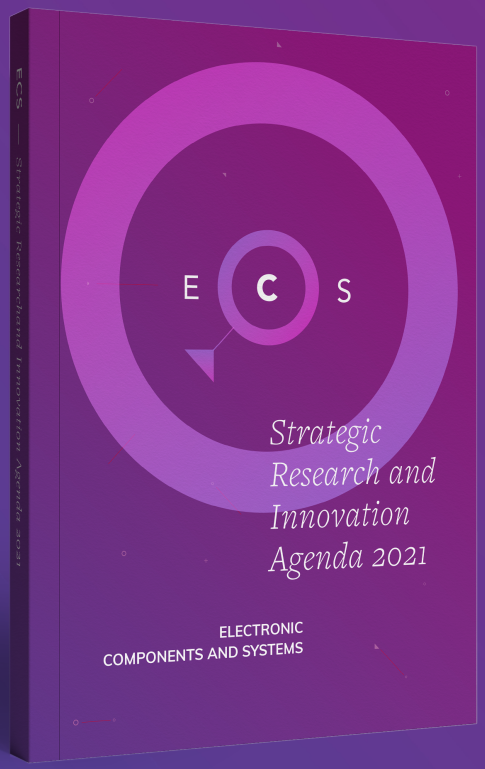

AI, IoT, Advanced Control and Edge Computing

Overview and initial priority settings

Online meeting, 2021/05/18

Paolo Azzoni

Head of EU Technology Programmes

Eurotech Group

Marc Duranton

Digital Systems and Integrated Circuits Division

CEA List

E C S

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ECS-based digitization

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The digital transformation has been and will remain a key factor for global economy, and digital technologies, adopted as an inherent element of the business model, are the key factors for market success.

The ECS value network covers a significant part of digitization,

- a non-linear network of complex relations between heterogeneous stakeholders,
- continuously evolving, depending on the technology and market trends, …
- and providing the key digital technologies to:
  - connect the physical world with the digital world,
  - smartly process the collected information,
  - ensure seamless connectivity of both single devices and large distributed infrastructures,
  - automate industrial and organizational processes,
  - create new business models.

Key enablers for digitization

AI, IoT, edge computing and advanced control represent important new axis for the KDT:

- **IoT** is an interdisciplinary domain providing all the structural elements required in digital transformation: sensing, actuation, processing, connectivity, integration and orchestration, interoperability, e2e trust, …
- **Edge computing** delocalizes data processing and analytics near the interface with the physical world, providing real-time visibility into operations, exactly where and only when it is required, with increased trustworthiness, in a more sustainable way, …
- **Embedded intelligence** is AI on the edge and distributed in SoS. It transforms the way we interact with technology in real time, it allows to analyse and to understand the environment, increases the autonomy, safety and automation of almost every industrial and organizational process, generates actionable information, enables business transformation, …
- **Advanced control** extends embedded AI allowing to analyze vast amounts of data and infer suitable control actions in a safe and reliable way, enabling critical application like autonomous mobility.

This presentation positions these technologies in the ECS value network, clarifies their role in digitization, identifies research focus areas in the short terms.

