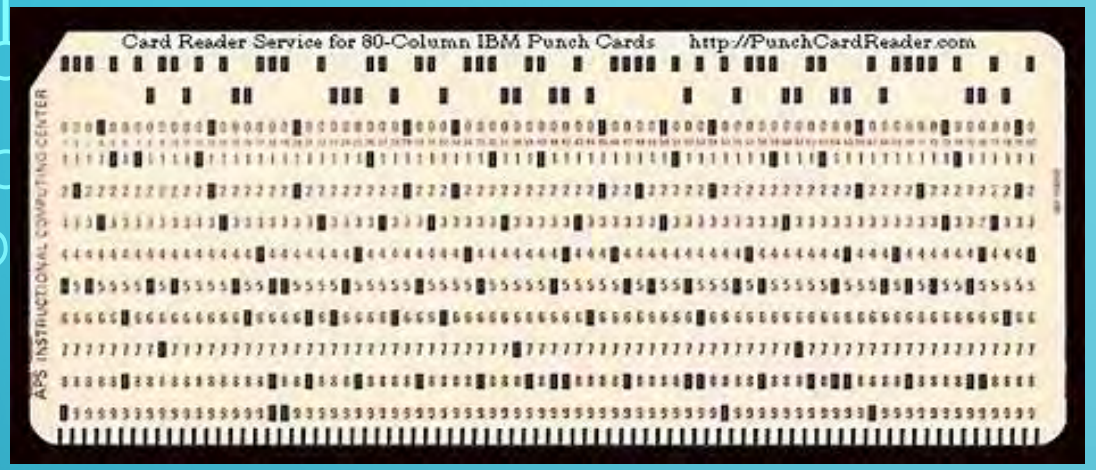
THE HISTORY OF THE MAINFRAME

Lou Guadagno – Retired FROM IBM
Bob Nasser - Retired FROM IBM
Cyril Price - Retired FROM IBM

Does This Look Familiar?



TABULATING MACHINES

IBM BEGINS THE FORMATION OF THE COMPUTER BUSINESS

- 1911 The Computing-Tabulating-Recording Company Starts (CTR)
- 1914 Thomas Watson, Sr. becomes the General Manager of CTR
- 1924 CTR renamed to International Business Machines with Thomas Watson, Sr. as its CEO
- 1952 the IBM 701 Computer is developed becoming the first IBM commercial and scientific computer
- Wave of computers continue to be developed - 1400, 1620, 7000 series…
- Upgrades, new models, of these machines and others came into existence.

7000 SERIES OF MACHINES (LOOK FAMILIAR – MOVIE "HIDDEN FIGURES")

SPREAD (SYSTEMS PROGRAMMING ENGINEERING AND DEVELOPMENT) TASK GROUP

- Members
  - J.W. Haanstra, Chairman
  - B.O. Evans, Vice-Chairman
  - Gene Amdahl
  - J.D. Aron
  - F.P. Brooks, Jr.
  - J.W. Fairclough
  - W.P. Heising
  - H. Hellerman
  - W.H. Johnson
  - M.J. Kelly
  - D.V. Newton
  - B.G. Oldfield
  - S.A. Rosen
  - J. Svigals

HIGH LEVEL OUTCOME OF SPREAD

- Family of central processing units, each of which could handle both scientific and business applications
- Standard peripheral-device interfaces
- Unified Technology across the SPREAD plan
- Control Program that could be used on all processors in the family
- A single high-level language was called for that had scientific, business and advanced applications ability
- Increase memory size with the final design to address 16 million characters
- A 8-bit character called the 'byte' was selected for the basic alphanumeric structure.

S/360 ANNOUNCED ON APRIL 7, 1964

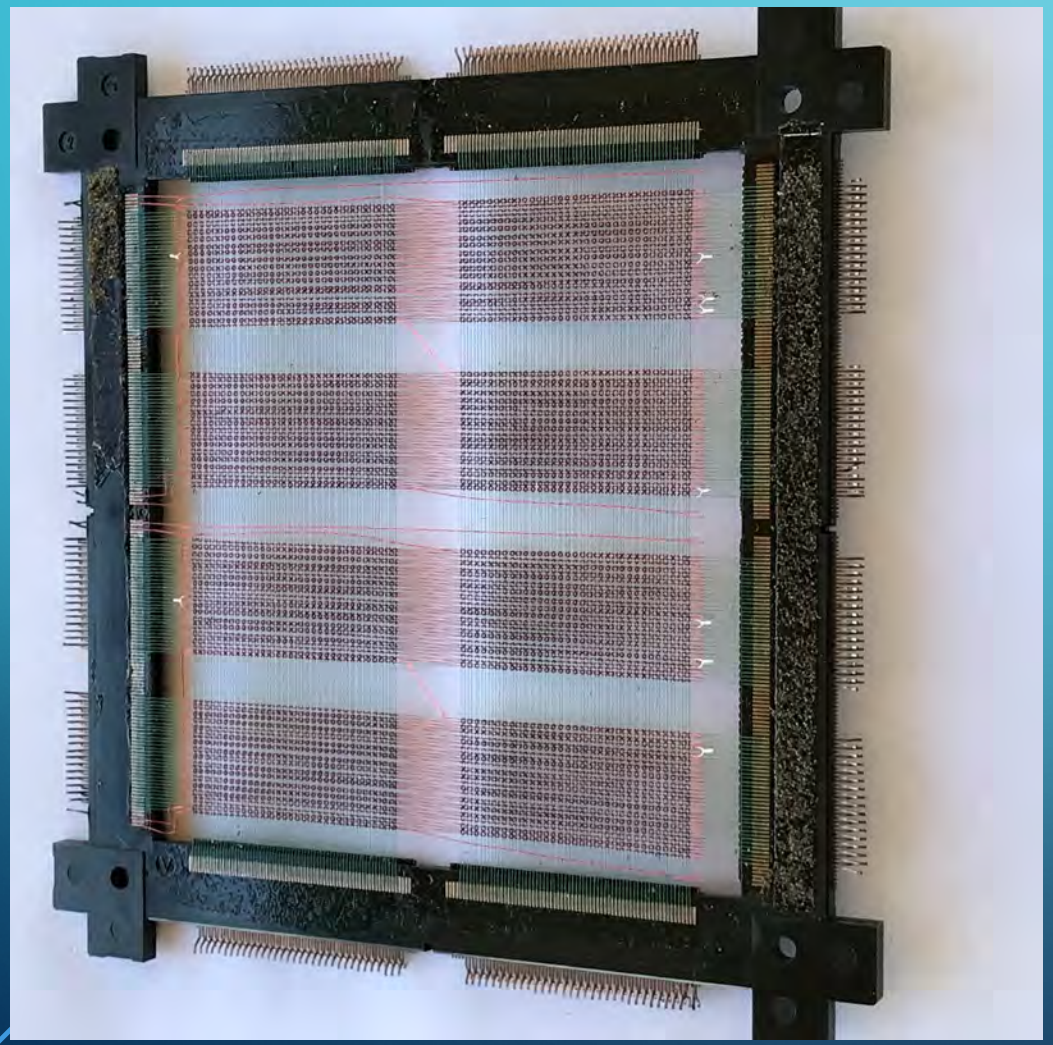
(MOST PEOPLE CONSIDER THE BIRTH OF THE MAINFRAME)

THREE ERAS OF MAINFRAMES

- *The Solid State Logic Card Era (60's & 70's) (S/360; S/370; 303X)*
- *The Bipolar Era (80's & 90's) (308x; 3090; 9000)*
- CMOS Era (Mid 90's to today) z1….z17……

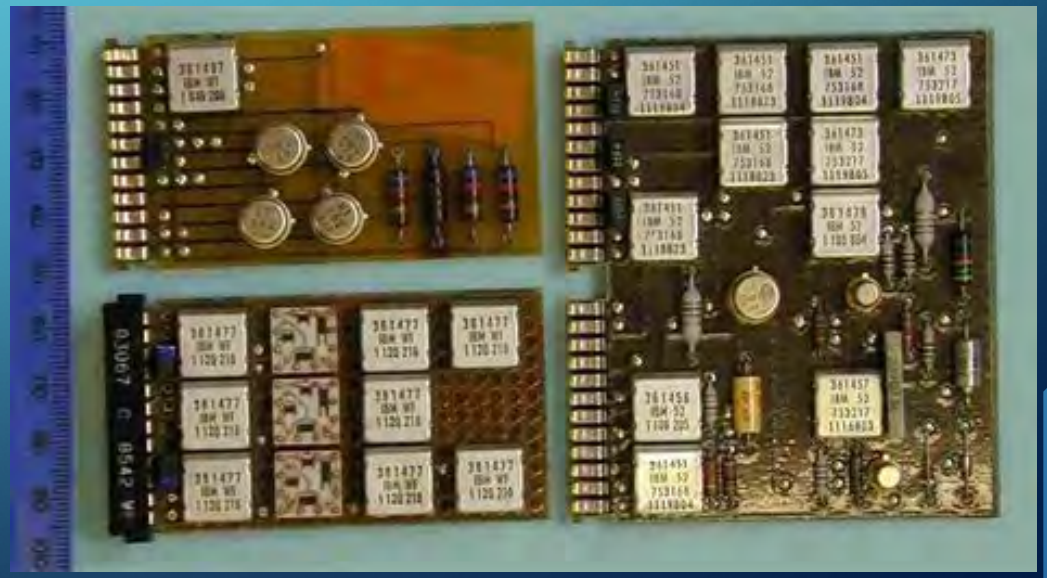
The Solid State Logic Card Era (S/360; S/370; 303X)

CORE MEMORY
(16K BITS – STACK 9 OF THEM = 16K BYTES)



