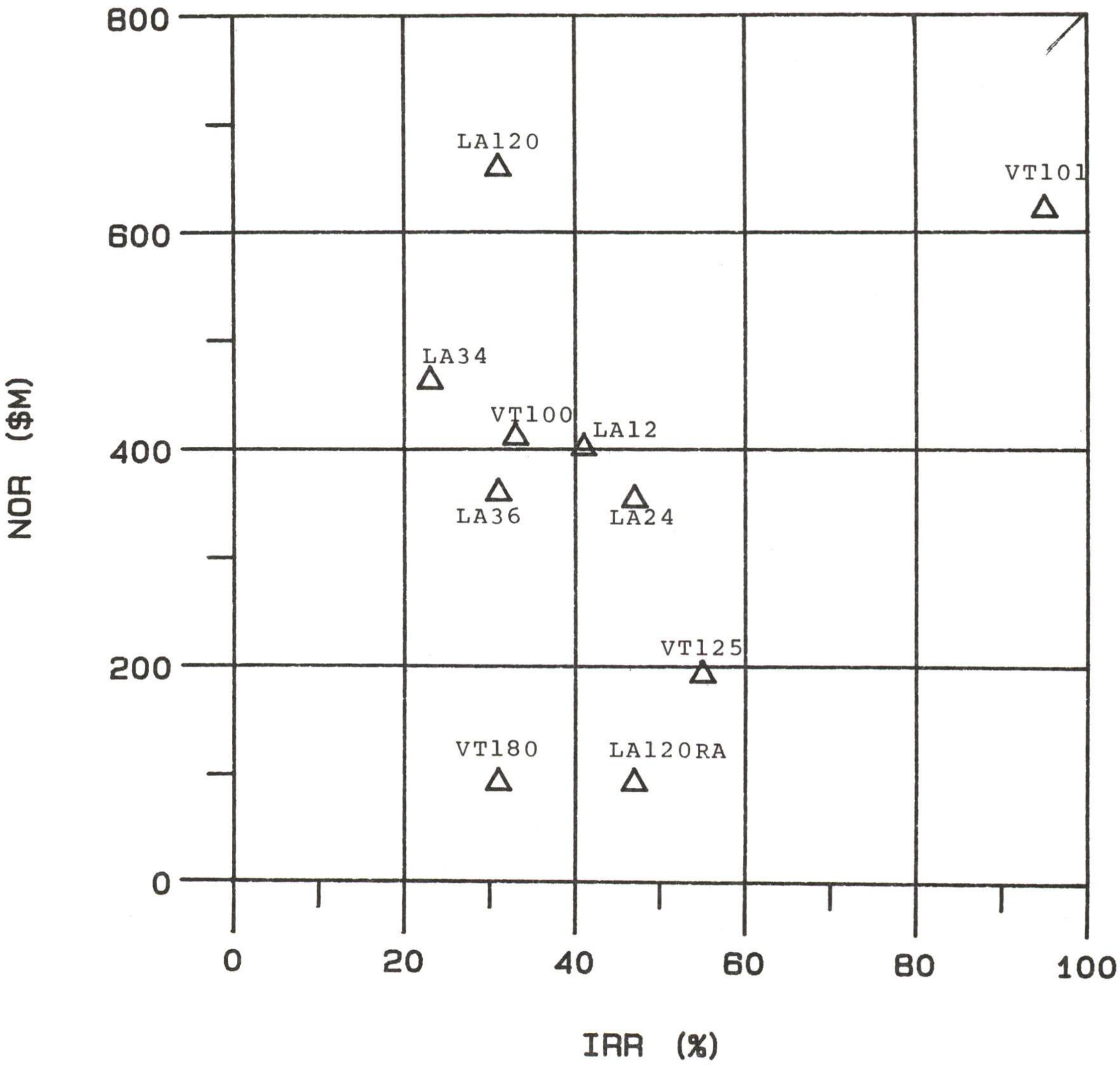
NOR VS. IRR- STORAGE



IRRSTO.RNO 30-JAN-82

SOURCE: PRODUCT BUSINESS PLANS (BURP)

