Technology session

Marc Duranton (CEA)

Jo De Boeck (imec)

Where innovators meet & shape OUR DIGITAL FUTURE

2019

15:00 Introduction, goals of the workshop

15:15 The Research Agenda for process technology, equipment, material and manufacturing (Jo de Boeck)

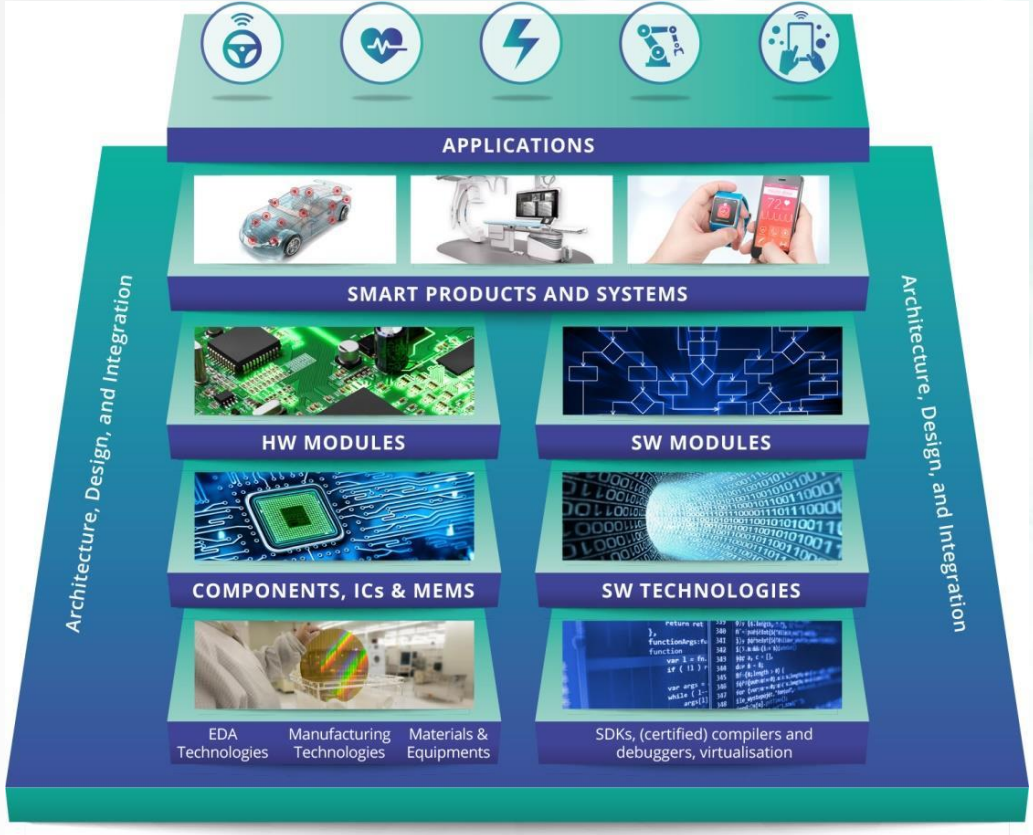
15:45 The Research Agenda for computing and storage (Marc Duranton)

16:15 Open discussion on

- new trends,
- gaps,
- connecting application needs with tech challenges and key drivers (HPC, Robotics)
- what should be done in Europe?

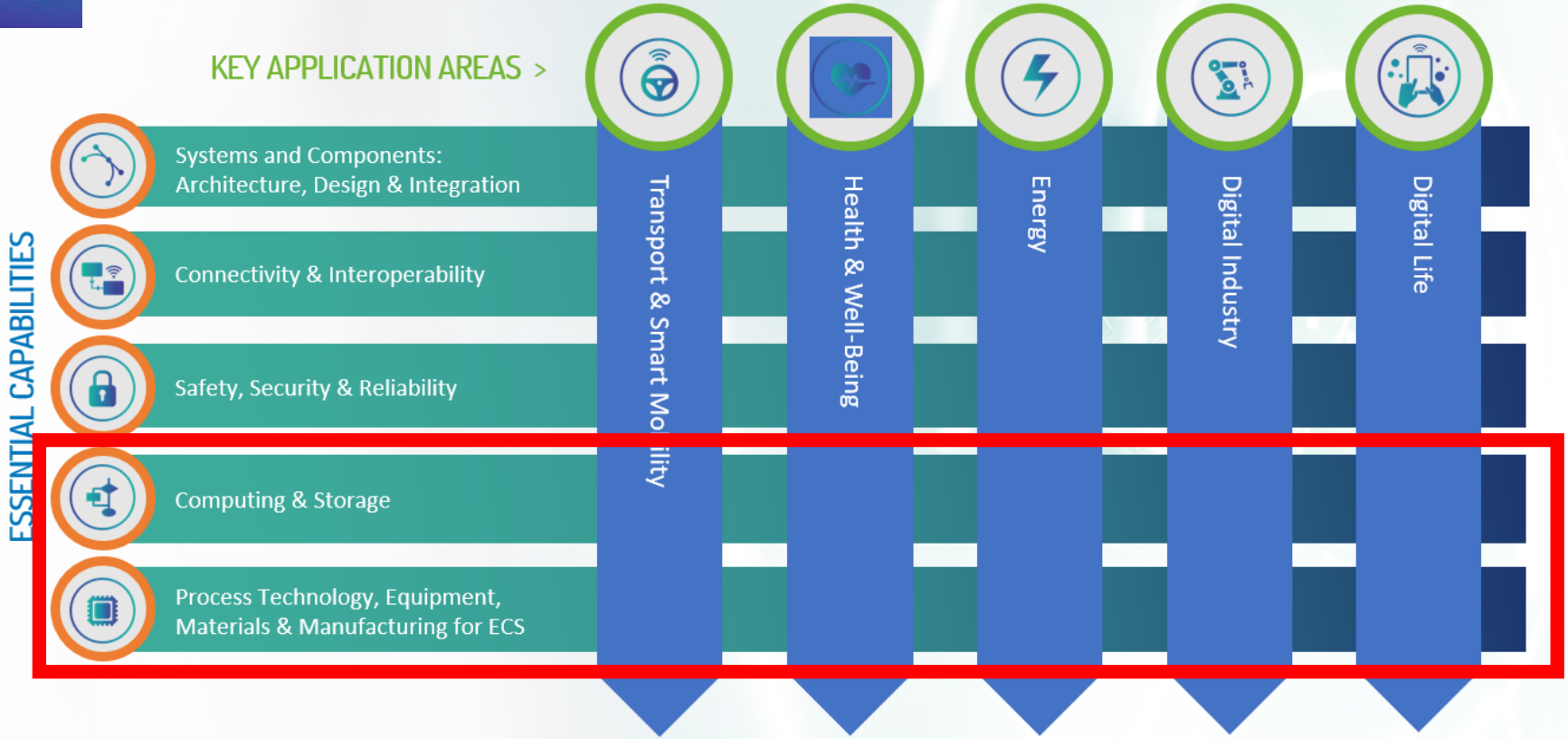
16:55 Close of the session

Electronics value chain



ECS Strategic Research Agenda

ECS 2019
Where innovators meet & shape OUR DIGITAL FUTURE



ECS 2019
Where innovators meet & shape OUR DIGITAL FUTURE

The Research Agenda for process technology, equipment, material and manufacturing

Jo De Boeck

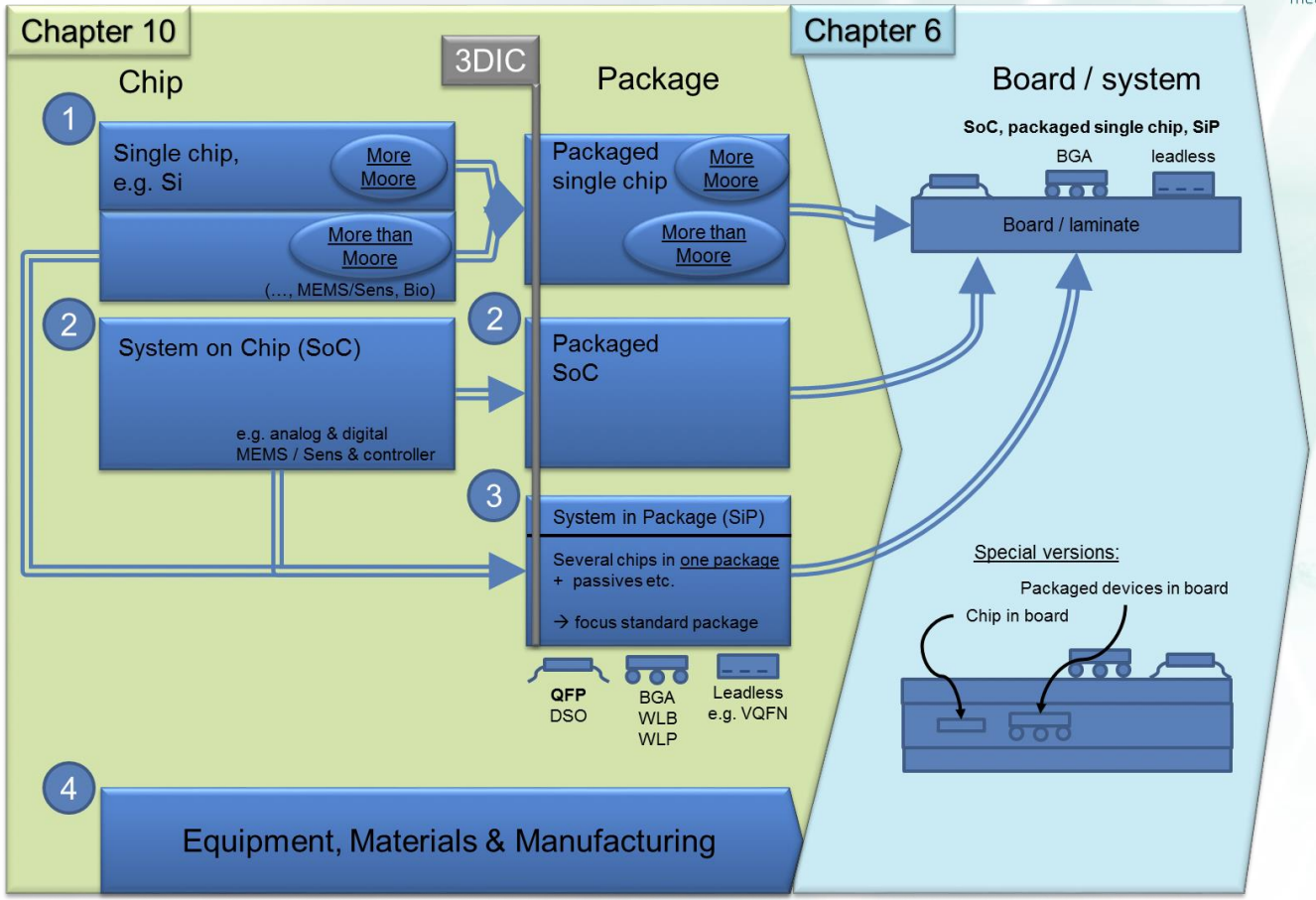
10. Process Technology, Equipment, Materials and Manufacturing for Electronic Components & Systems

