International Technology Roadmap for Semiconductors

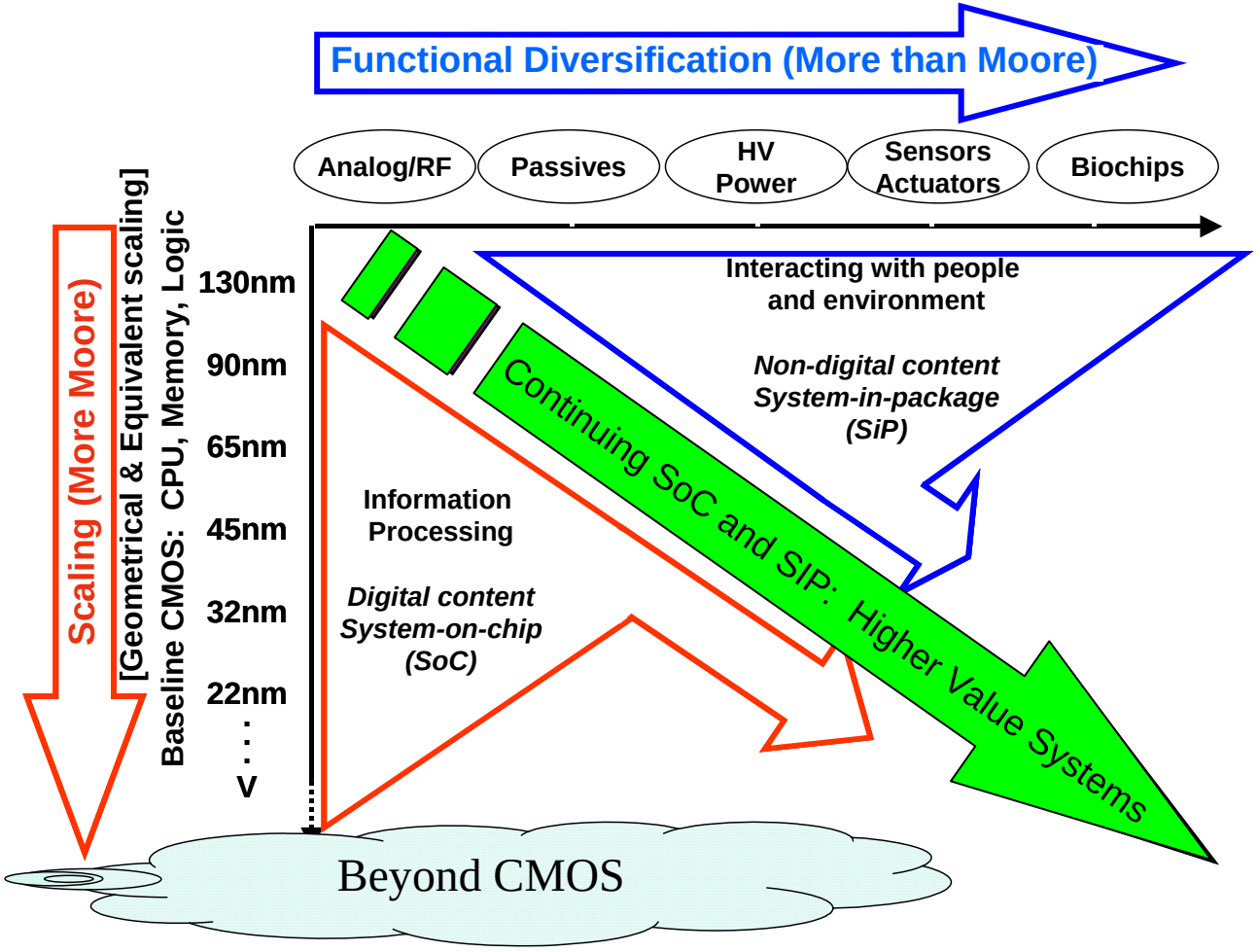
MORE THAN MOORE

MORE THAN MOORE:
What is It?

