

Green Design at Intel

Building in Ecology

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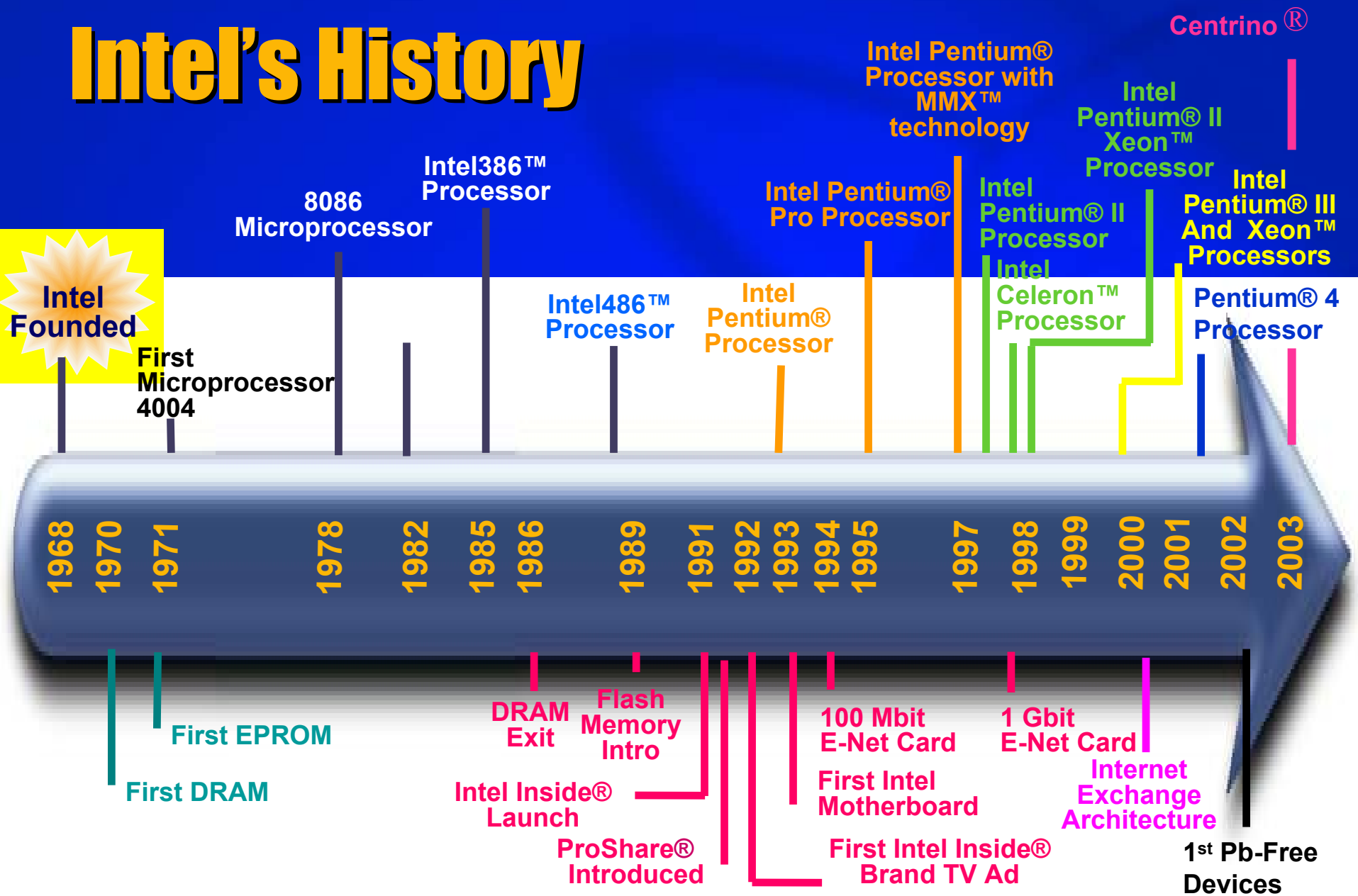
September 16, 2003

Agenda

- Brief Overview of Intel
- Product Ecology and Design for the Environment (DFE)
- Green Design Examples at Intel:
 - ❖ Lead-free Semiconductors & Electronics
 - ❖ Environmental Performance & Employee Safety
 - ❖ Energy Conservation in PCs
 - ❖ Scrap Wafers to Solar Energy