Arco.Krijgsman@ASML.com
Gerhard.Doell@zeiss.com
Jo.DeBoeck@imec.be

Content highlights

- Major challenges
  1. Develop advanced logic and memory technology for nanoscale integration and application-driven performance
  2. Develop technology for heterogeneous SoC integration
  3. Develop technology for advanced packaging and heterogeneous SiP integration
  4. Extend world leadership in semiconductor equipment, materials and packaging
- Strategy
  1. Explore new avenues of applications for ECS
  2. Implement pilot lines and test beds for ECS
  3. Demonstrate manufacturing-line capabilities for flexible, high-quality, competitive and ‘green’ semiconductors
  4. Invest in workforce education

10. Process Technology, Equipment, Materials and Manufacturing for Electronic Components & Systems

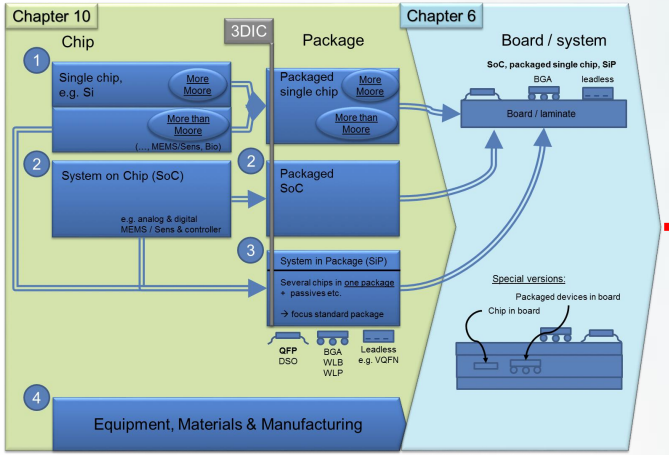


10. Process Technology, Equipment, Materials and Manufacturing for Electronic Components & Systems

Changes in the SRA

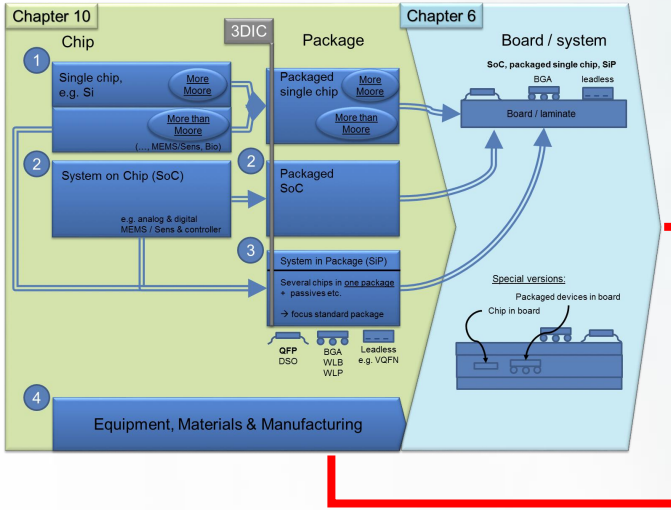
- Executive Summary strengthen the link to advancing applications, most importantly quantum information processing.
- The **impact** section:
  - On **FET flagship** (Graphene and Quantum technologies computing),
  - On advanced **education and training** and
  - On **technology sovereignty** in light of the growing strategic importance of a local base for KET.
- The following changes were made in terms of the major **challenges**:
  - Challenge 1 - added detail on nanowires, functional oxides, 2D and high-performance switches.
  - Challenge 2 – added new building blocks, materials and applications.
  - Challenge 3 – added new applications, such as quantum computing and testing.
  - Challenge 4 – used more technology-based terminology for the sub-challenges, and the addition of new technology challenges.