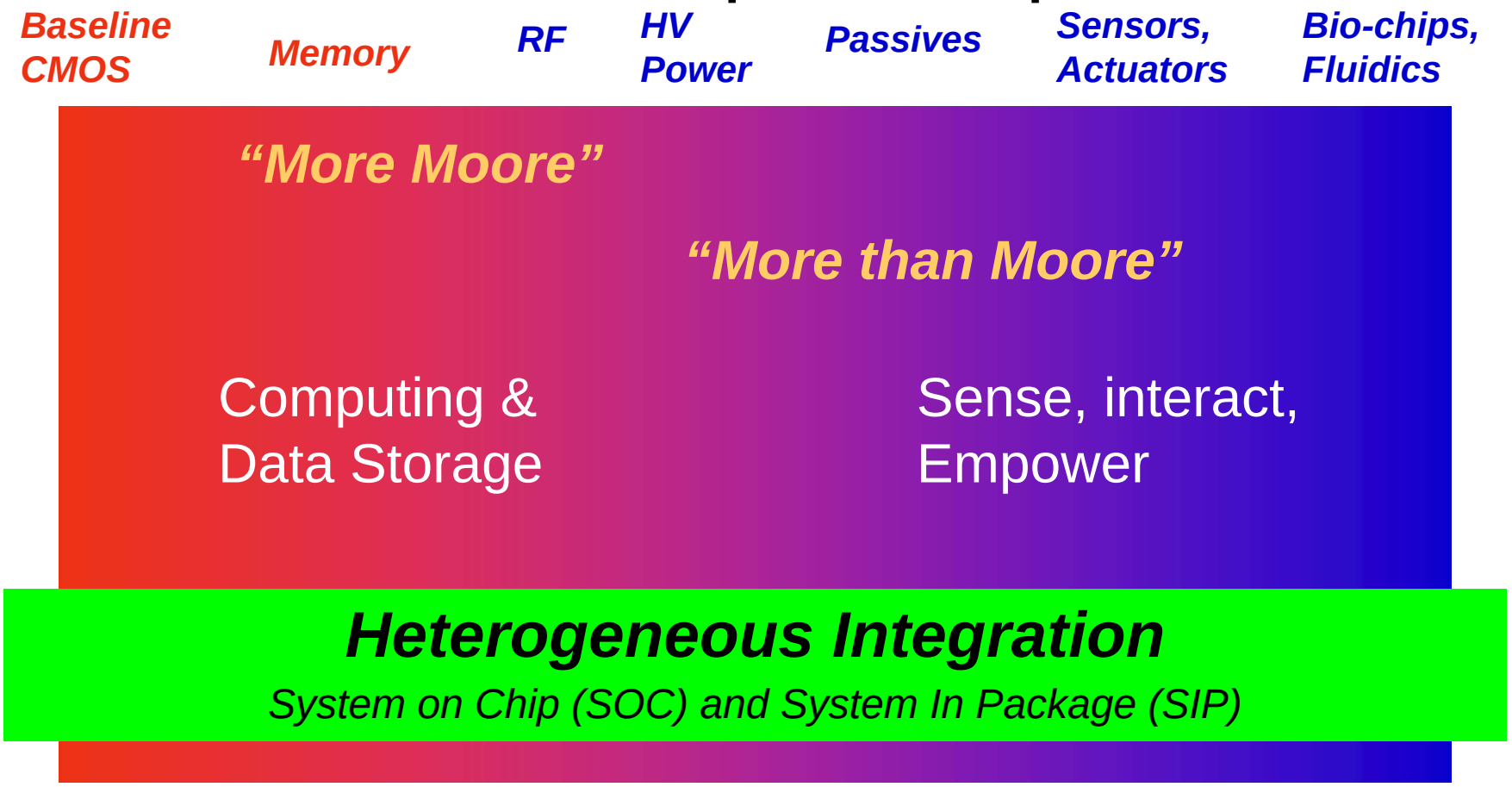
MART GRAEF

IRC – ESIA, Europe

Moore's Law & More



2007 ITRS "Moore's Law and More" Definition Graphic Proposal



Source: ITRS, European Nanoelectronics Initiative Advisory Council (ENIAC)

“More Moore” and “More than Moore”

- **“More Moore”: Scaling**

  Continued shrinking of physical feature sizes of the *digital* functionalities (logic and memory storage) in order to improve *density* (cost per function reduction) and *performance* (speed, power).

- **“More than Moore”: Functional Diversification**

  Incorporation into devices of functionalities that do not necessarily scale according to "Moore's Law“, but provide additional value in different ways. The "More-than-Moore" approach allows for the *non-digital* functionalities to migrate from the system board-level into the package (SiP) or onto the chip (SoC).

- **The Challenge: Integration of MM with MtM**

  Creation of intelligent compact systems.

