Legendary Engineering Success Stories

R. Gary Daniels talk to IEEE Central Texas Consultants Network Group 24 October 2012

email: RGD00111@yahoo.com

Legendary Engineering Success Stories

Criteria:

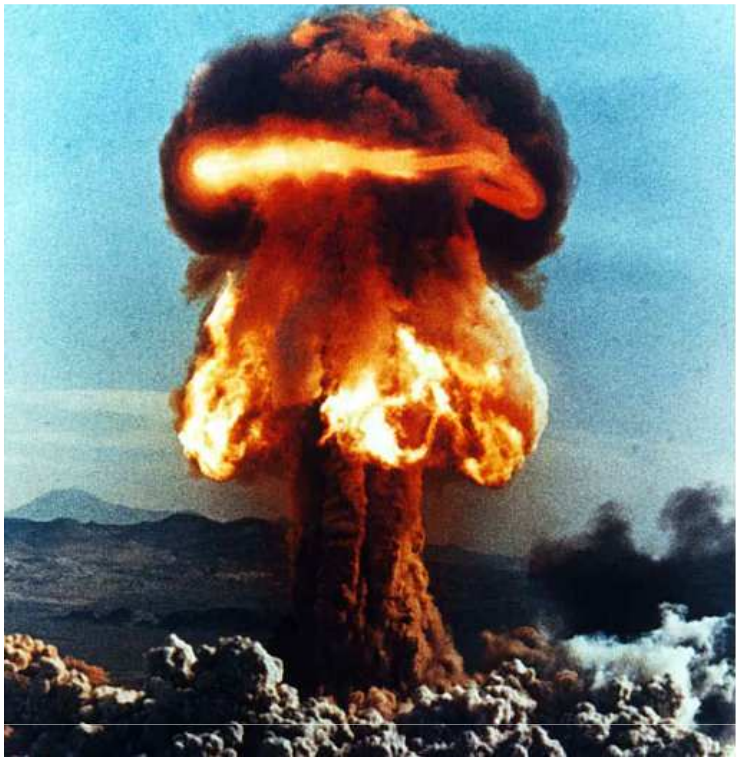
- In the past 75 years
- Substantial engineering effort
- Produced a useful result
- Clearly a Success – a Legend
- Top 10 (± personal bias)

Legendary Engineering Success Stories

Categories:

1. Government sponsored
2. Aircraft
3. Naval vessels
4. Automobiles
5. Semiconductors
6. Computers
7. Appliances
8. Communications

Manhattan Project



- **Time frame:** 1940's
- **Cost:** 2 Billion 1945 $
- **People involved:** over 130,000
- **Key Sites:** Los Alamos, NM, Oak Ridge, TN and Hanford, WA
- **Result:** Two Atomic Bombs – which ended World War II
- **Key Leaders:** Dr R. Oppenheimer & Gen Leslie Groves
- **Personal Note:** Met several Manhattan Project contributors at Sandia Labs

NASA and the Apollo Space Mission

- President Kennedy Initiative
- Timeframe: 1963-1972
- "One small step for man, one giant leap for mankind"
- Cost: 25 Billion 1973 $
- Many, many technological fringe benefits

Neil Armstrong - 1969
First man on the moon

Boeing B17 "Flying Fortress"

Boeing B-17E

- High altitude, long range, WW II Bomber
- Timeframe: 1934-1968 (13 air-worthy in 2011)
- Development Leaders: G. Emory & E. Wells
- Dropped most bombs in WW II
- Rugged, reliable – "wing & prayer"

Lockheed SR71 "Blackbird"

- None ever shot down
- Developed in "skunk works"
- Champion: Kelly Johnson – aeronautical genius
- Timeframe: 1964-1988
- Very, very fast (mach 3+), very, very high altitude, spy plane with stealth features

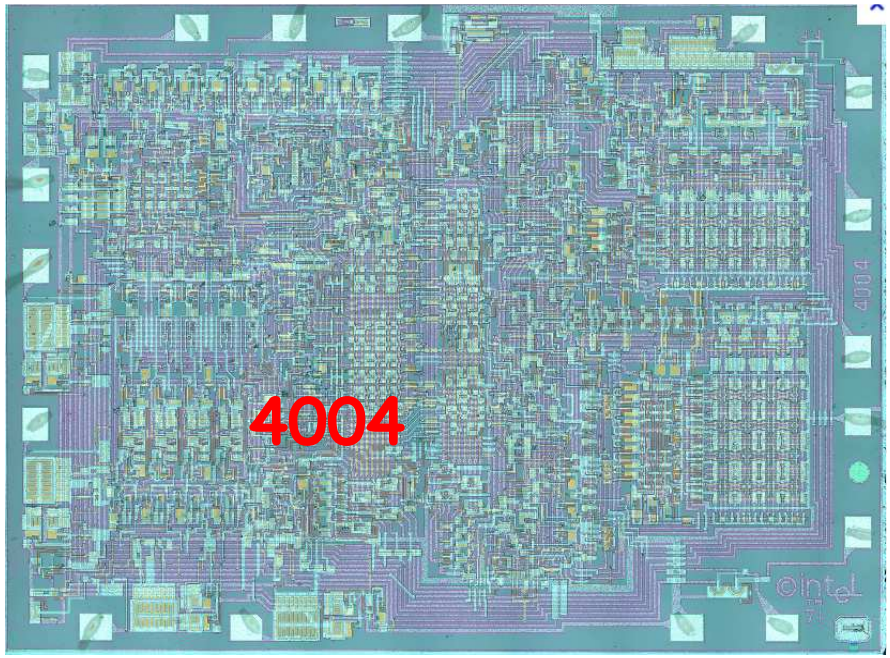
Nuclear Submarine

- Capable of operating for months without resurfacing
- Champion: Admiral Hyman Rickover
- Nautilus launched in 1954
- Carried Polaris ICBM's (first tested in 1960)
- Perhaps cold war's most awesome weapon