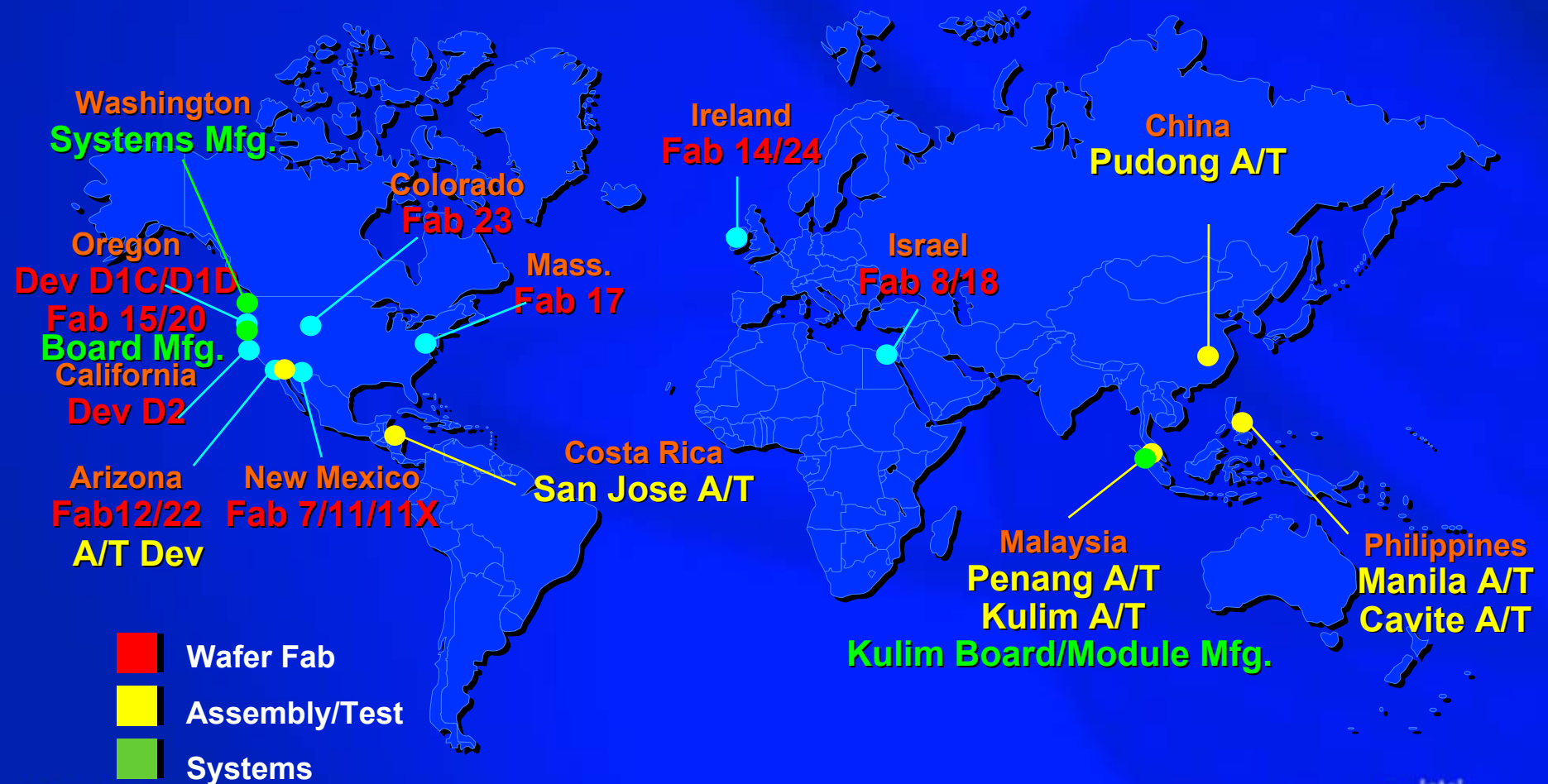
Brief Overview of Intel

Intel's History



Intel's High Volume Manufacturing Sites

80,000 Employees



Intel's EHS Guiding Principles:

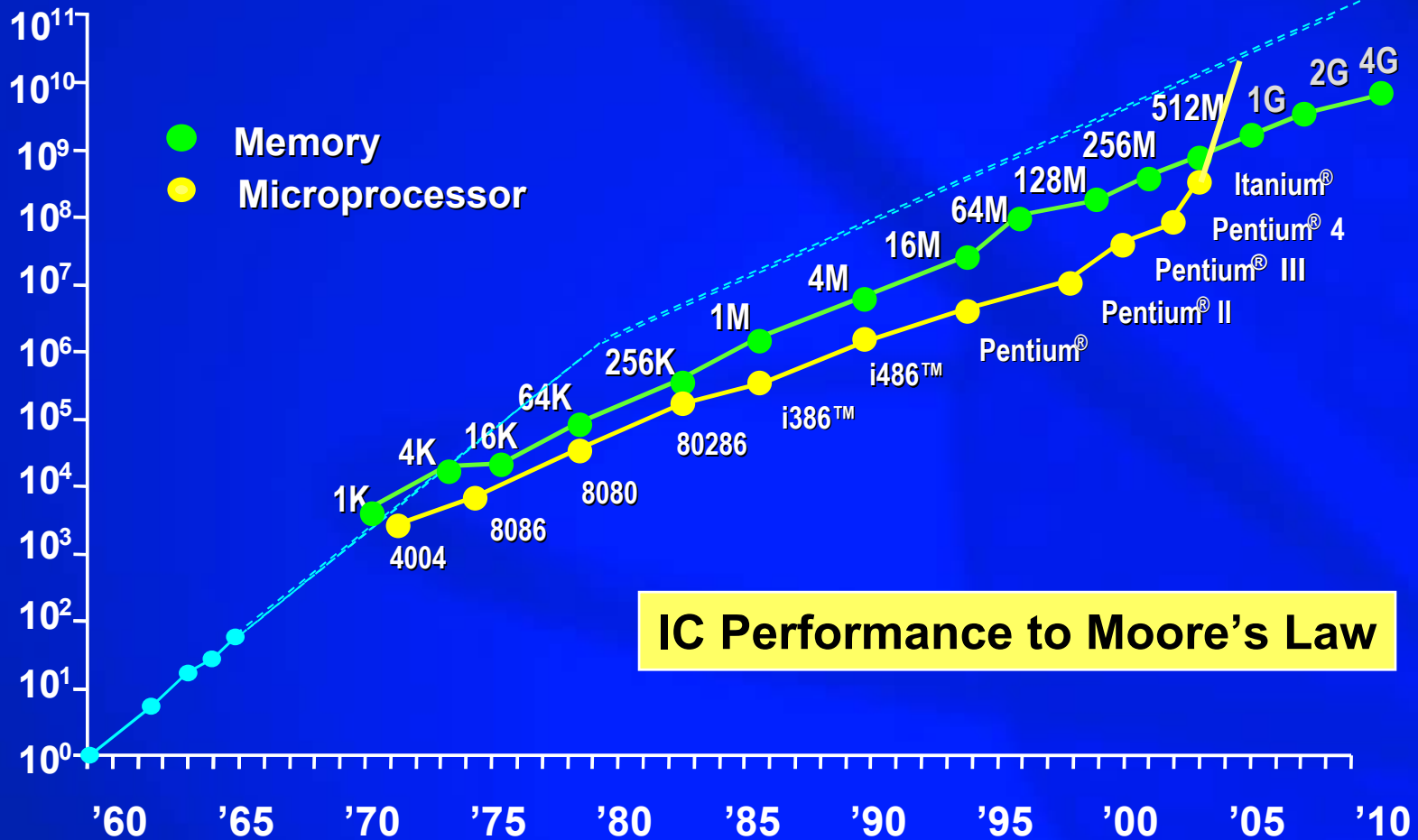
- Prevent all injuries in the workplace
- Be an EHS leader in our communities and our industry
- Reduce the environmental footprint of our products, processes and operations