Components

Electronic Card Example



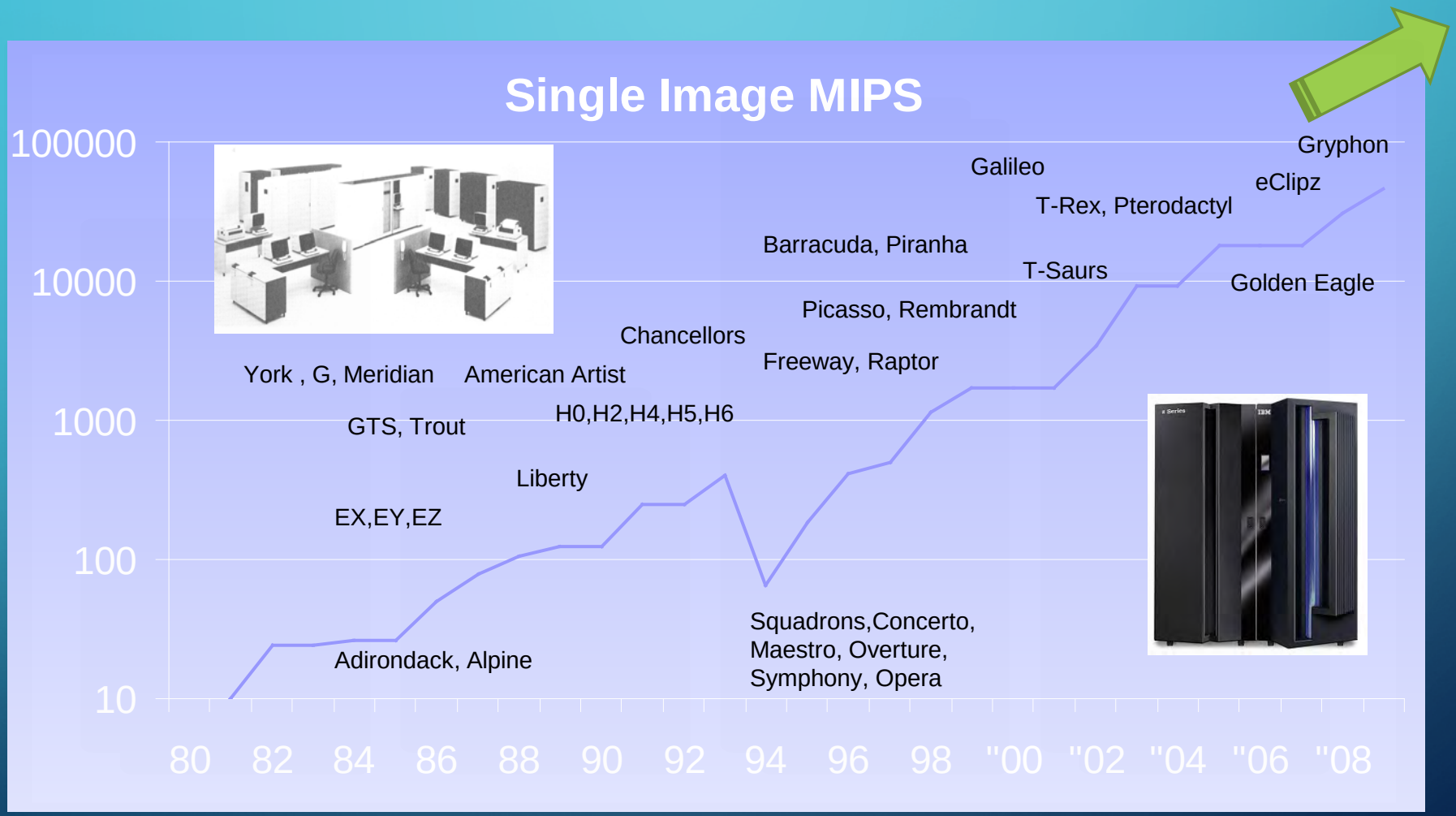
OPERATORS CONSOLE ON A S/360 & 370

IBM System 3033

The Bipolar Era (80's & 90's)

(308x; 3090; 9000)

MAINFRAMES
A SUCCESS STORY FOR THE AGES



3081 – 10 MIPS

THERMAL CONDUCTION MODULE (TCM)

CMOS Era (Mid 90's to today)
z1….z17

What Was Happening To The Mainframe Business In The Early 1990's

Lou Guadagno

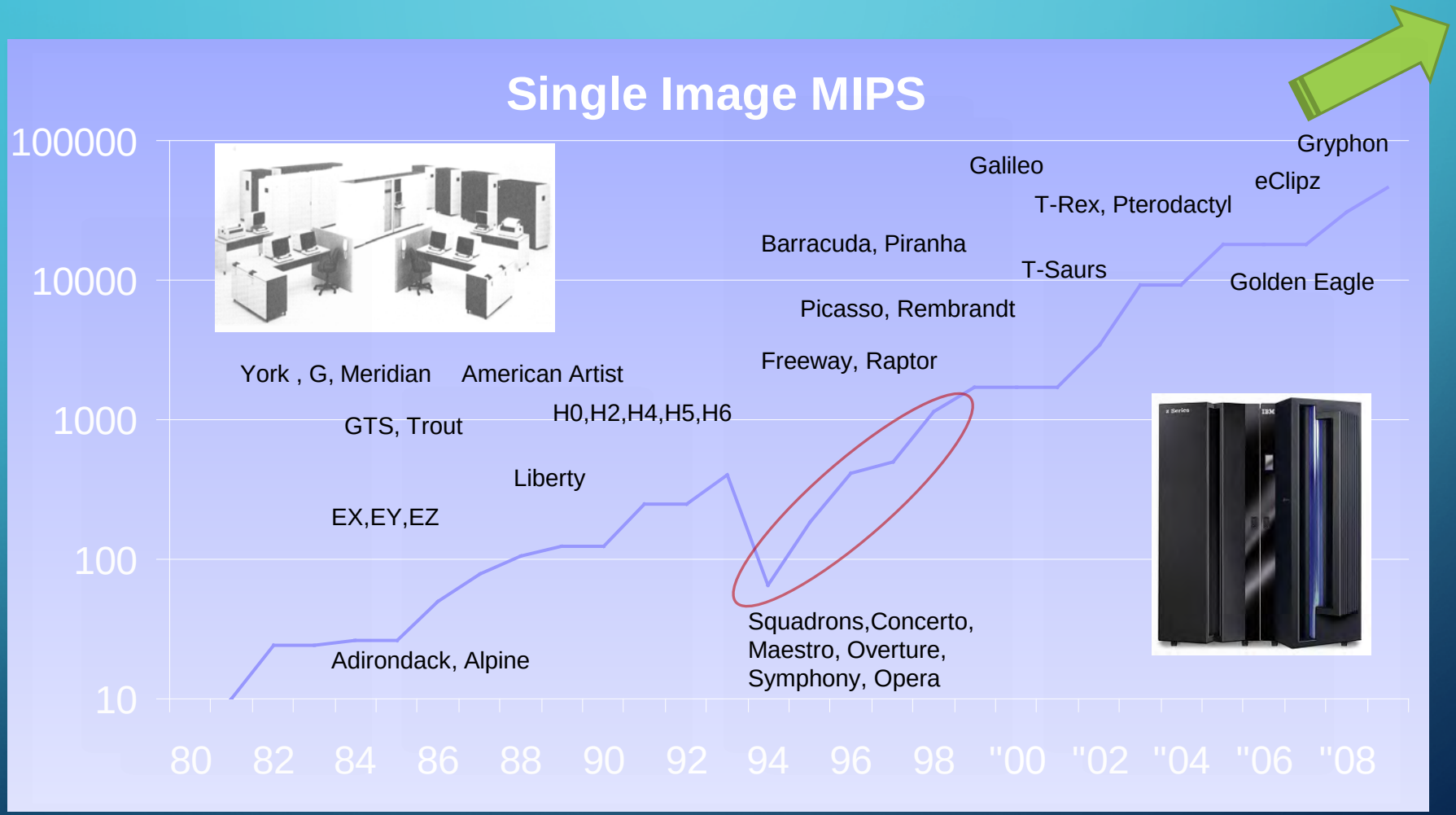
- *PC's were the "in thing"*
- *To build the next "turn of the crank" bipolar technology plant was unaffordable*
- *Bipolar was no longer following "Moore's Law" (2 times the performance every 18-24 mos)* ➔
  - *It was more like four years*
- *CMOS was, at the time, doing 2 times the performance every 18 months*
- *MAINFRAME IS DEAD "FRENZIE"*

So What did we do?

- *Major Change to the machine structure, switch to CMOS Technology and maintain and expand the architecture that was defined in the 1964.*
- *Resource Actions on ½ the workforce in the Hudson Valley*
- *Closed Kingston*
- *Shut down buildings all around the valley including East Fishkill*
- *Result was a major inflection in MIPS growth and the race was on of how we could get back on a par with where Bipolar was currently shipping with a lot fewer folks!*

"SEA CHANGE"

MAINFRAMES
A SUCCESS STORY FOR THE AGES



1990'S

LOU GUADAGNO – RETIRED FROM IBM
CYRIL PRICE - RETIRED FROM IBM
BOB NASSER - RETIRED FROM IBM

SEPTEMBER

Why Did We Need To Transition From Bipolar to CMOS Technology

Cyril Price

MULTIFACETED PROBLEM Required MULTIFACETED SOLUTION

POWER DISSIPATION (WATER AND AIR COOLED)	TRANSITION TO LOWER POWER CONSUMING CIRCUITS
BIPOLAR TECHNOLOGY SIGNIFICANTLY CHALLENGED TO SUPPORT RAPIDLY INCREASING PERFORMANCE REQUIREMENTS	TRANSITION TO TECHNOLOGY WITH SIGNIFICANT GROWTH POTENTIAL
PEOPLE - BUT NOT JUST TECHNOLOGY UNAFFORDABLE DEVELOPMENT REQUIREMENTS DROVE HIGH DEVELOPMENT EXPENSE	• REDUCE DEVELOPMENT REQUIREMENTS • OPTIMIZE DEVELOPMENT TEAM
SCHEDULE	
SYSTEM DESIGN COMPLEXITY	IMPROVE SYSTEM DESIGN – ERROR CORRECTION
INSTRUCTION PROCESSING CYCLE TIME	REDUCED INSTRUCTION PROCESSING CYCLE TIME
DESIGN SIMULATION PROCESS	EFFICIENT DESIGN SIMULATION PROCESS
TESTING	
• DEVELOPMENT ENGNEERING TEST • MANUFACTURING TEST	TIGHTER DEVELOPMENT / TEST / MFG INTEGRATION
PROGRAM MANAGEMENT	IMPROVED PROGRAM MANAGEMENT

BIPOLAR TECHNOLOGY SEVERELY CHALLENGED

KEY DRIVER TO IMPROVEMENT - SEMICONDUCTOR TECHNOLOGY CHANGE

- BIPOLAR CIRCUITS USE NPN AND PNP TRANSISTORS
  - HIGH TRANSIENT SWITCHING CURRENTS
    - DCS – Differential current switch
    - ECL – Emitter-coupled logic
    - TTL – Transistor-transistor Logic
- POWER DISSIPATION INCREASED TO INTOLERABLE LEVELS
- SINGLE IMAGE MIPS DROVE NEED FOR INCREASED CIRCUIT COUNTS
  - RESULTS IN HIGHER HEAT GENERATION
  - THERMAL CONDUCTION MODULES (TCM) USED TO COOL CHIPS
    - ~ 2700 WATTS PER TCM
- BIPOLAR DEVICES ARE NOT PERFECT - NPN / PNP JUNCTIONS
  - LEAKAGE CURRENTS INCREASES WITH DECREASING DEVICE SIZE