NOR VS. IRR- TERMINALS



IRRTER.RNO 29-JAN-82

SOURCE: PRODUCT BUSINESS PLANS (BURP)

P.G. ENGINEERING EXPENSE
($M)

		82	83	84	85	86
TECH VOLUME:	TOEM	2	2	3	3	4
	MICROS	7	9	11	14	16
TECH END USER:	MSG(MED)	2	2	3	3	4
	LDP	5	5	7	9	11
	TPL	1	1	1	2	2
	ECS(EDU)	2	2	2	2	3
	ESG(ENG)	2	3	4	6	9
	GSG(GOVT)	2	3	4	4	5
	LCG	2	1	3	6	4
COMM'L END USER:	CSI	1	1	1	1	1
	MDC	4	5	6	7	8
	TIG	5	7	10	12	18
	PBI	5	4	5	7	7
SMALL SYSTEMS:	COEM	4	4	5	6	8
	TPG	9	10	12	16	22
	WP	8	11	11	18	29
SERVICE:	A&SG	3	4	5	7	8
	CSS	5	6	7	10	12
	SERVICES	4	5	7	11	15
CORP. TOTAL		73	85	107	144	186

SOURCE: FINAL CORPORATE PG LRP DATED DECEMBER 1981

CLINTON
2/3/82

SYSTEMS, ARCHITECTURE AND TECHNOLOGY - Sam Fuller

Table of Contents

SYSTEMS, ARCHITECTURE AND TECHNOLOGY GROUP

PROVIDE THE TECHNICAL LEADERSHIP IN THE KEY AREAS AND PROCESSES NECESSARY FOR THE DEVELOPMENT OF DEC'S FUTURE PRODUCTS. IN PARTICULAR, SA&T IS RESPONSIBLE FOR:

* GETTING RESEARCH RESULTS THAT WILL LEAD TO INNOVATIVE PRODUCTS OR PROCESSES IN FIVE TO TEN YEARS

* FUNCTIONS THAT OF NECESSITY REQUIRE A CENTRAL FOCUS:

  SYSTEMS ARCHITECTURE
  STANDARDS
  POSITIONING PRESENT AND FUTURE PRODUCTS
  TECHNOLOGY STRATEGIES

* TECHNICAL ACTIVITIES MORE EFFECTIVELY DONE CENTRALLY:

  CROSS-ORGANIZATION/CROSS-PRODUCT STUDIES
  UNUSUAL (TO DEC) TECHNICAL EXPERTISE
  VERY NEW TO DEC
  SPONSORSHIP OF TECHNICAL CAREER LADDER

NOTE: THE ABOVE IS MY OPERATIONAL DEFINITION OF "TECHNICAL LEADERSHIP" AND IS ALSO THE CHARTER FOR OUR GROUP.

S. FULLER
6 JANUARY 1981

SA&T BASE PLAN
Scenario A
Central $K

	FY81 Actuals	FY82 Bud	83 Bud	84 Bud	85 Prop	86 Prop
Standards	410	480	535	626	736	846
Architecture	501	982	1100	1229	1413	1625
Opns & Plng.	382	450	479	547	627	721
Contingency	0	220				
Strategic Opp	0	214	350	413	487	575
XCON	286	400	450	504	562	630
CRG	2728	3186	3732	4295	4941	5679
SPA	1279	1410	1745	2017	2322	2689
Personnel	0	215	241	270	310	357
Hudson Relocation	0	1576	2182	2430	2795	3214
Subtotal	5586	9133	10814	12331	14193	16336
RAD	1387	1718	1969	2373	2800	3304
Total	6973	10,851	12,783	14,704	16,993	19,640

KEY OBSERVATIONS ON SA&T BASE PLAN

- THERE IS ZERO NET GROWTH IN PEOPLE. THIS IS

  INCONSISTENT WITH COMPANY'S NEED FOR STRONG RESEARCH, ARCHITECTURE, STANDARDS, AND PERFORMANCE ANALYSIS FUNCTIONS.