Product Ecology and Design for Environment

Integrated Circuit Complexity

Transistors Per Die



IC Performance to Moore's Law

Source: Intel

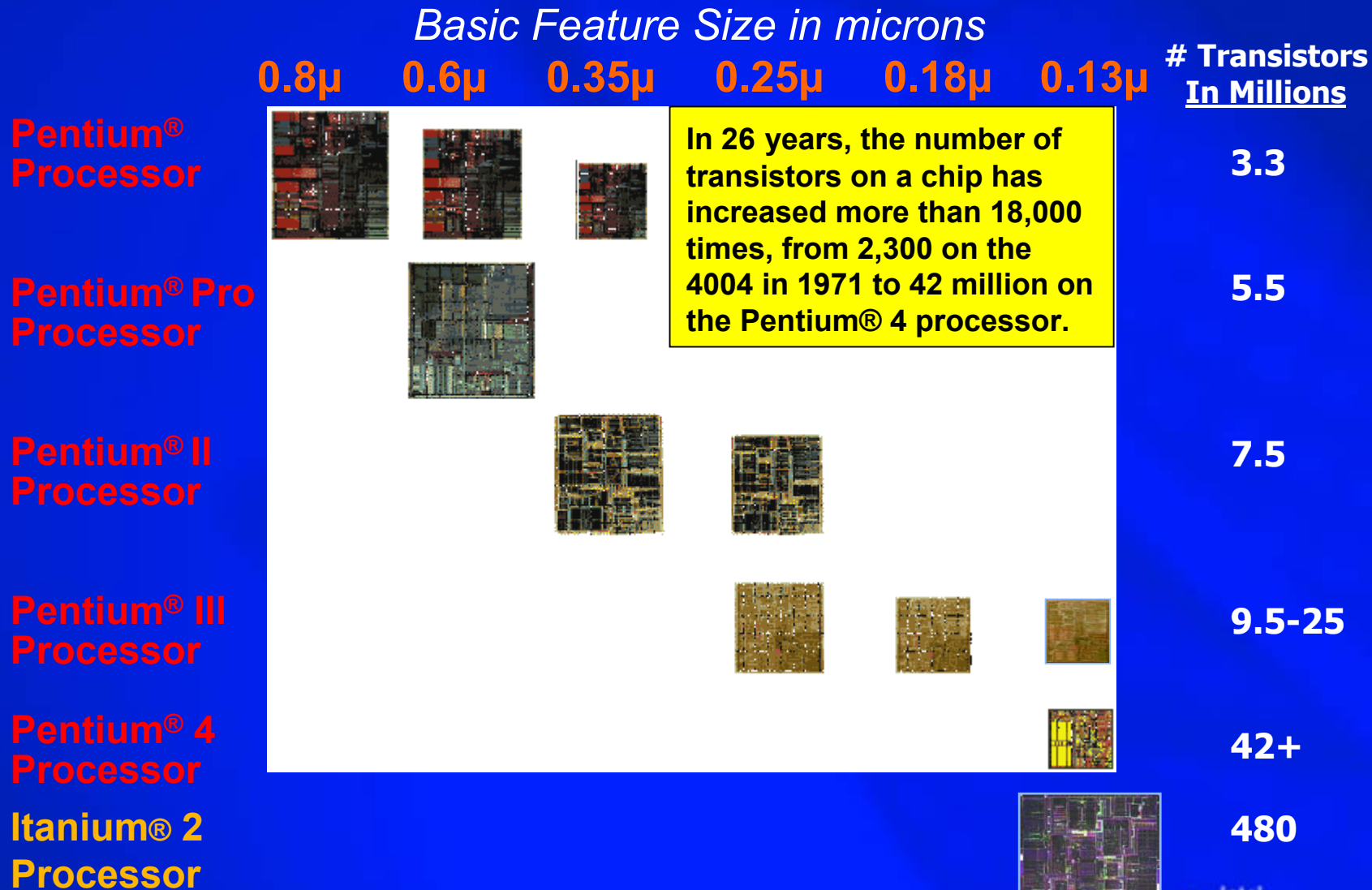


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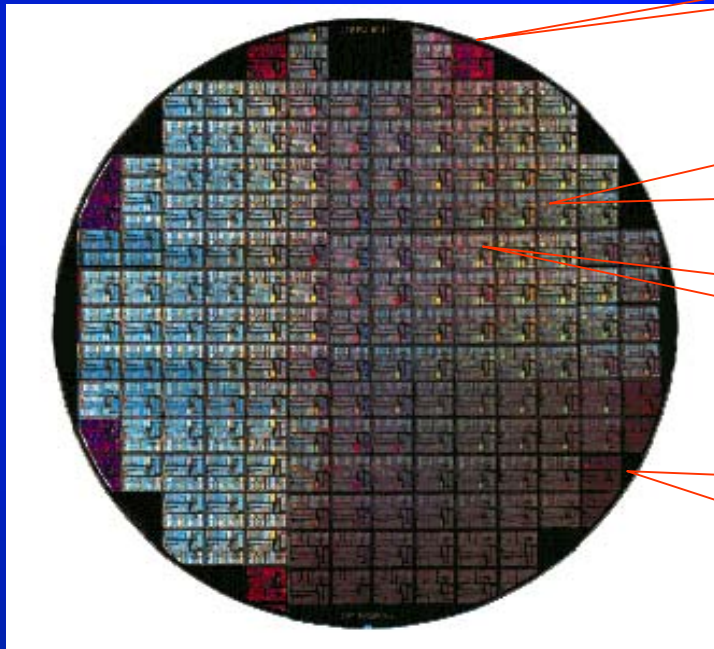
Intel's Process Technology

Source: Intel



130nm Technology

- Intel Technology – To produce leading edge microprocessors (1.0-3.0+ GHz) for desktop, mobile and server applications



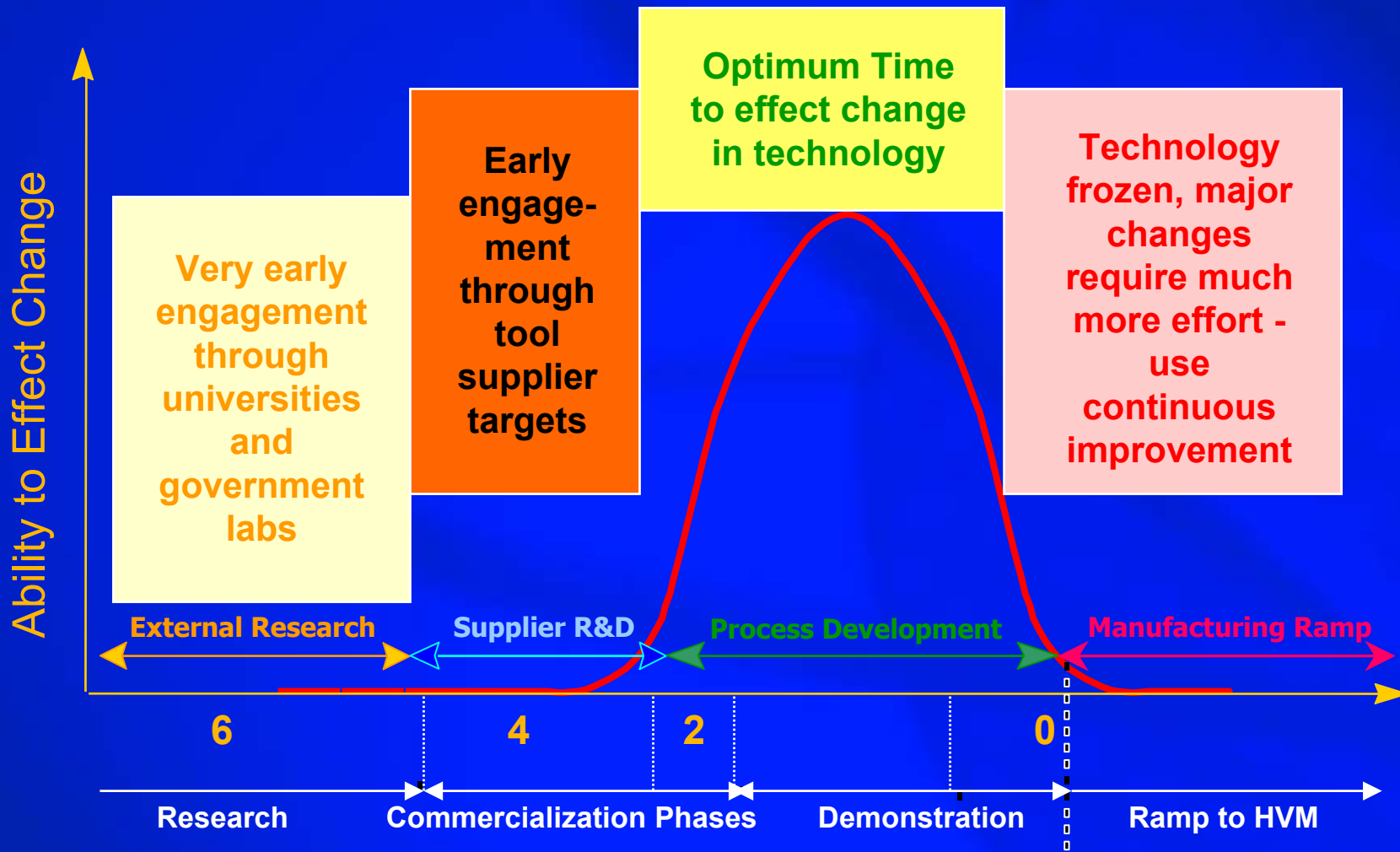
25 wafers in each lot (200mm)