MORE THAN MOORE

Why the Market Cares…

PUSHKAR APTE
IRC – SIA, USA

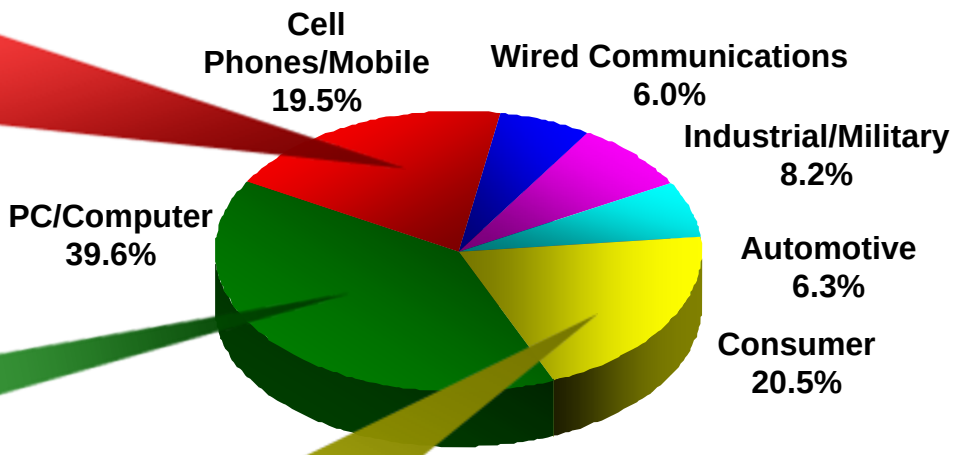
Semiconductor Growth: 2007

2007
Cell Phone Shipments
+10% (units)

2007
PC Shipments
+10% (Units)

2007
Digital TV
+51% (Units)

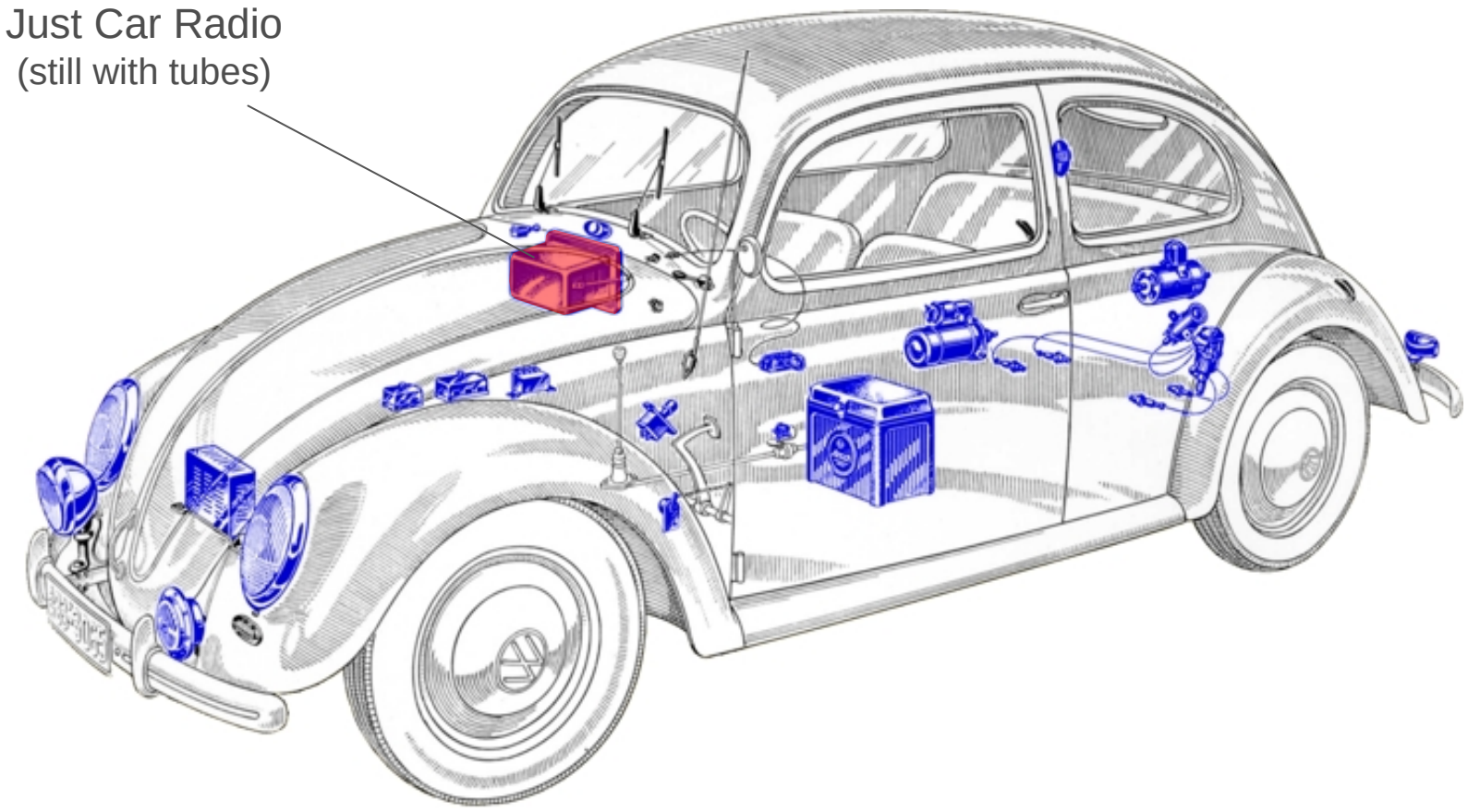
2007
MP3/PMP
+20% (Units)



$252.1B / +1.8%
2007

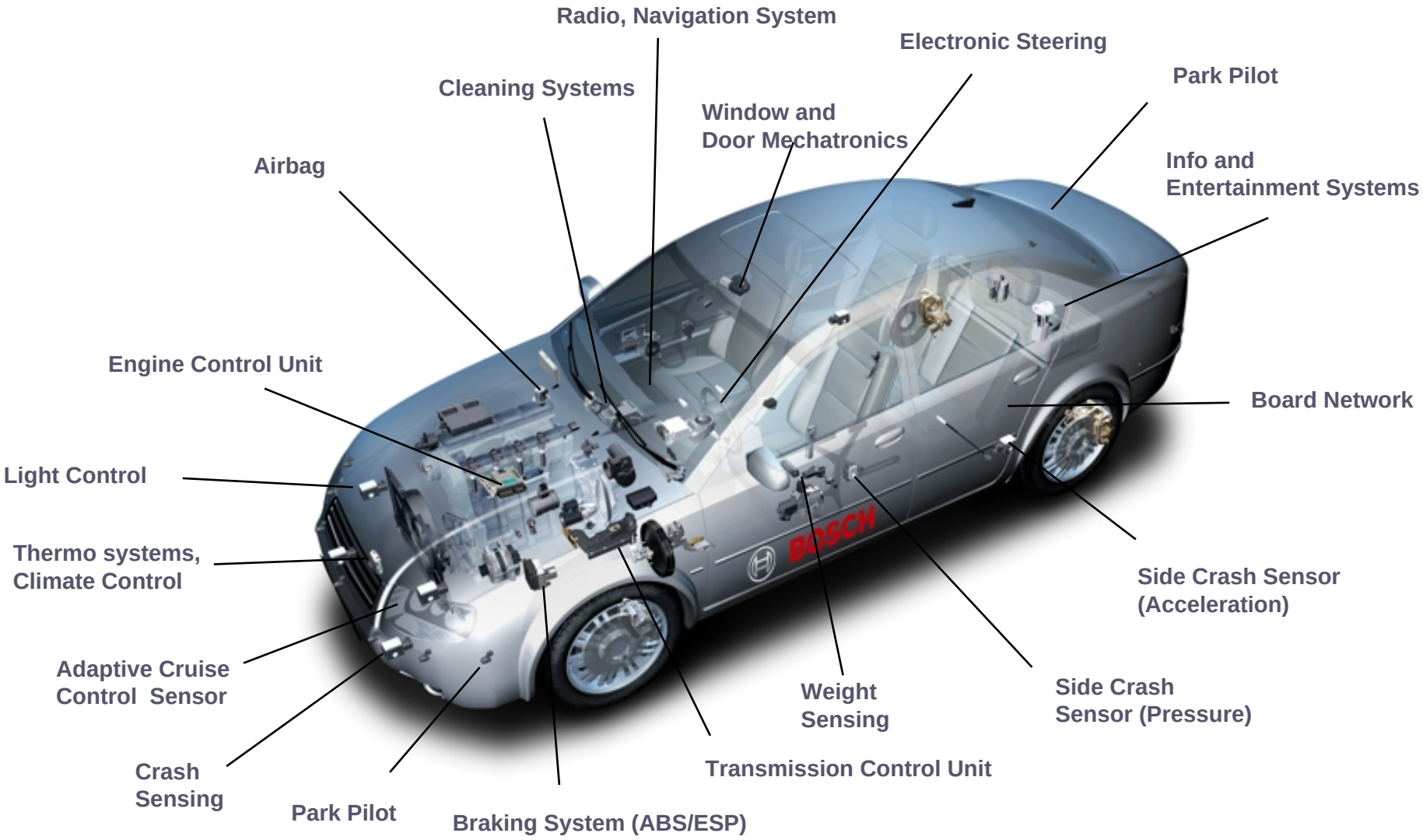
Sources: iSuppli/Gartner/SIA Spring 2007 Forecast

Automotive Electronics: Yesterday ...