The computing continuum

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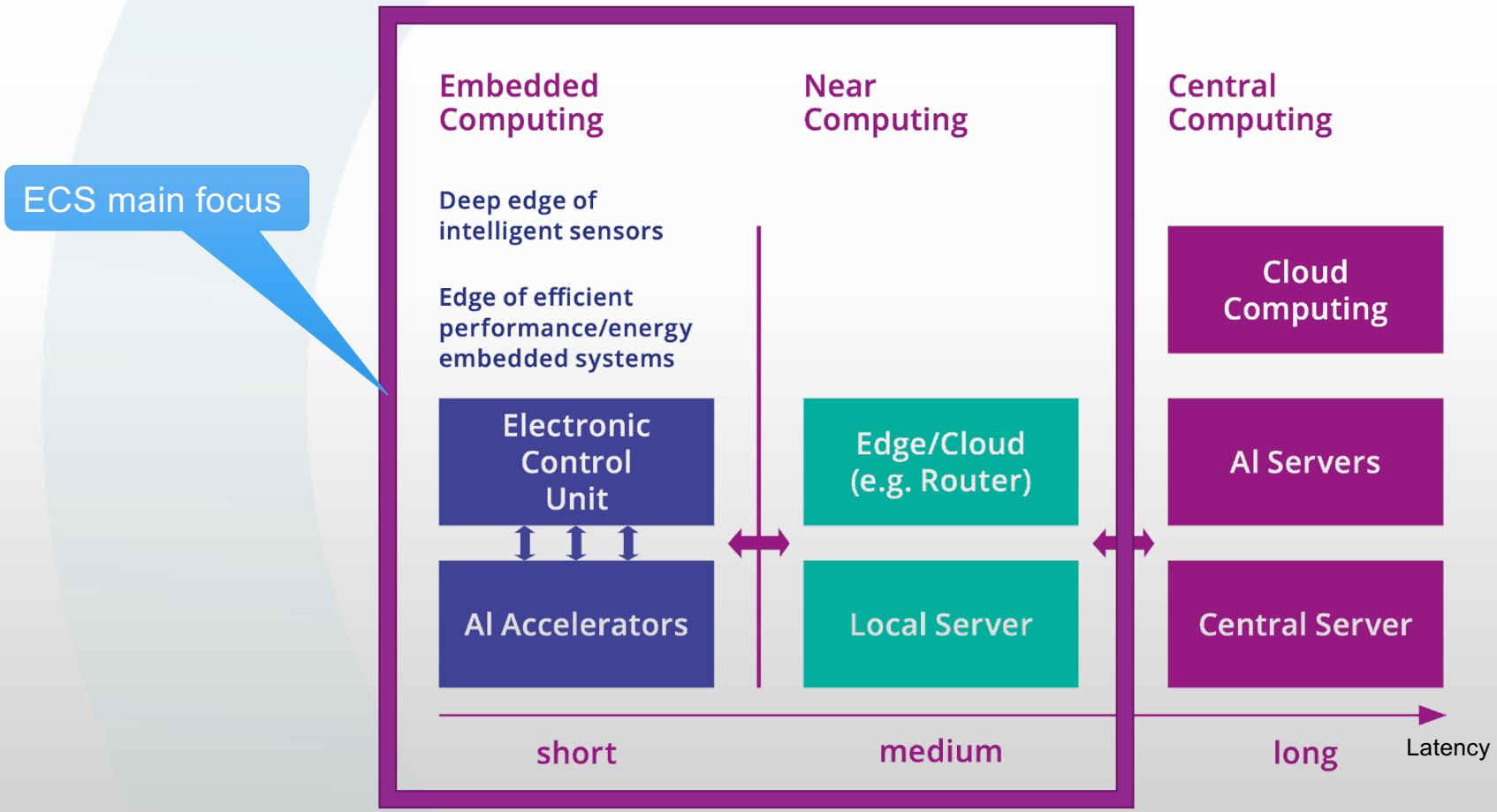

Analysing more of the created data and reducing energy footprint of ICT are major challenges

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Data creation and transfers are a major part of energy dissipation of ICT systems, therefore most of data should be efficiently used

CHALLENGES AND EXPECTED MARKET TRENDS OF AI

Date creation explosion & low level of use

only 15%

of global datasphere will be tagged and only 1/5 will be analysed[1].

Global ICT energy consumption:

10%

of worldwide energy consumption already in 2018.

Deep learning training footprint:

> 200 000 kg of CO_2

3,5 times higher than the emission of an average car during its entire lifetime[4].