CMOS

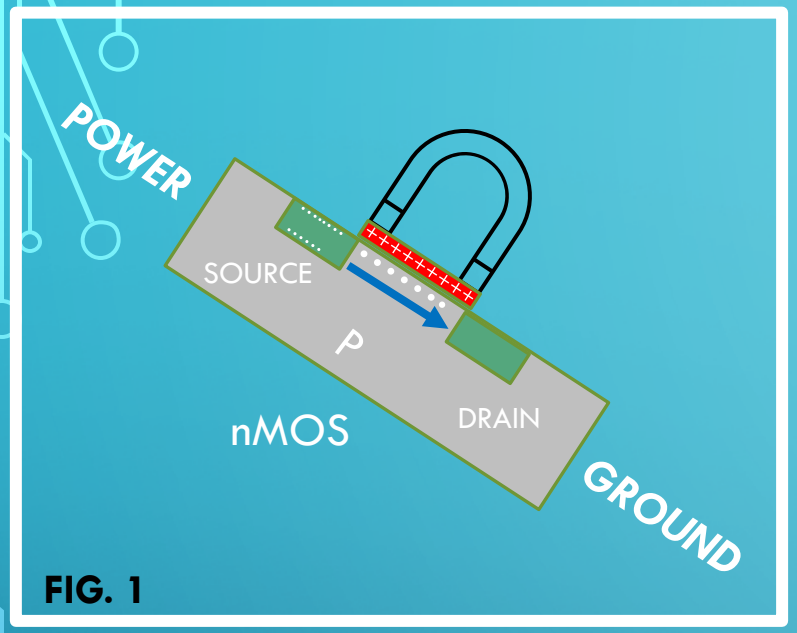


FIG. 1

SECTION	INPUT GATE	OUTPUT	INPUT GATE	OUTPUT
A	RED	BLUE	0	1
B	GREEN	ORANGE	1	0

Very low static power dissipation
Essentially only one device is on

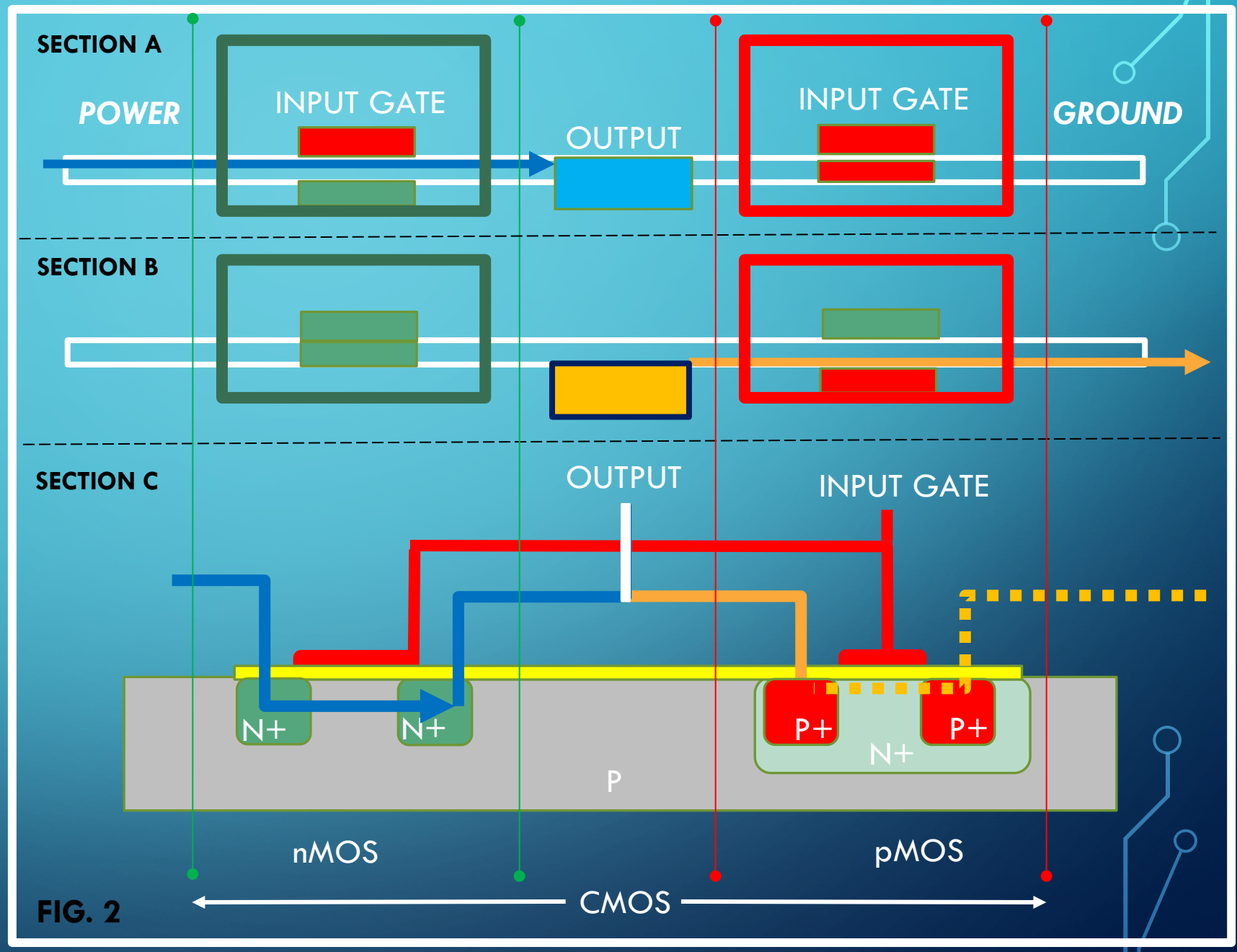


FIG. 2

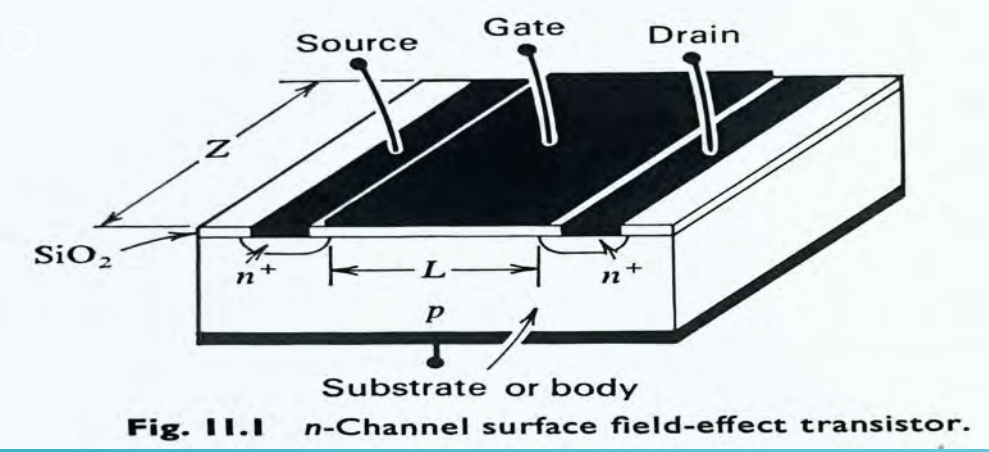
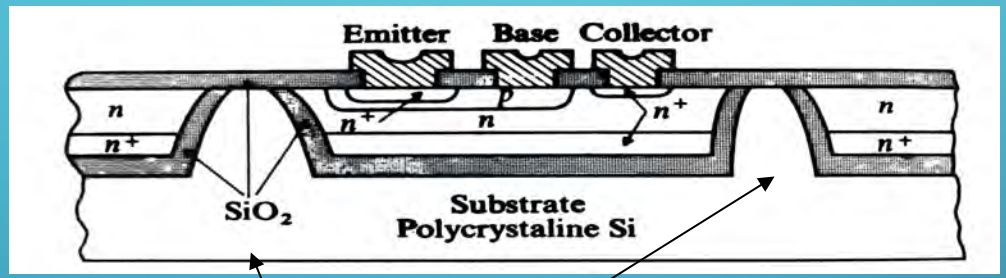


Fig. 11.1 *n*-Channel surface field-effect transistor.

CMOS is easier to fabricate. – Fewer layers

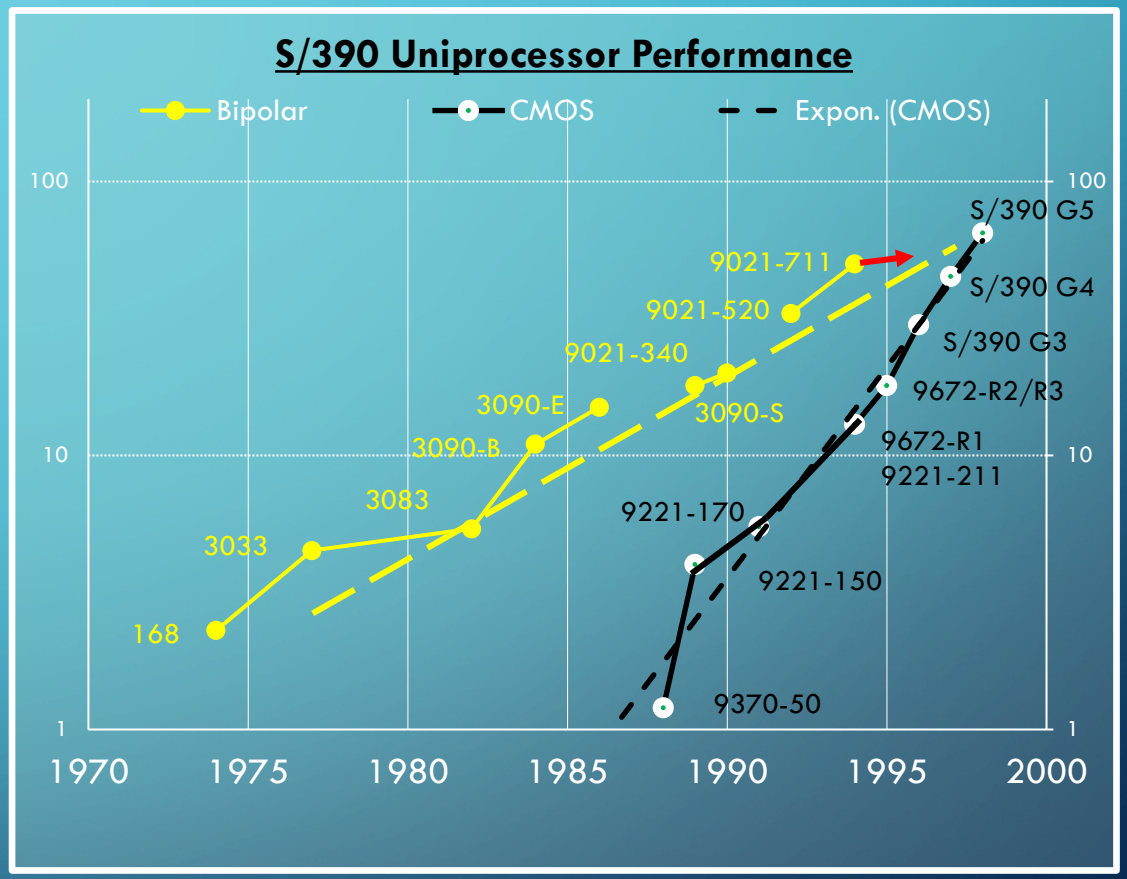


Denser than Bipolar – CMOS doesn't require isolation around devices

A single logic gate on a BIPOLAR chip can be comprised of a large number of components, as some extra components such as resistors are needed, while a single logic gate on a CMOS chip can be comprised of just two FETs.