- PERFORMANCE GROUP NEEDS MORE CENTRAL/STRATEGIC FUNDING OR LONG TERM CROSS FUNDING COMMITMENTS. CURRENT APPROACH FORCES FOCUS ON SHORT TERM RATHER THAN STRATEGIC ISSUES.

- UNPLANNED DEMAND FOR SA&T RESOURCES MUST BE RECOGNIZED IN THE APPROVED PLAN.

SAM FULLER
1/22/82

UNPLANNED DEMAND FOR SA&T RESOURCES - HISTORY

CRITICAL UNPLANNED PROJECTS IN PAST YEAR

- ROBIN/VT18X
- ECL 11/780 ANALYSIS
- OPERATIONAL ETHERNETS
- VAX SUBSET PROPOSAL
- IBM S/38 ANALYSIS
- ZEBRA
- ARPA PROPOSAL
- VAX 11/750 WORKSTATIONS TO UNIVERSITIES
- CMU PROPOSAL
- LSI-11/23 FRONT END PROTOTYPES
- LISP STARTUP
-

PEOPLE WHO LEFT SA&T FOR CRITICAL PROJECTS IN PAST YEAR

GLORIOSO, KOTOK AND EGGARS TO VENUS

GAUBATZ AND MORSE TO PDP - 11 (PSD)

PASSAFIUME AND TARDO TO DECNET

LINDENBURG TO NEW DIST. SYSTEMS GROUP IN MR

PEOPLE DIVERTED FOR SIGNIFICANT PERIODS

POTTER ON ETHERNET

STRECKER ON SEVERAL PROJECTS

CLARK ON NAUTILUS

RUPP TO ZEBRA/ONYX

BOTTOM LINE: PLAN MUST RECOGNIZE SA&T CONTRIBUTION TO UNPLANNED DEMANDS: RECOGNITION IS NEEDED IN THE FORM OF $, HEADCOUNT, PROJECT PRIORITIES

SAM FULLER
1/22/82

RISKS AND CONCERNS

O SA&T HAS A TECHNICAL INTEGRATION AND RESEARCH/ADVANCED DEVELOPMENT FOCUS

SOME CONSEQUENCES:

DIFFICULT TO RANK WITH REGULAR PRODUCT DEVELOPMENT GROUPS.
ZERO NET GROWTH - NO MAJOR NEW STARTS

O SA&T IS SEEN AS A SOURCE BUT RARELY A NEW ASSIGNMENT FOR KEY PEOPLE

O AS ENGINEERING BECOMES LARGER AND MORE DECENTRALIZED, THE INTEGRATION FUNCTION IS MORE DIFFICULT

SAM FULLER
1/22/82

<u>THE KEY MESSAGE IS</u>:

SA&T NEEDS SOME <u>REAL</u> GROWTH TO BE AN EFFECTIVE FORCE IN PRODUCT DEVELOPMENT.

<u>REAL GROWTH</u> MEANS FUNDING ADVANCED DEVELOPMENT OVER AND ABOVE THE "A SCENARIO" LEVEL.

SAM FULLER
1/22/82

CORPORATE* AD REQUIREMENTS

B & C .SCENARIOS - PRIORITIZED

	FY83	FY84	FY85	FY86
TERMINALS ARCHITECTURE	$ 160K	$ 180K	$ 200K	$ 220K
MICROVAX ARCHITECTURE	80	90	100	110
STANDARDS	50	58	67	77
LISP	542	621	713	700
SOFTWARE RESEARCH	200	400	500	500
END USER PRODUCTIVITY	330	400	450	325
VLSI	300	350	500	600
KNOWLEDGE BASED SYSTEMS	500	550	600	650
WORK STATION CLUSTERS	1452	1500	1140	730
ALTERNATIVE LAN TECHNOLOGIES	900	1315	1410	1230
DIAGNOSTIC ARCHITECTURE	80	90	100	110
VAX SUCCESSOR ARCHITECTURE	0	0	300	500

*THESE ARE VIEWED AS CORPORATE NEEDS AND SHOULD BE ADDRESSED BY SOME GROUP IF NOT SA&T.

SAM FULLER
1/22/82