ICT energy and CO_2 footprint

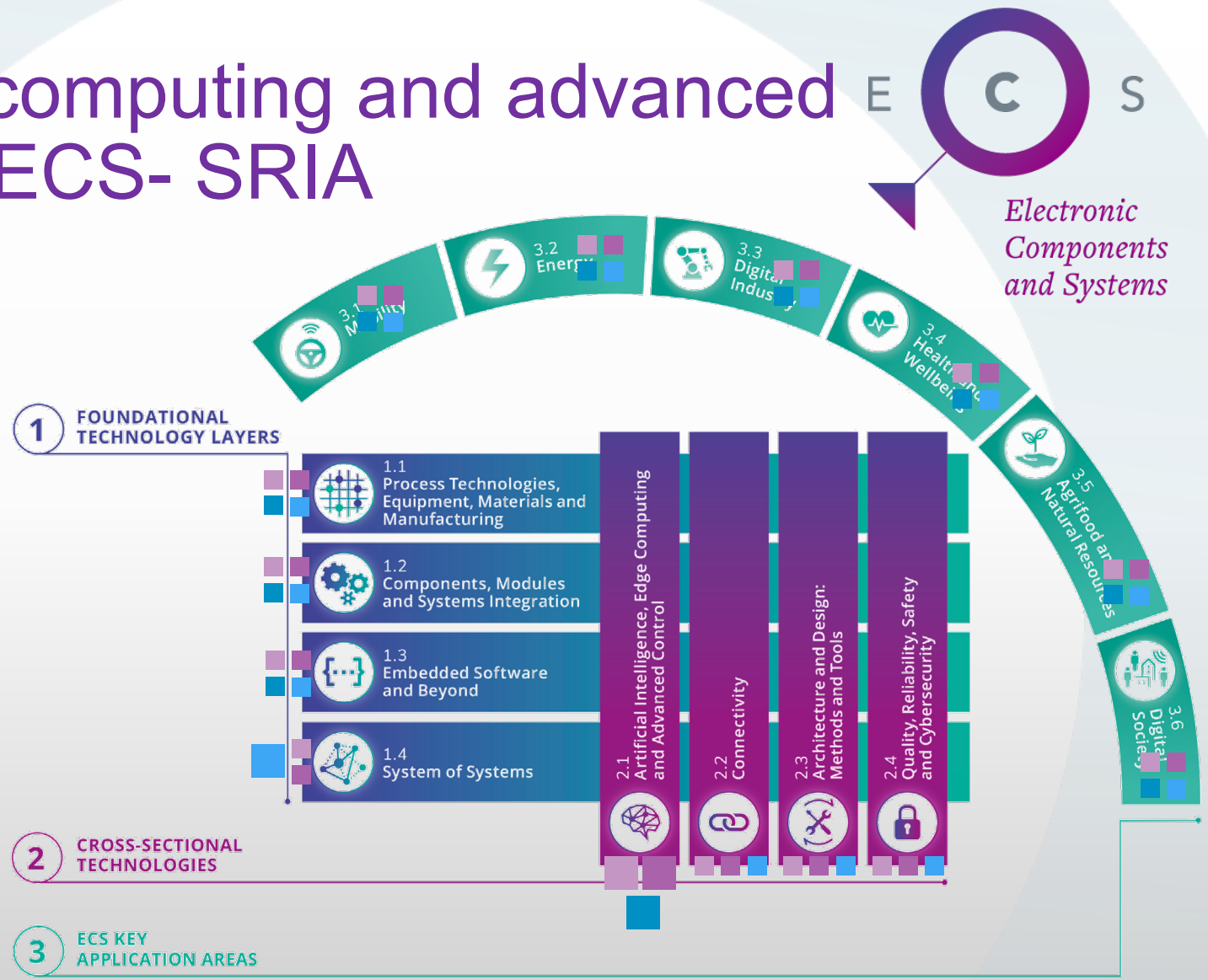
8–21%[2] (4% CO_2)[3]

of global worldwide electricity consumption and emissions.

[1] IDC Data Age 2025 study, sponsored by Seagate, April 2017 | [2] Challenges 2015, 6, 117-157; doi:10.3390/challe6010117, projection from Anders Andrae, https://www.nature.com/articles/d41586-018-06610-y | [3] Internation Energy Agency | [4] https://lejournal.cnrs.fr/articles/numerique-le-grand-gachis-energetique