Ford Mustang

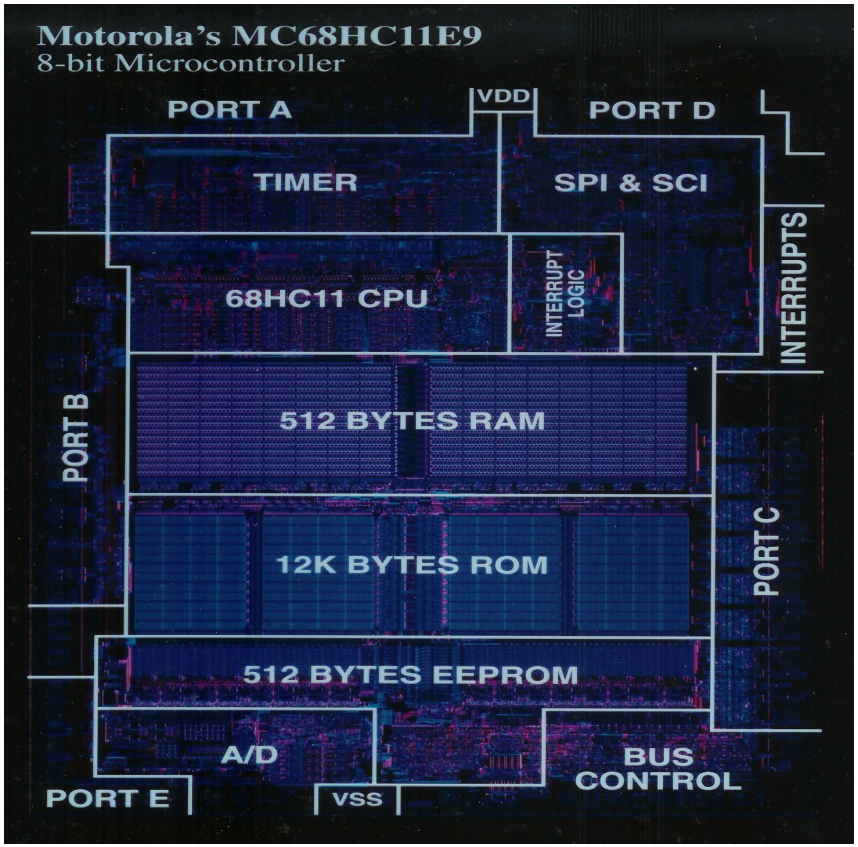
- Very popular "sports-car-like" coupe
- Time Frame: 1964 to the present
- Champion: Lee Iacocca
- 400,000 sold in first model year (record)
- Personal: We owned a 1965 Ford Fastback

Intel Microprocessor



- First MPU (4004)
  Introduced in 1971
- Programmable calculator chip: 4-bit, 10um
- Key contributor: Federico Faggin
- Intel is now one of the world's most valuable companies
- Personal: Met Faggin at IEEE conferences

Motorola 68HC11 Microcontroller



- Introduced in 1984
- Champion: Jim Sibigtroth
- Benchmark Microcontroller for two decades
- First MCU with embedded EEPROM
- Rich complement of on-chip peripherals
- Helped Motorola MCU Division reach 2B 1995 $

Personal Computer
The IBM PC

- Introduced in 1981
- CPU: Intel 8088
- Developed by a team led by Don Estridge at Boca Raton, Florida
- Featured an open architecture – allowed many software compatible copies and software "apps"
- IBM sold PC Business to Lenovo in 2005; Intel & Microsoft kept control – and became very rich

Microwave Oven

- Microwave heating effect **discovered by accident** in 1945 by Dr Percy Spencer at Raytheon while working on advanced Radar
- First food cooked was popcorn
- 90% of American households now own one

Apple IPhone "Smartest Smart Phone"

- Introduced in 2007 – accelerated the smart phone revolution
- Champion: Steve Jobs – his legacy product
- Apple is now the most valuable company on earth !
- Steve Jobs may be recognized as the "Henry Ford" of this century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30H

On the B-17

- It was neither the largest nor the heaviest
- It did not carry the heaviest bomb load
- Other aircraft were faster and could fly farther
- It was not built in the greatest number
- It was not a great many things
- But all agree she was <u>The Greatest Bomber</u> that ever took to the skies.

On the B-17

She was … rugged … steady … stable … reliable.

These are the ingredients from which great machines are made.

The B-17 was a pilot's airplane!

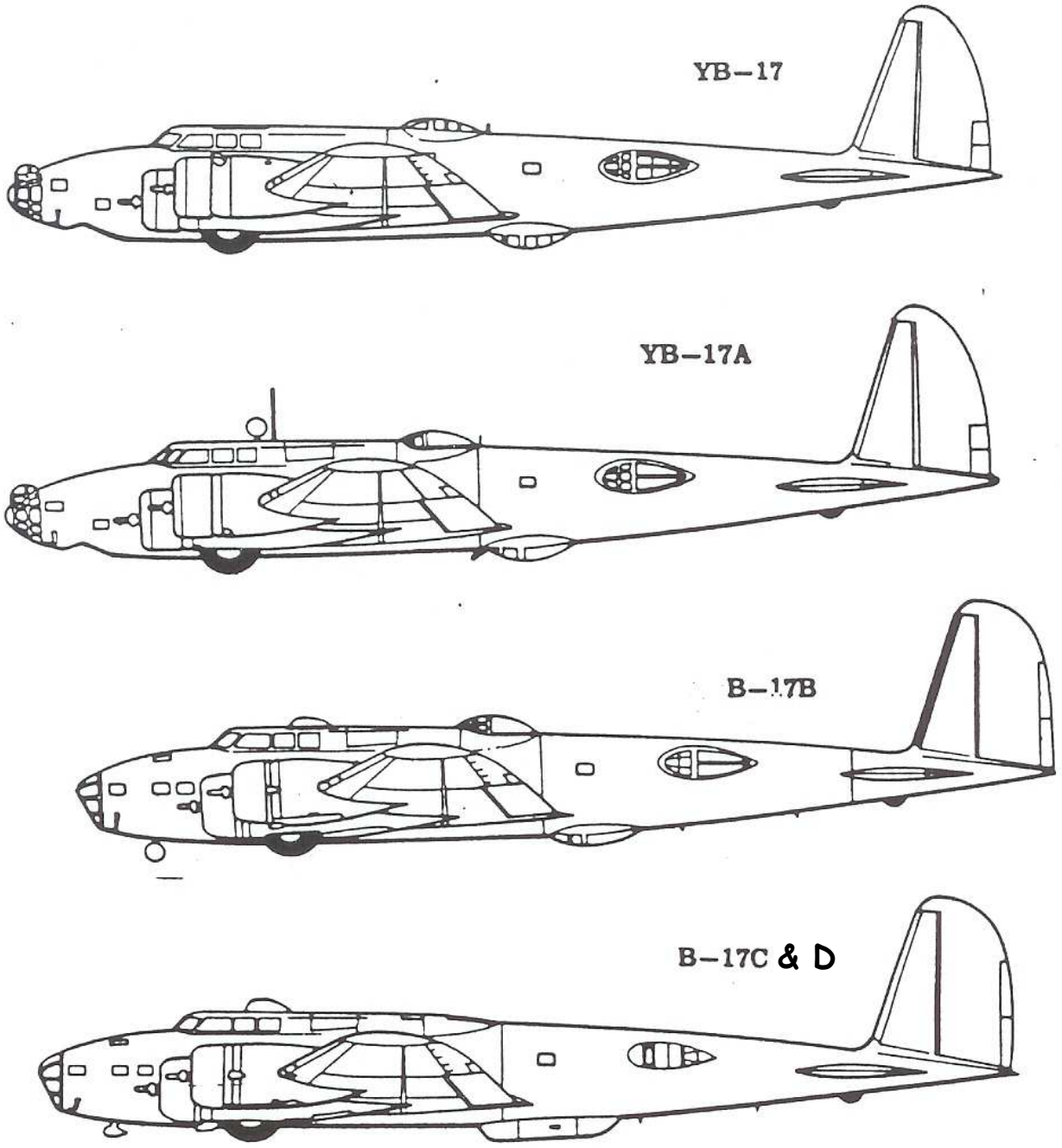
[RGD note: the B17 used electric controls – as opposed to hydraulic]