SOLUTION - CMOS TECHNOLOGY

TRANSITION TIMEFRAME H6/G4/G5	BIPOLAR TCM	CMOS MCM
CHIP COUNT	5960	30
MODULE COUNT/10 WAY	56	1
MODULE SIZE	110.5 X 117.5	127.5 x 127.5
BOARD	14	1
CYCLE TIME	??	3.5ns -> 2.5 ns
MIPS	~ 465	~ 440 -> 1040
MACHINE INTRODUCTIONS	> 2 YEARS	~ 1 YEARS
OPERATING TEMPERATURE RANGE	25 TO 70 °C	-55 to 125°C
NOMINAL SUPPLY VOLTAGE	~ 5V	~ 3 to 15 V
FLOOR SPACE FT^2	671.6	51.9
MACHINE POWER (KVA)	144	5
WEIGHT	31857	2067



MAINFRAME (Z SYSTEMS) TRANSITION IN THE 1990'S

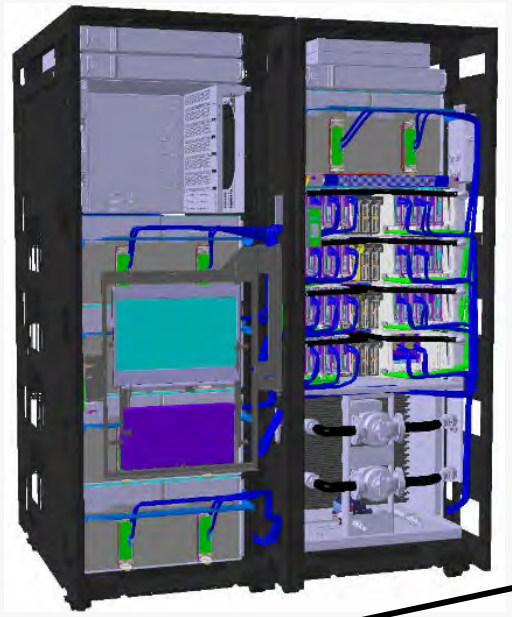
LOU GUADAGNO – RETIRED FROM IBM
CYRIL PRICE - RETIRED FROM IBM
BOB NASSER - RETIRED FROM IBM

SEPTEMBER

What Really Makes up A Mainframe

Lou Guadagno

z System Components



Processor Sub-system

Packaging/Cooling
System Controls
Mechanical

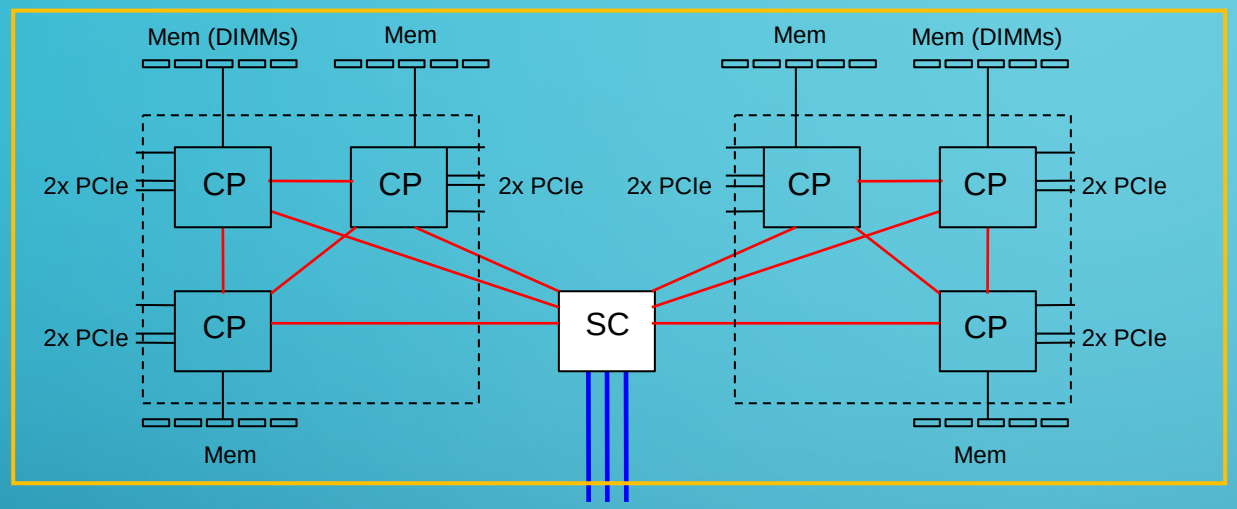
- Disk/Tape
- Flash
- Network

IO Sub-system

Memory
Sub-system

- DIMMs
- Buffer Chip
- DDR3/DDR4
- RAIM Protection

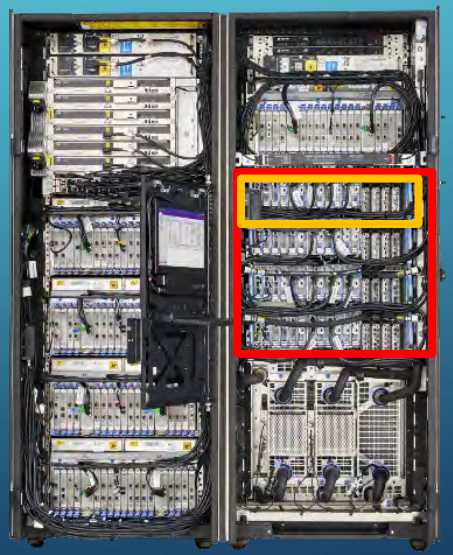
Z14 ON-DRAWER AND SYSTEM TOPOLOGY

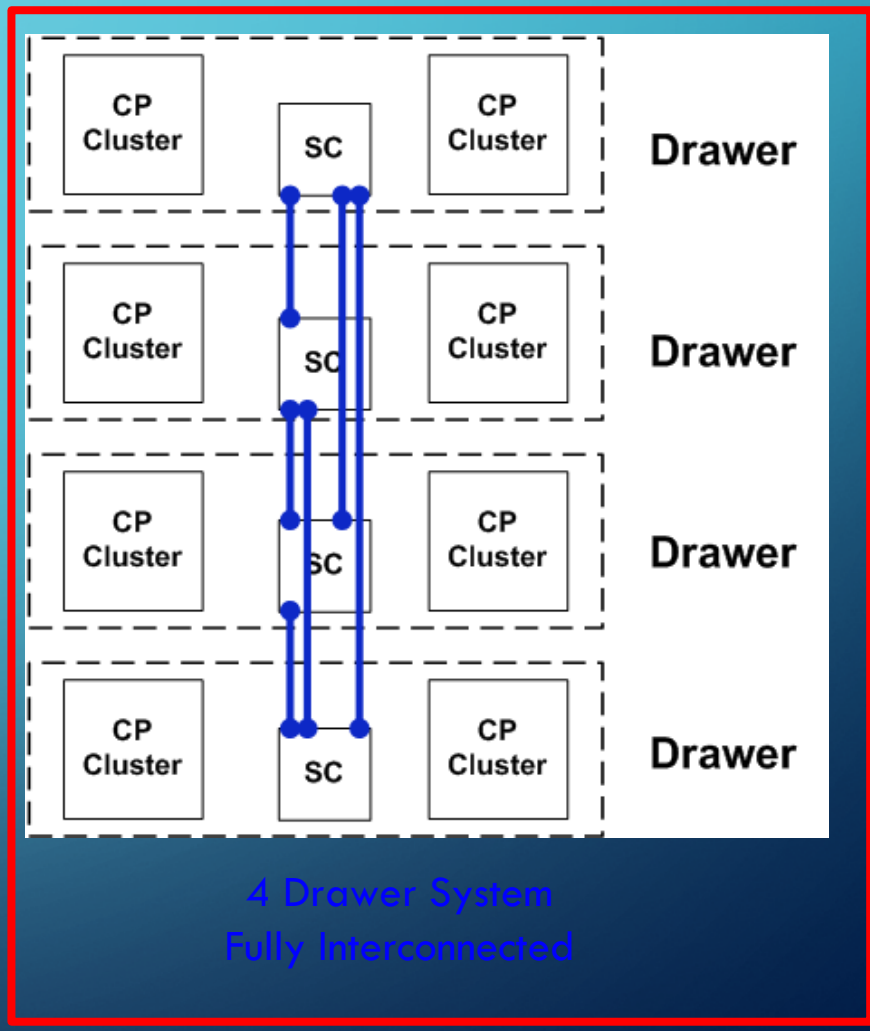


CP chip, 696 sqmm, 14nm, 17 layers of metal
- 10 cores, each 2+4MB I+D L2 cache
- Shared 128MB L3 cache

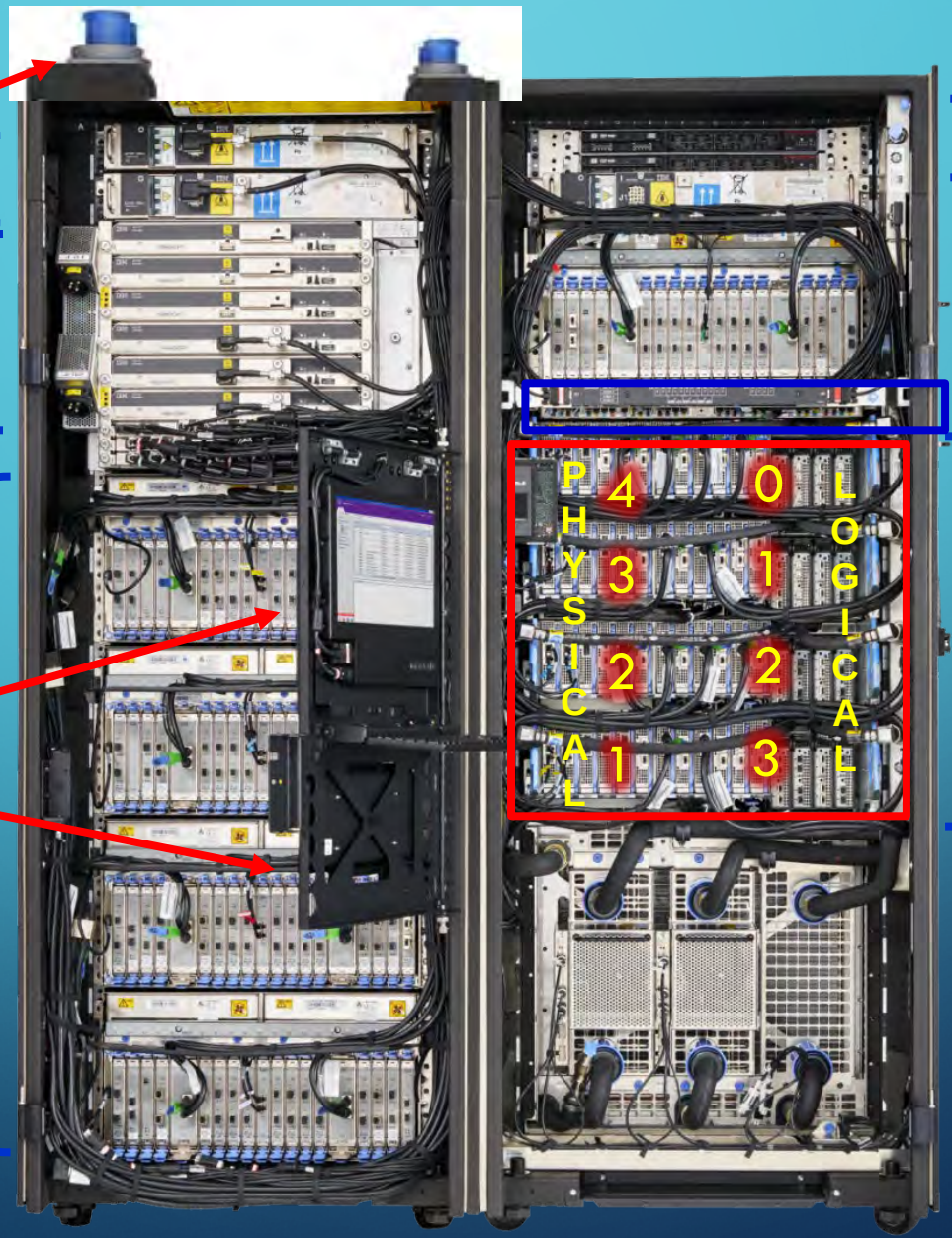
SC chip, 696 sqmm, 14nm, 17 layers of metal
- System interconnect & coherency logic
- Shared 672MB L4 cache