AI, IoT, edge computing and advanced control in the ECS- SRIA

1. Embedded and distributed intelligence
2. Edge computing
3. Advanced control
4. IoT



ECS-based scenarios (IoT/edge):
some examples

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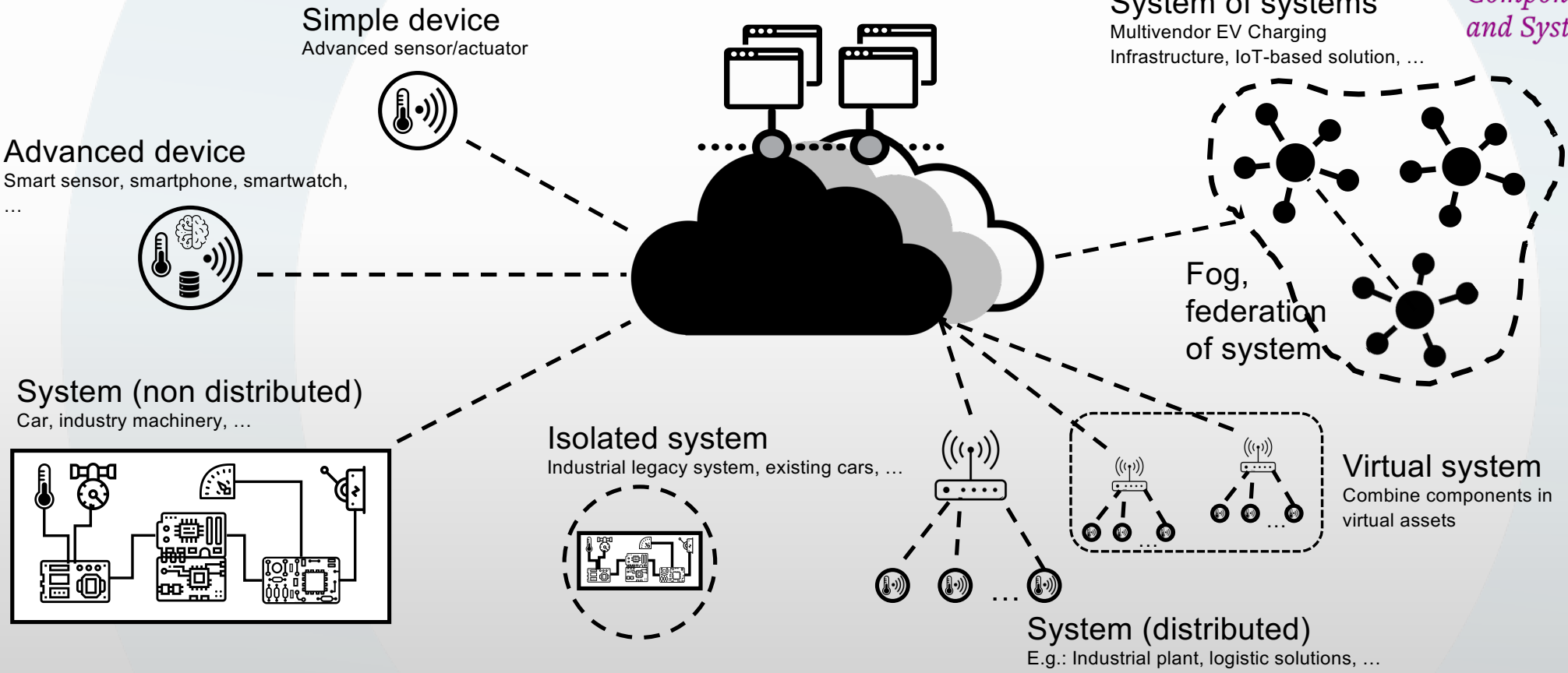
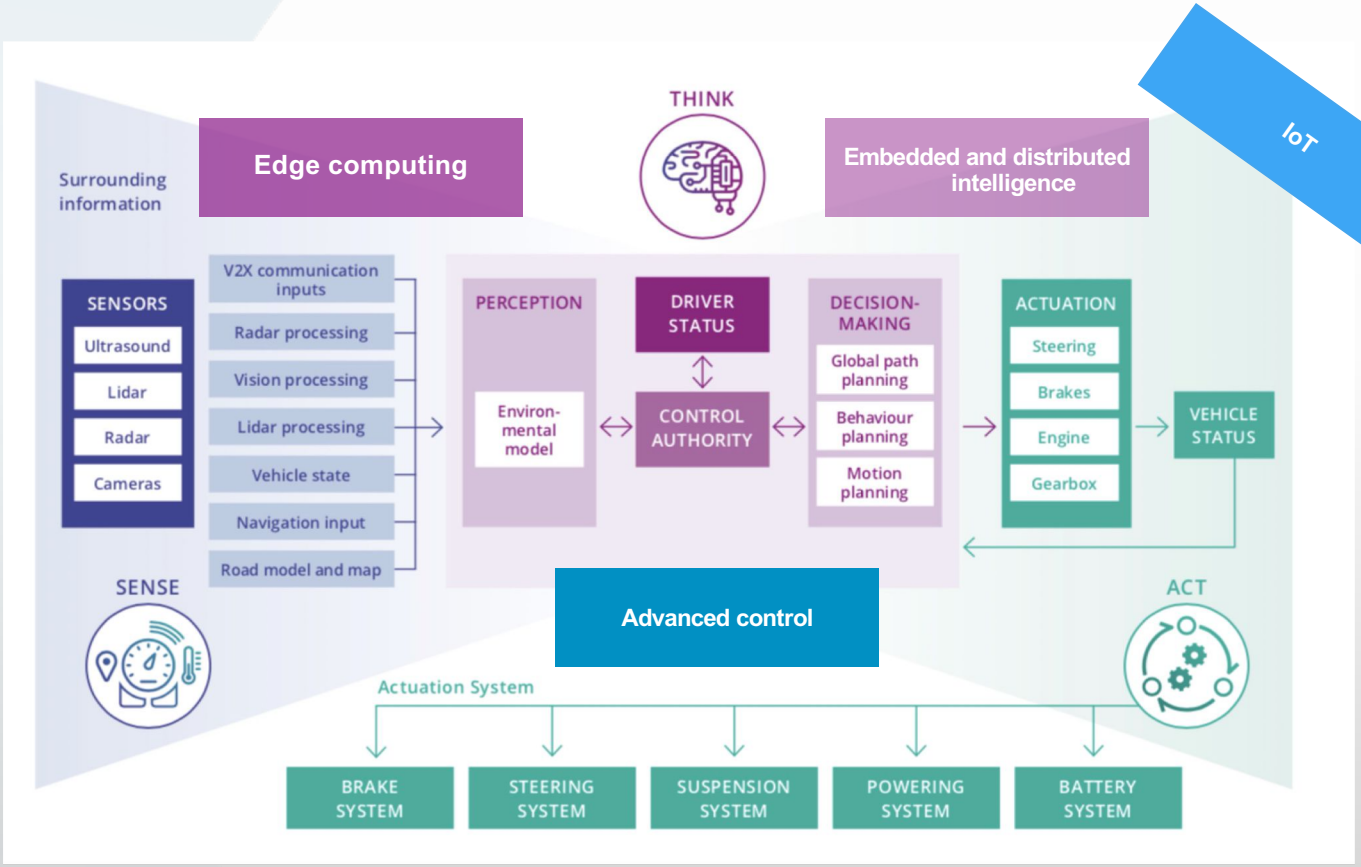