Source: Bosch

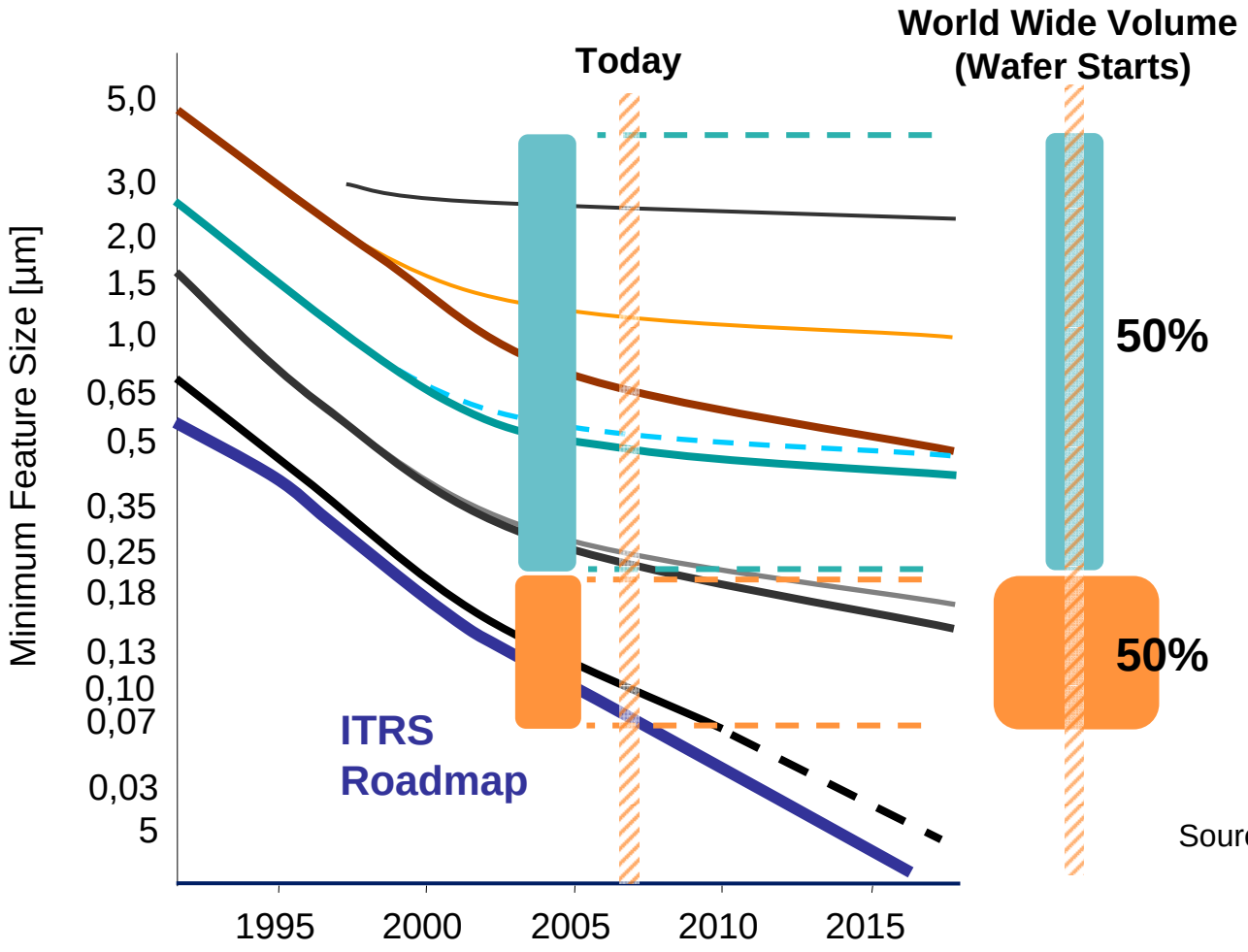
… and Today



Source: Bosch

Technologies for various applications scale with different speed

More than Moore contributes to 50% of world wide wafer volume



More than Moore:

- IGBT
- DMOS
- RF BiCMOS
- Bipolar-Analog
- RF BIPOLAR
- Anal. BiCMOS
- 5V CMOS

More Moore:

- CMOS logic
- DRAM
- Flash

Source: VLSI Research Q4 2005

Source: Infineon

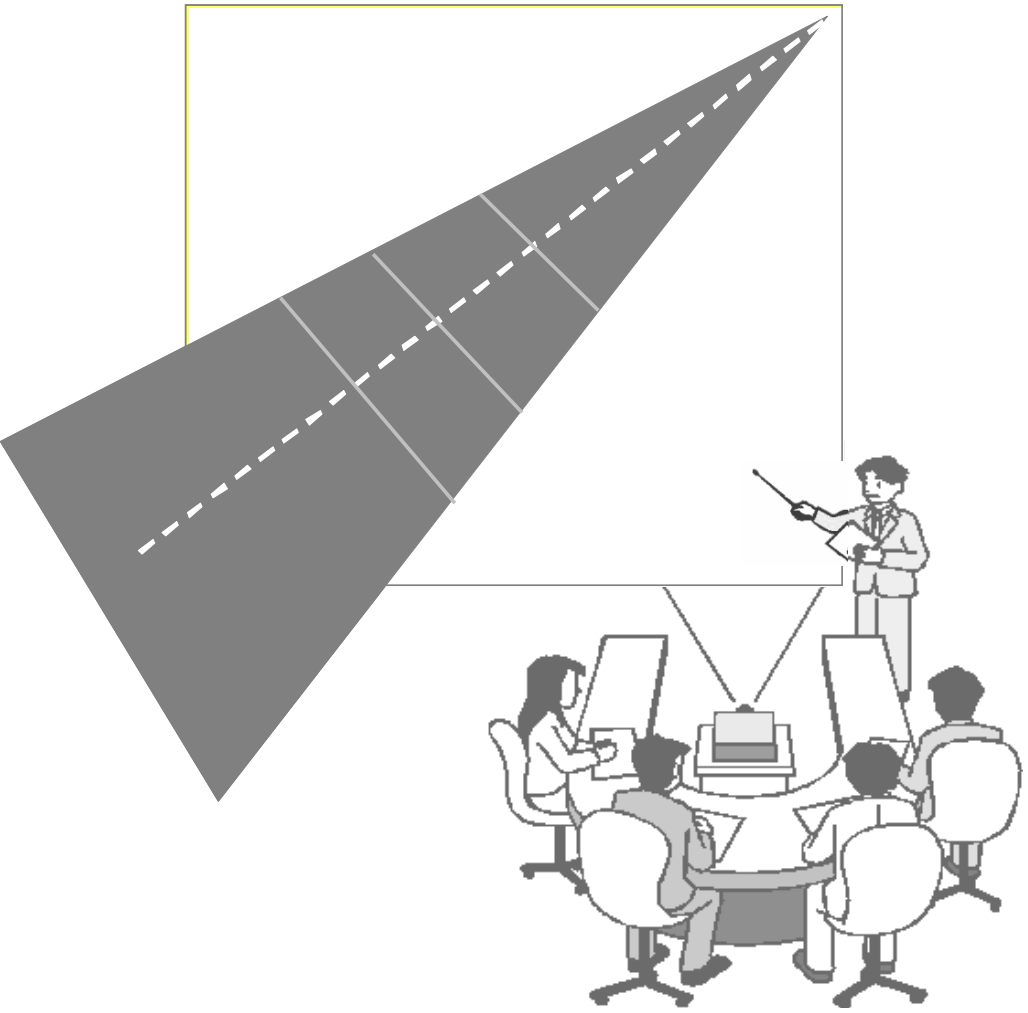
MORE THAN MOORE

Why should the ITRS care ?

PATRICK COGEZ
IRC – ESIA, Europe

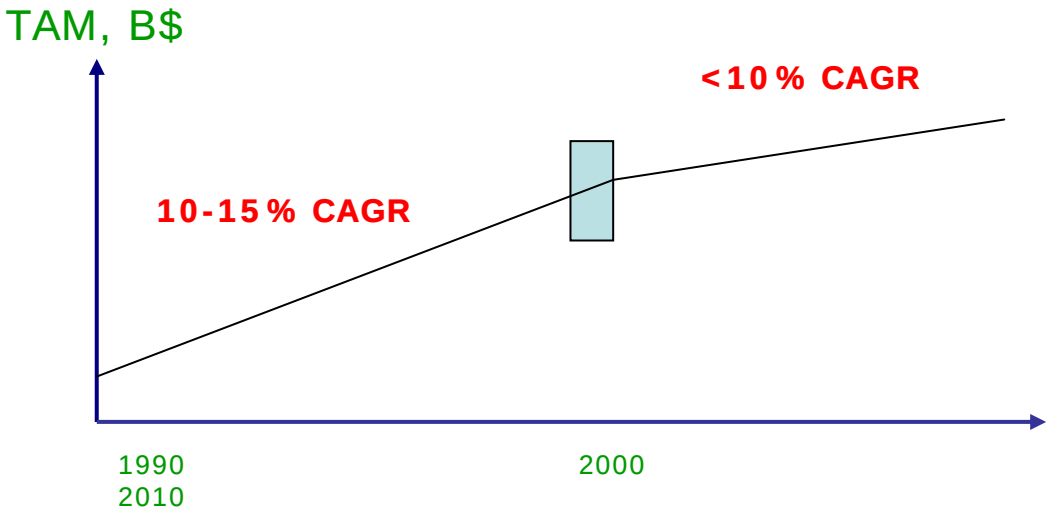
More Moore : Planned technological targets

More than Moore : Which technologies ? Which trade-offs ? Coordinations for technological explorations?