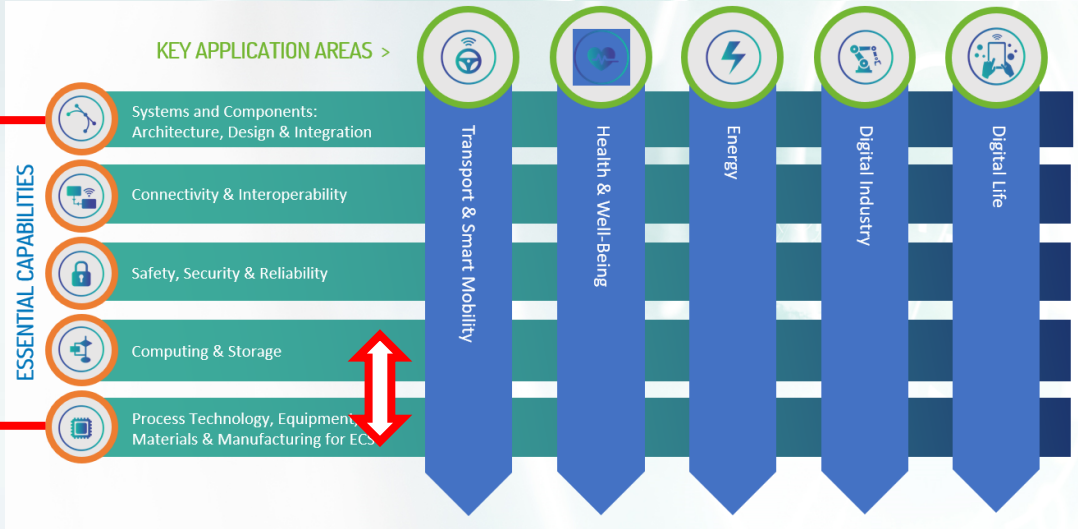
Co-optimisation



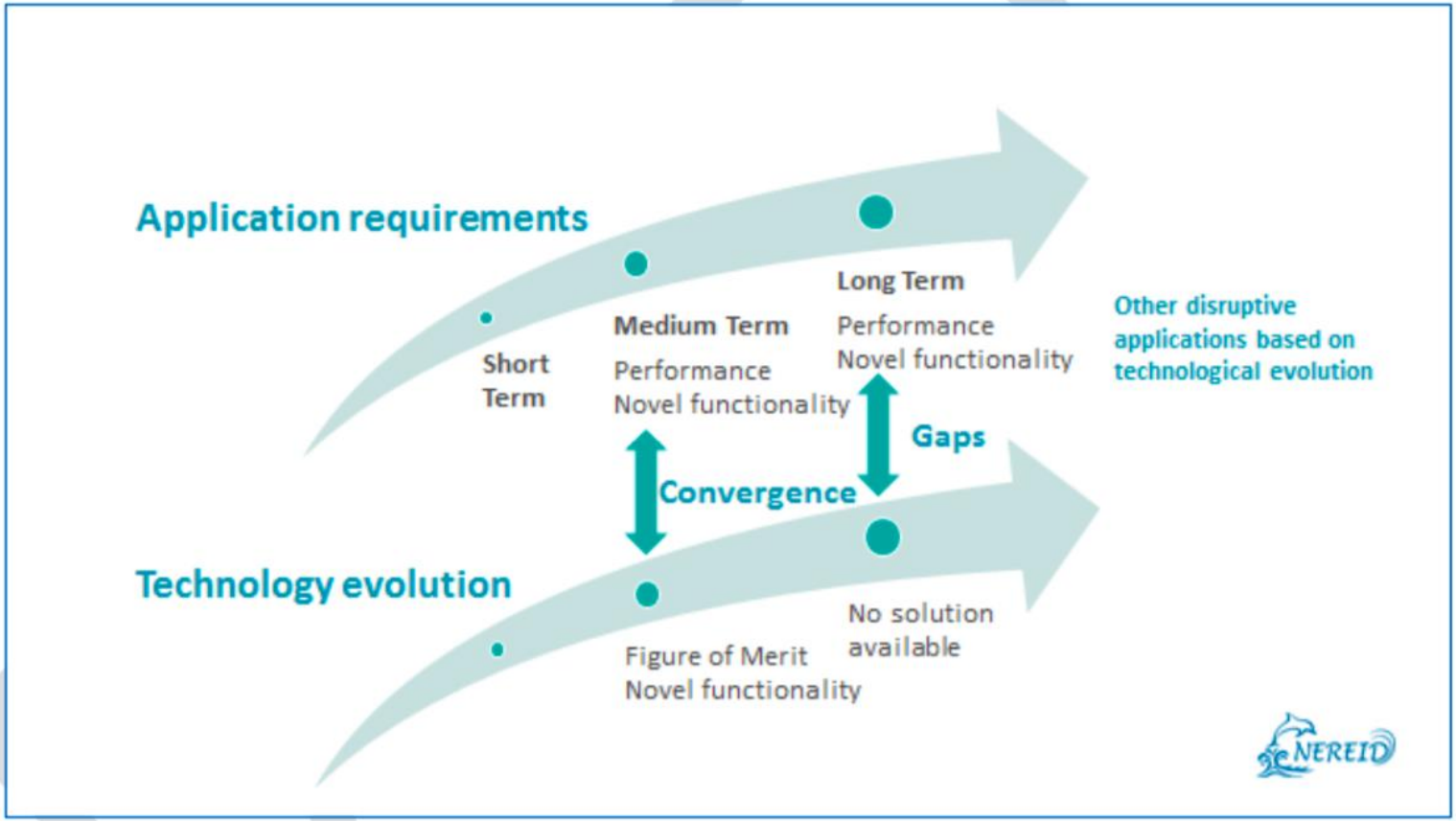
- Managing critical, autonomous, cooperating, evolvable systems
- Managing complexity
- Managing diversity
- Managing multiple constraints
- Integrating features of various technologies and materials into miniaturised smart components
- Effectively integrating modules for highly demanding environments
- Increasing compactness and capabilities by functional and physical systems integration

Co-optimization of system needs and technology development





Long term vision



The Research Agenda for computing and storage

Marc Duranton

ECS 2019
Where innovators meet & shape OUR DIGITAL FUTURE

Computing and Storage

Ronald.Begeer@tno.nl
Marc.Duranton@cea.fr

Content highlights

- 9.3. Major Challenges
  - 9.3.1. Increasing performance at acceptable cost
  - 9.3.2. Making computing systems more integrated with the real world
  - 9.3.3. Making "intelligent" machines
  - 9.3.4. Developing new disruptive technologies

- 9.4. Make it happen
  - 9.4.1. Educational Challenge
  - 9.4.2. Standardization
  - 9.4.3. Advices for policy makers
    - Boosting innovation and education in computing and storage in Europe
    - Organize the computing community to "synergies –
    - Foreign export restriction & sovereignty
    - Favorite emergence of AI-enabling technology to maintain [illegible] industry

Exponential increase of performances in 33 years

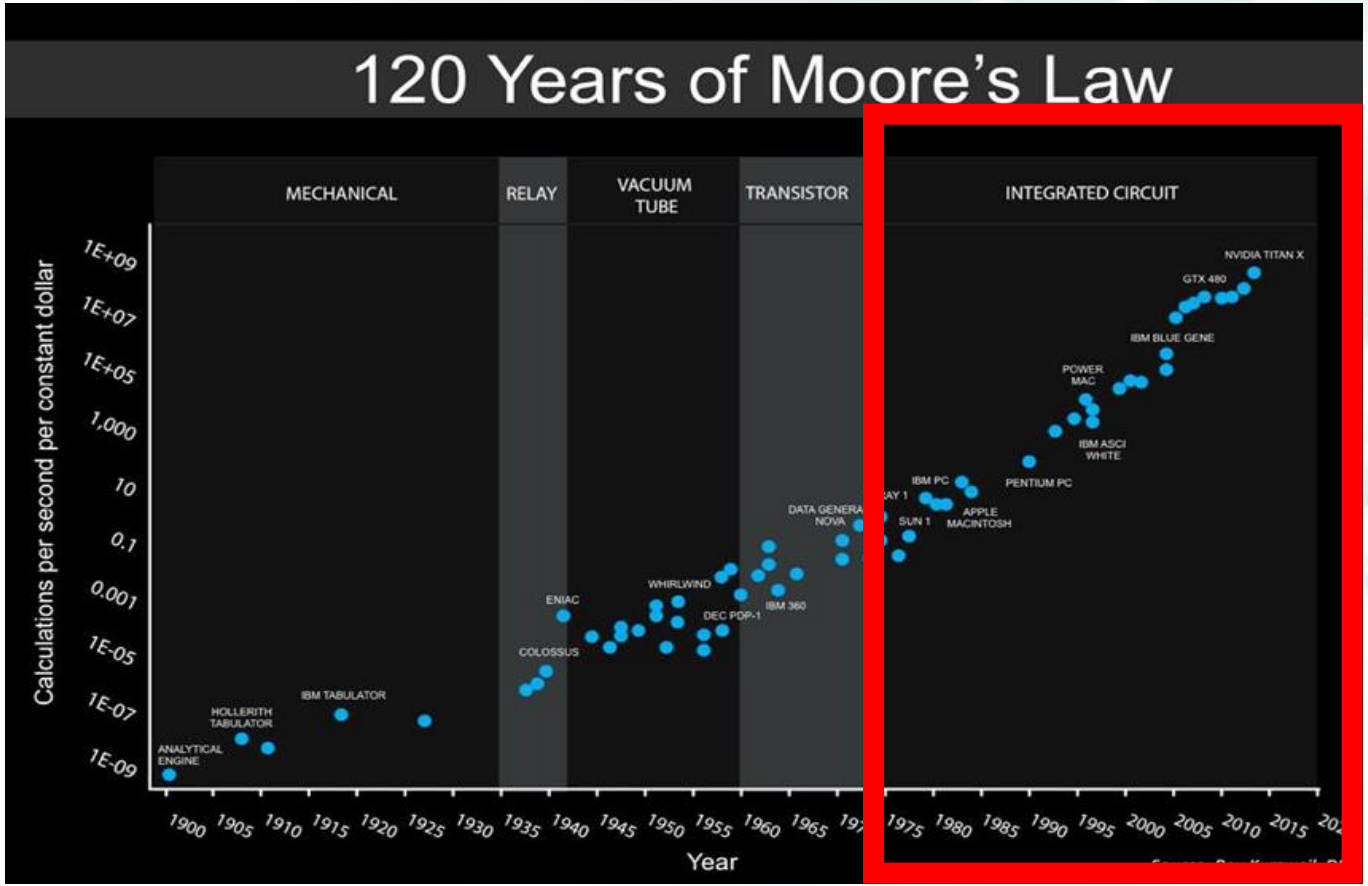
Production car of 1985
Lamborghini Countach 5000QV
Max speed 300 Km/h

X 100 000 000

27 times the speed of light
Warp 3 ?
Star Trek Enterprise
(Year: about 2290)

WHAT WILL BE THE NEXT TECHNOLOGY?

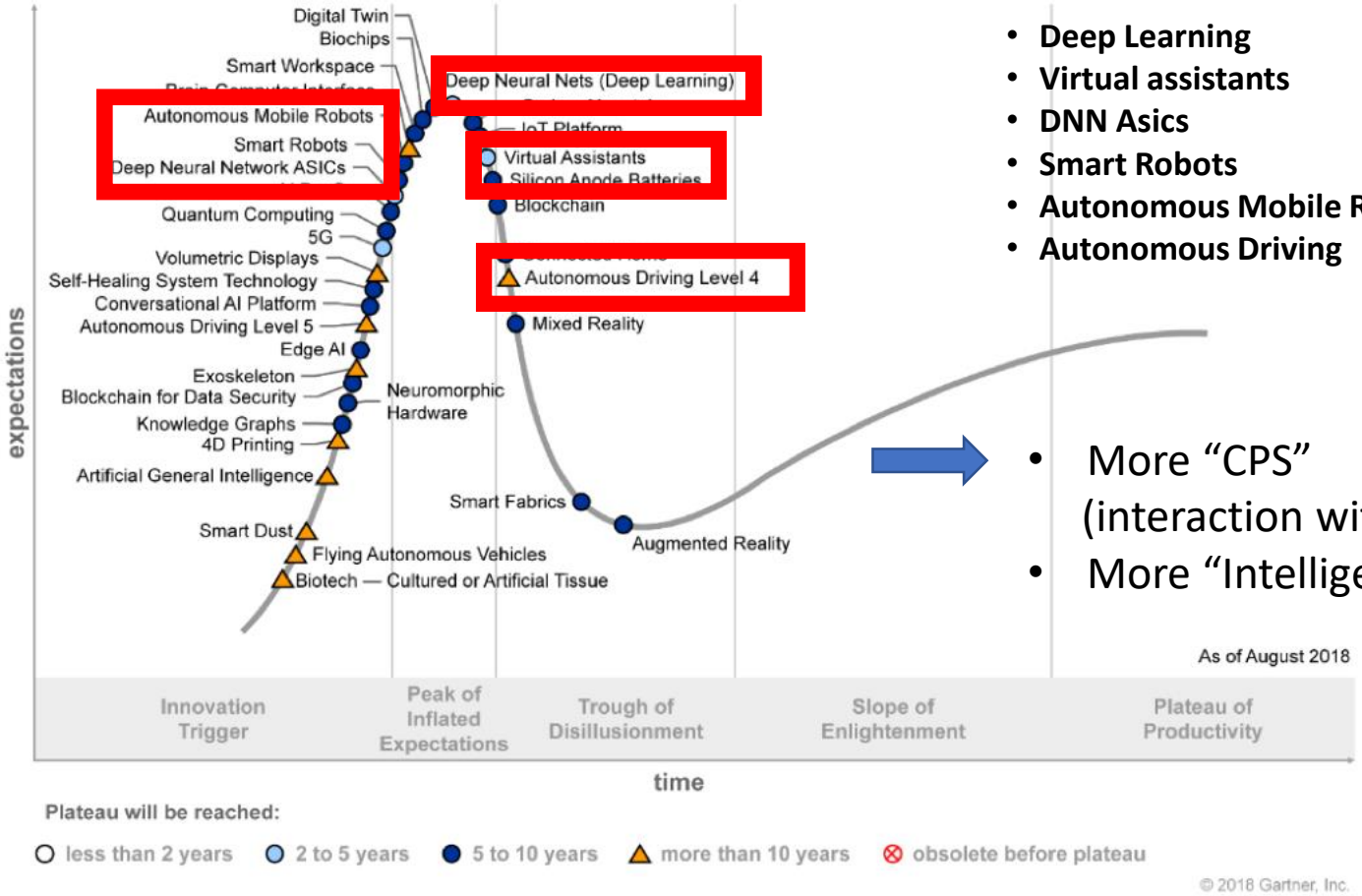
ECS 2019
Where innovators meet & shape OUR DIGITAL FUTURE