60 to 300+ microprocessors per wafer. It takes an average of 440 operation steps to make a microprocessor & 55 days on avg.

42 to 480 Million transistors per microprocessor

100% yield on one wafer (Intel Itanium® 2) requires 28 Billion transistors to work correctly

EHS Technology Engagement Model



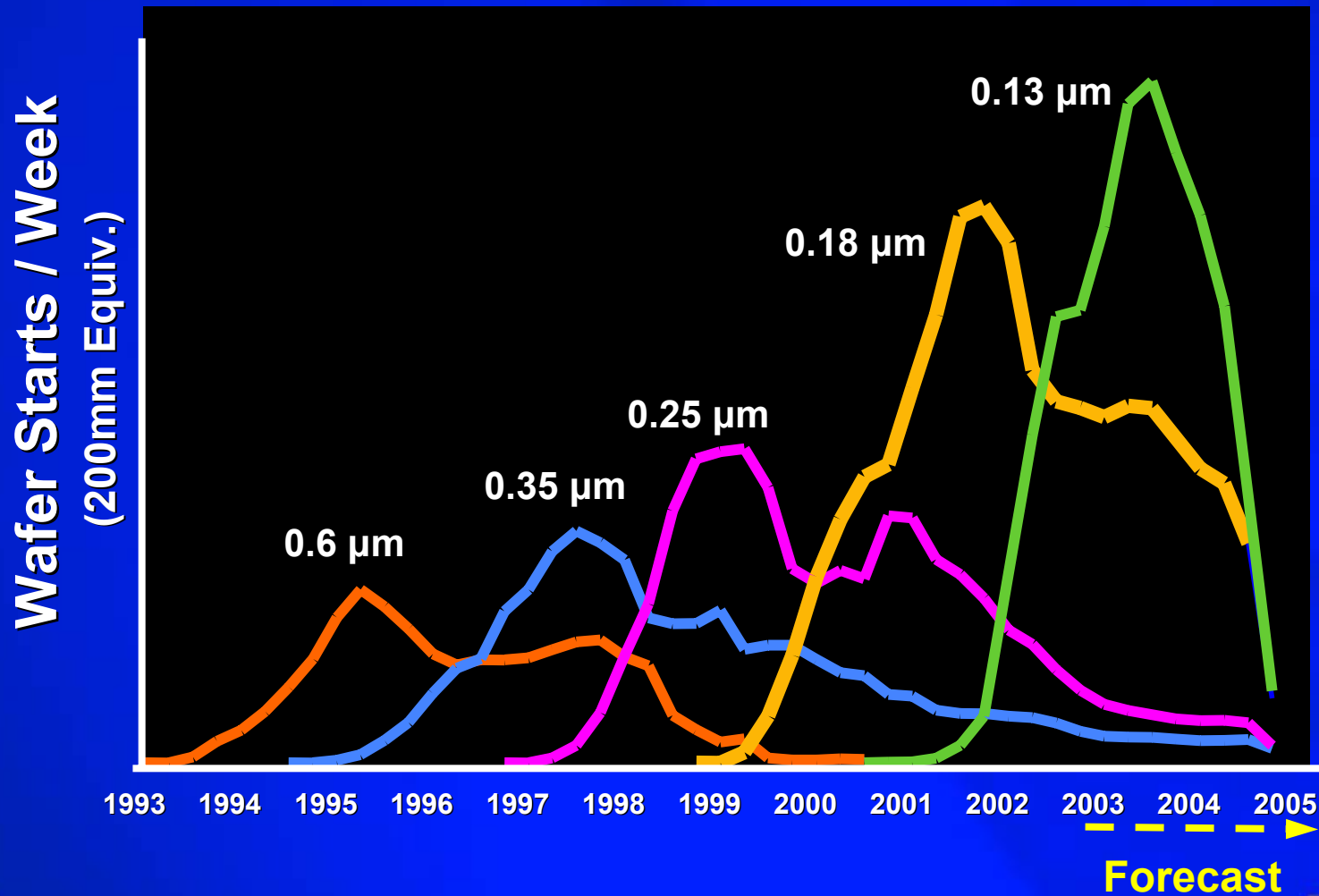
Source: Intel

YEARS to High Volume Manufacturing

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Microprocessor Ramp Trends



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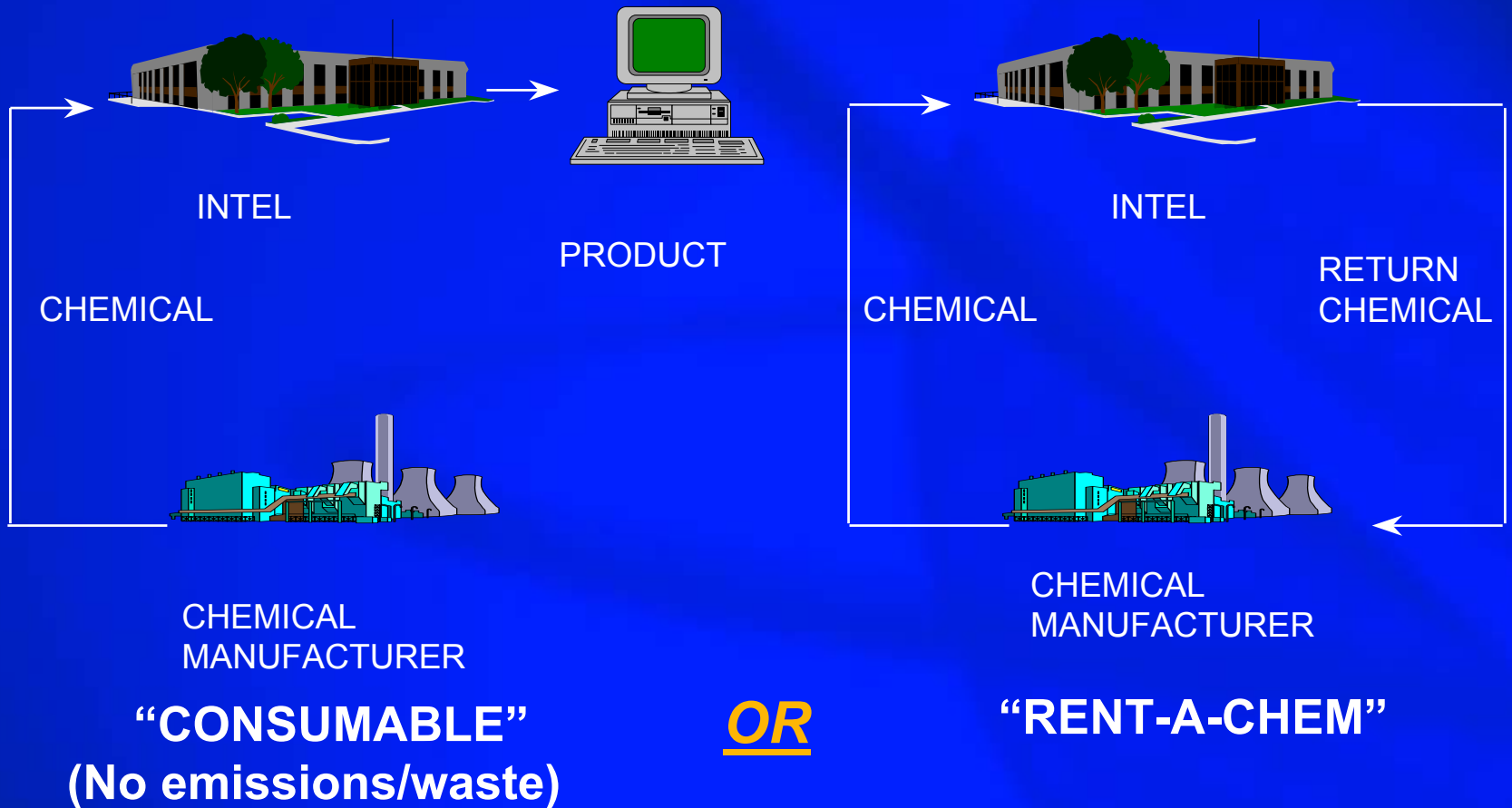


Rapid Technology Changes