A vertical application example



Automated vehicle: *Sense, Think, Decide, Act* in an “edge” device

Setting priorities for AI, IoT, edge computing and advanced control

Building on existing European strengths and businesses

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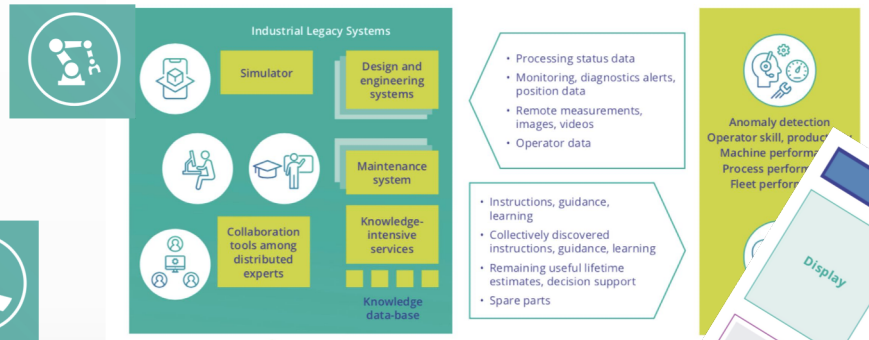
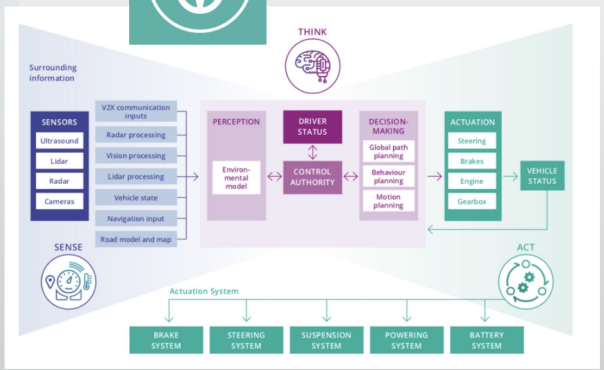
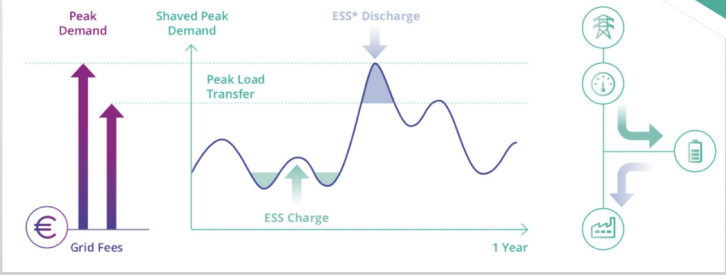
Year	Metric	Weight	CN	EU	US
2017	Number of AI Researchers	5	18,232	43,064	28,536
2017	Number of Top AI Researchers (H-Index)	5	977	5,787	5,158
2018	Number of Top AI Researchers (Academic Conferences)	3	2,525	4,840	10,295
2018	Educating Top AI Researchers	2	11%	21%	44%







