5E Roadmap and Digital Showcase

ECSEL Italy Session at SIE, 9 July 2021

Petra Weiler, VDI/VDE-IT petra.weiler@vdivde-it.de

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

5E Project

FEDERATING EUROPEAN ECOSYSTEMS

NANO-ELECTRONICS

FLEXIBLE, ORGANIC & PRINTED ELECTRONICS

ELECTRONIC SMART SYSTEMS

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

OBJECTIVES

- Support industrial perspectives of EU Electronics Ecosystems
- Position Electronics as fundamental for digitalisation
- Foster collaboration and cross-fertilisation in Electronics

HOW

- Federating a coherent European Electronics Community
- Developing a joint vision and implementing a respective meta-roadmap
- Increasing outreach and visibility of European electronics

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

30 Months
7 Partners
1 mio. € Budget
4 European Countries
France, Germany, Italy, Netherlands

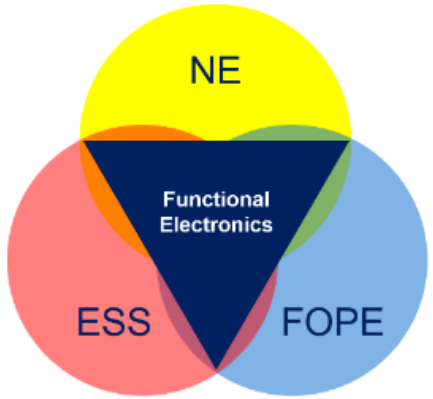
eeeee

5E TANGIBLE IMPACT

FROM PROJECT RESULTS TO WORK PROGRAMME DRAFT

At the convergence of Unconventional Nanoelectronics (NE), Flexible, Organic & Printed Electronics (FOPE) and Electronic Smart Systems (ESS), the term '**Functional Electronics**' encompasses this ever-increasing capability to integrate key digital technologies with cognitive functions, shifting from purely physical integration to functional integration. Smarter (hybrid) electronic components and systems will become viable notably at high structural density on and in novel substrates (including, but not limited to, flexible, organic, printed) and structural systems (e.g. textiles, plastics, laminates, glass, steel).

Functional Electronics will generate additional value from their use that is presently not realisable by using any of the electronics forms independently, enabling new and efficient eco-design approaches at product, process and business model levels. They will have capability to capture & manage multi-physics data and contextual information in real time, with high sensitivity, selectivity and reliability as well as being networked, autonomous and complemented by bespoke software (incl. AI) solutions. Functional Electronics allow for their seamless integration in everyday objects and thereby enable the full realisation of their sustainability benefits in a broad spectrum of new applications.



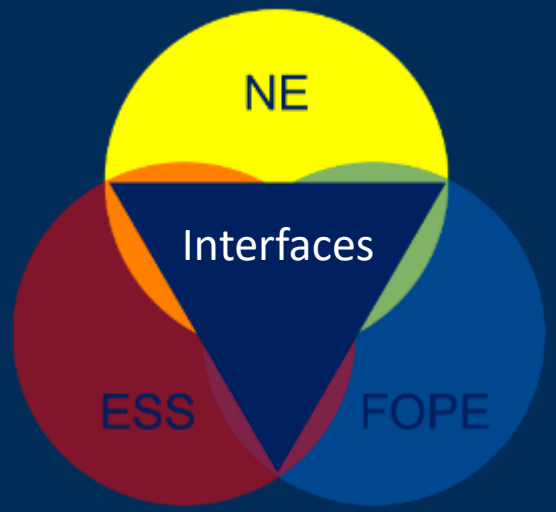
Horizon Europe Cluster 4 Draft Work Programme 2021 - 2022

ECS SRIA 2021

EPoSS European Technology Platform on Smart Systems Integration

New Taskforce on Green ECS

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113



VISION PAPERS OF INNOVATION

Addressing the European Areas of Intervention

JOINT VISION

Of European Electronics Ecosystems

→ Validation and ranking of 39 opportunities
Identification of additional opportunities

→ 4 Community events
2 Workshops at EFECS and OE-A
1 Online Survey

150+ STAKEHOLDERS INVOLVED

3 VALIDATION PATHS

TOP DOWN

ASSESSMENT APPROACH — VISION PAPERS — ANALYSIS APPROACH

BOTTOM UP

TOP10 OPPORTUNITIES

WOULD YOU LIKE TO LEARN MORE?
SCAN ME

39 OPPORTUNITIES

↳ Fact Sheets including
Title
Technologies
Applications
Challenges
Opportunities

→ DISCOVER MORE ON
www.5e-project.eu

6 FUNCTIONALITIES

↳ Actuating
Communicating
Computing/Processing
Energy Harvesting/Storage
Sensing
Signalling

13 APPLICATION SECTORS

↳ (Aero)Space
Building/Construction
Consumer Electronics
Digital Manufacturing
Energy
Environment

→ Food & Agriculture
IoT/Smart Connected Objects
Medical/Pharmaceutical/Life Science
Natural Resources
Packaging/Logistics
Safety/Security
Transport/Mobility/Automotive

11 SECTORIAL STATES OF PLAY

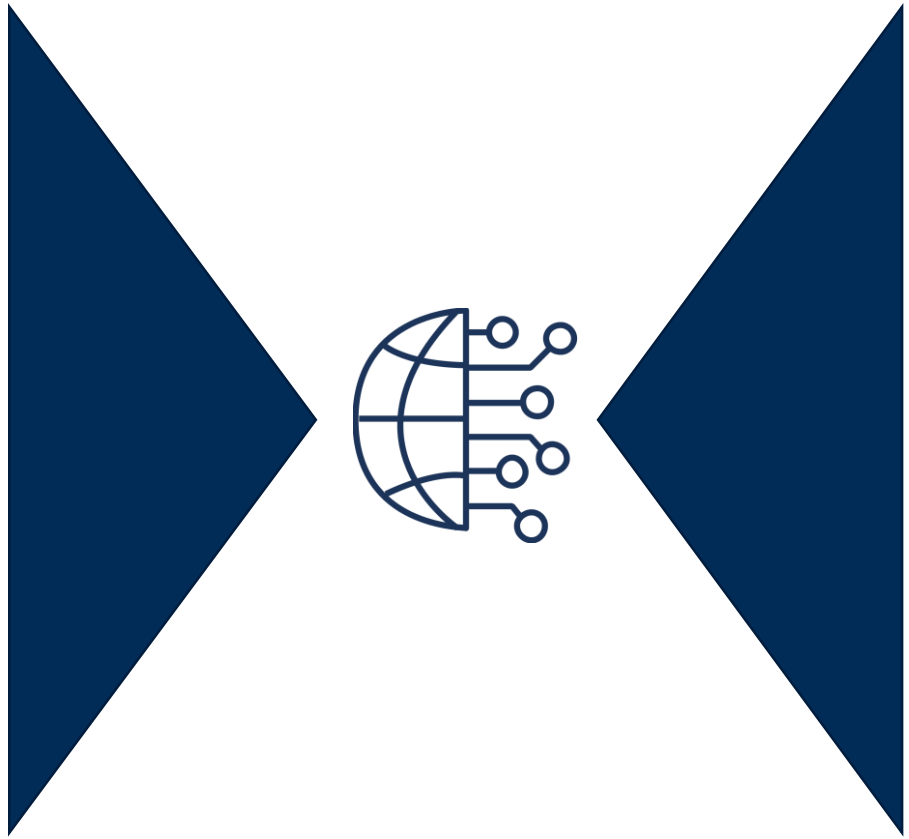
↳ Landscape Analysis
Extraction of opportunities at the interfaces of at least 2 electronics areas

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

OUTPUT:
5E DELIVERABLES

- Catalogue of 39 Opportunities
- Joint Vision based on Functional Electronics
- Vision Papers
- Meta-Roadmap
- Digital Showcase

All available on the 5E website



INPUT:
STAKEHOLDER FEEDBACK AND EOI

- Opportunities
- Joint Vision
- Functional Electronics
- Vision Papers and Meta-Roadmap modules
- Implementation of Meta-Roadmap recommendations
- Participation in calls