Semiconductor Market Growth

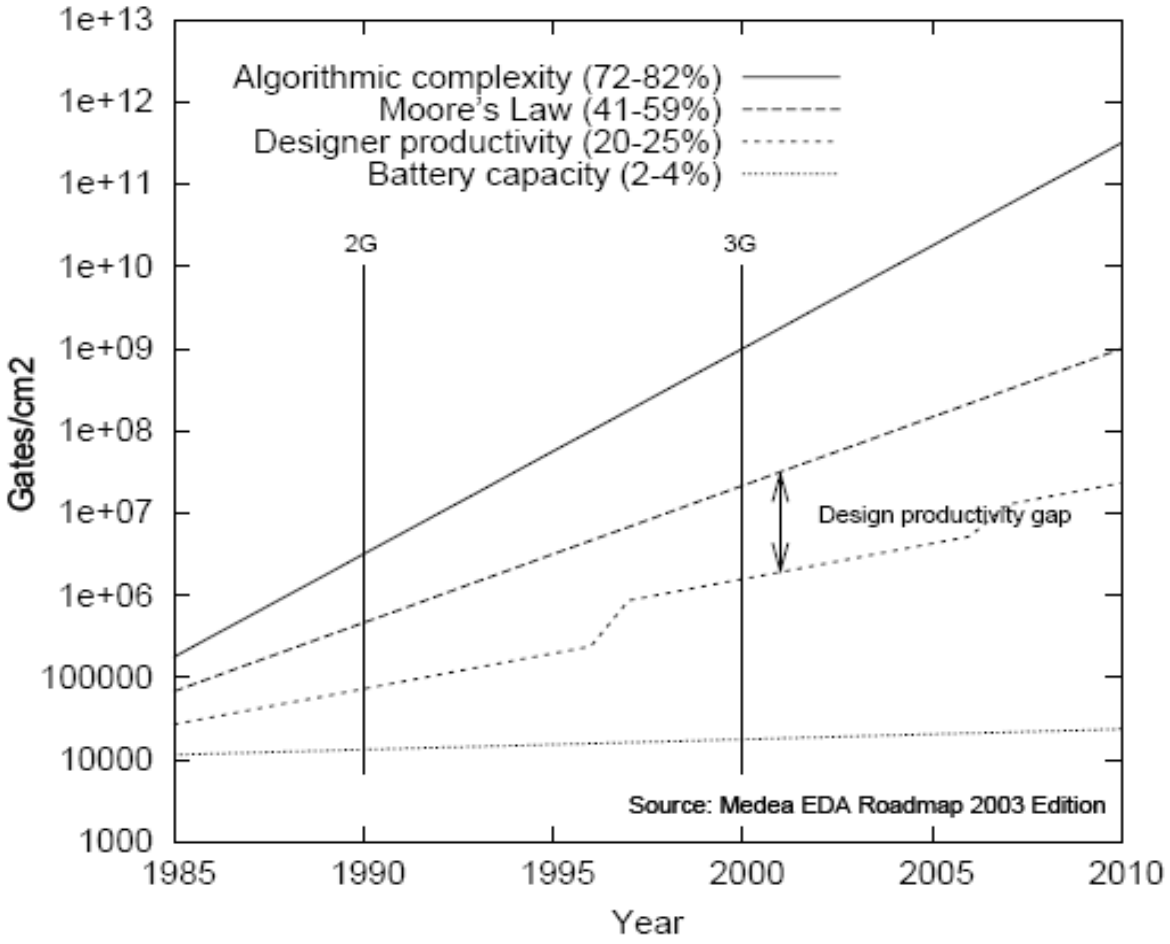
- From a historical CAGR of close to 15%, current visibility is at best 10% for the rest of the decade
  - R&D money is not unlimited
  - While R&D options are expanding



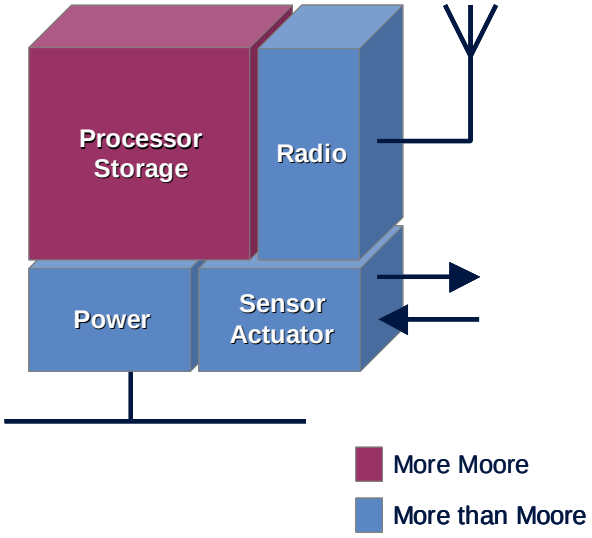
A renewed role for the ITRS

- ITRS goal
  - Provide research guidance for the industry
- In the past
  - Smaller was better, and cheaper
    - Criteria to gauge usefulness of research
  - ITRS role : identify the red brick walls
- Today
  - System performance no longer purely commanded by device performance
  - More Moore and More than Moore
  - What will bring more value to the end user ?
- ITRS role
  - Redefine the questions to be solved by the research community