Provides Opportunities and Challenges

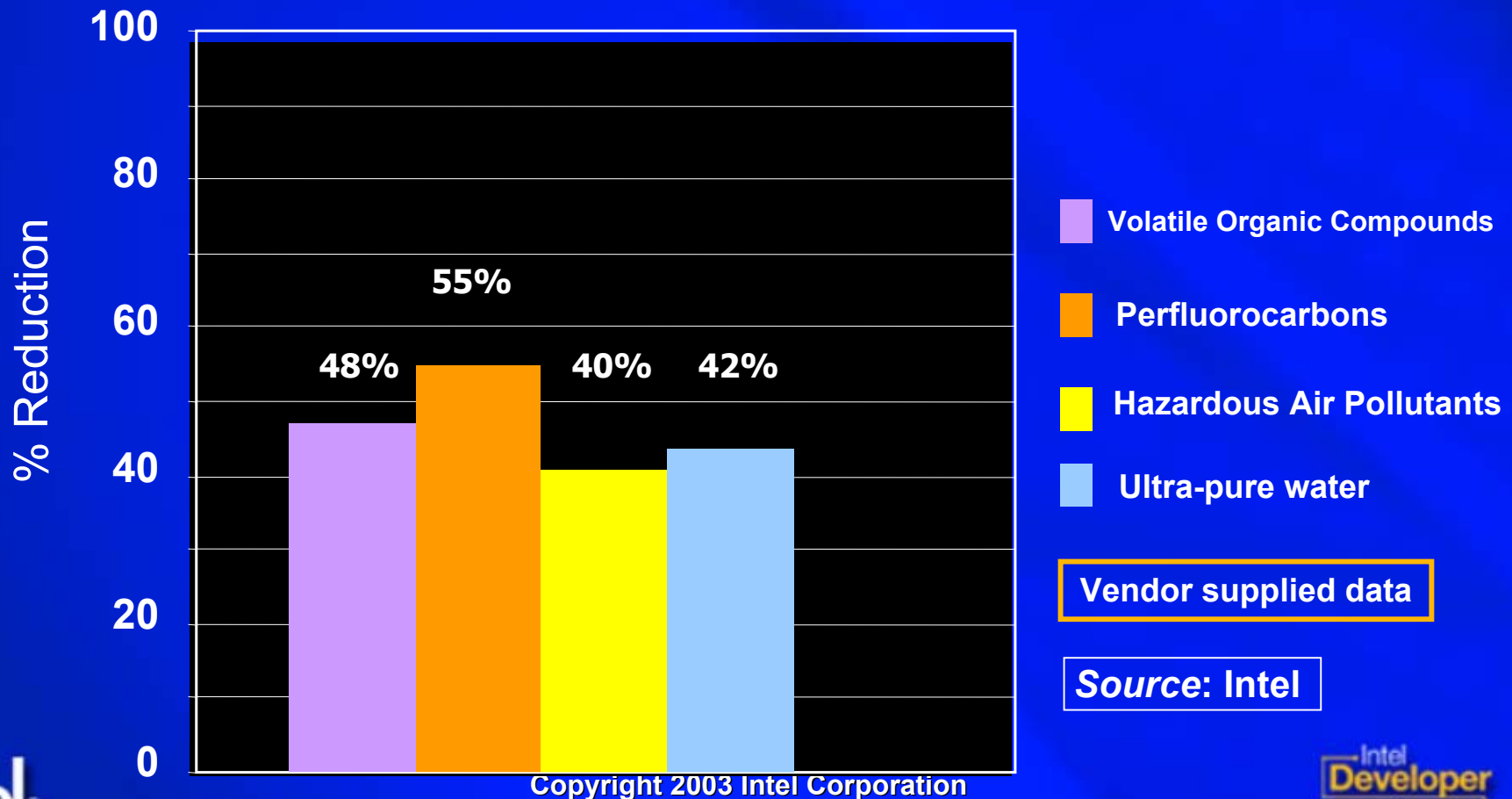
- Intel develops and delivers a new chip manufacturing process every 2 years:
 - ❖ Each new process is 30 months for Technology Development
- Primary opportunity for EHS improvements is in TD
- Intel has an integrated Design for EHS Program
- EHS is involved throughout the TD process for:
 - ❖ Manufacturing Process development
 - ❖ Chemical selection and Waste Management
 - ❖ Facility design
 - ❖ Ergonomics and Equipment Safety
 - ❖ Manufacturing equipment selection
- Manufacturing process is “Copy Exactly”