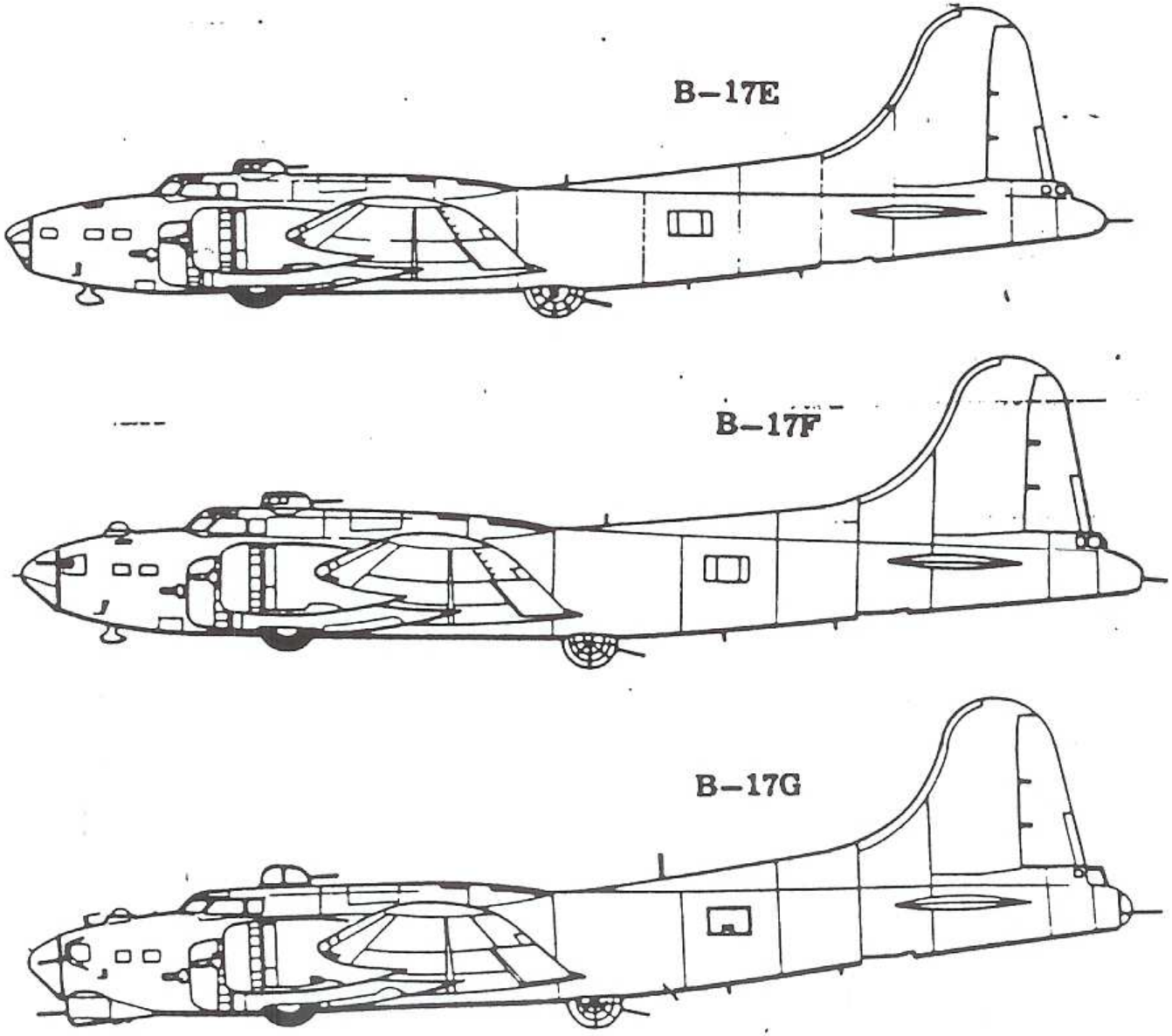
B-17 Production History

1935 ..... MOD 299 ..... 1 (crashed)
YB17 ..... 13 (# 1 crashed)
YB17A ..... 1 (?)
B17B ..... 39 (Navy squabble)
B17C ..... 38 (RAF action: NG)
1941 ..... B17D ..... 42 (Half lost in first week)

134 planes total

Boeing nearly bankrupt!


YB–17
YB–17A
B–17B
B–17C & D


B–17E
B–17F
B–17G

B-17 Production History

1942 ..... B17E 512

1942/43... B17F 3,405

1943/44... B17G 8,680

All Legends!

BOEING B-17G

Wing Span:	103' 9"
Length:	74' 9"
Gross Weight:	65,500 lbs.
Top Speed:	302 m.p.h.
Cruising Speed:	160 m.p.h.
Range:	3,400 miles
Service Ceiling:	35,600 feet
Power:	Four 1,200 h.p. engines
Armament:	13 .50-caliber machine guns
Bomb Load:	8,000 lbs.
Crew:	10

EAA AVIATION FOUNDATION™

ALUMINUM Overcast

B-17 Flying Fortress

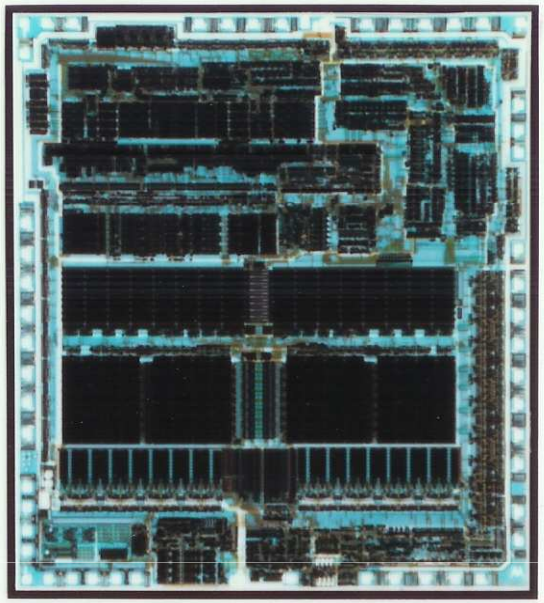
More on the B-17

From the B-17, Boeing went on to build: the B-29, B36, B47 & B-52; (the B-52 is still in active military service today).