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

	BUILDING / CONSTRUCTION
B1	High power and real-time computing facilities to support planning, construction, use and maintenance of buildings
B2	Ubiquitous and reliable energy supply and harvesting technologies to achieve efficient construction, use and maintenance of buildings
B3	Low power and energy autonomous sensing systems and IoT networks to monitor buildings with respect to their current status (structural health, user behaviour, occupancy, abrasion etc.)
B4	Increase of security and comfort of users of buildings by smart signalling solutions
	CONSUMER ELECTRONICS
C1	Actuating as a key functionality for enhancing Human Machine Interfaces (HMI), product value and enhancing users experience
C2	Independent high speed connectivity and low power communication for trusted nomad consumer solutions
C3	Low cost, reliable and recyclable energy harvesting & storage solutions for high volume consumer electronics markets
C4	Solutions for reliable and sensitive multi-sensing and data fusion/exploitation algorithms for signals dynamic management
C5	Signalling displays compatibility for sustainable manufacturing in Europe
	DIGITAL MANUFACTURING
D1	Actuating as key functionality for safe, efficient and optimised production processes in industry 4.0
D2	Next generation sensor systems for safe, efficient, optimised and self-enabled manufacturing
	ENERGY
N1	High yield energy harvesting approaches for replacing or reducing primary energy uses
N2	Flexible energy storage solutions with extended systems lifetime and multi-uses, including secondary use
	ENVIRONMENT
E1	Gas, pollutant, particle and waste monitoring solutions for healthy and safe working & living environments
	FOOD & AGRICULTURE
F1	Sensing for quality, safety and security tracing & monitoring along food value chains

	IOT/SMART CONNECTED OBJECTS
I1	Efficient and secure protocols for high-data transmission rate of IoT devices
I1	Sustainable energy harvesting and energy storage solutions for low-power and autonomous IoT devices
I3	Multi-sensing capability to monitor complex environment via extended networks of connected devices
	MEDICAL / PHARMACEUTICAL / LIFE SCIENCE
M1	Efficient, safe and integrated actuating to improve healthcare outcome and assist professionals with advanced automation and HMI
M2	High-performance and secure communication building blocks to increase autonomy and efficiency of electronic devices intended for medicine and Healthcare
M3	Advanced hardware/software processing for in-depth analysis of large and complex health-related datasets to improve decision-making and outcome of healthcare
M4	Combining energy harvesting, storage and efficiency to power complex, autonomous and interconnected medical & healthcare devices
M5	Disruptive & high-performance sensing capability as key enabler for Digital Healthcare and Well-being
M6	Advanced Signalling for immersive visualisation tools to improve interfaces with and proficiency of medical professionals
	PACKAGING / LOGISTICS
P1	Secure data/information wireless transmission in packaging/labels for goods interconnectivity and e-services
P2	Multi-sensing, data fusion and management in packaging/labels for goods interactivity and e-services
	SAFETY / SECURITY
S1	Secure data transfer technologies for flexible and adaptable IoT systems to enable trusted solutions in data communication, across wireless standards and applications
S2	Sensors systems with a "trusted label" for protection of people and goods to be easily integrated into products
S3	Creating visibility or convey information as informative or preventive action to promote effective operation and physical safety
	TRANSPORT / MOBILITY / AUTOMOTIVE
T1	Seamless integration of actuators in car interiors for human machine interaction
T2	Technologies to secure data transfer and enable trusted solutions for people and information in car2car communicating for autonomous / self-driving vehicles
T3	Low-power loss and energy harvesting for emission and CO_2 reduction in electrical driving
T4	Novel sensors to act on changing situations in surrounding, varying from traffic, weather, … to assist in ADAS (autonomous driving assistance system), safety and power consumption
T5	Seamless integration of displays for human machine interaction and signalling

39 opportunities across 6 functionalities and 13 sectors

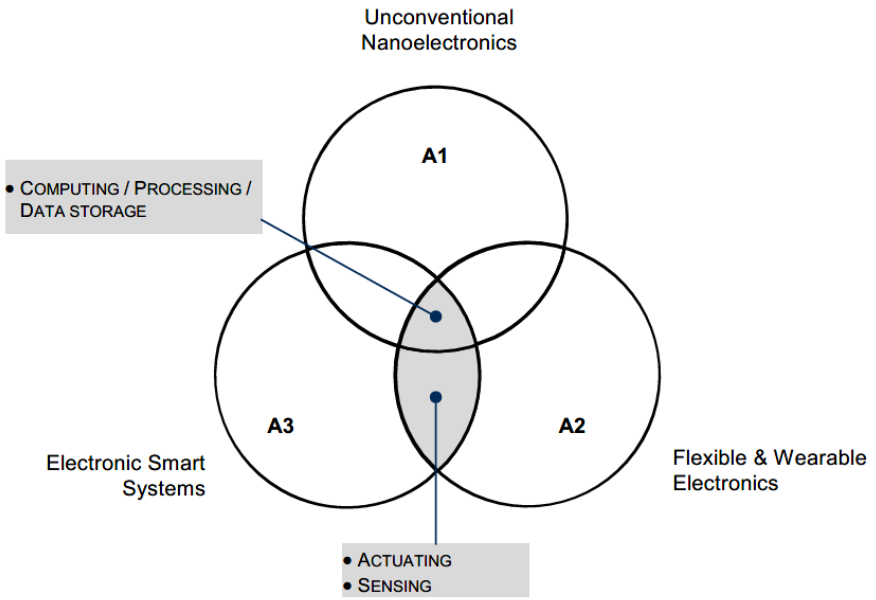
	New opportunities based on stakeholder feedback
A1	High performance and high reliability sensing tools & technologies for embedded applications in harsh environment such as aeronautics &/or (aero)space
D3	Explainable AI – Transparent, comprehensible and traceable classification and decision processes in safety critical applications
N3	High-performance and compact power electronics for grid connection of distributed resources and storage, based on wide-band gap components
N4	Smart solutions combining monitoring, control and diagnostics for optimal operation of energy systems and smart grids
T6	Edge AI for autonomous mobility

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Available on the 5E website

39 Fact Sheets → Example D2

Fact Sheets for each spot showing activities from 2 or more Areas
→ Technologies & Applications
→ Challenges & Opportunities



ID	Title	Interface	Functionality	Rank
D1	Actuating as key functionality for safe, efficient and optimised production processes in industry 4.0	A2A3	ACTUATING	17
D2	Next generation sensor systems for safe, efficient, optimised and self-enabled manufacturing	A2A3	SENSING	1
D3	Explainable AI – Transparent, comprehensible and traceable classification and decision processes in safety critical applications	A1A3	COMPUTING / PROCESSING / DATA STORAGE	N.A. NEW GREY SPOT

D2: Next generation sensor systems for safe, efficient, optimised and self-enabled manufacturing

Technologies / Value:

- MEMS, MOEMS, optical, chemical, electrochemical, magnetic, acoustic, inertial sensors for combinational sensing;
- Advanced materials with "sensing" properties;
- Position, pressure, temperature, humidity, gas, acceleration sensors for multi-parameter sensing.

Applications:

- Monitoring of all relevant parameters at the level of equipment, machines, tools, parts, materials, workers, manufacturing environment and monitoring of processes;
- Delivering data for decision support in safe, efficient, optimised and smart manufacturing;
- Sensor systems for Industry 4.0.

Challenges:

- Combinational sensing, multi-parameter sensing and smart sensing;
- Interface with data processing and analytics, AI, software;
- Real-time.

Coupling with other functionalities: Smart sensor systems for monitoring and control integrate sensing, processing, communicating and actuating

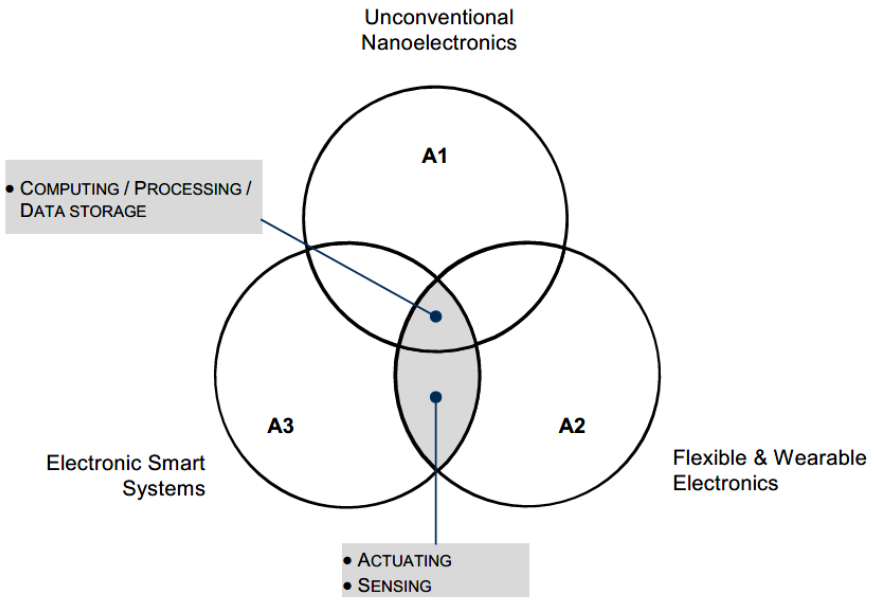
Opportunities:

1. **Next generation sensor systems will allow self-calibrating machines and tools as well as self-organised, self-learning and self-maintained manufacturing**
2. **Multi-level efficiency, safe production and overall process optimisation will be achieved thanks to the exploitation of combinational and multi-parametric sensing**

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

→ Example D3

Fact Sheets for each spot showing activities from 2 or more Areas
→ Technologies & Applications
→ Challenges & Opportunities



ID	Title	Interface	Functionality	Rank
D1	Actuating as key functionality for safe, efficient and optimised production processes in industry 4.0	A2A3	ACTUATING	17
D2	Next generation sensor systems for safe, efficient, optimised and self-enabled manufacturing	A2A3	SENSING	1
D3	Explainable AI – Transparent, comprehensible and traceable classification and decision processes in safety critical applications	A1A3	COMPUTING / PROCESSING / DATA STORAGE	N.A. NEW GREY SPOT

D3: Explainable AI – Transparent, comprehensible and traceable classification and decision processes in safety critical applications

Technologies / Value:

- AI is usually realised in semiconductor technology and is needed to process and control sensing, actuation and communication;
- Hybrid modelling, i.e. the combination of data driven and physically based models for artificial neural networks, making use of sensor fusion and virtual sensing, and corresponding machine learning methods contribute to transparency of AI.