Priorities for the KDT

Foundational and cross technology priorities

- Embedded intelligence & advanced control
- Internet of things
- Edge computing
- Software aspects of edge to cloud continuum (integration, orchestration, interoperability, trustworthiness, ...) have been addressed in WS1
- Engineering support for AI, edge computing, advanced control and IoT

Application-specific priorities

- Mobility
- Digital industry
- Energy
- Health and wellbeing
- Agrifood and natural resources
- Digital society

Embedded intelligence & advanced control

see also WS1

ECS Electronic Components and Systems

ECS must be provided with intelligence and autonomy:

- to better manage their complexity,
- to provide novel advanced functionalities,
- support the evolutionary nature of systems and SoS,
- improve the interaction with humans,
- enable vertical applications,
- improve sustainability and resilience of ECS and of the associated value network.

PRIORITY

Develop AI-distributed solutions to support edge computing, IoT and SoS.

Distributed AI requires less access to central resources, such as incremental learning done at the edge, or federated learning performed by a set of edge devices. Development of advanced control concepts for distributed (multi-agent) systems with uncertainties in communication and structure (topology) into account. Scalable and modular AI.

PRIORITY

Managing the increasing complexity of systems to achieve higher automation.

E.g. exploit AI to improve interoperability of systems, facilitate software modularity, adoption of standards and common interfaces, complexity management in systems and SoS.

PRIORITY

Increase trustworthiness in computing systems based on AI.

E.g. safety and cybersecurity of AI-based system, modular (pre-)certification AI, certified data-sets, …

PRIORITY

HW/SW solutions for robust and safe advanced control in real-time.

E.g. controller networks, swarm control; adaptive edge-AI enhanced controller; cybersecurity of (adhoc) controller networks; edge based self adjusting control systems; stability of AI enhanced controllers; distributed monitoring of reliability of advanced control systems; distributed (multi-agent) systems supporting uncertainties in communication and structure (topology).

PRIORITY

Support sustainability with AI-based software solutions.

E.g. AI-based energy management; develop the concept of 2nd life to increase the lifespan of computing devices and systems; self-X (adaptation, reconfiguration, ...) for embedded systems; improve HW/SW upgradability; develop open source HW/SW and sustainable training data-sets and algorithms; improve interoperability, modularity and complementarity between generations of devices.

Edge computing

Edge computing allows to selectively shift the data processing from the enterprise servers to the intermediate nodes of an IoT infrastructure or directly to the edge:

- limiting data processing only when and where it is required,
- allowing to extract insightful information on the field, without sending huge amount of useless data to the cloud,
- minimizing latency and allowing to react promptly,
- keeping data locally, preserving privacy and security,
- increasing the intelligence and autonomy of devices,
- enabling specific application (e.g. automated driving),
- reducing energy consumption and connectivity costs,
- improving the sustainability of digitization.

Edge computing requires the right equilibrium between available computing power, storage, energy efficiency, offered functionalities, … a challenge that only interdisciplinary research and innovation can overcome.

PRIORITY

Efficiently improve the processing capabilities on the edge and deep edge.

From technology to systems: e.g. integration and packaging of SoC, 3D integration, chiplet technologies, smart System-in-Package, heterogeneous and hybrid SoC and sensors integration, … non-volatile memories for embedded processing and near/in-memory computing. Embedded high-performance computing. New embedded accelerators.

PRIORITY

Increase the energy efficiency …

… especially on the deep-edge, where devices should work for months on a small battery or by scavenging energy from the environment.

PRIORITY

Promote the development of new computing paradigms.

E.g. neuromorphic and bio-inspired computing, hybrid architectures, using physics to make computation (analog computing).

PRIORITY

Develop new software architectures for edge computing.

E.g. solutions that simplify the adoption and diffusion of edge computing technologies, like cloudlets, micro data centres, local clouds and cloud of things.

ECS

Electronic Components and Systems

PRIORITY

WS1

HW/SW solutions to support AI on the edge and on deep edge …

… adding intelligence close to the sensors and/or to data sources (IoT), integrating the components in a form factor that perfectly suits their applications. With edge AI devices can directly process data take decisions independently. Edge AI extends embedded computing and has a positive impact on digitisation sustainability. New energy efficient and performant HW solutions are needed.

PRIORITY

WS1

Develop open and distributed platforms for edge computing …

… providing remote monitoring and control, security and privacy protection, inked to appropriate business models. Solutions for the inclusion/integration of existing embedded computers on the edge and legacy systems.