And, commercial aircraft: the 707, 727, 737, 747, 757 ..... (many of which are still flying).

MOTOROLA

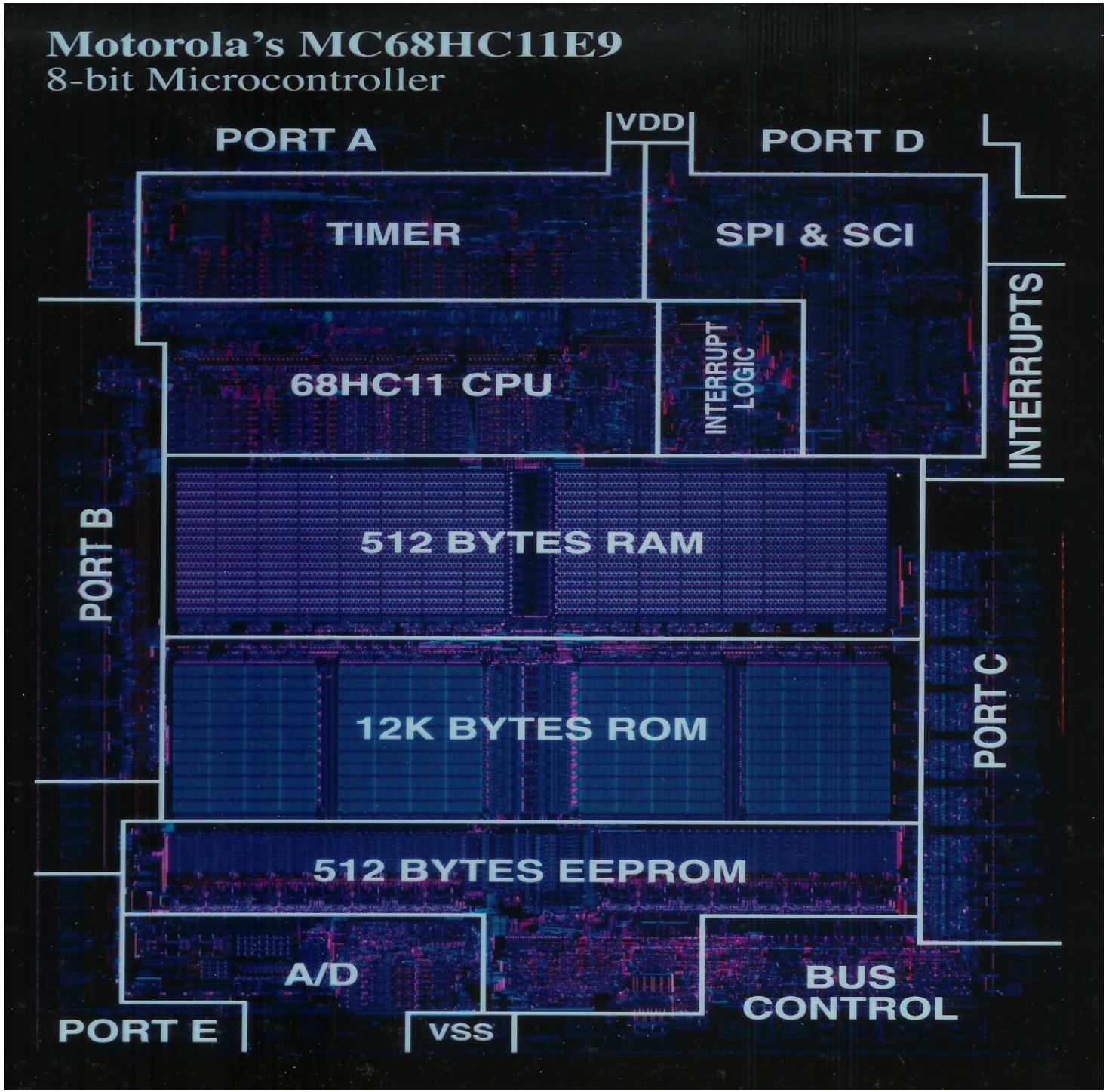
First Silicon: 1984
Introduction: 1985



MC68HC11A8
SINGLE CHIP HCMOS MICROCOMPUTER

- DIE SIZE: 250 × 275 MILS (2 MICRON HCMOS)
- TRANSISTOR COUNT: 127,000
- PACKAGE: 52 PIN PLCC (OR 48 PIN DIP)
- FREQUENCY: 2.1 MHz BUS AT 5 V SUPPLY (1 MHz AT 3 V)
- RAM: 256 BYTES (512 ON 'E8)
- ROM: 8K BYTES
- EEPROM: 512 BYTES—BYTE ERASE
- PARALLEL I/O: 40 PINS BIDIRECTIONAL SOFTWARE PROGRAMMABLE (27 INPUTS MAX, 29 OUTPUTS MAX) PLUS INTERRUPT AND RESET
- SERIAL I/O: SERIAL COMMUNICATIONS INTERFACE (SCI) FOR INTER-PROCESSOR COMMUNICATIONS, AND SERIAL PERIPHERAL INTERFACE (SPI) FOR PERIPHERAL EXPANSION
- ANALOG TO DIGITAL CONVERTER: 8 CHANNELS, 8 BIT ACCURACY
- TIMER: 16 BIT "6801 TYPE," 3 INPUT CAPTURE, 5 OUTPUT COMPARE REGISTERS (or 4 & 4 ON 'E8)
- CPU: 8-BIT "6801 TYPE" UPWARD OBJECT CODE COMPATIBLE, PLUS SECOND INDEX REGISTER, BIT MANIPULATION, STOP AND WAIT, INTEGER AND FRACTIONAL 16-BIT DIVIDE
- SYSTEM FAILURE PROTECTION: WATCH DOG TIMER, TRAP ON ILLEGAL OP CODE, RESET ON CLOCK FAILURE
- DEVELOPMENT SUPPORT: HDS300, EVM BOARD, EVB, THIRD PARTY
- OTHER FAMILY MEMBERS: MC68HC811A2 (2K EEPROM), MC68HC811A8 (8.5K EEPROM) 1987, MC68HC11E8 IN 1987, MC68HC811D4/MC68HC11D4 (LOW COST VERSION) 1987