Applications:

Explainable AI is important in all sectors, where AI is intended to be used, and where the qualification process for products requires the complete understanding of the implemented information processing and the used reasoning. This is usually the case in all safety relevant applications, notably in manufacturing for machine control.

Challenges:

As a usual artificial neural network (ANN) is working like a black box in which it is not clear what criteria and what particular features finally lead to the classifications or decisions taken, the challenge is to make this process transparent, comprehensible and traceable.
One approach to achieve this transparency is to use so-called hybrid modelling, meaning the combination of data-driven and physically based models for ANN. This combination and the corresponding machine learning methods are subject to ongoing research activities.

Coupling with other functionalities:

The demand for explainable AI arises wherever AI is intended to be used, which is a very broad scope, and wherever safety critical applications are tackled. Combination with actuating, communicating, sensing and signalling are of particular relevance.

Opportunities:

- **There is an opportunity for explainable AI whenever the qualification process of the products requires transparent and traceable information processing.**

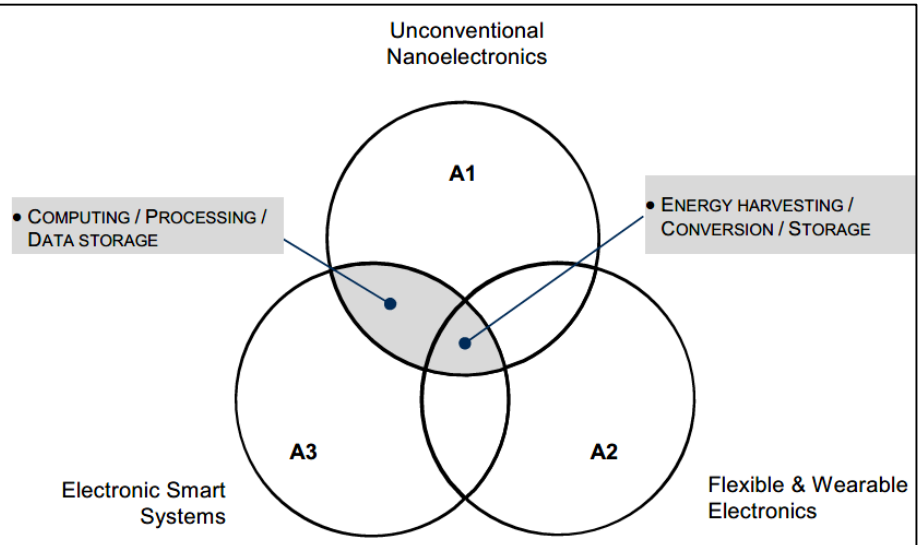
The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

→ Example N1

Fact Sheets for each spot showing activities from 2 or more Areas

→ Technologies & Applications

→ Challenges & Opportunities



ID	Title	Interface	Functionality	Rank
N1	High-yield energy harvesting approaches for replacing or reducing primary energy uses	A1A2A3	ENERGY HARVESTING	8
N2	Flexible energy storage solutions with extended systems lifetime and multi-uses, including secondary use	A1A2A3	ENERGY STORAGE	29
N3	High-performance and compact power electronics for grid connection of distributed resources and storage, based on wide-band gap components	A1A2A3	ENERGY CONVERSION	N.A. NEW GREY SPOT
N4	Smart solutions combining monitoring, control and diagnostics for optimal operation of energy systems and smart grids	A1A3	COMPUTING / PROCESSING / DATA STORAGE	N.A. NEW GREY SPOT

N1: High-yield energy harvesting approaches for replacing or reducing primary energy uses

Technologies / Value:

- Several energy vectors: electric, piezo-electric, electrostatic, heat, light, chemical, magnetic, acoustic, mechanic;
- Large energy window: from mW (RF, piezo, electrostatic) to kW (e.g. PV module);
- Variety of transducer technologies for direct conversion of harvested energy (from any vectors) into electrical energy;
- Use of advanced and functionalised materials for energy harvesting.

Applications:

- Generic by nature;
- Any applications in any sectors where energy is critical for the effective operation of a product and where fossil energy can be advantageously replaced or complemented
- Energy solutions for remote sensors in harsh environment;
- Applications in aerospace: drones / aircraft electrification.

Challenges:

- Selecting the best energy harvesting technology for a given application (e.g. harsh environment, remote sites) with high system/product integration level (energy vector, energy scale, reliability, lifetime & cost).

Coupling *energy harvesting* with other functionalities: energy storage, sensing, communicating for wireless sensors node (abandoned / remote sensors)

Opportunities:

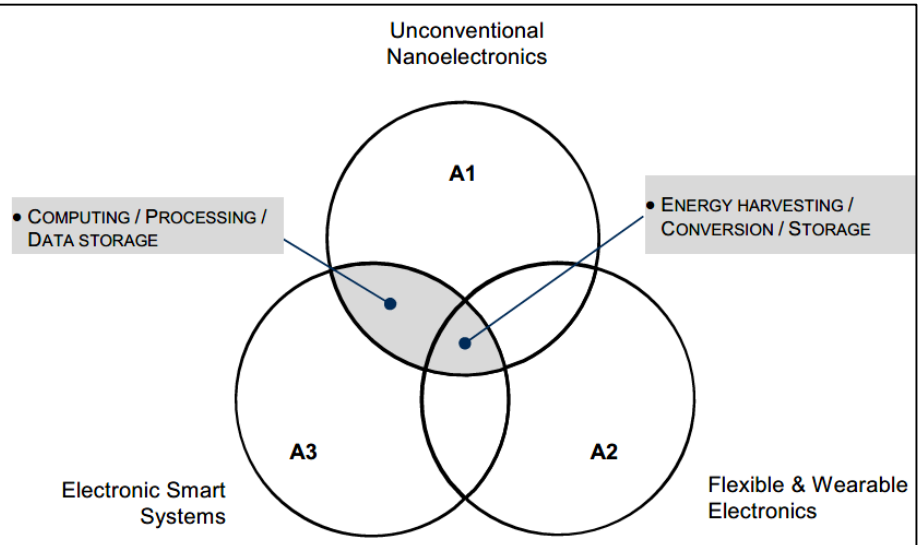
1. **Energy harvesting as a (sole) primary energy source: roadmapping of technologies for self-powered products or product functionalities (e.g. PV for IoT)**
2. **Energy harvesting as a (significant) secondary energy source :** roadmapping of technologies for products with high harvested/primary energy substitution ratios and high CO2 footprint reduction level (e.g. PV for street lighting, PV tiles)
3. **New approaches for energy harvesting and storage integration at system/component levels (two-in-one solution):** roadmapping of technologies for products with large energy autonomy and/or remote or low-accessibility needs

→ Example N1

Fact Sheets for each spot showing activities from 2 or more Areas

→ Technologies & Applications

→ Challenges & Opportunities



ID	Title	Interface	Functionality	Rank
N1	High-yield energy harvesting approaches for replacing or reducing primary energy uses	A1A2A3	ENERGY HARVESTING	8
N2	Flexible energy storage solutions with extended systems lifetime and multi-uses, including secondary use	A1A2A3	ENERGY STORAGE	29
N3	High-performance and compact power electronics for grid connection of distributed resources and storage, based on wide-band gap components	A1A2A3	ENERGY CONVERSION	N.A. NEW GREY SPOT
N4	Smart solutions combining monitoring, control and diagnostics for optimal operation of energy systems and smart grids	A1A3	COMPUTING / PROCESSING / DATA STORAGE	N.A. NEW GREY SPOT

N3: High-performance and compact power electronics for grid connection of distributed resources and storage, based on wide-band gap components

Technologies / Value:

- Innovative power components: Silicon Carbide (SiC) and Gallium Nitride (Gan)
- Power component integration: packaging, power modules, discrete components
- Topologies: two levels, multi-levels, single-stage, multiple-stages
- Controls: algorithms and embedded code

Applications:

- Power converters for renewable energy sources (photovoltaic, windpower,…)
- Bidirectional power converters for batteries and hydrogen storage
- Power converters for electrical vehicles and charging infrastructure

Challenges:

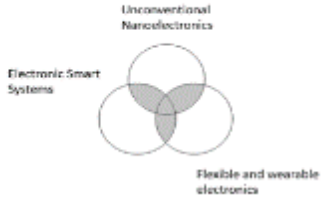
- Optimally design the converters: selection of the topology, selection of the active power components, sizing of passive components
- Increase the switching frequency/speed
- Guarantee high reliability of power components

Coupling *energy conversion* with other functionalities: energy storage, energy management, sensing

Opportunities:

1. **Power electronics for energy systems for building applications:** road-mapping of technologies for products with low power (~kW), high compacity and high safety (eg hybrid converters for PV and battery systems with an energy self-consumption objective)
2. **Power electronics for Utility-Scale power plants for feeding into the grid and grid services**: road-mapping of technologies for products with mid/high power and low voltage (~100kW to ~MW; <1500Vdc <1000Vac)
3. **Power electronics for High-Voltage plants:** road-mapping of technologies for products with mid/high power and **HIGH** voltage (~100kW to ~MW; ~3 to 6 kVdc and ~10 kVac)
4. **Power electronics for Electrical Vehicle charging:** roadmapping of technologies for products with high power (~100kW) and high density integrated in the charging infrastructure or embedded in the electrical vehicle

Matching of opportunities with Global Challenges



	(Aero)Space	Building / Construction	Consumer electronics	Digital Manufacturing	Energy	Environment	Food & agriculture	IoT/Smart connected objects	Medical / Pharmaceutical / Life science	Natural resources	Packaging / Logistics	Safety / Security	Transport / Mobility / Automotive
Actuating			■	■					■				■
Communicating			■					■	■		■	■	■
Computing / Processing / Data storage		■			■				■				■
Energy harvesting / conversion / storage		■	■		■			■	■				■
Sensing	■	■	■	■		■	■	■	■		■	■	■
Signalling (optical imaging, lighting)		■	■						■			■	■

Sweet Spots for Innovation

Clusters in 'Global Challenges and European Industrial Competitiveness'

Clusters	Areas of intervention	
Health	• Health throughout the life course • Non-communicable and rare diseases • Tools, technologies and digital solutions for health and care, including personalised medicine	• Environmental and social health determinants • Infectious diseases, including poverty-related and neglected disease • Health care systems
Culture, creativity and inclusive society	• Democracy and Governance • Social and economic transformations	• Culture, cultural heritage and creativity
Civil security for society	• Disaster-resilient societies • Protection and Security	• Cybersecurity
Digital, Industry and space	• Manufacturing technologies • Advanced materials • Next generation internet • Circular industries • Space, including Earth Observation • Emerging enabling technologies	• Key digital technologies, including quantum technologies • Artificial Intelligence and robotics • Advanced computing and Big Data • Low-carbon and clean industry • Emerging enabling technologies
Climate, Energy and Mobility	• Climate science and solutions • Energy systems and grids • Communities and cities • Industrial competitiveness in transport • Smart mobility	• Energy supply • Buildings and industrial facilities in energy transition • Clean, safe and accessible transport and mobility • Energy storage
Food, bioeconomy, natural resources, agriculture and environment	• Environmental observation • Agriculture, forestry and rural areas • Circular systems • Food systems	• Biodiversity and natural resources • Seas, oceans and inland waters • Bio-based innovation systems in the EU Bioeconomy

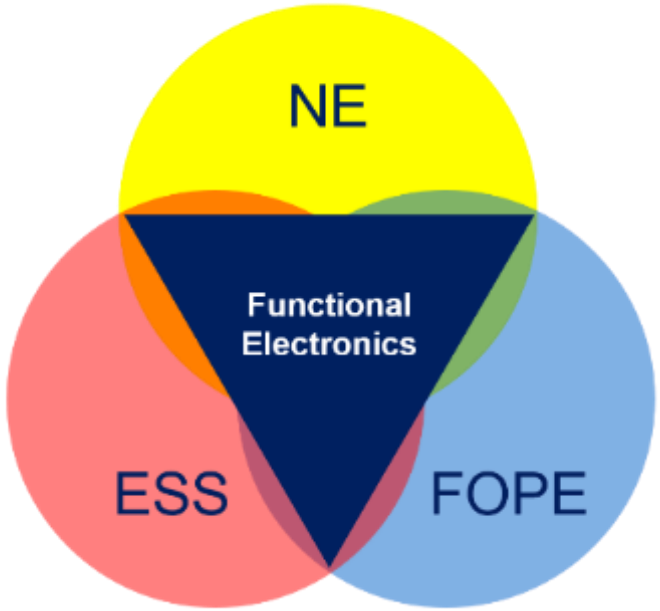
The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Functional Electronics

A transversal enabler and differentiator for Europe's digital transformation

The concept of Functional Electronics

Examples and Success stories identified



Shift from physical to functional integration (cognitive)

Use of novel substrates (flexible, organic, printed) and structural systems (textiles, plastics, laminates, glass, steel)

Eco-design approaches at product, process and business model levels

Real time capture & management of multi-physics data and contextual information (high sensitivity, selectivity and reliability)

Networked, autonomous operations, complemented by software solutions (incl. AI)

Seamless integration in everyday objects in a broad spectrum of new applications

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Available on the 5E website

Success Stories on Functional Electronics

The Success Stories highlight electronics innovations based on the **convergence** among the three Electronics Areas. This convergence paves the way towards the realisation of novel solutions in the field of **FUNCTIONAL ELECTRONICS**

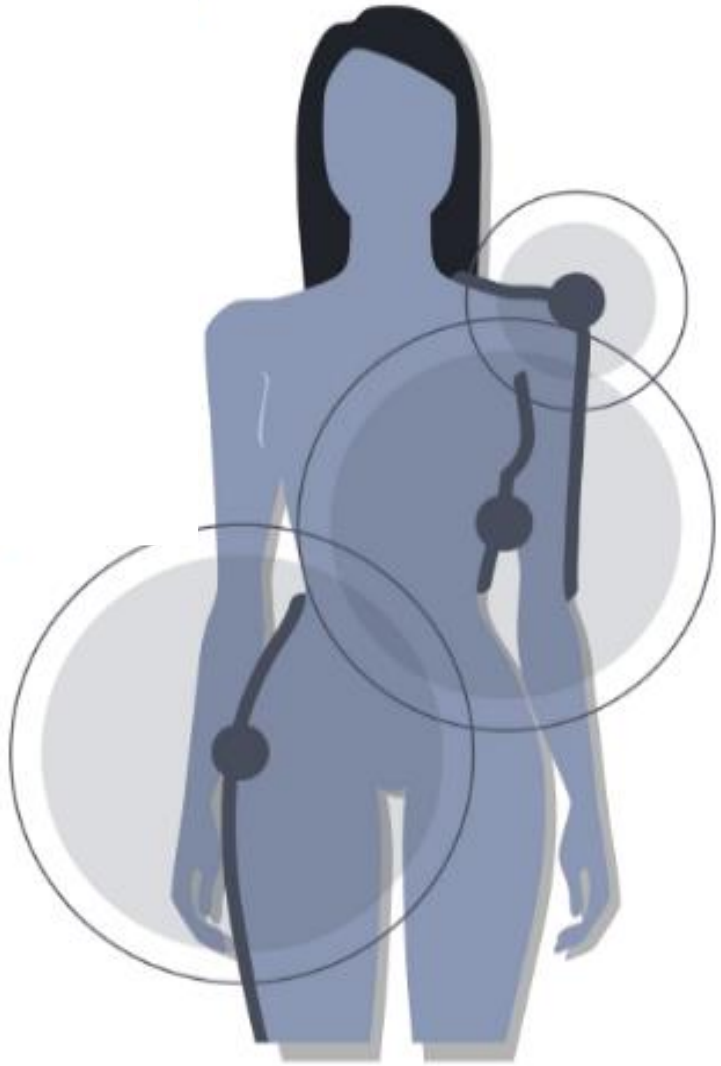
The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

LILITH – A PERSONAL SHIELD TO COMBAT VIOLENCE AGAINST WOMEN

Motivation:

Lilith is a system made up of smart female bodysuits capable of collecting data directly from the user's body and sending them to a mobile App. The App, thanks to integrated AI algorithms, can recognize and analyze situations of violence, forwarding an alarm to contacts set up by the user.

Lilith is a comfortable, invisible, autonomous and automatic system that aims to intervene suddenly in events of violence, quickly alerting aid, and gives a voice to the victims of violence.