Chemical Use & Recycle Approach



Estimated 300mm emissions & water use Relative to 200mm

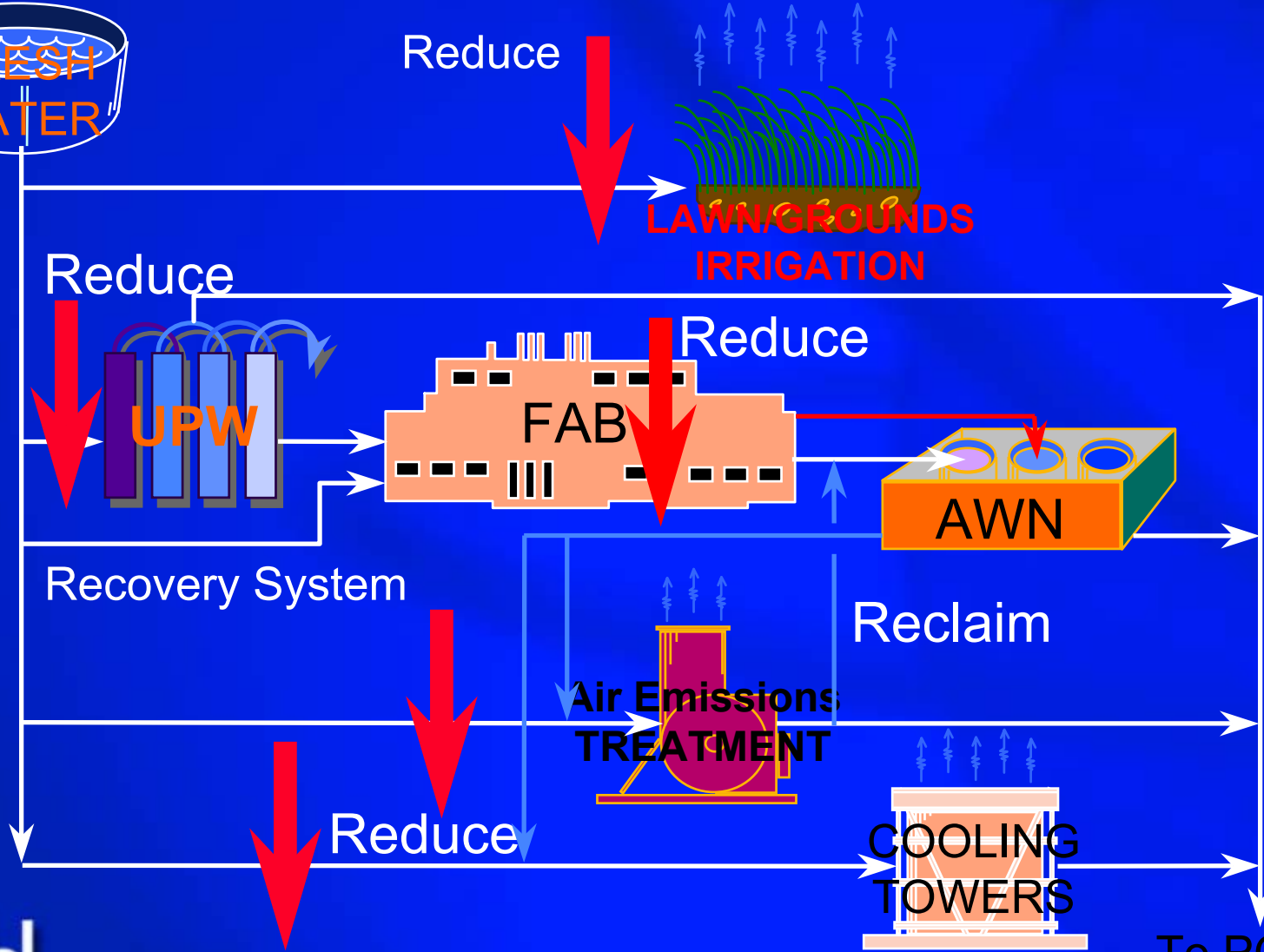
300mm is more Environmentally Friendly



Water Model – with Conservation

47 %

- Xeric Landscaping
- UPW System Reduction
- Manufacturing Reduction
- Process Water Reuse



Product Ecology – Definition & Focus

- **Product Ecology** – Designing environmentally compatible products and manufacturing processes while maintaining product price/performance and quality characteristics.
- Key Focus Areas for “**Green Products**” are:
 - ❖ Material Composition
 - ❖ Manufacturing Design for Environment (DfE)
 - ❖ Design for Disassembly (DfD)
 - ❖ Energy Usage (Products & Manufacturing)
 - ❖ End-of-Life Management
 - ❖ Product Packaging

Green Product Drivers

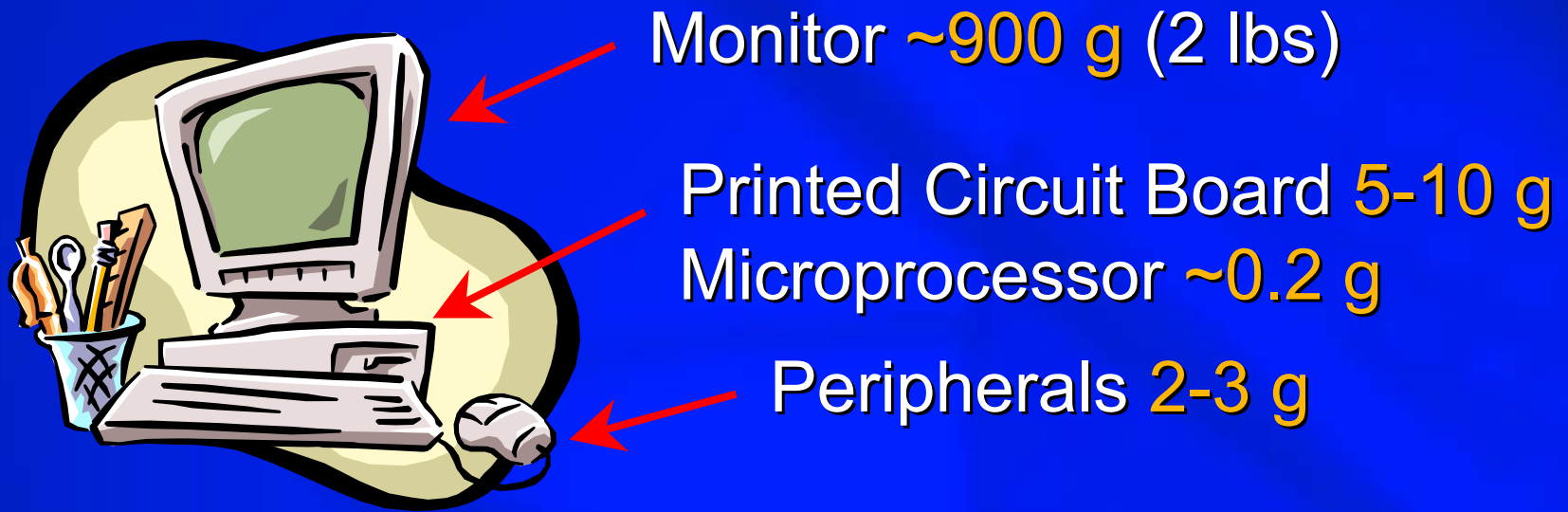
- **The Market Place** – Japan OEMs are setting “**Green Specifications**” with Sony one of the leaders and their “**Green Supplier**” Audits.
- **Regulations** – The EU is driving thru the RoHS and WEEE Directives. Japan has recycle requirements for white goods including PCs and other electronics.
- **Voluntary Initiatives** – The US is driving thru “Energy Star” to reduce electricity usage and global warming.