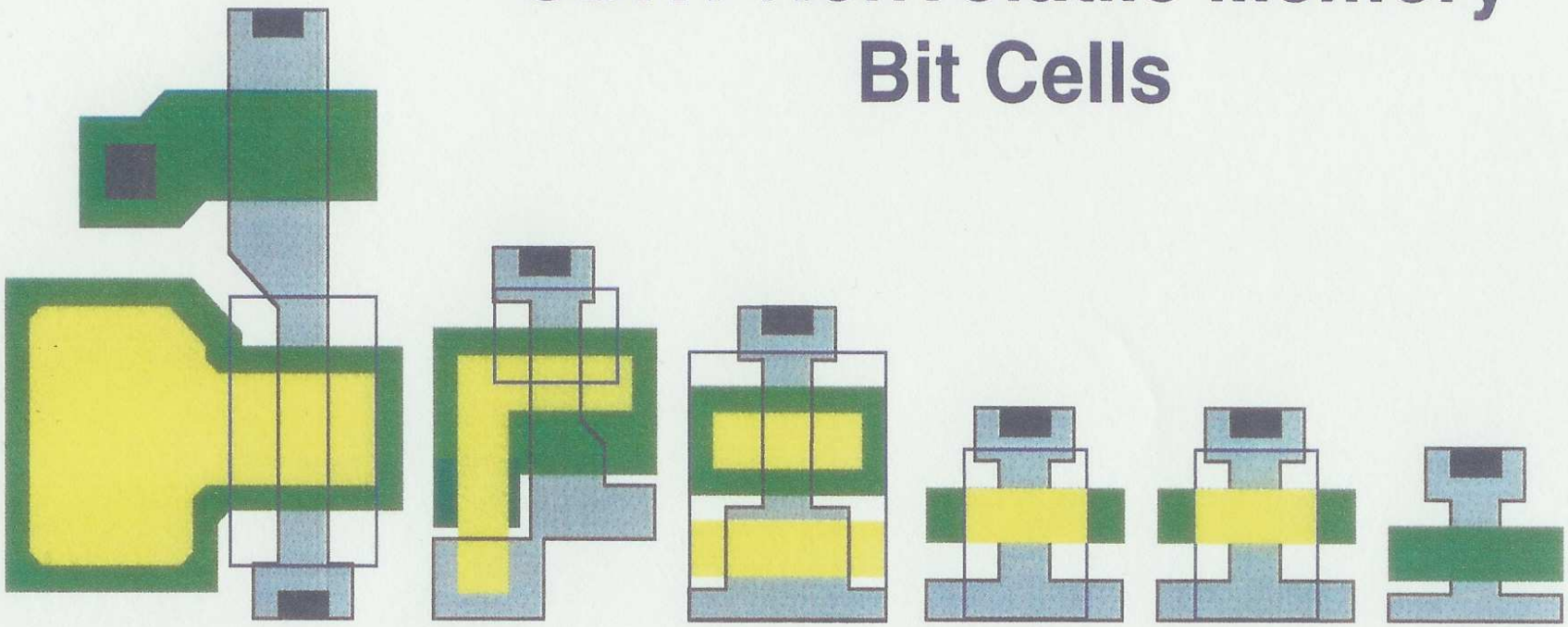
AB2779-2


Motorola's MC68HC11E9
8-bit Microcontroller
PORT A
VDD
PORT D
TIMER
SPI & SCI
INTERRUPTS
68HC11 CPU
INTERRUPT LOGIC
PORT B
512 BYTES RAM
12K BYTES ROM
PORT C
512 BYTES EEPROM
A/D
BUS CONTROL
PORT E
VSS

'HC11 Challenges

- Customer Demand terrific
- Initial wafer (probe) yield terrible
- Initial final test yield terrible
- Initial (sample) Burn-in yield terrible
- Production cycle time was terrible
- P & L statement terrible
- Product on allocation
- New Operations Manager (me)
- Five Wafer Fabs involved

UDR1 Nonvolatile Memory Bit Cells



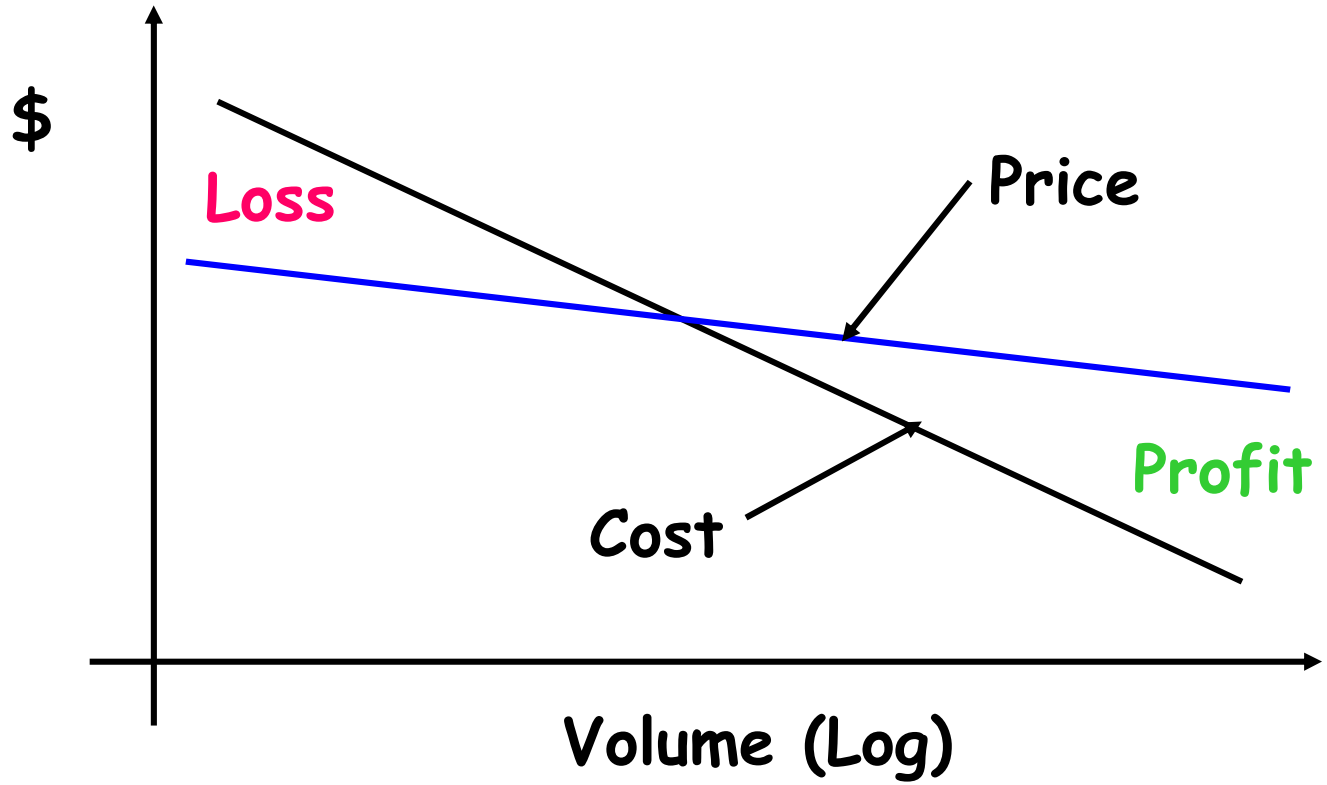
EEPROM	1.5 Transistor FLASH EEPROM	2 Transistor SOURCE-SELECT FLASH EEPROM	1 Transistor FLASH EEPROM	SELF-ALIGNED EPROM	ROM
IN PRODUCTION	IN PRODUCTION	IN DEVELOPMENT	IN DEVELOPMENT	IN PRODUCTION	IN PRODUCTION
Byte-Programmable and Erasable	Electrically Erasable	Low Voltage	High Density	UV Erase	Mask-Programmed

April 1996

Microcontroller Technologies Group
Sector Technology Review

Learning Curve Pricing

A 75% Learning Curve means the cost will be reduced by 25% every time the volume doubles. This is typical in the semiconductor industry.