And after CMOS?

- Quantum computing?
- Neuromorphic?
- Optical computing?
- Spin-based computing?

The Hype cycle - 2018



- **Deep Learning**
- **Virtual assistants**
- **DNN Asics**
- **Smart Robots**
- **Autonomous Mobile Robots**
- **Autonomous Driving**

- More “CPS” (interaction with the real world)
- More “Intelligence”

Computing and Storage

Ronald.Begeer@tno.nl
Marc.Duranton@cea.fr

Content highlights

- 9.3. Major Challenges
  - 9.3.1. Increasing performance at acceptable cost
  - 9.3.2. Making computing systems more integrated with the real world
  - 9.3.3. Making "intelligent" machines
  - 9.3.4. Developing new disruptive technologies

- 9.4. Make it happen
  - 9.4.1. Educational Challenge
  - 9.4.2. Standardization
  - 9.4.3. Advices for policy makers
    - Boosting innovation and education in computing and storage in Europe
    - Organize the computing community – “synergies –
    - Foreign export restriction & sovereignty
    - Favorite emergence of AI-enabling technology to maintain a high-stake industry

Computing and Storage

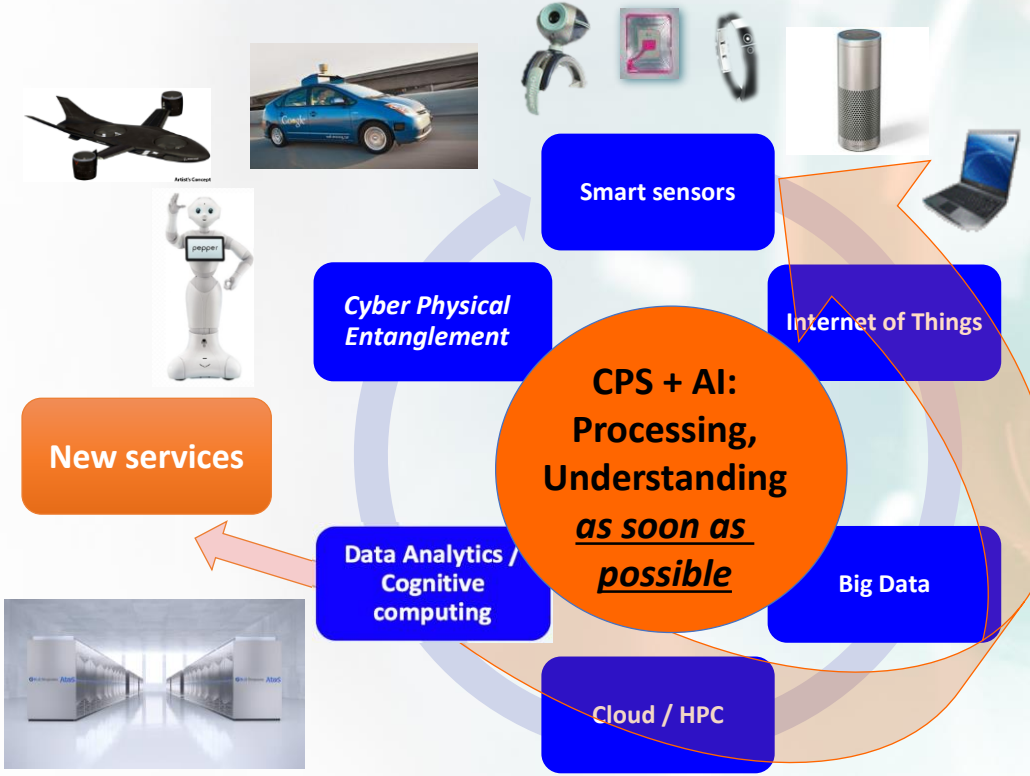
Changes: several additions

- Computing now forms a continuum between extreme edge devices, edge devices, IoT, fog, cloud and HPC.
- Energy consumption of cloud/computing is a growing concern.
- AI requires much computing power (and therefore energy) for the learning and applications require highly efficient accelerators for inference.
- GAFA and BATX are now developing their own hardware, and Europe has to act quickly to remain competitive.
- Open source hardware, such as RISC V, is becoming increasingly attractive.
- CPS implies multi-domain/multi-paradigm design and global system view, which is becoming also an educational challenge.
- Software complexity is a real bottleneck.
- AI techniques can be used to help design better hardware and software.

COMPUTING NOW FORMS A CONTINUUM

ECS 2019
Where innovators meet & shape OUR DIGITAL FUTURE

aka *Intelligent Embedded Systems*
aka *Autonomous CPS (ACPS)*
aka Cognitive CPS (C^2PS)



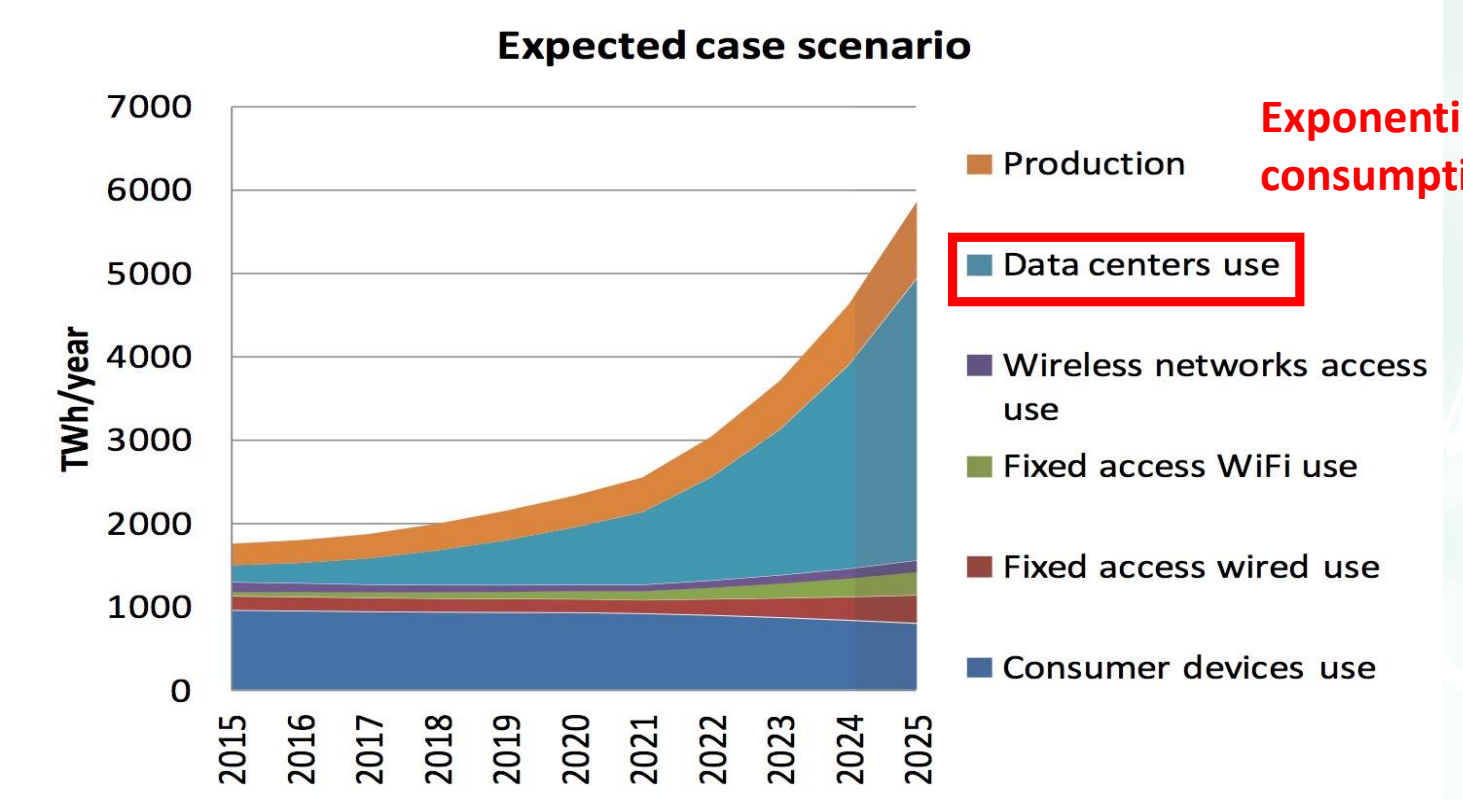
Enabling Intelligent data processing at the edge:
Fog computing
Edge computing
Stream analytics
Fast data…