Winner of the 5E contest 2021, Category:
Best product convergence among the Electronics Areas

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

LILITH – A PERSONAL SHIELD TO COMBAT VIOLENCE AGAINST WOMEN

Solution:

- **Smart fabric** (integrated metal oxides, **textile flexible sensors**, direct signal acquisition: e.g. acceleration, pressure, biometric data), total concealment, maximal wearability
- Mesh network **(BT communication** with mobile App.), robustness, security
- **Proprietary AI** (ML models based on FNN) for motion recognition, autonomous & immediate analysis
- Scalable (adaption to any outfit), easy to use, flexibility

Status / Impact:

- TRL 3 reached
- TRL 4 planned for next months

Funding:

- Regional / local means (Piedmont)

More information:

HYPE S.r.l.
Via San Paolo, 5
10098, Rivoli (TURIN) – ITALY
www.hype-design.it
info@hype-design.it

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

SUSTAINABLE MULTIFUNCTIONAL BIFACE SENSOR

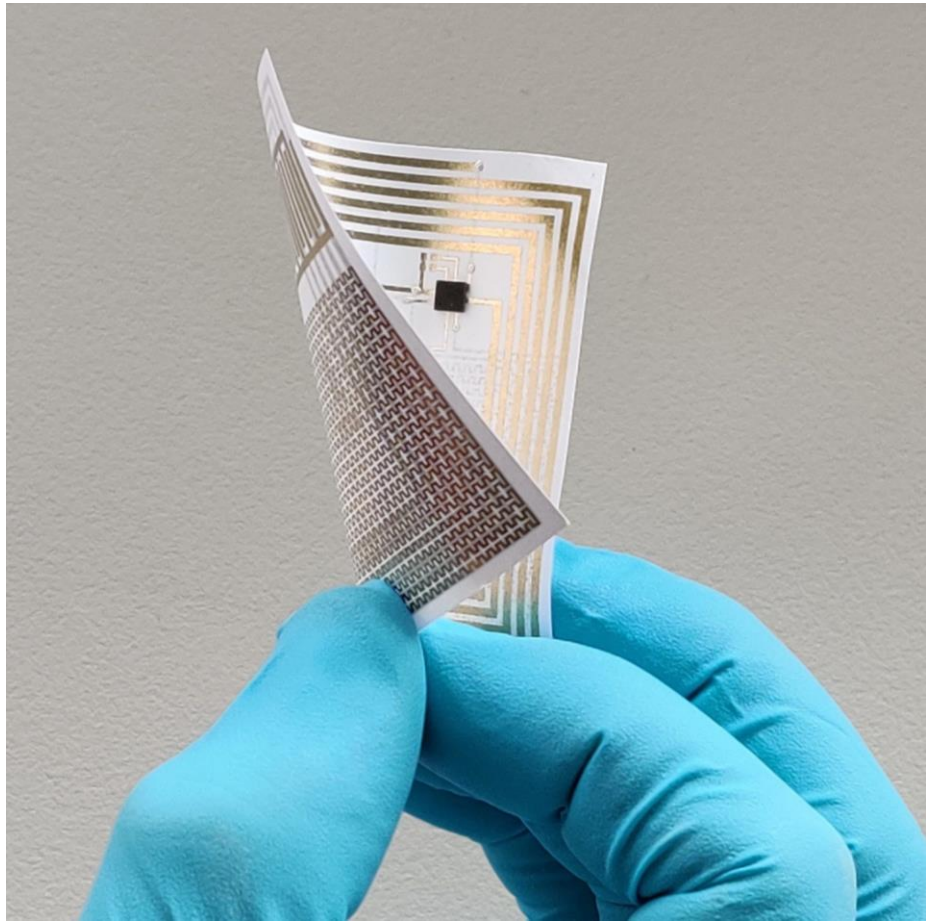
Motivation:

Electronic waste is the fastest growing waste stream in the EU.

→ Urgent need for sustainable „green“ Electronics:
raw **materials**, fabrication **processes** and **devices** themselves.

Vision:

Ubiquitous versatile and low-cost sensing platform for harsh environments (food industry) by embedding the sensor into EVA foil.



Winner of the 5E contest 2021, Category:
Best electronics product developed in-house by an interested party

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

SUSTAINABLE MULTIFUNCTIONAL BIFACE SENSOR

Solution:

- Sustainable, multifunctional, flexible, adaptable sensor platform (temperature, humidity, strain)
- Passive NFC chip (no battery), wireless, printed antenna on uncoated paper substrate
- Freedom of design, optimized performance and minimal material consumption
- Several production related benefits are addressed:
  e.g. cost-effective and resource-saving processes, additive manufacturing, adaptability to user needs …

Status / Impact:

- TRL 4 reached
- TRL 5 partially realised
- Silicon Austria Labs aims at a solution for industrial applications with target costing below 1€ per sensor tag

More information:

Silicon Austria Labs
Europastraße 12
9524 Villach, Austria
www.silicon-austria-labs.com

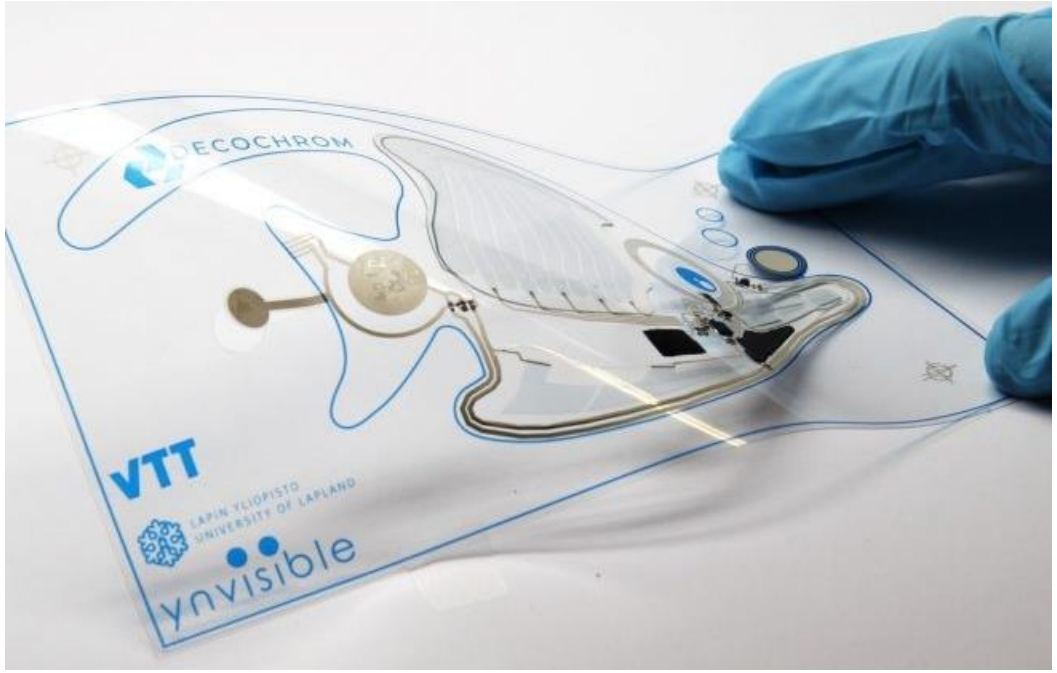
The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

SENSYS: THE ELECTROCHROMIC FISH

Motivation:

Use electrochromic materials and systems as a source of creativity in design and manufacture of consumer products. Build aesthetically pleasing practical interfaces to smart consumer goods and environments.

Winner of the 5E contest 2021, Category: Best electronics product developed in the context of a funded project

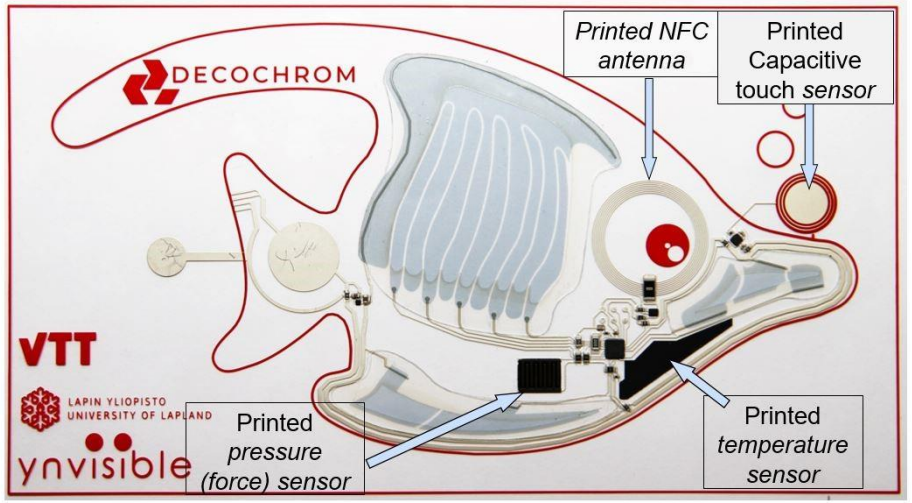


The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

SENSYS: THE ELECTROCHROMIC FISH

Solution:

- Demonstration of structural electronics of a hybrid integrated sensor system: Combination of printed electronic elements and traditional SMDs, hybrid backplane overmolded with plastics (TPU)
- multi-sensor hybrid system (NFC antenna, printed touch sensor, temperature and force sensors, plug-in power source options…)



Exploitation Potential:

- Printed components (ECDs, sensors etc)
- Flexible hybrid electronics (chip-on-foil, integrating displays, energy harvesting, connectivity…)
- Post processing to integrated systems (in-mold labeling, lamination, laser-cutting etc.)