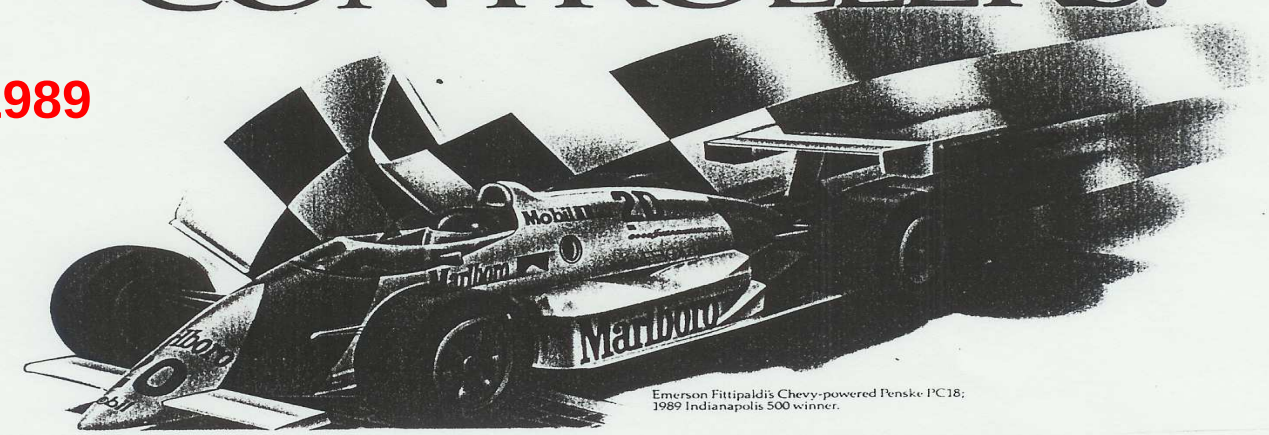


'HC11 Major Actions

- Formed special 40 person Task Force
- Staffing mis-match corrected
- Daily lunch meetings
- Bench-marked wafer fabs – TSC best
- Implemented 100% "smart burn-in"
- Prioritized customers – most painful
- No "silver bullet" – many 2-5% fixes

GENTLEMEN, START YOUR MICRO-CONTROLLERS.

1989



Emerson Fittipaldi's Chevy-powered Penske PC18; 1989 Indianapolis 500 winner.

Two hundred miles an hour is no place for a mistake. At that speed there's no time for hesitation, only quick, reliable, accurate performance. That's why the Indianapolis 500 is considered the toughest test of a racer's equipment. It's also why Motorola microcontrollers were there, and how they won.

The Chevy-Indy engine dominated this year's Indy 500 with first, second, and fourth places. At its heart, tucked snugly within its Delco Electronics Engine Control Module, twin 68HC11 microcontrollers, specially programmed to manage vital functions, boosted its awesome power to peak performance.

Control of such massive horsepower, in one of the toughest electronic environments imaginable, is a job for only the best. Which is why we're proud to be part of the winning Chevrolet-Delco Electronics-Motorola team.

With nearly 500 million microcontrollers in operation around the world, Motorola has proven itself to be the first choice for the toughest tests. Not all microcontroller applications demand this level of toughness, reliability and performance. But whatever your application, Motorola microcontrollers are your surest path to victory lane.

68HC11

Malcolm Baldrige National Quality Award Winner 1988

FIRST CHOICE FOR THE TOUGHEST TESTS.®

MOTOROLA

This ad (#395) will first appear in publications on June 18, 1989. The complete media schedule is Austin American Statesman, San Jose Mercury News, Detroit News, Indianapolis Star News, Kokomo Tribune 6/18 Sunday (Bus Section), USA Today 6/20, Auto Elec. News 6/19, Elec. Eng. Times 6/26 and Elec Buyers' News 6/26/89.

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The Phone.

POWERED BY MOTOROLA

At 7.5 ounces, Motorola's MicroT·A·C Lite™ is the world's lightest cellular phone, yet is loaded with sophisticated features.

The Operator.

The MicroT·A·C Lite™ calls on the 68HC11 microcontroller to direct its complex operations. From cellular phones to race cars, the world's most innovative products are powered by Motorola.

MOTOROLA
Microprocessor and Memory Technologies Group

The Rebel.