Max System:
- 24 CP sockets in SMP interconnect
- 32TB RAIM-protected memory
- 40 PCI gen3x16 fanouts to IO-drawers
- 320 IO cards





Z14 RADIATOR-BASED AIR COOLED – FRONT VIEW



Overhead Power Cables (option)

Internal Batteries (optional)

Power Supplies

Displays and keyboards for Support Elements

PCIe I/O drawers numbers 1 to 4

2 x 1U Support Elements

PCIe I/O drawer number 5

System Control Hubs (used to be BPHs)

CPC Drawers, PCIe Fanouts, Cooling water manifold and pipes, PCIe I/O interconnect cables, FSPs and Ethernet cables

Note: CPC Drawer plugging numbers are on the left and logical numbers on the right

Radiator Pumps

Overhead I/O feature is a co-req for overhead power option

1990'S

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CYRIL PRICE - RETIRED FROM IBM
BOB NASSER - RETIRED FROM IBM

SEPTEMBER

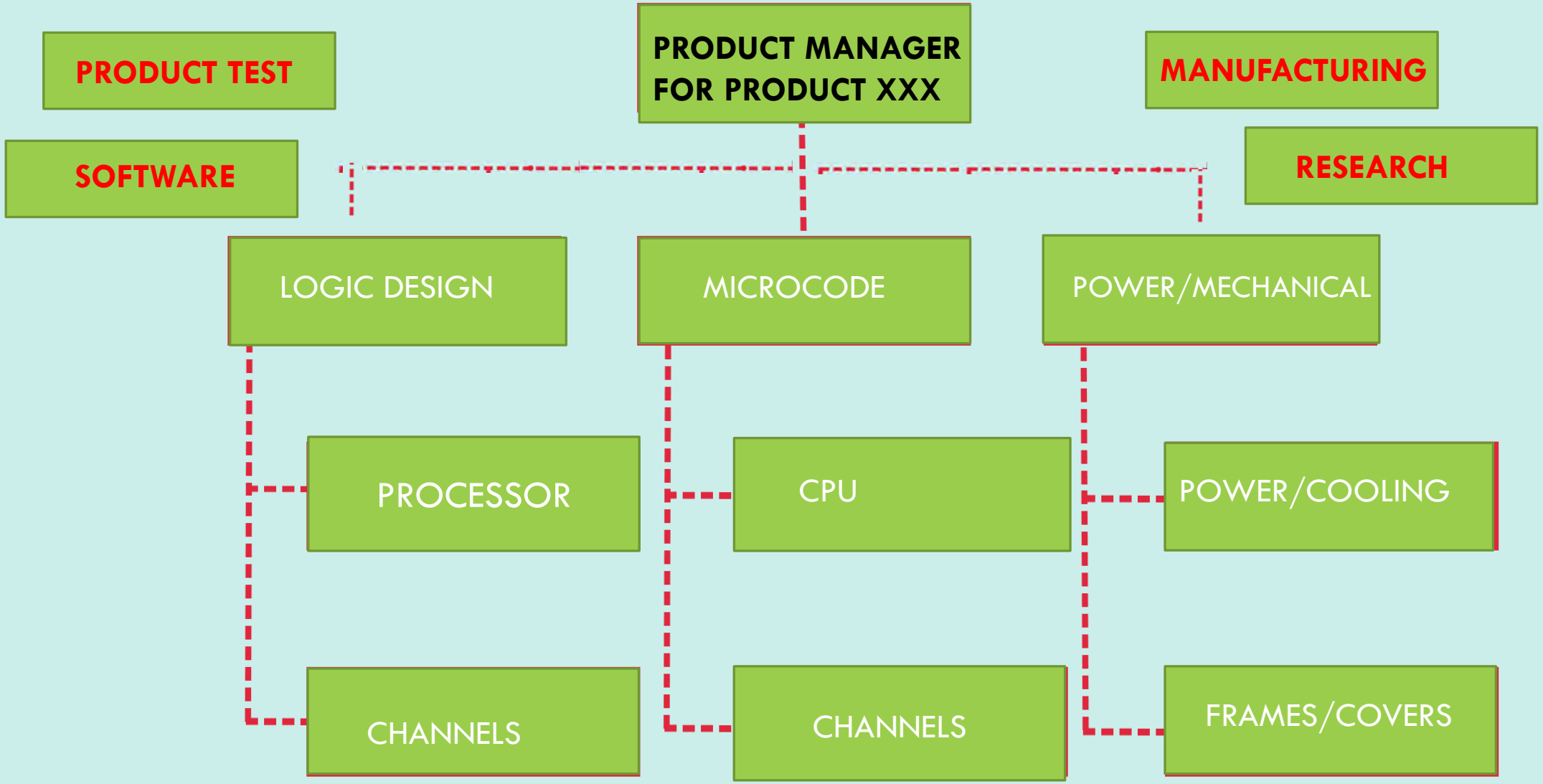
Change Of Methodology Of Managing Machine Development/Manufacturing To The "Program Management" Model

Bob Nasser

THE WAY WE WERE – CIRCA 1969

Product Development was owned by a single organization

TRADITIONAL STRUCTURE



PRODUCT DEVELOPMENT IN MULTIPLE LOCATIONS

- POUGHKEEPSIE – High End Mainframes
- KINGSTON – Printers, Displays, Telecommunication Products
- ENDICOTT – Midrange Mainframes
- BOEBLINGEN, GERMANY – Low End Mainframes, Memory

ADVANTAGES

- CENTRALIZED CONTROL – EVERYONE UNDER THE SAME MANAGAMENT
- GEOGRAPHICALLY LOCATED – EVERYONE IN THE SAME LOCATION
- SUPPORT ORGANIZATIONS – LOCATED LOCALLY
  - PRODUCT TEST
  - MANUFACTURING
  - PROCUREMENT
  - . . .

DISADVANTAGES

- REDUNDANT SKILLS ACROSS MULTIPLE LOCATIONS
- DUPLICATION OF SUPPORT PROCESSES
  - “NIH” ATTITUDE “NOT INVENTED HERE”

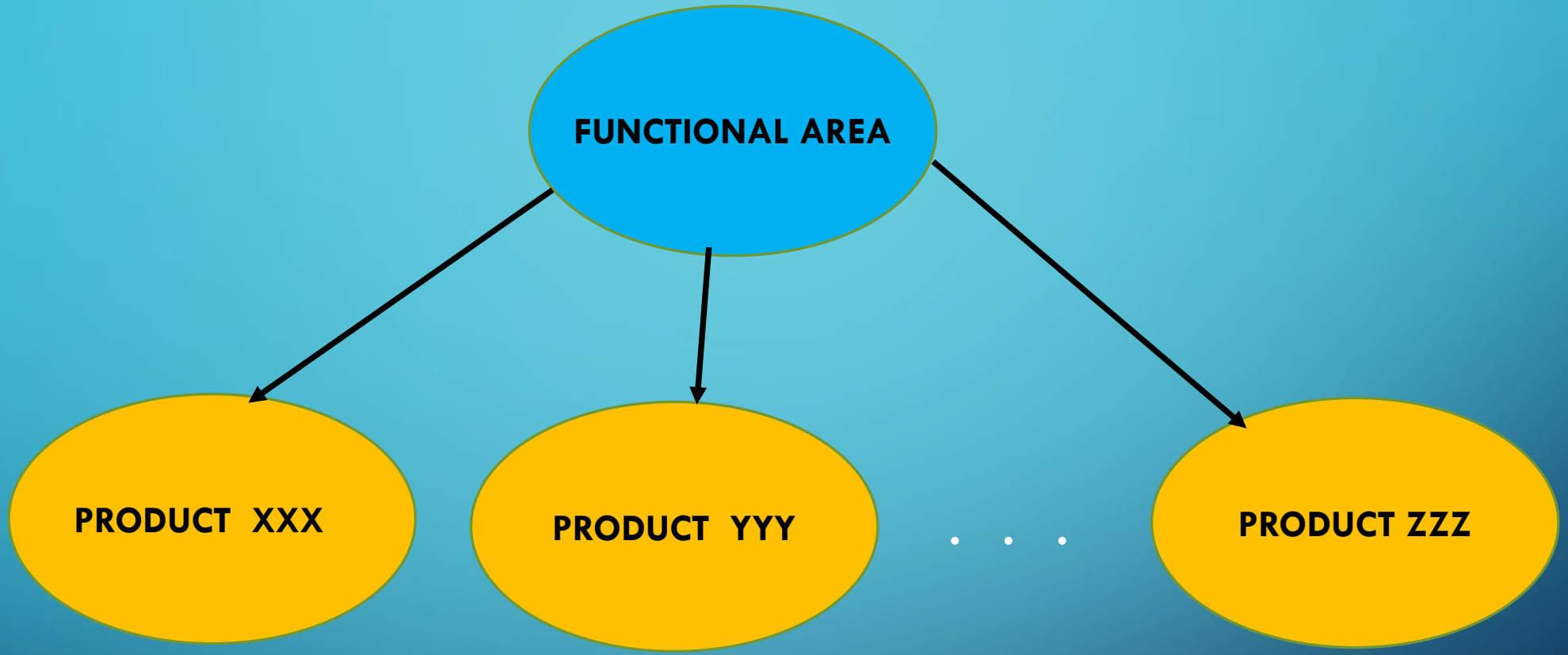
EVOLUTION TO THE WAY WE ARE NOW

1993 - NEW CEO, LOU GERSTNER, DECLARES:

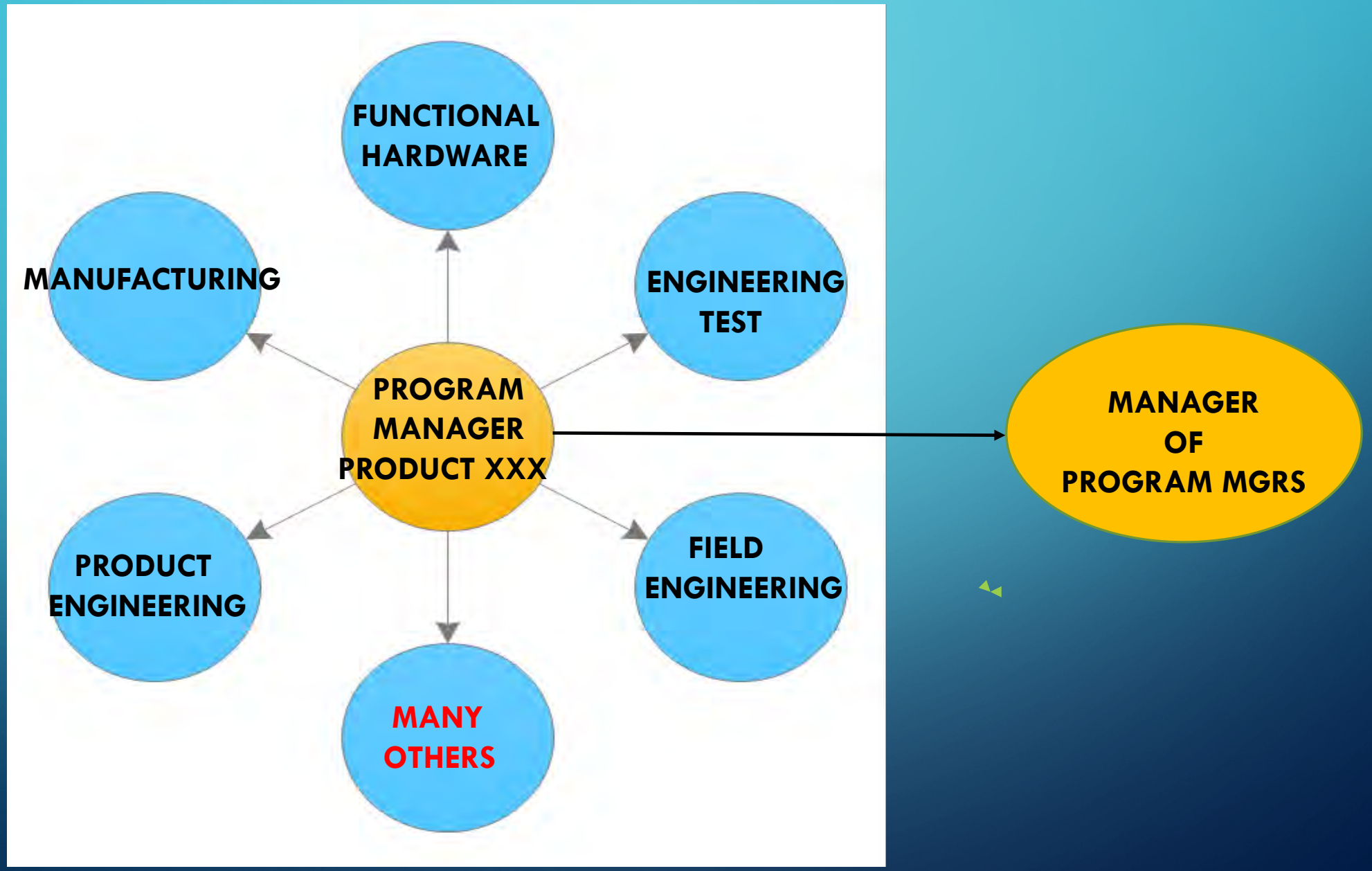
“IBM WILL BECOME A PROJECT BASED ORGANIZATION”

A NEW CAREER PATH CREATED: PROJECT MANAGER

PREVIOUSLY SKILL ORIENTED:
ENGINEER, PROGRAMMER, TECHNICIAN, . . .


FUNCTIONAL AREA
PRODUCT XXX
PRODUCT YYY
PRODUCT ZZZ

MATRIX - WHEEL AND SPOKE



ADVANTAGES

- CENTERS OF COMPETENCY FOR CRITICAL SKILLS
  - SOURCE FOR SKILLS FOR EACH PRODUCT.
- COMMON METHODOLOGIES AND SUPPORT PROCESSES
  - ELIMINATED “NIH” ATTITUDE.

DISADVANTAGES

- GEOGRAPHIC AND TIME ZONE DIFFERENCES.
  - WORK DAY EXPANSION
    - POUGHKEEPSIE AND GERMANY – 6 HOURS APART
    - POUGHKEEPSIE, GERMANY, JAPAN – 12 HOUR DIFFERENCE
- MORE FREQUENT TRAVEL
  - PERIODIC IN-PERSON MEETINGS TO PROMOTE TEAM BUILDING

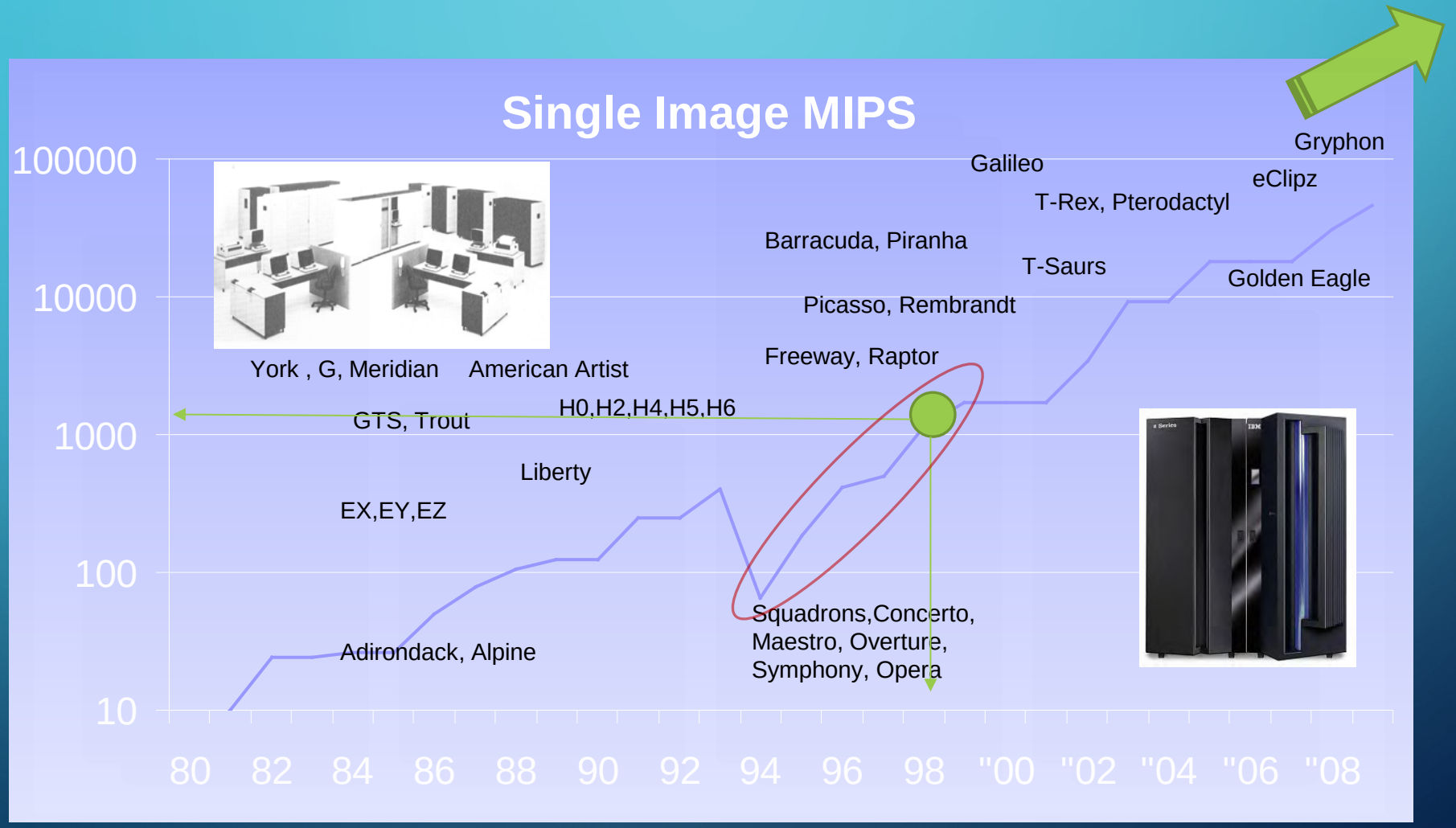
1990'S

LOU GUADAGNO – RETIRED FROM IBM
CYRIL PRICE - RETIRED FROM IBM
BOB NASSER - RETIRED FROM IBM

SEPTEMBER

Division Of Workload and Workforce Interaction Methodology Changes To Accomplish What Seemed Like An Impossible Challenge

MAINFRAMES
A SUCCESS STORY FOR THE AGES



WHAT WAS THE ENVIRONMENT LIKE

- *We had just lost ½ the workforce.*
- *We were staffed in five sites (Poughkeepsie/Boeblingen/Endicott/Yorktown Research).*
- *There was some feeling of stress of who would take the lead in Developing this new wave of computers => Poughkeepsie or Boeblingen.*
- *Great deal of pressure to recover the Bipolar MIPS, keep our Customers committed to us as we went through the transition, and maintain this wonderful business for IBM to be the legendary franchise it was and will be in the future.*

WHAT BECAME OUR HIGH LEVEL PLAN

- *Develop and ship 4 machines in 4 consecutives years*
  - *Concerto - 1995*
  - *Maestro - 1996*
  - *Overture - 1997*

Bipolar Threshold

  - *Symphony – 1998 =>1000 MIPS*
    - *This would far exceed the biggest Bipolar we ever shipped*
    - *Send a message to our Customers and the World that we could be counted on to be relevant to the times and their needs now and in the future.*