ENABLING EDGE INTELLIGENCE
Transforming **data** into ***information*** ***as early as possible***

True collaboration between edge devices and the HPC/cloud
⇨ creating a
continuum

The problem:

IT projected to challenge future electricity supply



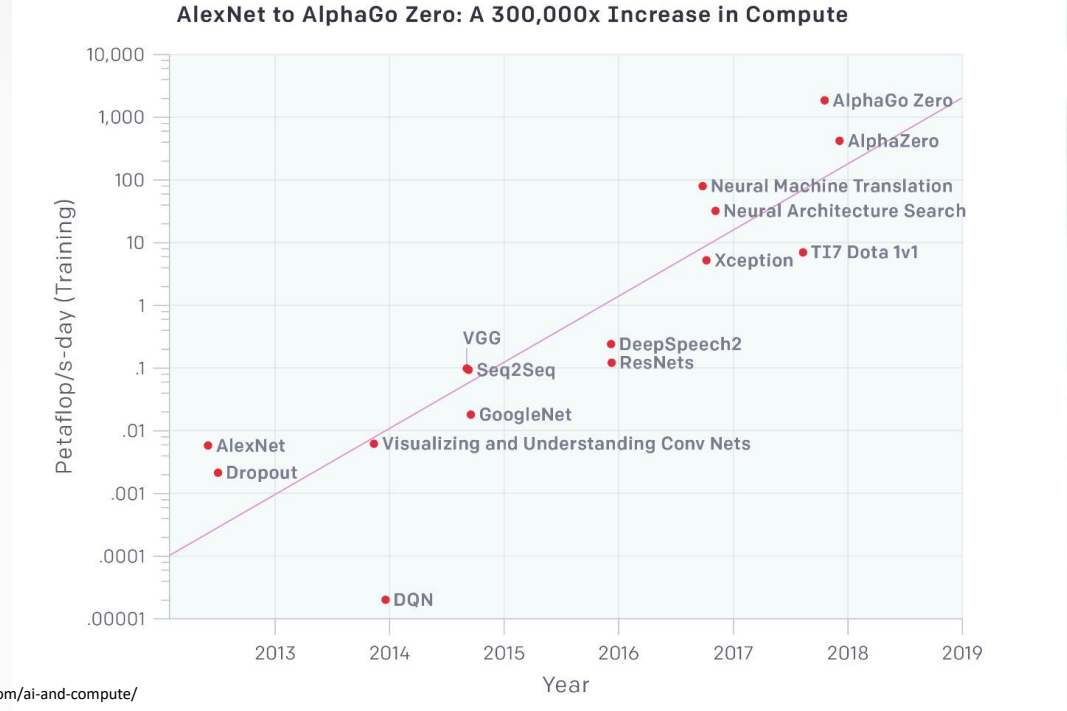
Exponential power consumption

From "Total Consumer Power Consumption Forecast", Anders S.G. Andrae, October 2017

EXPONENTIAL INCREASE OF COMPUTING POWER FOR AI TRAINING

*"Since 2012, the amount of compute used in the largest AI training runs has been increasing exponentially with a **3.5 month-doubling time***

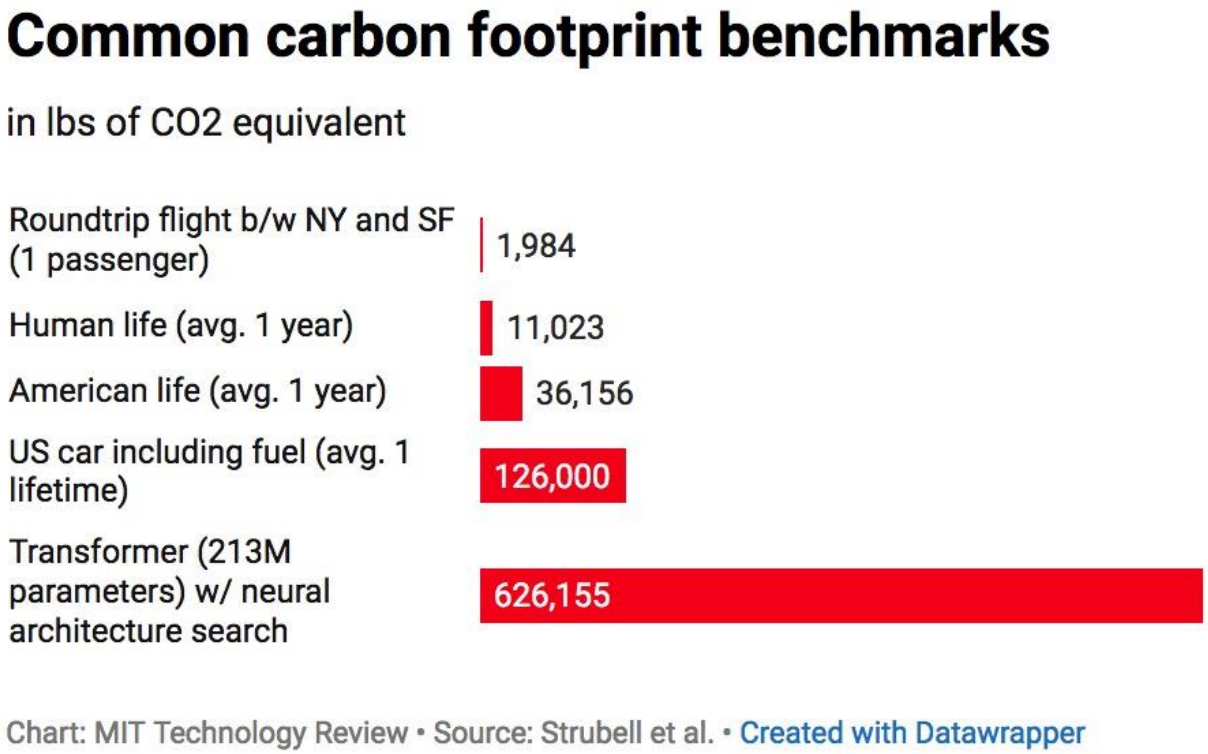
(by comparison, Moore's Law had an 18-month doubling period)"*



Peta= 10^{15}

* https://blog.openai.com/ai-and-compute/

SOME OTHER ICT ENERGY FIGURES…



From https://www.technologyreview.com/s/613630/training-a-single-ai-model-can-emit-as-much-carbon-as-five-cars-in-their-lifetimes/