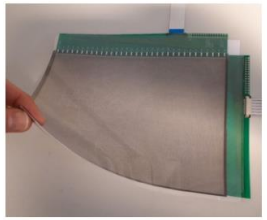
More information:

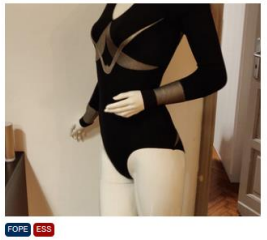
VTT Technical Research Center
Kaitoväylä 1
90590 Oulu, Finland
https://www.vttresearch.com/en
https://decochrom.com/

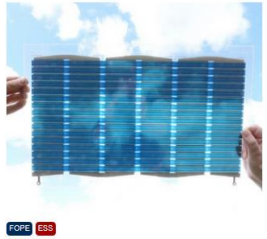
The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

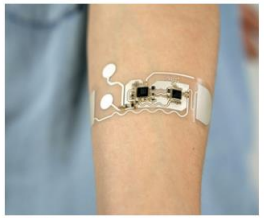
5E DIGITAL SHOWCASE – more examples

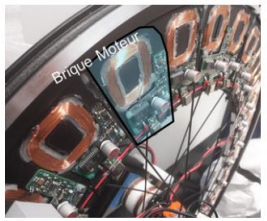
- Online platform to increase visibility of innovative European electronics products that combine
  - → Nano-Electronics
  - → Flexible, Organic & Printed Electronics
  - → Electronic Smart Systems
- Register your own innovation free of charge at https://5e-project.eu/showcase/











The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Functional Electronics

will provide key solutions to global societal challenges

Addressed in 4 Vision Papers resulting in meta-roadmap modules

Circular Economy

Energy

Autonomous Operation of Machines

Sensing

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Available on the 5E website

Vision Paper	Topic	Issue
Autonomous	AI for autonomous operation	Edge AI for autonomous mobility Level 1
Autonomous	Data Transfer and IoT systems	Technologies to secure data transfer and enable trusted solutions for people and information in car2car communicating for autonomous / self-driving vehicles
Autonomous	AI for autonomous operation	Explainable AI – Transparent, comprehensible and traceable classification and decision processes in safety critical applications
Autonomous	AI for autonomous operation	Edge AI for autonomous mobility Level 2
Autonomous	Transverse	Discuss liability issues with the stakeholders (industry, academia, public authorities etc.)
Autonomous	Sensor and mulit sensor systems	Next generation sensor systems for safe, efficient, optimised and self-enabled manufacturing
Autonomous	Data Transfer and IoT systems	Secure data transfer technologies for flexible and adaptable IoT systems to enable trusted solutions in data communication
Autonomous	Transverse	Set-up of a legal framework for development, testing and use of autonomous operating machines
Circular economy	Green Electronics	1. Ecodesign
Circular economy	Green Electronics	4. Sustainable product policy framework
Circular economy	Green Electronics	2. Circular electronics initiative
Circular economy	Green Electronics	3. Ecodesign approaches
Circular economy	Transverse	9. Holistic impacts assessment
Energy	Power management circuit	Power supply in the high-power and real-time computing sector
Energy	Energy harvesting	High-efficiency energy harvesting approaches for replacing or reducing primary energy uses
Energy	Transverse Energy harvesting / energy storage / Wireless power transmission	Sustainable energy harvesting and energy storage solutions for low-power and autonomous system: - harsh environment & remote sites - Multi-energy harvesting - extended systems lifetime
Energy	Power electronics	High-performance and compact power electronics for grid connection of distributed resources and storage, based on wide-band gap components (SiC and/or GaN)
Energy	Energy management system	Safe, efficient and optimised production processes in industry: multi-level efficiency and safety (energy supply..)
Energy	Transverse Energy harvesting / energy storage / Wireless power transmission	New approaches for low-cost, reliable and recyclable including secondary use energy harvesting and storage integration at system/component levels
Sensing	Environment	High density monitoring for fast changing conditions in situation based awareness (Big data sensing)(*): Sensing products, history and waste streams
Sensing	Environment	High density monitoring for fast changing conditions in situation based awareness (Big data sensing)(*): Sensing waste streams and data management

45 recommen-dations drafted

Importance vs. Urgency Ranking

21 classified as highly important (+5)

15 classified as important and urgent

9 issues classified as most urgent (+5)

Autonomous	AI for autonomous operation	Edge AI for autonomous mobility Level 1
Autonomous	Sensor and multi sensor systems	Novel sensors to act on changing situations
Autonomous	Transverse	Create Living Labs to test the technological achievements and to include the general public
Autonomous	Transverse	Establish centers for knowledge transfer of best practice into all relevant sectors and domains
Circular economy	Green Electronics	1. Clean materials cycles
Circular economy	Green Electronics	4. Sustainable product policy framework
Sensing	Medical	Beyond algorithms sensor development (re-active towards proactive, AI, product integration): sensors for patient well-being (monitoring), prevention, prediction (AI)
Sensing	Data and IoT	Large, area, high density monitoring in sensing platforms: 1 Trillion sensors, sensor swarms, integration, data cloud storage monitoring
Sensing	Data and IoT	Building/ city integrated safety sensors: data storage, cloud computing AI

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

15+2 Recommendations in 4 Meta-Roadmap Modules

Circular Economy

1. Ecodesign
2. Sustainable product policy framework

Energy

1. Real-time computing
2. High-efficiency energy harvesting approaches for replacing or reducing primary energy uses
3. High-density storage technologies
4. High-performance and compact power electronics for grid connection of distributed resources and storage, based on wide-band gap components (SiC and/or GaN)
5. Smart energy management and smart solutions for ubiquitous and reliable energy supply: harvesting technologies, digital twin and AI

Autonomous Operation of Machines

1. Novel sensor systems to act on quickly changing situations
2. AI liability issues
3. Edge AI for Autonomy Levels 1 and 2
4. Centres for knowledge transfer

Sensing

1. Smart sensing systems to monitor fast changing conditions in self driving cars
2. Environment monitoring sensing systems
3. Sensors in medical applications
4. Data acquiring sensors for IoT applications

1. Reliability of Functional Electronics
2. From Functional Electronics towards other key digital technologies (integrated photonics, quantum, …)

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Available on the 5E website

5E Meta-Roadmap

From Vision Papers to recommendations (e.g. call texts)

1. Topics of recommendations
2. Issues to be addressed
3. Links to 5E catalogue of opportunities
4. Importance
5. Urgency (timeline)
6. Targeted stakeholder groups
7. Technical and non-technical barriers
8. Proposed funding scheme

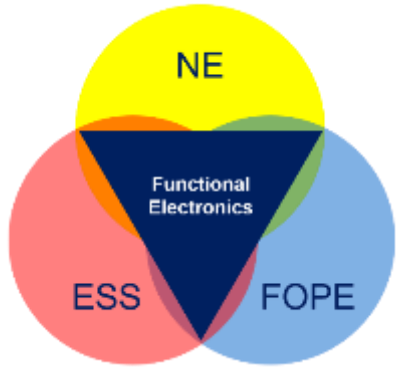
To be shown for each of the Vision Papers

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Circular Economy

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Role and Impact of Functional Electronics on the Transition towards a Circular Economy