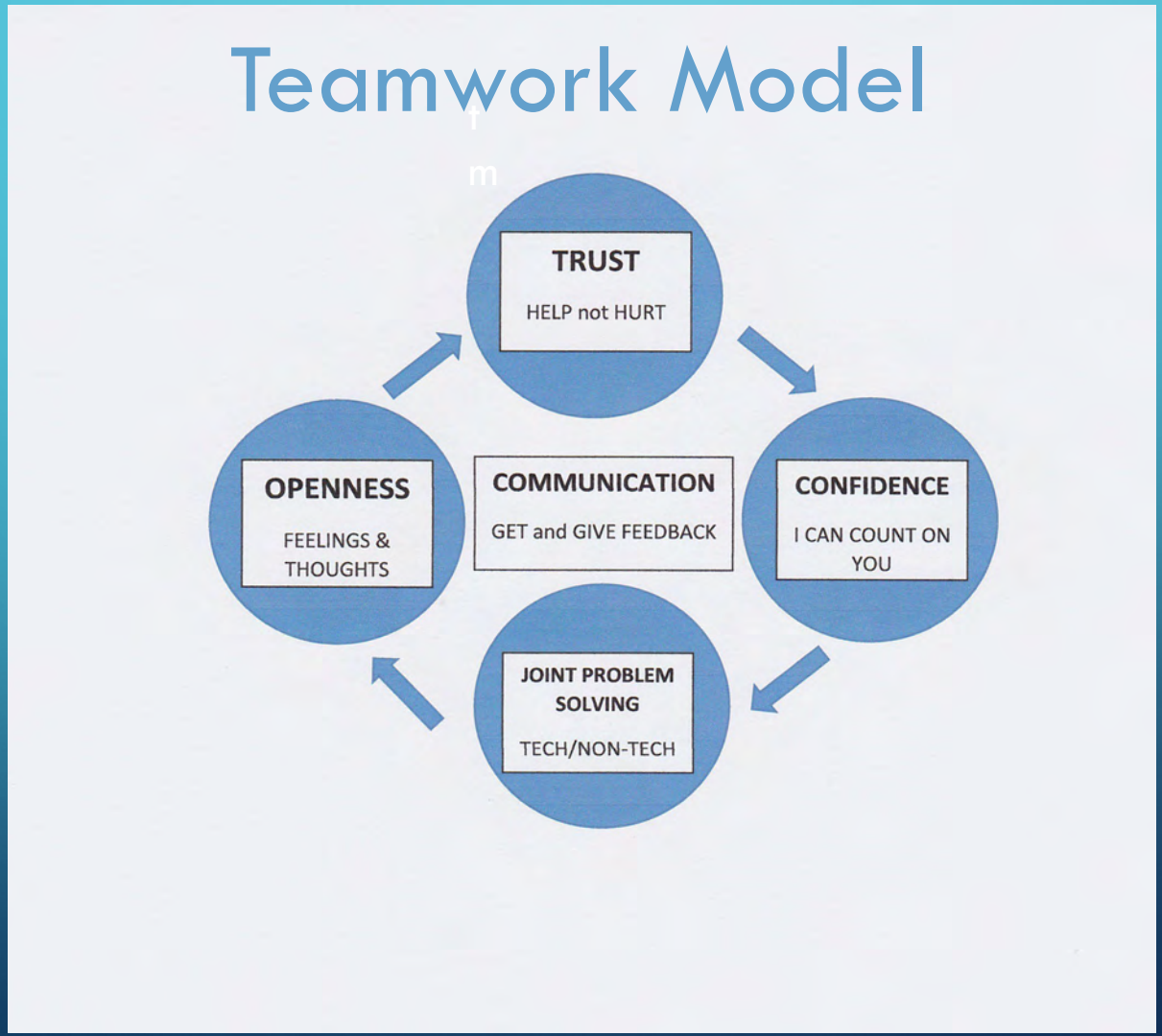
HOW WERE WE GOING TO DO THIS WITH THE WORK FORCE WE HAD

- *Define two microprocessor teams*
  - *One in Boeblingen who already had developed the initial stages of a microprocessor to be used on Concerto and Maestro*
  - *Second team here in Poughkeepsie/Kingston had started to develop a new microprocessor for Overture and Symphony*
- *Divide the remainder of the work between Poughkeepsie, Boeblingen and Endicott (I/O, Power/Thermal/Mechanical, Memory, microcode etc.) for all machines*
- *Use the "Program Management" Model to execute the plan Worldwide.*

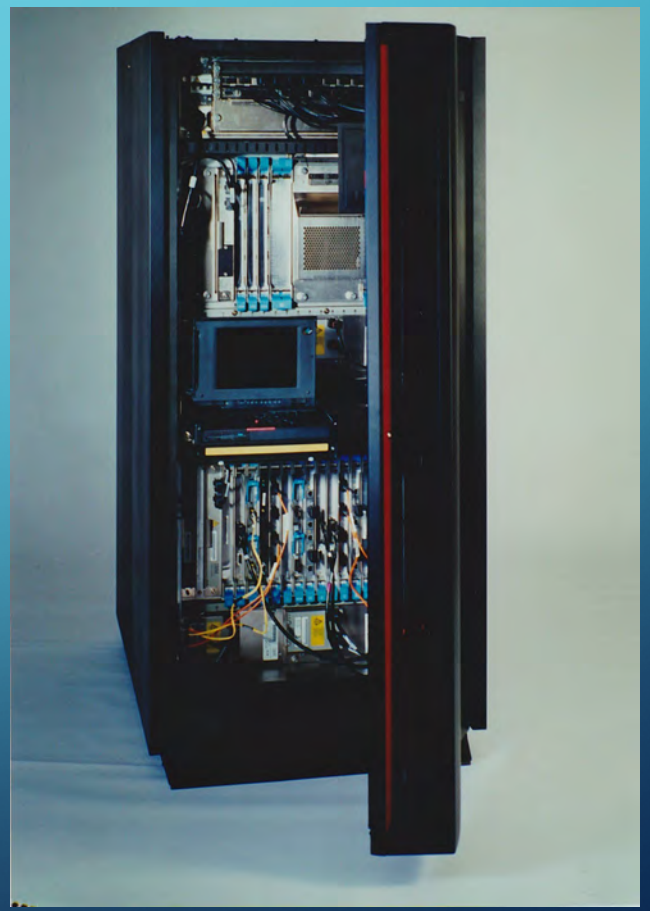
IT WAS GOING TO TAKE MORE THAN JUST A PLAN FOR THE WORK!

- *Needed a level of unparalleled teamwork*
- *Leadership from all three sites including Montpellier from both Development and Manufacturing met in Triberg, Germany*
  - *In the middle of the Black Forest*
  - *This is where Cuckoo clocks are made*
- *Bonded and developed a teamwork model to pull it off.*

THEME TO OPERATE AS A WORLDWIDE TEAM AFTER 1993 MAJOR RESOURCE ACTION.



IN 1995 CONCERTO – G2
(Z2 IN TODAYS TERMINOLOGY)
186 MIPS



IN 1998 SYMPHONY – G5 (Z5 IN TODAYS TERMINOLOGY) 1000+ MIPS

IBM

S390 G5 and G6

S/390 G5 and G6

WORLD'S LEADING BUSINESSES RUN ON THE MAINFRAME (CIRCA 2019)

92

of the top 100 worldwide banks

10

out of 10 of the world's largest insurers

23

of the top 25 US retailers

23

out of 25 of the world's largest airlines

Mainframes process

30 billion business transactions per day

Mainframes enable

$6 trillion in card payments annually

80 percent of the world's corporate data resides or originates on mainframes

91 percent of CIOs said new customer-facing apps are accessing the mainframe

IBM Z17: ADVANCED AI WHERE IT MATTERS MOST

Rick Schoonmaker
IBM Z and LinuxONE HW Product Management Director
raschoon@us.ibm.com

MAINFRAME IS CRUCIAL IN THE WORLD TODAY

70%

of all transactions by value go through an IBM mainframe[1]

$8.5T

Value of U.S. payments being processed on mainframe[2]

99.999999%

industry-leading availability equivalent to 315ms of downtime per year [3]

IBM Z17

FULLY ENGINEERED STACK FOR AI WHERE IT MATTERS MOST

Transaction processing platform

Operating systems & firmware

IBM Z infrastructure

450 billion

Inference operations per day with 1ms response time vs. 300B on IBM z16[8]

7.5x AI throughput

Utilizing 8 AI processing units vs. one on IBM z16[9]

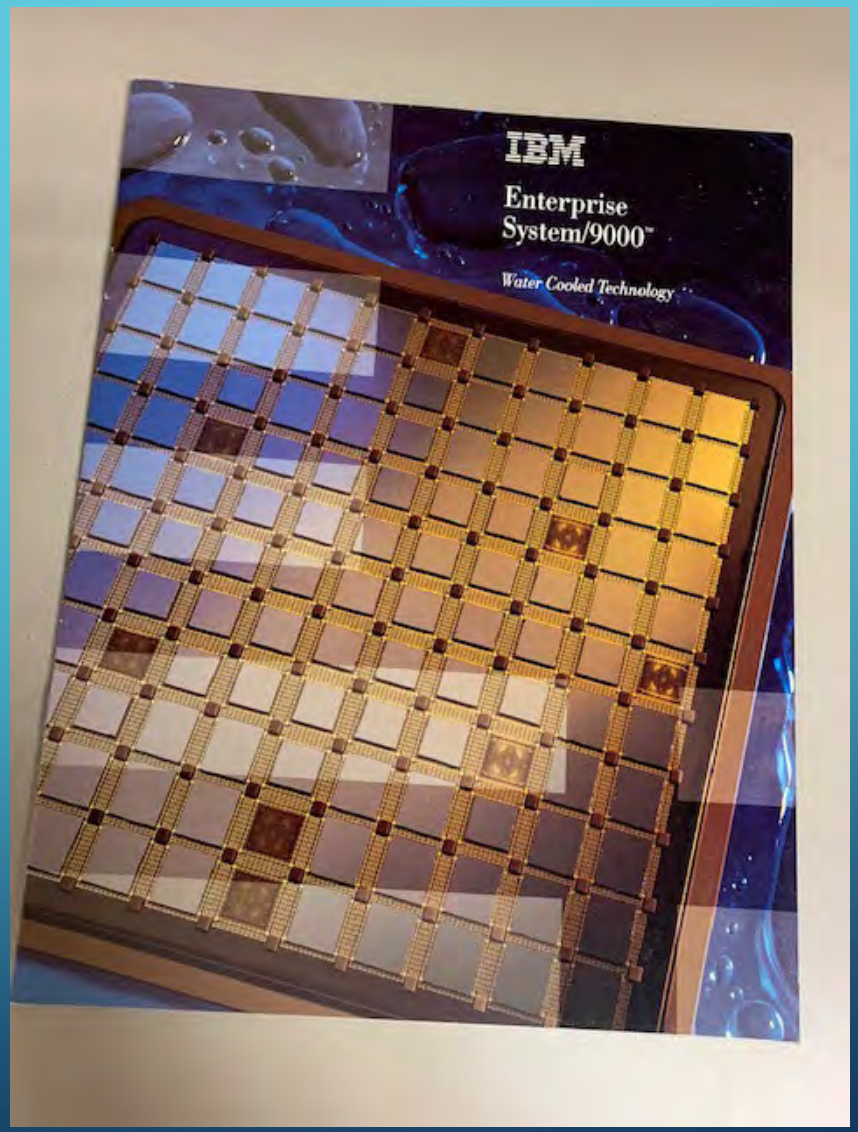
250K MIP's

Built on a foundation of security, resiliency, and high availability.

- *Back up*

SYMPHONEY - G5
(Z5 IN TODAYS TERMINOLOGY) – 1000 MIPS

MODULE FOR 9000 SERIES MAINFRAMES




Enterprise System/9000™
September 5, 1990
A New Era Begins
IBM

Special Edition

Full-color, pull-out poster included in center pages.