Green Design Examples at Intel:

- Lead-free Semiconductors & Electronics
- Environmental Performance & Employee Safety
- Energy Conservation in PCs
- Scrap Wafers to Solar Energy

Lead in PCs – Where is it ?



For comparison:

- ❖ House key ~0.1-0.3 g
- ❖ Car battery = 9000 g (20 lbs)

Where's the Lead in PCBs ?

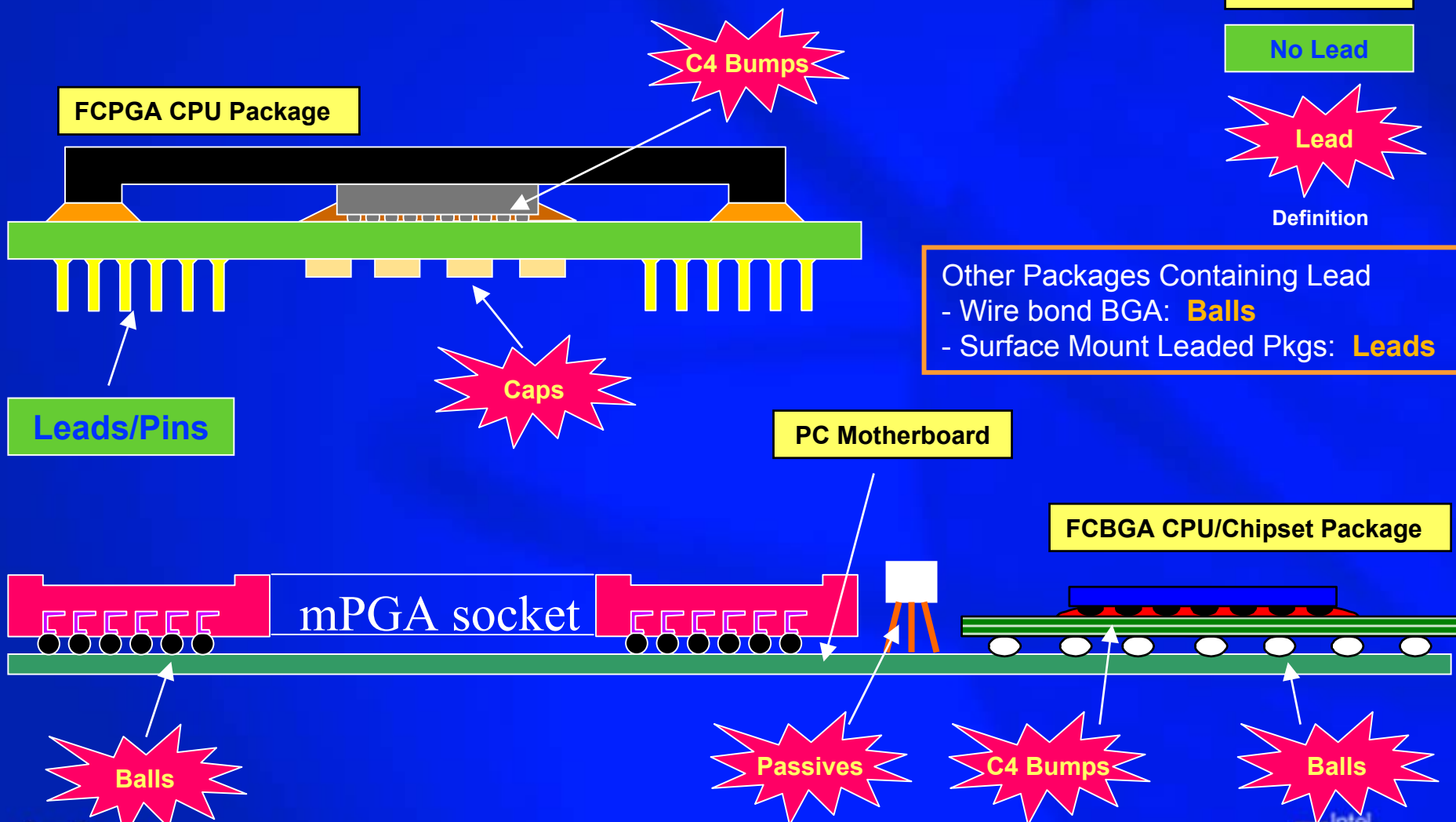
LEGEND

Description

No Lead

Lead

Definition



Other Packages Containing Lead
 - Wire bond BGA: **Balls**
 - Surface Mount Leded Pkgs: **Leads**



Lead-free BGA packages

Today's Lead-Tin Process

New Lead-Free Process

Gold wire bond



Gold wire bond



Silicon Die
Package

Lead-Tin solder ball



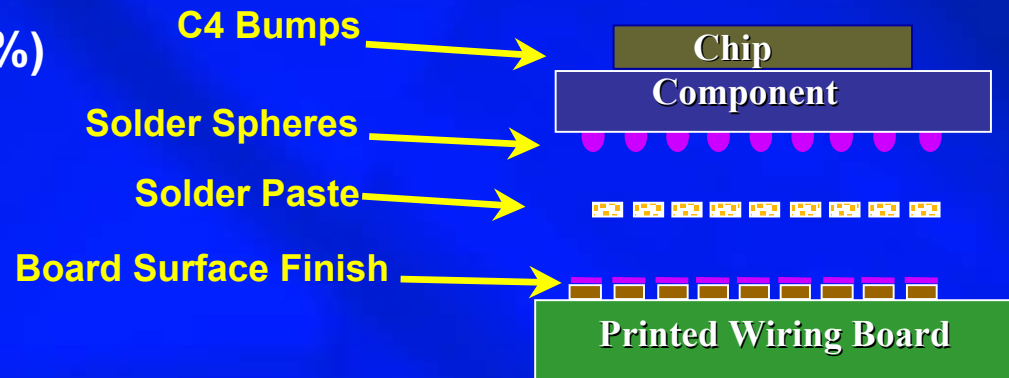
Tin-Silver-Copper solder ball



BGA = Ball Grid Array

Pb-free Challenges

- Solder Paste and Solder Spheres
 - ❖ SnAgCu (95.5% / 4% / 0.5%)
- Wave Solder
 - ❖ SnCu (99.3% / 0.7%)
- Board Surface Finish
 - ❖ ImAg* and OSP*
- Flip Chip Bumps – FCxGA
 - ❖ Legacy processes: Due to exemption, no plans to convert
 - ❖ Future processes: Under investigation. No conversion schedule at this time
- Lead Frame Packages
 - ❖ Matte-Sn finish
 - ❖ Still need to address Tin Wisckers