POWERED BY MOTOROLA

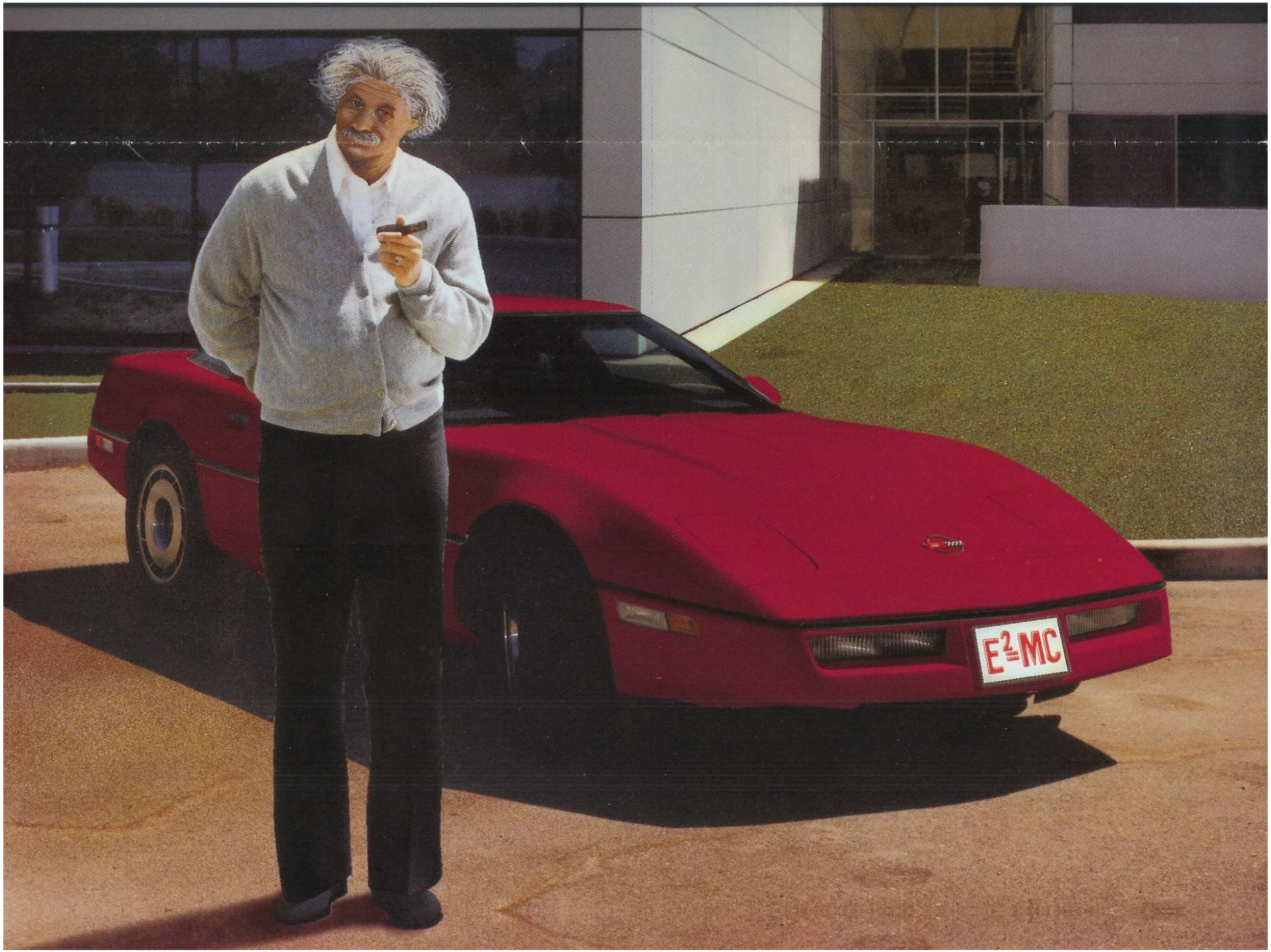
Once again, Canon has produced a revolutionary camera. And it's aptly named the EOS Rebel.

The Cause.

Motorola's 68HC11 microcontroller powers the Rebel's most radical features. From cameras to cars, the world's most innovative products are powered by Motorola.

MOTOROLA

Microprocessor and Memory Technologies Group


E=MC²

HOW TO WIN FAME, FORTUNE, AND A MAC II TO BOOT.

GET A WEALTH OF KNOWLEDGE AND GREAT PRIZES, TOO, WITH MOTOROLA MICROCONTROLLER TECHNOLOGY.

Break into the much talked-about world of Motorola microcontrollers by entering Motorola's 1990-1991 University Design Contest. It's an incredible opportunity to gain design experience with the industry-standard 68HC11 microcontroller. The HC11 contains on-chip EEPROM, A/D, UART, and many other features that make this 8-bit microcontroller an essential tool for your college projects as well as your future design work.

The Design Contest also offers you impressive resume opportunities. Plus recognition, cash, even a Macintosh™ II.

But first things first. To get your HC11 and participate in the contest, order a specially-priced S68HC11EVB Design Kit from Motorola.

Your kit will include a fully assembled HC11 evaluation board with all the software and technical literature you need. The HC11 design kit also includes an on-board monitor program which allows single line assembly/disassembly to simplify program development and debugging. Connect the board up to an external power supply and any PC, Macintosh, or dumb terminal, and it becomes an efficient low-cost HC11 development tool you can use for years to come.

GET THE DESIGN KIT THAT DELIVERS A LOT WITHOUT COSTING A LOT.

savings of $100. In addition to the invaluable design experience you'll gain from the kit, you'll also get everything you need to enter Motorola's University Design Contest. Just present your innovative design to a professor at your university, secure his or her sponsorship, and, follow the guidelines in your Design Contest manual to submit your entry to Motorola.

First prize in the final judging for undergraduates is a Macintosh II system with a laser printer, valued at $10,000. Second prize is a Macintosh II. And third prize is a Macintosh SE. Graduate student entries will compete for a grand prize Macintosh II system with laser printer. Plus, we'll award $100 to every student whose outstanding entry is published in our Student Project Guidebook, an honor that will look great on any resume.

MOTOROLA UNIVERSITY DESIGN CONTEST

But whether you enter the Design Contest or not, you can't lose with this special offer. You'll save big bucks on a S68HC11EVB Design Kit. And get a wealth of information about the world's most popular 8-bit microcontroller.

Ready to boot up your career in microcontrollers? For fastest delivery, be sure to order your kit by December 31, 1990. Deadline for entries is June 1, 1991.

S68HC11EVB Order Form

Name _____

Address _____

City _____

State/Province _____ Zip/Postal Code _____

Country _____ Telephone (___) _____

University _____

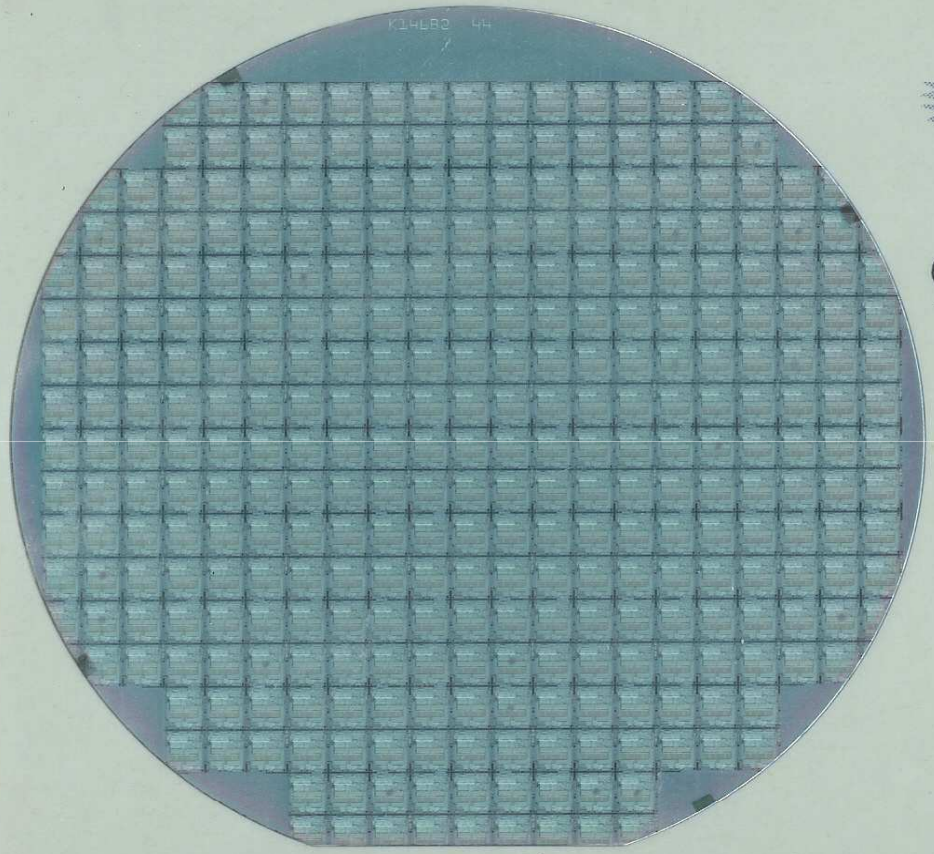
Sponsoring Professor (if known) _____

Send your money order for $68.11 payable to Motorola Inc. with your completed order form to:
Motorola University Support Program/56-242
505 Barton Springs Road, Suite 450
Austin, TX 78704
ATTN: Chet Freda (S68HC11EVB)