System of systems (SoS) & Internet of things (IoT)

SoS/IoT are essential for digitization, a key point for the edge to cloud continuum, a hierarchical physical/digital infrastructure, providing the HW/SW elements to:

- map the physical world with the digital world,
- process data in various ways, where and when it is required,
- ensure a seamless flow of information, from the deep edge to the cloud.

Priorities span the entire SoS/IoT domain: materials, HW architectures, sensors, actuators, smart devices, processing, connectivity, interoperability, integration platforms, e2e trustworthiness, ...

SoS/IoT cover the phases of the ECS value chain that are expected to grow tenfold by 2025.

PRIORITY

Advanced computing, memory and in-memory computing.

E.g. new materials, memory concept and technologies for mobile computing, and ultra-low power data processing at the IoT node level up to the highest possible performance.

PRIORITY

Novel circuits and devices that enable advanced functionalities.

E.g. application-defined sensors, novel IoT solutions, complex sensor systems and new (bio)medical devices, new RF and mm-wave device options (including radar), photonics options, electronics and packaging solutions.

PRIORITY

Efficient physical/functional integration satisfying heterogeneous needs

IoT devices operate in heterogeneous environments, with different energy consumption and autonomy profiles, provides multiple types of information, heterogeneous functionalities, across sensing, actuation, connectivity, information processing, …

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PRIORITY WS1

SoS and IoT architectures, supported by appropriate design and architecting tools.

PRIORITY WS1

Open SoS/IoT integration and orchestration platforms.

PRIORITY WS1

Support composability , complexity, evolvability, heterogeneity and diversity in integration and orchestration process.

PRIORITY WS1

- **Integration platforms interoperability**
- **Autonomous interoperability**
- **Existing and emerging SoS/IoT interop.**

PRIORITY WS1

Ensure end-2-end cyber-security, safety and privacy of SoS/IoT.

Engineering and lifecycle support

Engineering and lifecycle support are key factors for industrial competitiveness,

- to increase productivity and creativity of system and solution providers,
- to consolidate research results in products,
- for their sustainable evolution,
- for the existence of a healthy, sustainable and resilient value network and a successful market,
- for EU strategic autonomy, industry competitiveness and sustainable labor market,
- to enable professional training and education.

The complexity of AI, edge computing and IoT require more engineering support than "conventional" products.

PRIORITY

Electronics design automation (EDA) supporting the adoption of new materials, processing technologies, architecture, …

EDA supporting new materials, processing technologies, production, advanced interconnect, encapsulation and packaging technologies, low power solutions, 3D integration, simulation, enhanced HW reliability, robustness and sustainability, …

PRIORITY

EDA supporting the integration of multiple functions in the same HW module.

E.g. EDA tools to support multiple functions in system in a package (SiP), or the heterogeneous integration of devices with different fabrication processes and methods.

PRIORITY

HW-SW codesign

WS1

A traditional approach to increase the predictability of design characteristics and evaluate them, that is particularly effective for the design of AI, edge computing and IoT hardware and software.

PRIORITY

Frameworks for engineering automation and continuous life cycle support, to handle connected, smart, autonomous, evolvable systems and SoS.

WS1

PRIORITY

Managing new functionalities in evolving, safe, secure, and trustable systems and SoS.

WS1

PRIORITY

Managing complexity, in terms of capabilities, properties, operative environment, tasks, dynamicity, reconfigurability, composability, …

WS1

PRIORITY

Managing ECS diversity, with a multi-layered approach covering all the design hierarchy.

WS1

Application-specific priorities

Electronic Components and Systems

Mobility

Smart mobility is changing the mobility ecosystem, with a positive impact on the economic growth, on the labor market and on sustainability.

Enable affordable, energy optimal, automated and connected mobility.

PRIORITIES

- **Shift to automated driving:** ECS for sensing and perception, edge high-performance processing, ADAS/AD control software (computing, machine learning, distributed control architectures, safe navigation).
- **AI-based energy reduction:** route planning, fast charging, smart power electronics.
- **IoT-based fleet management solutions for connected, upgradable and maintainable cars, light mobility and mobile machinery,** including OTA upgrades, new services & feature, in-vehicle performance monitoring, diagnostic and predictive maintenance, …
- **Safety:** sensing and AI-based processing for driver monitoring and support, active safety systems
- **Engineering support** for validation/certification of embedded AI, control systems, ADAS automated and connected vehicles. Validation of comfort and customer acceptance of automated vehicles.

Energy

Our lives, our daily activities and the way we do business depend on sustainable energy supply and its efficient management.