“Artificial Intelligence at the Edge” hardware is well recognized… in USA

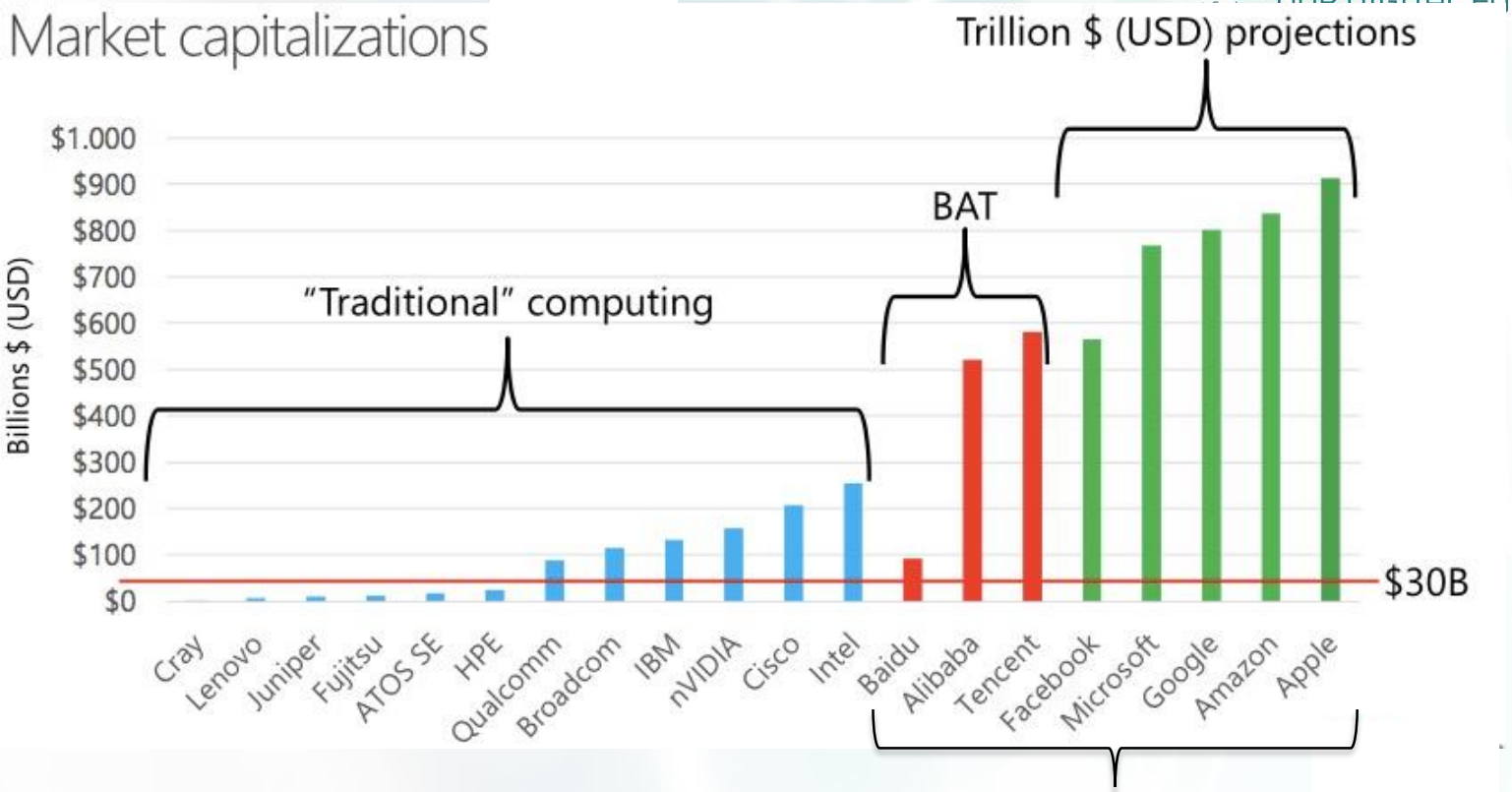
Intel® Neural Compute Stick 2 at $99
Powered by the Intel® Movidius™
Myriad™ X Vision Processing Unit

Google Edge TPU
The $75 USB Accelerator provides the
Edge TPU’s high-performance ML inferencing

NVIDIA Announces Jetson Nano:
$99, 472 GFLOPS, 5 W, 69.6 mm x 45 mm
NVIDIA CUDA-X AI Computer
(Performances x236 compared to Cray 2)

For example, the European car industry which is very good up to know, is threatened by control of the mandatory-in-near-future of AI inside dominated by non EU countries…

Evolution of society: data (information) is the new fuel



Most of them are also developing (AI) hardware!

Original slide rom Dan Reed, University of Utah

Business Wire
A Berkshire Hathaway Company

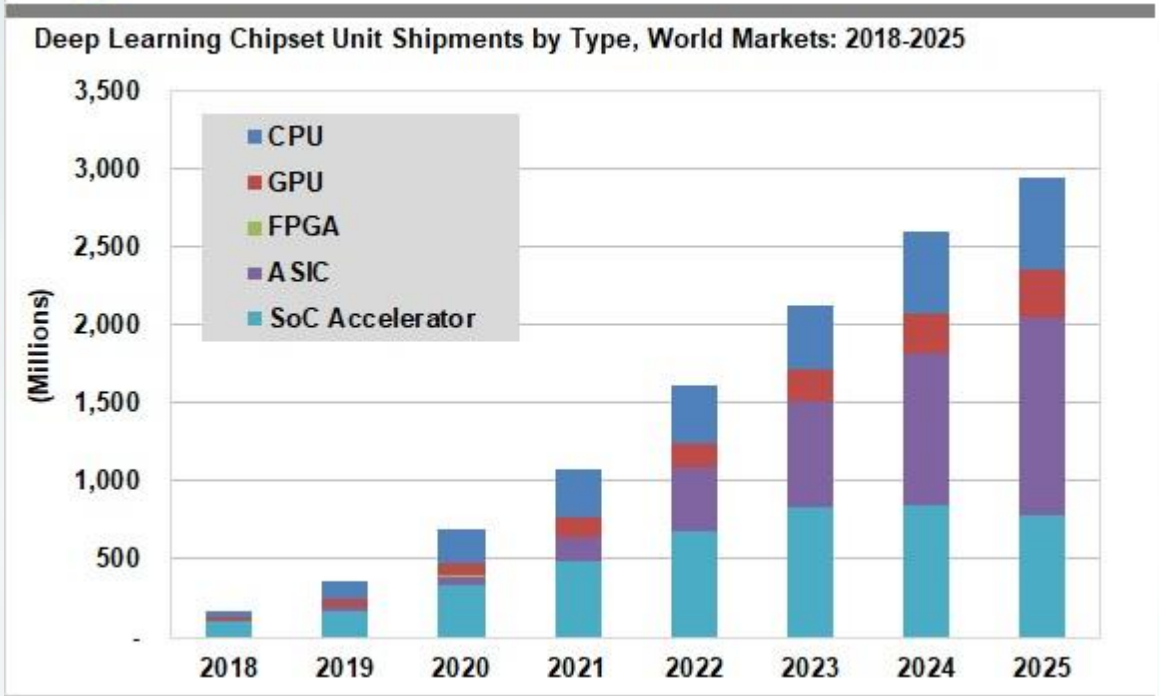
ECS 2019
Where innovators meet & shape OUR DIGITAL FUTURE

Deep Learning Chipset Shipments to Increase to 2.9 Billion Units Annually by 2025, According to Tractica

GPUs and CPUs Currently Lead in Market Share, but ASICs will Capture the Lead by 2022, with Expanded Opportunities for SoC Accelerators and FPGAs

May 06, 2019 07:20 AM Eastern Daylight Time

Hardware developments for AI accelerators will grow



Source: Tractica

Are we able to estimate the impact of Open Source ?

ECS 2019
Where innovators meet & shape OUR DIGITAL FUTURE

Pivotal acquisition foreshadows strategic shifts at VMware; VMworld announcements confirm them

By Kurt Marko August 27, 2019

SUMMARY: Up

VMware always
associated with
announcements
VMworld custom
more acquisition
Container Store.

By outright acqui
Software and un
transform its nar
a container-first
is simultaneousl
the way cloud-sa

NVDLA

The NVIDIA Deep Learning Accelerator (NVDLA) is a free and open architecture that promotes a standard way to design deep learning inference accelerators. With its modular architecture, NVDLA is scalable, highly configurable, and designed to simplify integration and portability. The hardware supports a wide range of IoT devices. Delivered as an open source project under the NVIDIA Open NVDLA License, all of the software, hardware, and documentation will be available on GitHub. Contributions are welcome.

- **Open Source:** Developed on GitHub in an open directed community where contributions are encouraged.
- **Complete Solution:** Comes complete with a Verilog and C-model, compiler, Linux drivers, test benches and test suites, kernel- and user-mode software, and software development tools. Easily portable to other operating systems.
- **Scalable:** Well-suited to scale across a wide range of IoT devices.
- **Proven Hardware Architecture:** Based on Xavier — the world's first autonomous processor that NVIDIA designed for automotive products and more — and backed by a full verification suite.
- **Deep Learning Savvy:** Smart, efficient, and ready to work with the wide range of NVIDIA supported solutions.

The Economist | Topics | Current edition | More

Open-source computing

A new blueprint for microprocessors challenges the industry's giants

designs

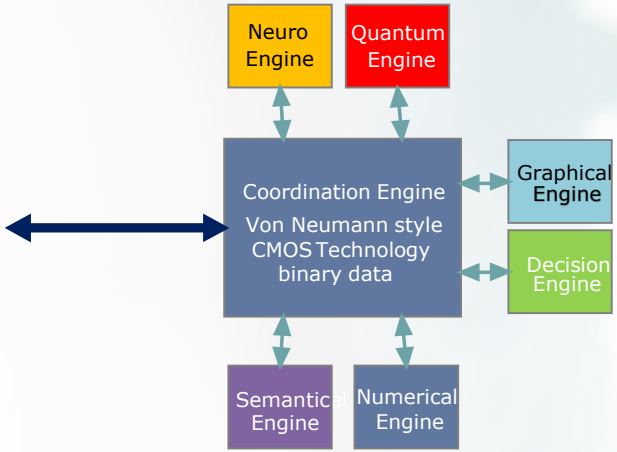
MOST MICROPROCESSORS—the chips that do the grunt work in computers—are built around designs, known as instruction-set architectures (ISAS), which are owned either by Intel, an American giant, or by Arm, a Japanese one. Intel's ISAS power desktop computers, servers and

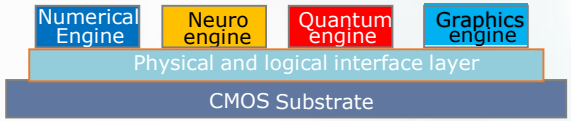
Original slide from Arnaud Samama, Thalès

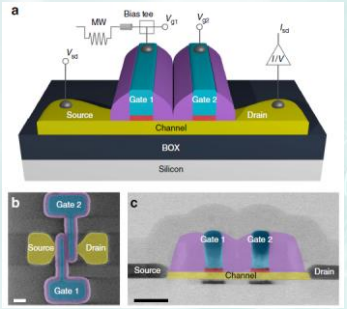
FUSING PARADIGMS AT HARDWARE LEVEL

At the hardware level, the good old Von Neumann/ CMOS partnership can act as a computing substrate, or orchestrator of various accelerators/technologies

- Acting as coordination / communication node
- Allowing Hardware / Software integration



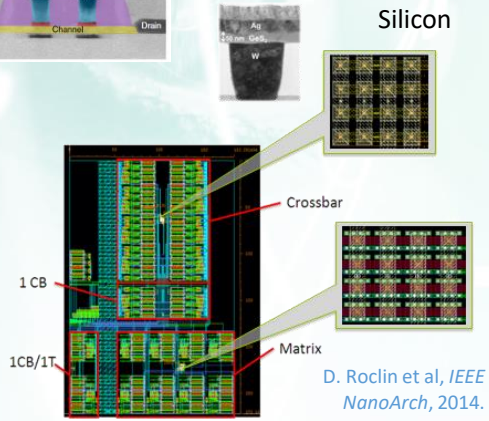




Qubits on Silicon

Maurand et al, *Nature Com.*, Jul. 2016.