*ImAg – Immersion Silver

*OSP – Organic Solder Preservative

Intel's Product Conversion Status

- Intel has been developing Pb-free products for over 3 yrs
- New materials sets have been selected and certified to support the transition
- Intel is shipping Pb-free product
- SCSP, vfBGA, and EasyBGA are Pb-free certified
- Pb-free products are 'build to order' (at this phase of the transition). Six months notice required.
- RoHS exemptions & definitions need further clarification
- Many new Intel products are 'Pb-free ready' allowing rapid conversion to Pb-free leads/balls
- Legacy products: Some will not convert

Approaches in Japan, US and China

➤ Japan

- ❖ No ban on the use of lead in electronics and encouragement of Green Products
- ❖ Selected electronics recycle law (PC, TV and appliances)
- ❖ Postal Service provides transportation for recycling
- ❖ Energy Star Program

➤ United States

- ❖ No ban on the use of lead in electronics and encouragement of Green Products
- ❖ Have banned lead in gasoline, paints and plumbing
- ❖ Voluntary e-recycling (HP, Dell, IBM, etc.)
- ❖ EPA funding Pilot e-recycling Program
- ❖ Energy Star Program delivers big energy savings
- ❖ Life Cycle Assessment on tin-lead & lead-free solders



➤ China

- ❖ Drafting regulations to RoHS, WEEE and Product Ecology

WEEE Directive & Intel's Focus Areas

- Mark plastics for easy identification (ISO 11469)
- Design for disassembly (fewer parts, fasteners, adhesives, etc)
- Use single polymer or compatible polymer type, where possible.
- Use recycled plastics in structural plastics and case parts.
- Use packaging with recycled content and return shipment packaging from our Customers (OEMs)

WEEE = Waste in Electrical and Electronic Equipment Directive

RoHS Directive's Flame Retardants

- PBDE and PBB are banned under RoHS
 - ❖ Intel products are free from PBDE and PBB
 - ❖ Many OEMs have restricted use of PBB and PBDE
- TBBPA (tetrabromobisphenol-A) is the flame retardant widely used in electronic products for fire safety
 - ❖ TBBPA is commonly used in components and Printed Circuit Boards
 - ❖ No bans currently exist for TBBPA, although it is under evaluation

RoHS = Restriction of the Use of Hazardous Substances in EEE Directives

Environmental Performance & Employee Safety

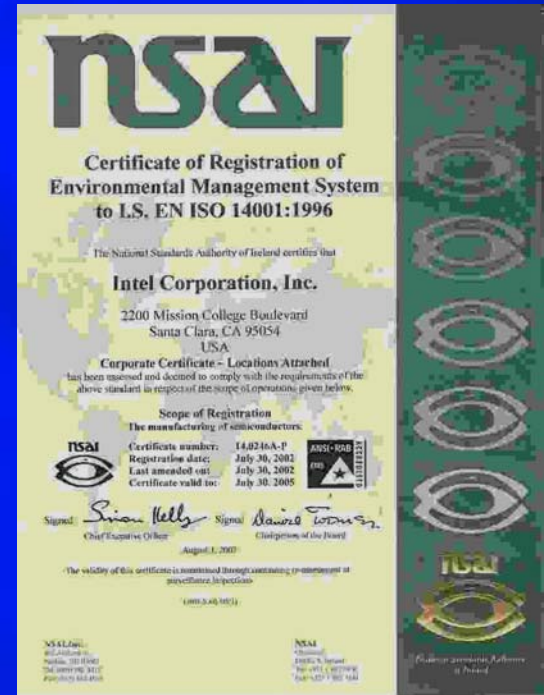
Environmental Performance 2002

- >55% of Chemical Waste recycled worldwide
- >65% of Solid Waste recycled worldwide
- Fresh water usage 16 million gallons/day worldwide
- 30% reduction in VOC emissions since '99 (218 tons worldwide in 2002)
- Global warming emissions 1.03 MMTCE (includes electricity usage)
- ISO 14001 Certified
- 30,000 PCs refurbished and delivered to schools and non-profit organizations

Intel's EHS Report: www.intel.com/go/ehs

Intel's is ISO 14001 Certified

- **Approach** – Corporate Wide Registration
- **Scope** – All semiconductor manufacturing operations and sites
- **Registration Process** – Based on registrar audits of the Corporate EMS and 5 site audits (Shanghai, AZ, Costa Rica, CA, & Malaysia)
- **Sustaining Audits** – Remaining sites audited over next three years (9 countries and states)
- **Certification Issued** – 30 July 2002
- **Registrar** – National Standards Authority of Ireland



World-class Safety Performance

Recordable Rate per 100 Employees



Green Cross Award for Safety

- Craig Barrett accepts on behalf of Intel, the National Safety Council's Green Cross for Safety Award, June 2001
- Intel's injury rates are 37X lower than the average for US manufacturers



Energy Conservation in PCs

Product Energy Landscape



- Global Warming is a reality
- Kyoto Protocol – Sets international focus
- Proliferation of Energy Star in US, EU, Japan
- New product requirements:
 - ❖ Smaller Form Factors and Light Weight
 - ❖ Wireless Connectivity
 - ❖ Always Connected Computing/Ease of Use

How is Intel Saving Energy?

Instantly Available PC (IAPC)

Intel's IAPC technology enable PC Manufacturers to:

- Deliver PCs that consume < 5 watts in “Sleep mode”
- Provide Quick “wake-up” ~5 seconds
- Improve Global energy savings vs. Energy Star
 - ❖ Energy Star standard is <15 watts in “Sleep Mode”
- Advance PCs capabilities + reduce global warming and electricity generation – ideal for the home office



US EPA estimates energy savings by 2010 vs. Energy Star:

- Equivalent to removing 60 million cars from the roads for one year
- 7.5 Million Metric Tons per year of CO2 eliminated in US
- Intel's worldwide global warming emissions = ~1 MMTCE

IAPC balances energy conservation with technology

Scrap Wafers to Solar Energy

Recycling Scrap Wafers

- Semiconductor fabrication generates reject and test scrap wafers
- Silicon is an excellent material to convert light (photons) to electricity (electrons)
- Since 1999, 3 Million Intel scrap wafers have been converted to 2.4 Million solar cells
- Produce 11.4 Million Kwh of power/year



Summary

- Product Ecology/DfE are the right things to do
- Intel invested a significant EHS effort in 300mm
- Intel has successfully developed Pb-free package and process technology
 - ❖ Management of a flawless transition to Pb-free products is a major challenge for the industry
 - ❖ RoHS exemptions and definitions need clarification
- Continue to develop new recycle opportunities
- Drive energy conservation with Intel technology

Questions?