A SOUND INTEGRATION FOR AN EFFICIENT TWINING OF GREEN AND DIGITAL TRANSITIONS

THE EUROPEAN GREEN DEAL
New Circular Economy Action Plan

SHAPING EUROPE'S DIGITAL FUTURE
New Industrial Strategy for Europe

HOLISTIC IMPACTS ASSESSMENT

CLEAN MATERIALS CYCLES

CIRCULAR DATA SPACE

ECODESIGN APPROACHES

PRODUCT PASSPORT

CIRCULAR ELECTRONICS INITIATIVE

SMART MAINTENANCE

SUSTAINABLE PRODUCT POLICY FRAMEWORK

NEW BUSINESS MODELS

Unlock digital potential to maximise product value

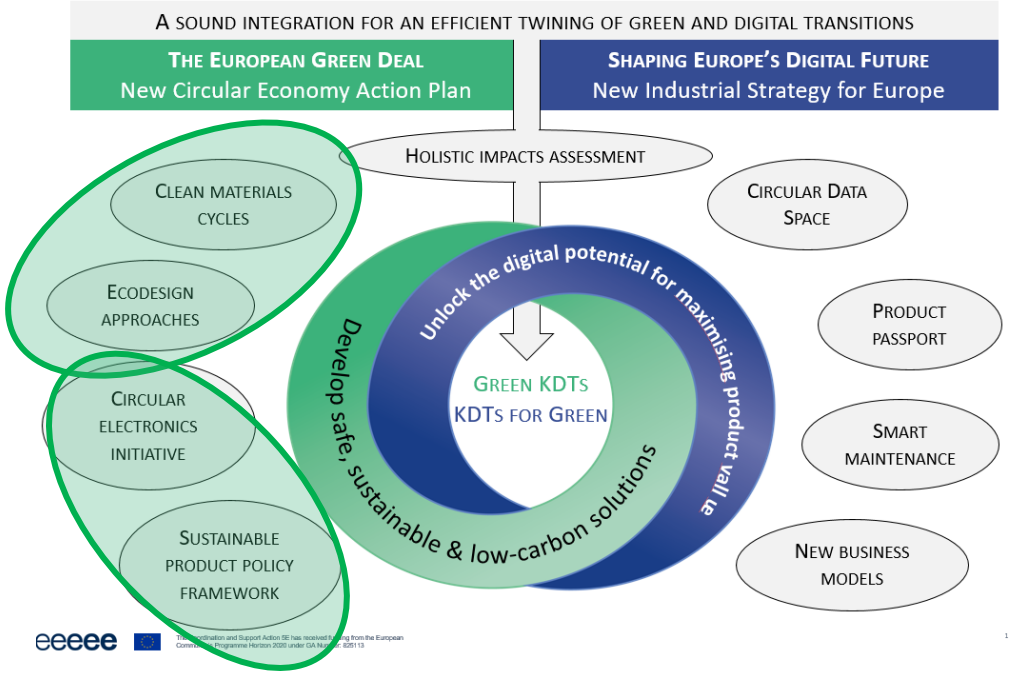
Develop safe, sustainable & low-carbon solutions

FUNCTIONAL ELECTRONICS

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Ensuring sustainability is put at the heart of all solutions containing electronics

Clean Materials Cycles	Shift to '**safe-by-design chemicals**' through the progressive substitution of hazardous substances to better protect citizens and the environment / **Recycling**
Ecodesign approaches	Take into account **all environmental impacts** of a product (including the use of raw materials and natural resources, manufacturing, packaging, transport, disposal and recycling) right **from the earliest stage of design**.



Accompany the transition by a proper and meaningful regulatory and legislative framework

Circular Electronics Initiative	**Implement regulatory measures** for electronics and ICT so that devices are designed for **energy efficiency and durability, reparability, upgradability** (incl. software), **maintenance, reuse and recycling**.
Sustainable Product Policy Framework	Propose a **sustainable product policy** legislative initiative to **widen the Ecodesign Directive** beyond energy-related products so as to make the Ecodesign framework **applicable to the broadest possible range of products** and make it **deliver on circularity**.

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

CIRCULAR ECONOMY

ECODESIGN

RIA/IA

Public and private RDI efforts should **concentrate on the progressive substitution of critical raw materials, hazardous substances and the recycling of all materials, in general**, for the benefit of citizens and the environment. **Research organisations, Academia, education and industry should collaborate** in establishing centres for knowledge transfer of best practice into all relevant sectors and domains, including the general public. They should proceed in close **international cooperation**, aligned with the objectives of Horizon Europe and the Digital Europe Programme, and based on additional private investment.

SUSTAINABLE PRODUCT POLICY FRAMEWORK

CSA/RIA/IA

Industry, especially producing and manufacturing enterprises should follow strictly the commonly accepted regulatory and standardisation measures to better address user perspective and achieve broad acceptance.

There is a need to **better address the user perspective, specifically "acceptance", flanked by correlated regulatory and standardisation measures** to set a **legal framework for the development, testing and use of lower footprint electronics as well as novel uses of electronics enabling a more circular economy**, in general.

This could be the base for a generally accepted and adopted set of successive **updates of policies and standards** currently in place, or even new measures, to be designed in priority around products cases & usage of acknowledged high environmental footprint, but with high economic impacts.

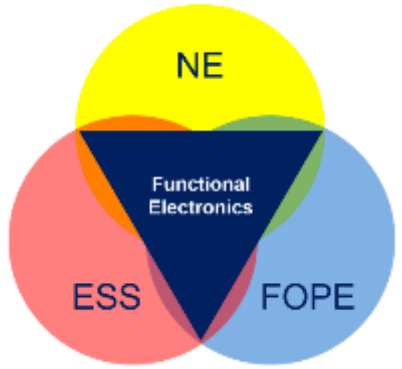
eeeee

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Energy

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Functional Electronics enabled energy solutions for the digitalisation of European industries and societies



Power electronics

Power converter

Electronics for energy

Energy management system

Wireless power transmission

New functions for **safe operation** and **secure energy supply**

FUNCTIONAL ELECTRONICS AND ENERGY

Optimization of energy consumption

Power management circuit

Energy harvesting

Powering Electronics

Energy Storage

Low power electronics

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

ENERGY 1-2-3

CSA/RIA/IA

Power management: Real-time computing

Public and private R&D effort should concentrate on edge vs cloud computing, calculation resources, latency and storage requirements. Manufacturing, suppliers, marketers & service providers for e.g. virtual reality techniques will be impacted.

RIA/IA/INFRA

Energy harvesting: High-efficiency energy harvesting approaches for replacing or reducing primary energy uses

Public and private R&D effort should concentrate on the high system / product integration level (energy vector, energy scale, reliability, lifetime & cost) and on multi-energy harvesting integration opportunities.

RIA/IA

Energy storage: High-density storage technologies

Public and private R&D efforts should concentrate on the selection of the best energy storage technology for a given application with high system / product integration level (storage capacity, energy scale, low power management, reliability, lifetime & cost) and on safety and recyclability challenges.

eeeee

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

CSA/RIA/IA/INFRA

Power electronics: High-performance & compact power electronics for grid connection of distributed resources and storage, based on wide-band gap components (SiC and/or GaN)

ENERGY 4-5

Public and private R&D effort should concentrate on new material investigation for power electronics by guaranteeing high reliability of power components, converters design (topology, selection of the active power components, sizing of passive components) and specifications (Increase the switching frequency/speed).

CSA/RIA/IA/INFRA

Energy management system: Smart energy management & smart solutions for ubiquitous and reliable energy supply: harvesting technologies, digital twin and AI

Public and private R&D effort should concentrate on Smart solutions combining monitoring, control and diagnostics for optimal operation of energy systems and smart grids.