NVM Synapses on Silicon



D. Roclin et al, *IEEE NanoArch*, 2014.

Original slide from Christian Gamrat, CEA

PROCESSOR ARCHITECTURE EVOLUTION?

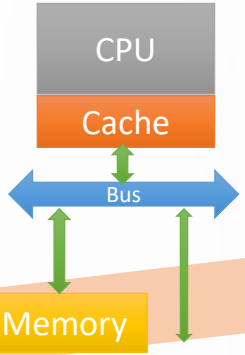
HECS 2019
Where innovators shape OUR DIGITAL FUTURE

End of Dennard's scaling

Moore's law slow-down

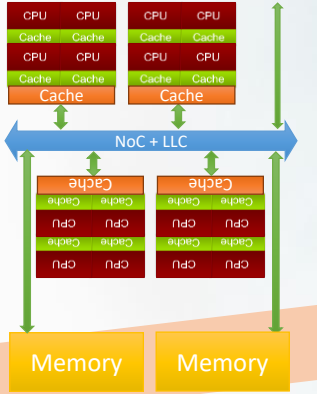
Quantum Computing

Mono-core architecture for single thread performance



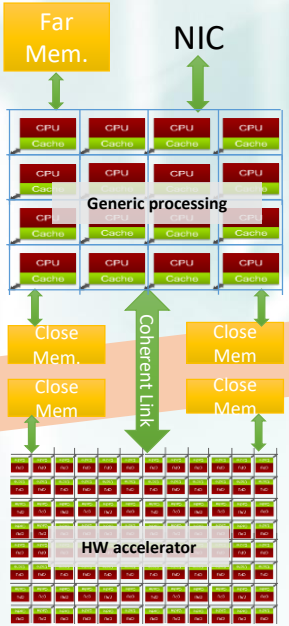
~2006

Many-core architecture for parallelism



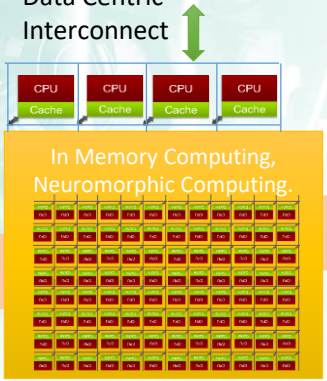
~2016

Heterogeneous architecture for energy efficiency



~2026…

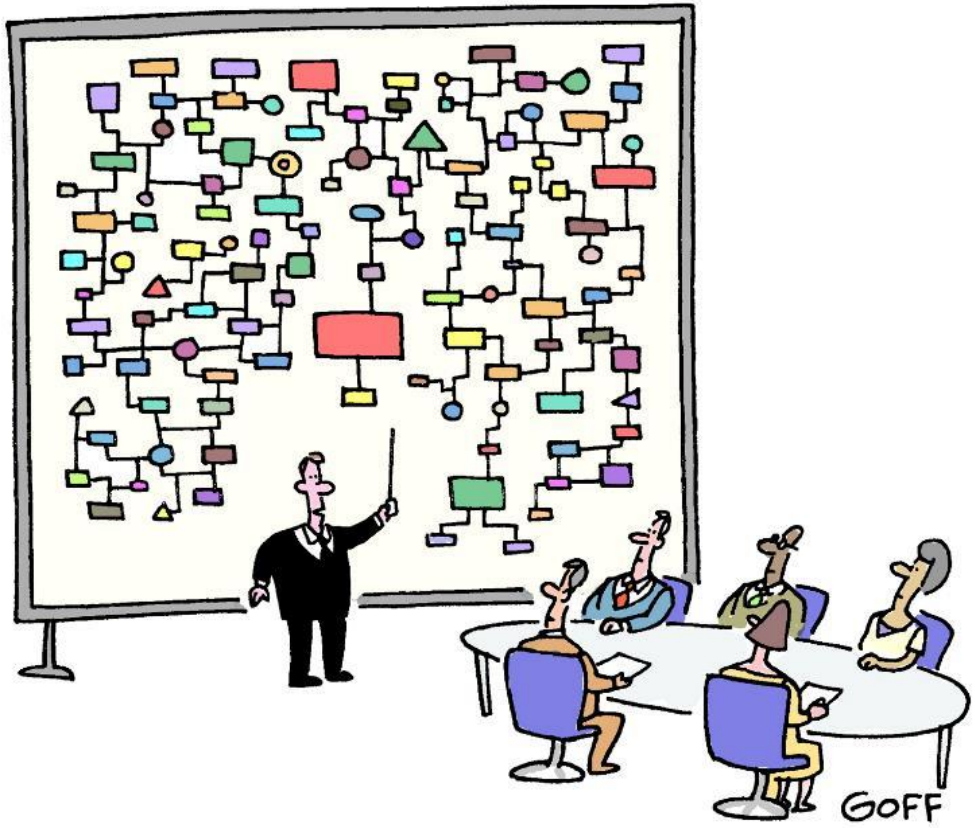
Disruptive Architecture for data management



Memory invades logic

Original slide from Denis Dutoit, CEA

MANAGING COMPLEXITY



"And that's why we need a computer."

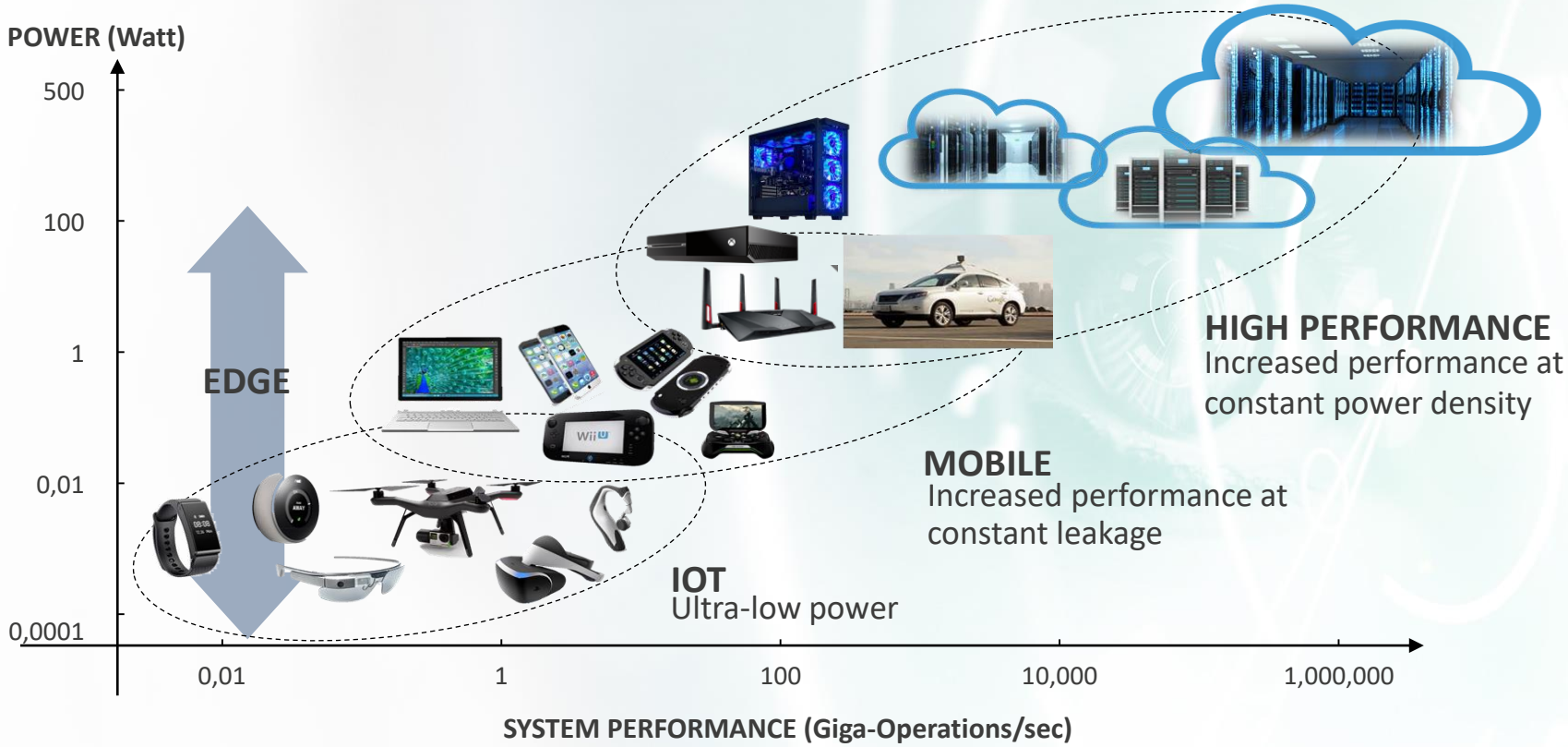
Cognitive solutions for complex computing systems:

- Using **AI and optimization techniques for computing systems**
  - Creating new hardware
  - Generating code
  - Optimizing systems
- Similar to ***Generative design*** for mechanical engineering

Open discussion

introduction

LOW POWER & increased functionality



ARTIFICIAL INTELLIGENCE IS A KEY STRATEGIC DRIVER

Augmenting human intelligence by technology

Pre-processing of data & understanding data patterns

Making useful predictions & decisions

Triggering action and self-regulation

ARTIFICIAL INTELLIGENCE IS A KEY STRATEGIC DRIVER

MORE ENERGY-EFFICIENT COMPUTATION
HIGHER BANDWIDTH NETWORKING

COMPUTE

STORE

CONNECT

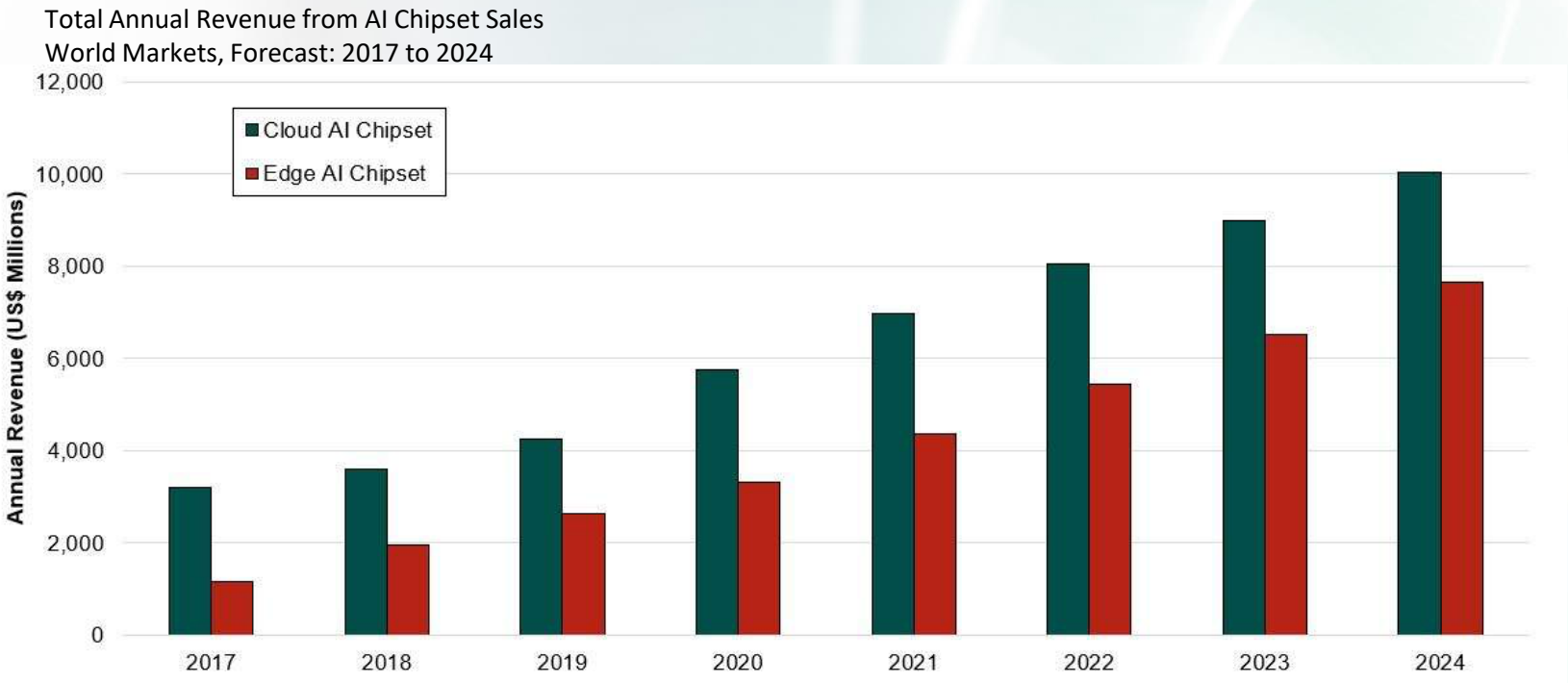
MORE INTELLIGENT SENSORS & ACTUATORS
MORE EFFICIENT POWERING

SENSE

ACTUATE

POWER

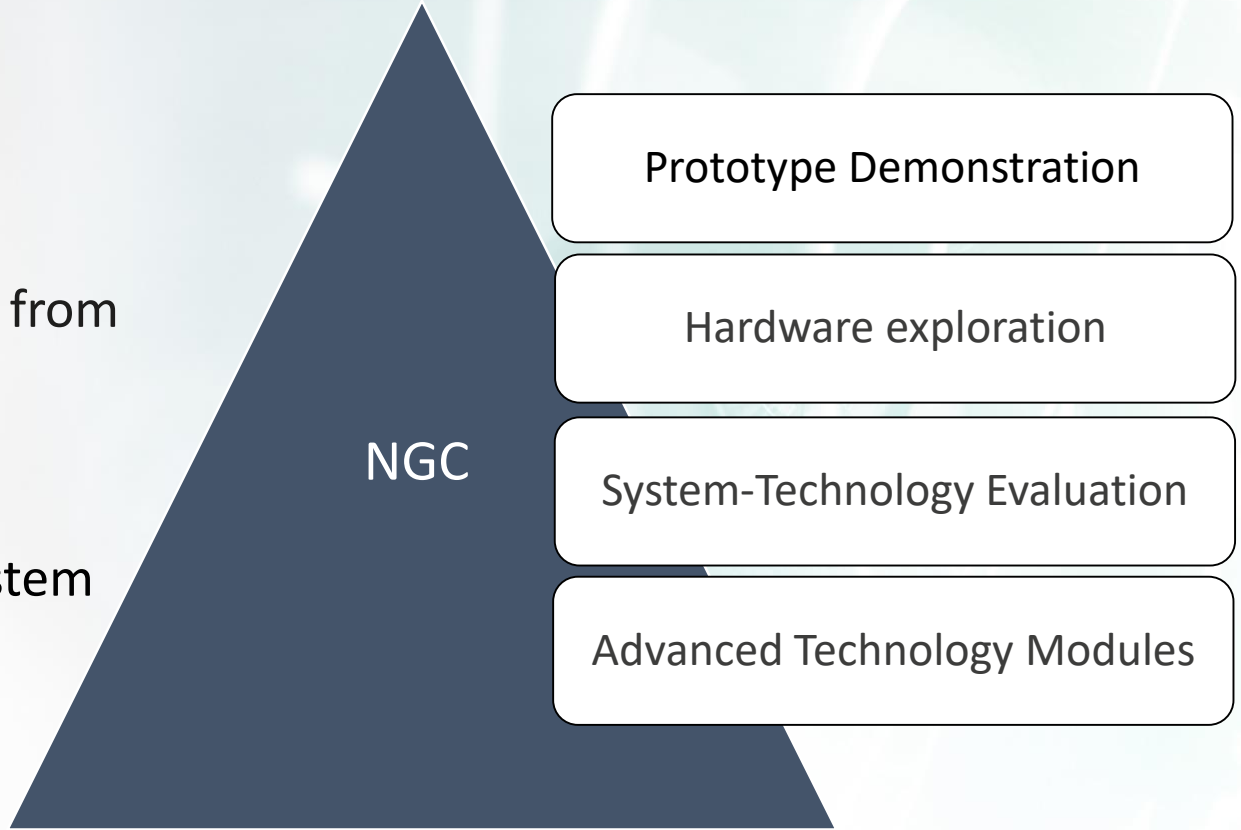
AI CHIPSET sales to double over 5 years



Source: ABI Research

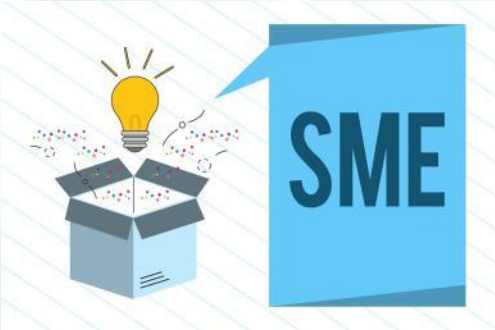
Next Generation Computing MISSION

- **Drive** high-impact technology research from system perspective
- **Evaluate** technology opportunities for system companies



Open Source hardware leading to Open Innovation?

Remove upfront barriers



OS Business models encourage innovations

Share cost among users

Owned by a community

Original slide from Arnaud Samama, Thalès

Open discussion

- New trends
- Gaps
- Application <> Tech challenges <> Key drivers (HPC, Robotics)
- Europe?

Strengths / Weakness / Threat / Opportunity

New trends….

Gaps….

Application <> Tech challenges <> Key drivers (HPC, Robotics)

Position of Europe, recommendations…