Bring intelligence to the grid, for asset management, security, generation and demand management, from the grid edge to cloud services.

PRIORITIES

- **HW/SW solutions for smart & efficient management of energy generation, conversion, storage and grid integration** (smart sensors & sensor networks, AI-ML based self-adaptive control, smart and secure edge devices, IoT enabled ECS and grid components, …)
- **Intelligent distributed solutions for the grid management based on IoT and edge computing:** energy management, distribution & transmission, 24/7 generation/consumption monitoring and forecasting. Plug & play self-adaptive grid. Integration of electricity, heating, cooling, and transport. Grid virtualization.
- **AI-based efficient community and regional energy management,** increasing the share of renewable generation, self-consumption and building optimization.

Digital industry

AI, edge computing and IoT represent fundamental enablers for the digitization, automation and sustainability of the industry sector.

Enable & improve industrial automation, remote operations, efficient and agile production, legacy systems inclusion, …

PRIORITIES

- **HW/SW solution to support the digitization of legacy systems** (smart sensors and actuators, multiservice edge controllers, high-performance edge computing solutions, …) **and modular factories.**
- **Embedded intelligence,** for production, operations, maintenance, dynamic and autonomous management, asset monitoring, decision-making and huma-assistance, … autonomous systems, industrial machines and robots.
- **AI and IoT based solutions for responsive, agile, smart and sustainable production,** to quickly react to changes, efficient work allocation, improve use & reuse of the resources, real life cycle assessment, human safety monitoring, enable production as a service.
- **IoT solutions for remote operations and control,** with fleet management, edge to cloud support, remote diagnosis, maintenance, engineering, …

Application-specific priorities (2)

Electronic Components and Systems

Health & wellbeing

AI, edge computing and IoT are fundamental enablers for P4 approach (predict, prevent, participate, personalize) & healthcare digitization.

HW/SW ECS-based solutions to support the edge-to-cloud continuum in health care and wellbeing, ensuring security, privacy, efficiency, improving remote services, …

PRIORITIES

- **AI & edge computing for patients:** HW/SW solutions for physiological parameters & activity monitoring, diagnosis and prevention, health improvement, personal assistants, personal emergency response systems, telemedicine, smart drugs delivery, digital twin, …
- **AI SW & smart devices for medical personnel:** optimization of hospital workflow, point of care diagnostic systems, telemedicine, decision support, …
- **Medical diagnosis SW:** AI SW supporting data analysis and diagnosis generation, diagnosis app for patients (e.g. covid app).
- **IoT based solutions for medical equipment management and control:** manage and maintain in a secure, automatic and efficient way fleet of medical equipment in clinics and at home.

Agrifood and natural resources

Planet Earth and its resources are humanity's most important treasures, to be conserved and protected.

Bring sensing, data analysis, intelligence, monitoring & control to the entire agrifood and natural resources value chains.

PRIORITIES

- **IoT for food security & safety:** multi data source analysis, farms management systems, plant and herd health monitoring; AI-based food production analysis.
- **IoT for environmental protection and sustainable production:** in-situ, real-time monitoring of soil nutrients and herbicides with AI support for fertilization strategies; digitization and monitoring of greenhouse impact of livestock; farm waste management.
- **Water resources**: IoT based distributed, society-inclusive smart solutions for water management, quality and consumption monitoring; smart water treatment; fresh waters and hydrogeologic risks monitoring.
- **Soil and air quality monitoring, greenhouse gas monitoring, smart waste & remediations management.**
- **IoT for biodiversity monitoring, ecosystems resilience, conservation and preservation.**

Digital society

We already live in a digital society, but digitalization is accelerating, and we need to be sure that it is for the benefit of all, is sustainable, inclusive and safe.

HW/SW solutions for individual inclusion, development and protection, towards the collective wellbeing of a resilient and sustainable society.

PRIORITIES

- **AI and smart devices for individual inclusion, development and protection of citizens:** smart devices and SW (wearables, robots, cobots, chatbots, …) to support online education, improve human interaction, personal development & inclusion, privacy and protection.
- **AI, edge computing and IoT to safeguard the collective wellbeing and resilience of society:** crowd management; crisis management; platforms for surveillance, emergency & crisis response; homeland security and cybersecurity.
- **Contribute to environmental sustainability:** IoT and AI-based management of physical infrastructure, industrial areas, traffic and logistics; SW platforms for distributed digital infrastructure management; mobile e-government and citizen support; resources monitoring and management; environmental monitoring.

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Thank you for the attention.

Any question?