MOTOROLA

This offer is available only to students and professors in the United States and Canada.

Join the cast and cruise with Motorola MCU's Cruisin' for Business III.



HC11A8

3C96N SC98012

98.2% (277 dpw)

0.06 D/cm²

MADE IN

MOS 5

December 1991 (ww 48)

'HC11 Legacy

- Pioneered embedded EEPROM memory
  - Most MCU's today offer (block erase) embedded Flash EEprom program memory
  - **Most MCU's with embedded Flash employ 100% burn-in to screen out infant mortality**
- The 'HC11 was replaced by the 'HC12 which continues in moderate volume production today
- **Peripherals on the 'HC11 have been used (and copied by others) on many later model MCU's**
- Microcontrollers remain Freescale's largest and most profitable Division

Legendary Engineering Success Stories: Key Factors

- **Leadership** – Genius and/or Bulldog ("Champion" or "Boot-Legger")
- **Sponsor** with vision ("God-Father")
- Right place at right time and knew what to do about it

Leslie Richard Groves, Jr.

Major General Leslie R. Groves

Manhattan Project Director

First, General Groves is the biggest S.O.B. I have ever worked for. He is most demanding. He is most critical. He is always a driver, never a praiser. He is abrasive and sarcastic. He disregards all normal organizational channels. He is extremely intelligent. He has the guts to make difficult, timely decisions. He is the most egotistical man I know. He knows he is right and so sticks by his decision. He abounds with energy

Hyman George Rickover

Rickover pictured in 1955 as rear admiral (upper half)

Nickname "Father of the Nuclear Navy"

Hyperactive, political, blunt, confrontational, insulting, flamboyant, and an unexcelled workaholic who was always demanding of others — without regard for rank or position — as well as himself, Admiral Rickover was a thundering force of nature and lightning rod for controversy. Moreover, he had "little tolerance for mediocrity, none for stupidity." "If a man is dumb," said a Chicago friend, "Rickover thinks he ought to be dead."[41] Even while a Captain, Rickover did not conceal his opinions, and many of the officers he regarded as dumb eventually rose in rank to be admirals and were assigned to the Pentagon.[42]

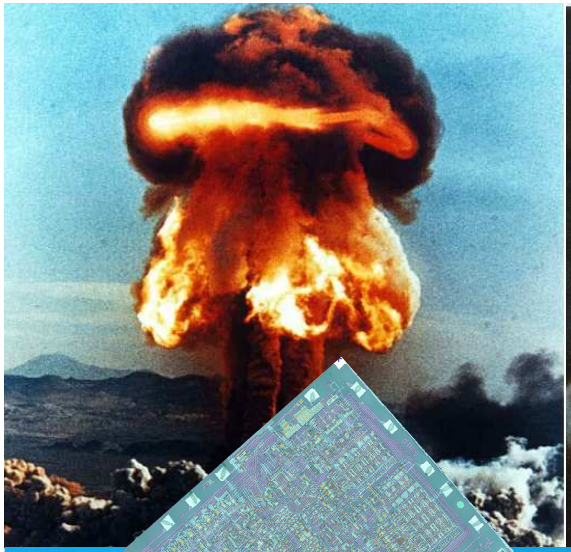
Steve Jobs

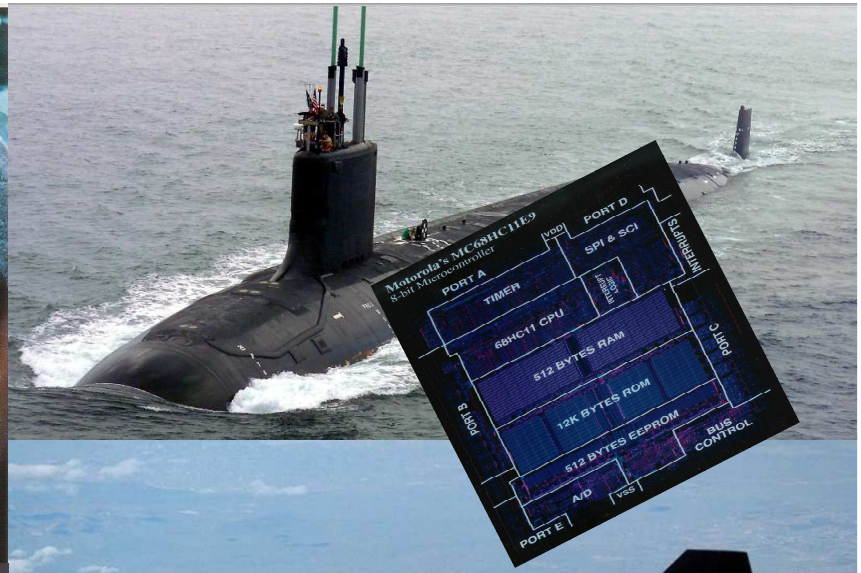
Jobs holding a white iPhone 4 at Worldwide Developers Conference 2010

Steve Jobs and Bill Gates at the fifth *D: All Things Digital* conference (*D5*) in 2007

Jobs was a demanding perfectionist[109][110] who always aspired to position his businesses and their products at the forefront of the information technology industry by foreseeing and setting trends, at least in innovation and style. He summed up that self-concept at the end of his keynote speech at the Macworld Conference and Expo in January 2007, by quoting ice hockey player Wayne Gretzky

> There's an old Wayne Gretzky quote that I love. 'I skate to where the puck is going to be, not where it has been.' And we've always tried to do that at Apple. Since the very very beginning. And we always will.[111]




Motorola's MC68HC11E9
8-bit Microcontroller
PORT A
TIMER
68HC11 CPU
512 BYTES RAM
12K BYTES ROM
512 BYTES EEPROM
A/D
VSS
PORT E
PORT B
PORT C
PORT D
SPI & SCI
INTERRUPTS
BUS CONTROL


W
H
30H


NASA
844
849