"More than Moore" and design tools

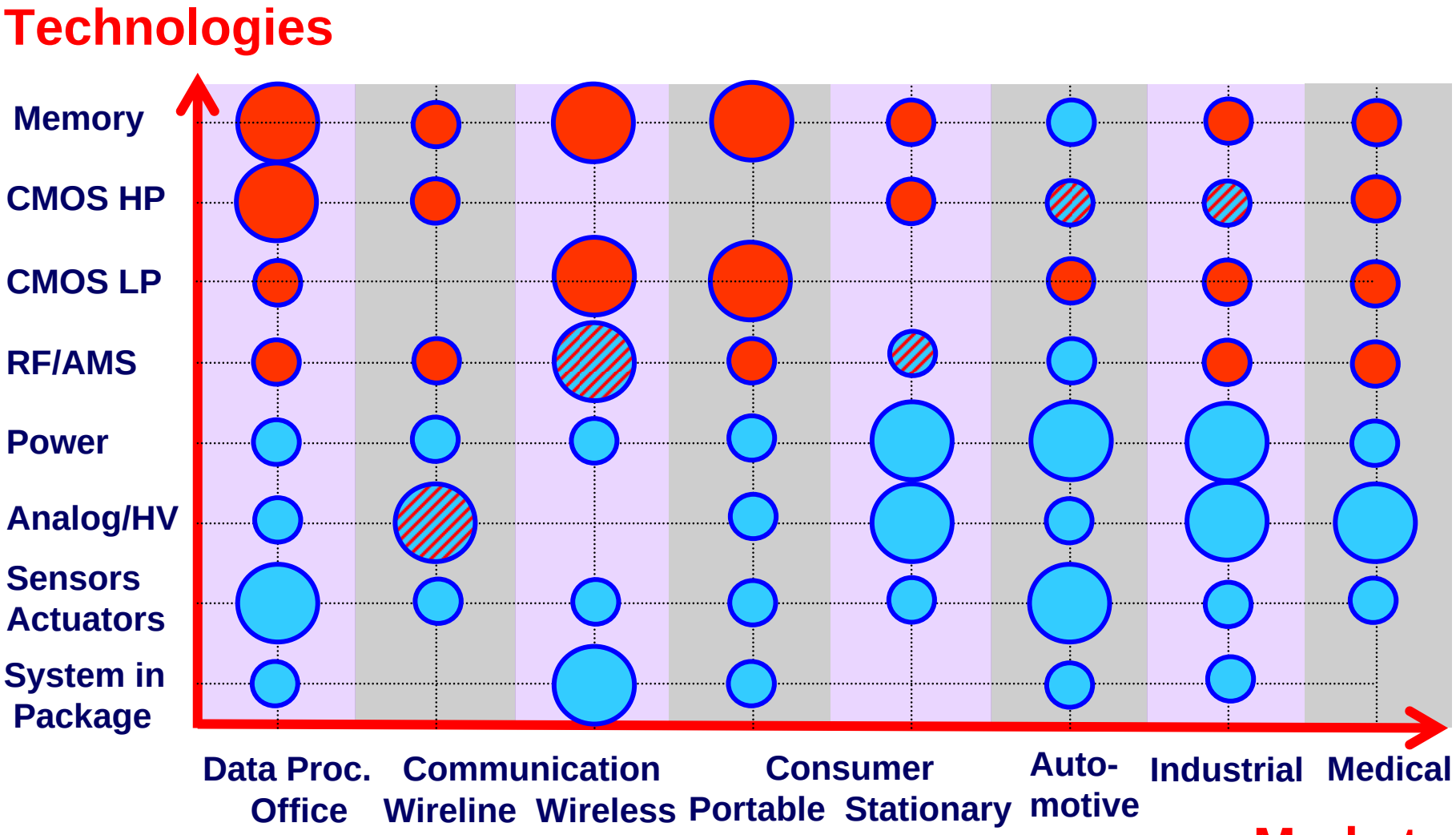


Society Needs:
Intelligent Compact Systems



Need for heterogeneous design platform

Market Drivers for Technology Roadmap

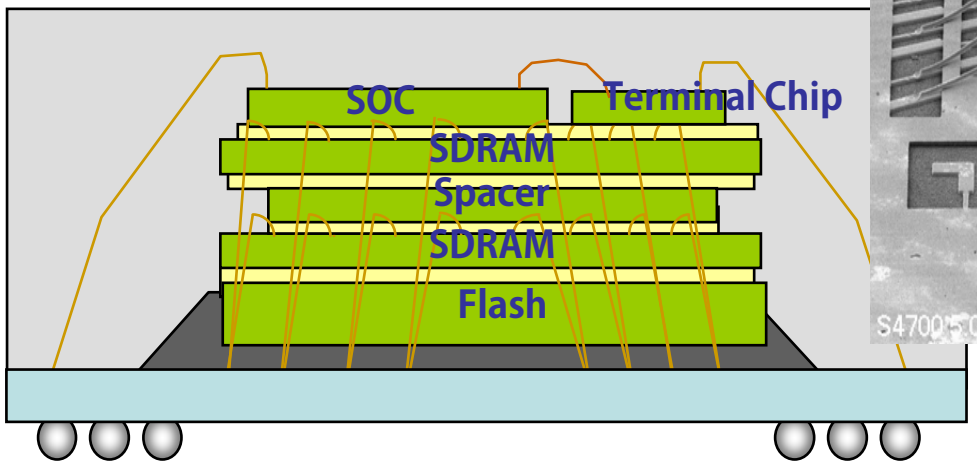


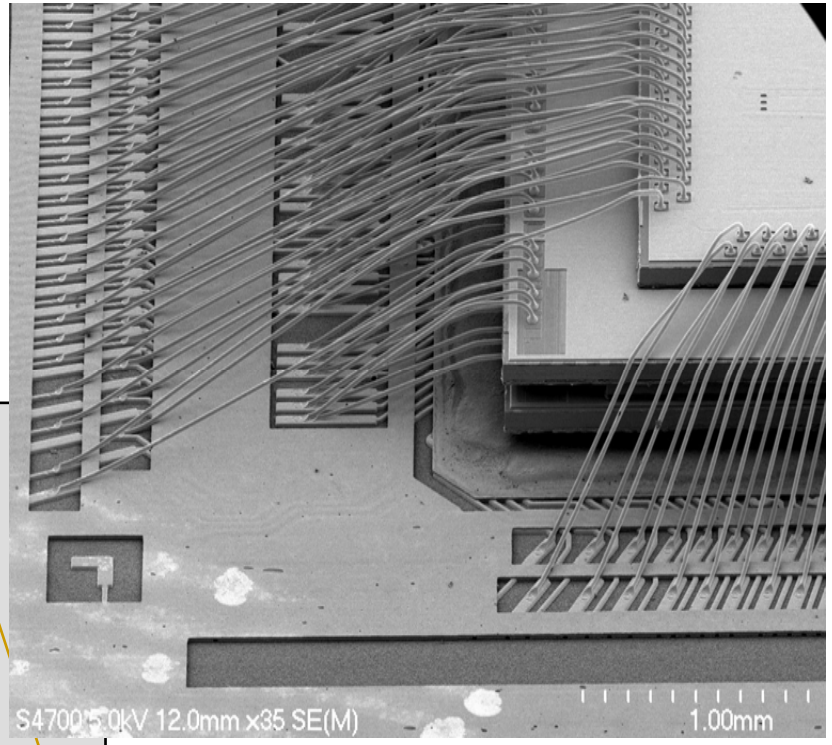
MORE THAN MOORE and Beyond CMOS *Technologies as Key Components of "Extended CMOS"*