IBM news

November 1980

New IBM system announced today

IBM 3081 takes a major evolutionary step into the future

The IBM 308' processor announced today represents a major evolutionary step in the computer age and a giant step into the future as measured by the advanced technologies it brings to users in the marketplace.

For IBM, and especially for the Data Systems Division, the IBM 3081 is an accomplishment of immense proportions, the fulfillment of tireless efforts of countless individuals.

"The credit for this new processor," says Jack Bertram, IBM vice president and DSD president, "belongs to everyone – not only those in DSD directly involved in the immediate task, but also those who provided support services of every kind both within and without the division.

"I doubt if there has ever been a new IBM product announcement whose success depended so much on the interaction of so many employees in so many different sites."

This endeavor's technological roots can be traced back nearly a decade. As a result of the revolutionary technology it incorporates, the IBM 3081 offers lower cost, higher performance and greater reliability than any other computer in IBM's history.

Consider these comparisons.

The IBM 3081 has up to 2.1 times the internal operating speed of the 3033. And, of course, it offers substantial improvement in overall performance with improved availability and reliability.

The 3081 processor uses 60 percent less energy and dissipates 55 percent less heat – significant cost and environmental considerations.

Floor space is improved as well. The processor occupies 55 percent less floor space even though – as a workhorse for IBM customers who are constantly adding new applications – it can turn out far more work in less time.

And largely because of its compactness, IBM customer engineers will be able to install it in 24 hours compared with 72 for a 3033.

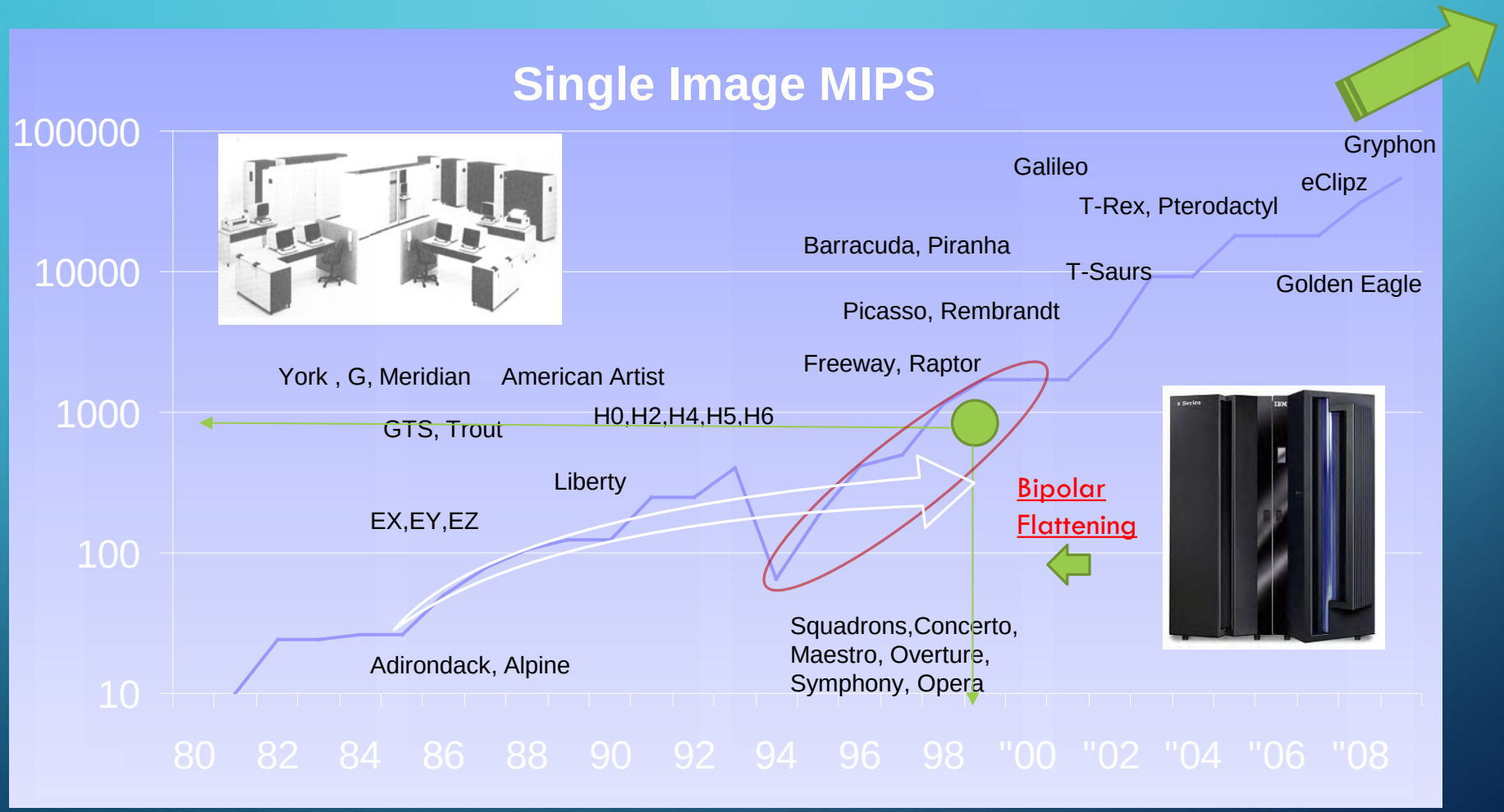
Yet, for all these improvements, the IBM 3081 is still part of the System/370 family. It uses the same software control programs (MVS and VM) so customers can migrate easily from System/370 to the IBM 3081 without disrupting their data processing workload.

Equally important, the IBM 3081 offers tremendous improvements in reliability. This is largely the result of an ingenious package, known as the thermal conduction module (TCM).

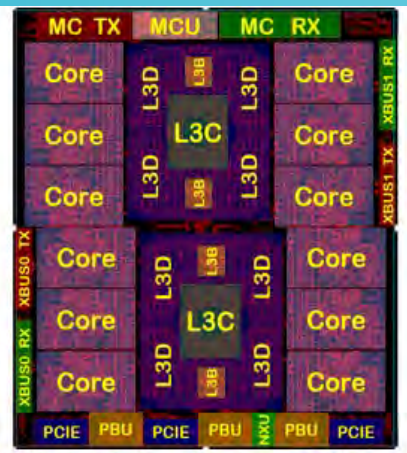
Continued on page 36.

e this issue:

MAINFRAMES
A SUCCESS STORY FOR THE AGES

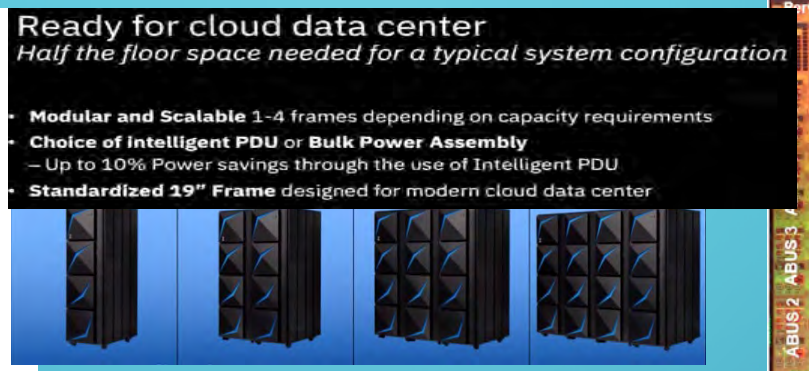


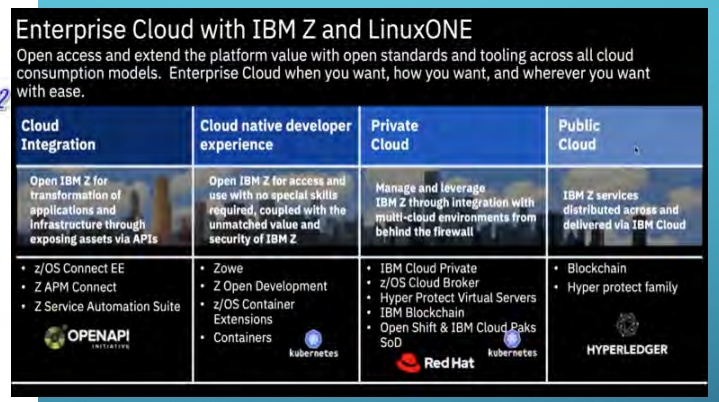
z15 Processor and Storage Controller Chips, Modules, Systems

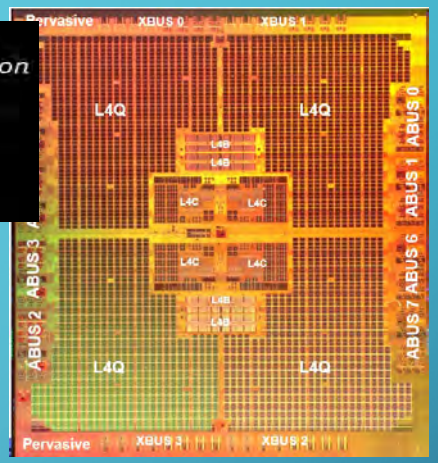


Z15 CP Chip 12-Core Design 5.2GHz 696mm2

14nm SOI Technology, Chip Power: 282 W
17 BEOL Wiring Layers
12 Cores With Dedicated L1 & L2 Cache
8MB Private L2 Cache
9.2 Billion Devices
4.0 Billion eDRAM Cells
189 Million SRAM Cells
15.6 Miles of Wire 26.2B Vias 6 Pwr Domains
7 Clock Domains Shared 256MB L3 Cache
5 Port Memory Interface
2 X-Bus Interfaces
3 PCI Express Interfaces GEN-4







SC Chip 980 MB L4 EDRAM Cache 696mm2

14nm SOI Technology, Chip Power: 100W
17 BEOL Wiring Layers
12.2 Billion Devices
9B eDRAM Cells
591.8 million signal nets 18M SRAM Cells
13.5 Miles of Wire, 22.3B Vias
6 Voltage Domains, 5 Clock Domains,
980 MB L4 Cache
4 X-Bus Interfaces
4 A-Bus Interfaces

IBM Z team delivered a system that is 40% smaller than previous z14s, but with increased capacity and 14% single thread performance improvement! This coupled with increases of up to 190 cores in a single system, ultimately delivers a 25% max system capacity increase, which means our clients can now execute a huge **1 trillion web transactions per day!**

Z SYSTEMS (A.K.A. MAINFRAME - DEF.): *AN INTEGRATED, HIGHLY SCALABLE COMPUTER SYSTEM THAT ALLOWS MANY DIFFERENT PIECES OF WORK TO BE HANDLED AT THE SAME TIME, SHARING THE SAME INFORMATION AS NEEDED WITH PROTECTION, HANDLING VERY LARGE AMOUNTS OF INFORMATION FOR MANY USERS WITH SECURITY, WITHOUT USERS EXPERIENCING ANY FAILURES IN SERVICE.*

THE 165 MIPS G3 (Z3) REQUIRED UNPRECEDENTED TEAMWORK