HIDEMI ISHIUCHI
IRC -- JEITA, Japan

SiP Example for Digital Still Camera

5 stacked chips

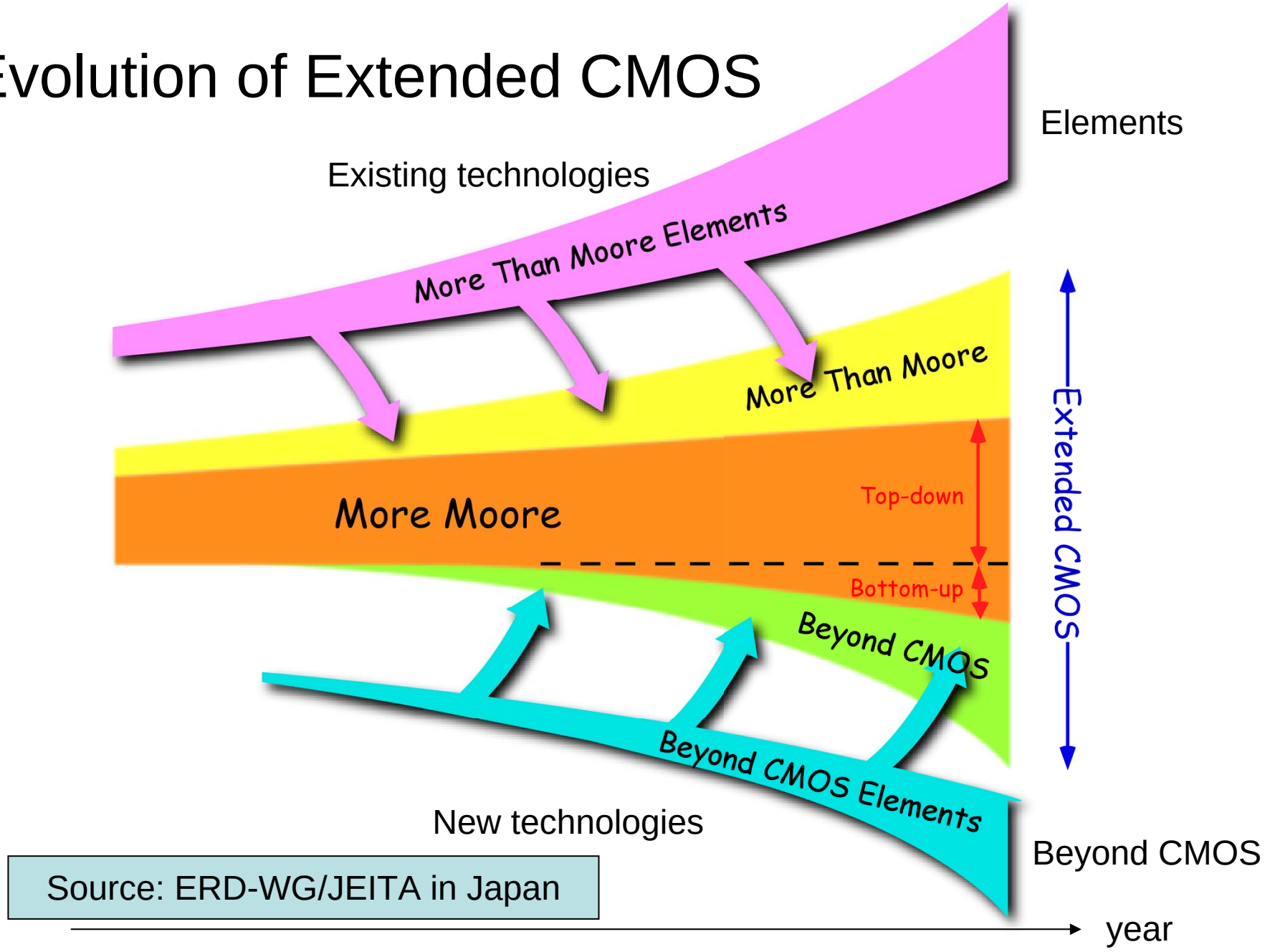




Courtesy of Renesas Technology Corp.

Source: A&P-WG/JEITA in Japan

Evolution of Extended CMOS



Source: ERD-WG/JEITA in Japan

More than Moore Elements and Beyond CMOS Elements

- More than Moore Elements
  - Analog CMOS, Passive Elements, Power Devices, Sensors & Actuators, Bio Chips, etc.
  - to be integrated into CMOS Technology
- Beyond CMOS Elements
  - Non-Charge-Based Devices: Quantum Devices, Spin-state Devices, Molecular Devices, etc.
  - to be integrated into CMOS Technology
  - or to be realized without using CMOS Technology

Extended CMOS

- Extended CMOS
  - “More than Moore Elements” and “Beyond CMOS Elements” are integrated into Scaled CMOS (“More Moore Technology”)
- Top-down
  - Fabrication methods using lithography and etching
- Bottom-up
  - Self-organized or Self-assembled

Panelists

MART GRAEF – **International Roadmap Committee**

PUSHKAR APTE – **International Roadmap Committee**

PATRICK COGEZ – **International Roadmap Committee**

HIDEMI ISHIUCHI – **International Roadmap Committee**

ALAN ALLAN – **Overall Roadmap Technology Characteristics**

BILL BOTTOMS – **Assembly and Packaging**

GEORGE BOURIANOFF – **Emerging Research Devices**

JUAN-ANTONIO CARBALLO – **Design**

HAROLD HOSACK – **Interconnect**

JACK PEKARIK – **Wireless**

PETER ZEITZOFF – **Process Integration**