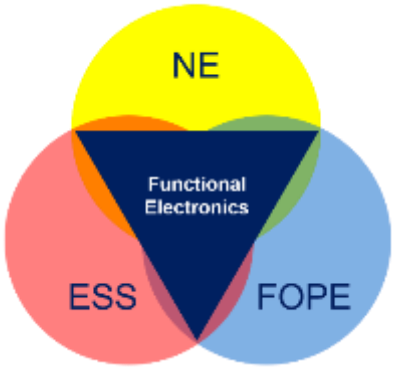
eeeee

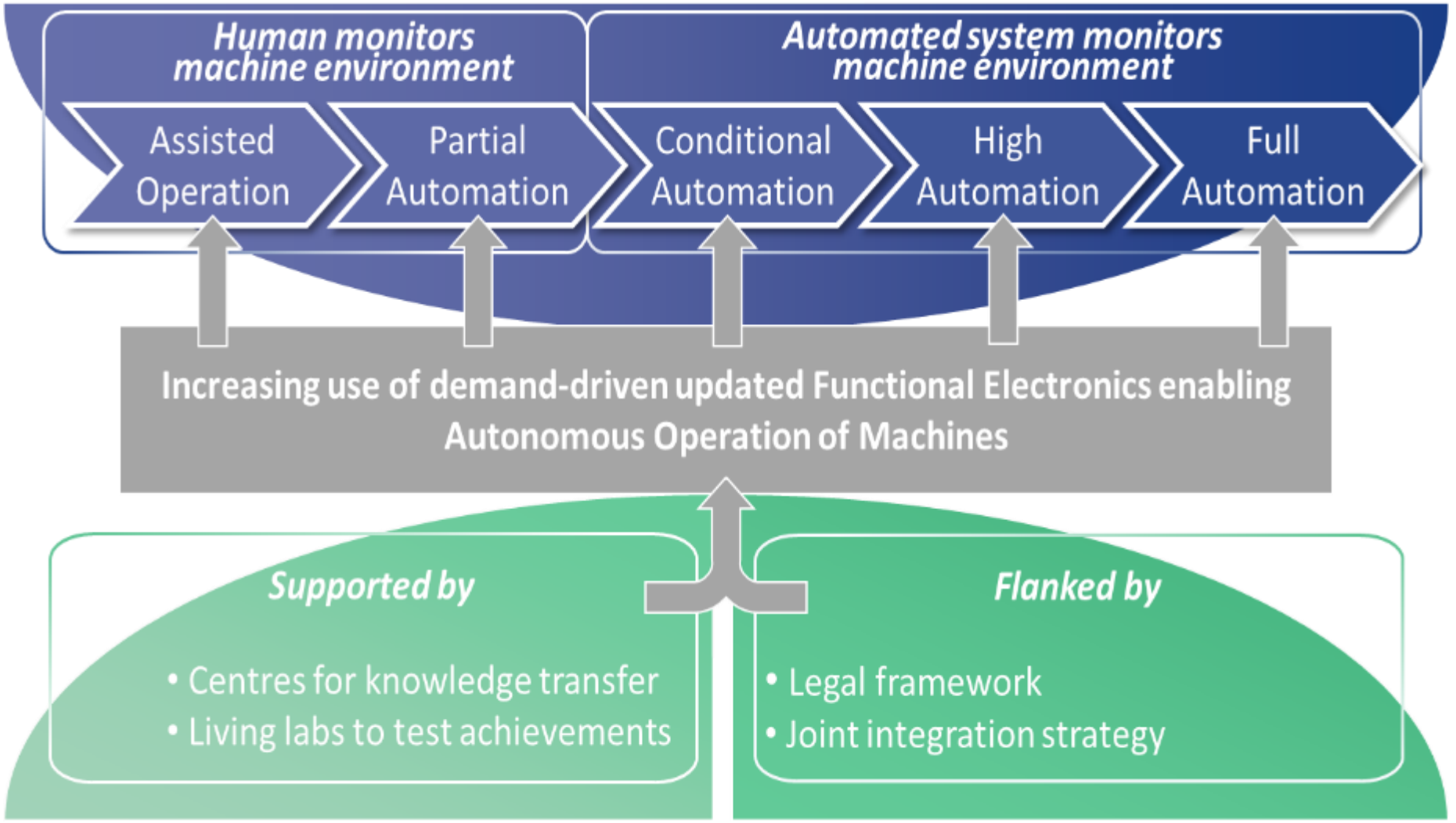
The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Autonomous Operation of Machines

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Functional Electronics as Enabler for Autonomous Operation of Machines





The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

AUTONOMOUS OPERATION 1-2

CSA/RIA/IA

Sensor and multi-sensor systems: Novel sensor systems to act on quickly changing situations

Public and private R&D efforts should concentrate on novel sensors and multi-sensor systems that recognise and react on quickly changing situations.

AI for autonomous operation (Transversal): AI liability issues

CSA

Multipliers and intermediaries like Clusters, Associations, Chambers or Consultants should take the lead in a public discussion about AI-related liability issues with the stakeholders (industry, academia, public authorities etc.).

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

AUTONOMOUS OPERATION 3-4

AI for autonomous operation: Edge AI for Autonomy Levels 1 and 2

RIA/IA

Industry, especially producing and manufacturing enterprises should improve suitability for daily use of AI in general and especially edge AI supporting the autonomous operation at the currently up-to-date autonomy levels 1 and 2.

Transversal: Centres for knowledge transfer

CSA/RIA/IA

Research organisations, Academia, education and training centres should cooperate in establishing centres for knowledge transfer of best practice into all relevant sectors and domains, including the general public.
In parallel the establishment of Living Labs is necessary to provide manifold “test before invest” possibilities as already proven successfully in the pan-European DIH-network.

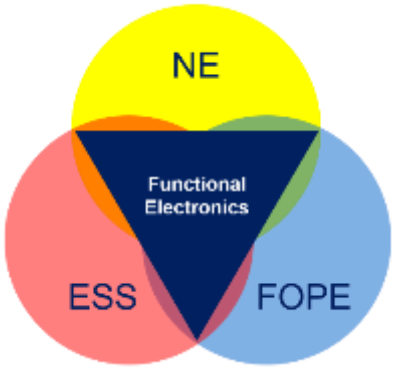
eeeee

The Coordination and Support Action 5E has received funding from the European Community’s Programme Horizon 2020 under GA Number: 825113

Sensing

The Coordination and Support Action 5E has received fun
Community's Programme Horizon 2020 under GA Number: 825

Sensing the Future: Sensors Development and the Role of Advanced sensing solutions for the digitalisation of European industries and societies



Sensing Landscape

- Re-active towards pro-active
- Fast changing conditions
- Fast changing occurrences

Distributed Sensing

- High density monitoring
- Large area coverage
- Product integrated

Cross-Sectoral Application

- Safety
- IoT
- Urban monitoring
- Smart grid
- Infrastructure
- Self driving cars

Technical Challenges

- Beyond algorithms
- Reliable
- Accurate
- Situation based Awareness
- Long lifetime products
- Remote fatigue monitoring

Electronics Roadmap

- AI
- Big data
- Smart systems
- Sensor Swarms
- A trillion sensors

eeeee

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

SENSING 1-2

Smart sensing systems to monitor fast changing conditions in self driving cars

RIA/IA

Next generation sensors need to be developed going beyond the sensing algorithm, including multi-model, AI, proximity. There are 2 major topics in this subject:

1. **Novel sensors that go beyond the algorithm of existing sensors. (TRL 3-5)**
2. **Upscaling and integrating novel sensors and adjust these to the automotive specifications. (TRL6-7)**

Environment monitoring sensing systems: High density monitoring for fast changing conditions in situation based awareness (Big data sensing)

RIA/IA

Sensor networks are set up including **large area monitoring** of e.g. weather conditions, air quality, in a very **detailed** matter. This is requiring sensors deployed in **large numbers (e.g. 1.000.000 sensors) and large area** (e.g. remote fatigue monitoring in hard to reach equipment). Both set ups require novel sensors and production methods thereof. Flexible electronics and smart systems can be the technologies to provide this.

eeeee

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

SENSING 3-4

Sensors in Medical applications: Beyond algorithms sensor development (re-active towards pro-active, AI, product integration)

RIA/IA

New sensors are needed to monitor persons health and support the transition from monitoring to prediction and prevention. For that on body sensors are needed that are either applied to the skin or integrated in wearables like clothing. The sensors need to be improved and standardised thus integrating these in existing products.

Data acquiring sensors for IoT applications: Large area, high density monitoring sensing platforms

RIA/IA

New sensors are needed to monitor fast changing conditions, people management, crowd control etc. following e.g. the smart cities paradigm. These sensors are integrated in products that act in an autonomous matter, remote and hard to reach areas systems exploited in large numbers. The sensing systems are mutually connected forming sensor swarms requiring a new approach/ technology platform for data storage and communication.

eeeee

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Additional Recommendations

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Additional 1-2

Reliability of Functional Electronics

RIA/IA

Addressing new challenge from Functional Electronics (increasing integration of functionalities, use of new substrates and materials, incl. those compatible with circular strategies and lower environmental impact). RIAs and potentially testbeds, including Characterisation & Testing, are needed to meet the requirements of demanding applications, e.g. in healthcare, transportation, production, energy. Data is particularly needed for modelling and simulation of behaviour of functional electronics in real environment and usage. This will contribute to improving maintenance and life-time of Functional Electronics based products.

From Functional Electronics towards other key digital technologies (integrated photonics, quantum, …)

CSA

Methodology used to identify sweet spots at the interface of the three areas of electronics, through the focus on functionalities, opens up the field to a broader range of technological areas. Further actions are needed, such as consultations, engagement with communities representing other emerging technologies, to foster the potential for innovation of digital technologies. A Coordination and Support Action covering these aspects and adding further circles to the 5E model, for instance photonics, biotechnologies and quantum technologies would therefore be needed in the short term.

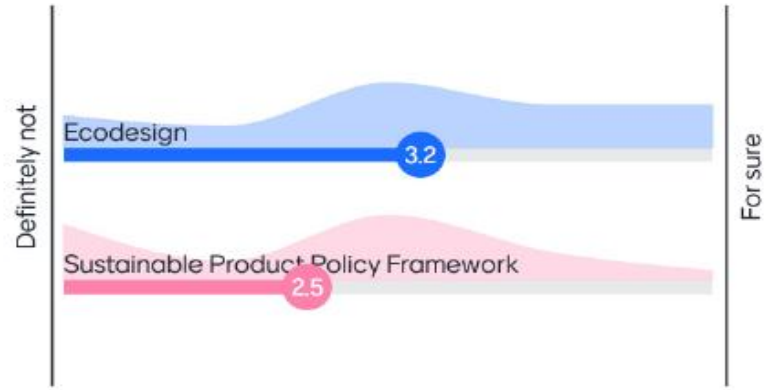
eeeee

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

Agreement with Recommendations

Expressions of Interest

15. When the Meta-Roadmap recommendations are implemented: How likely are you to participate in the respective calls of the "Circular Economy" module?

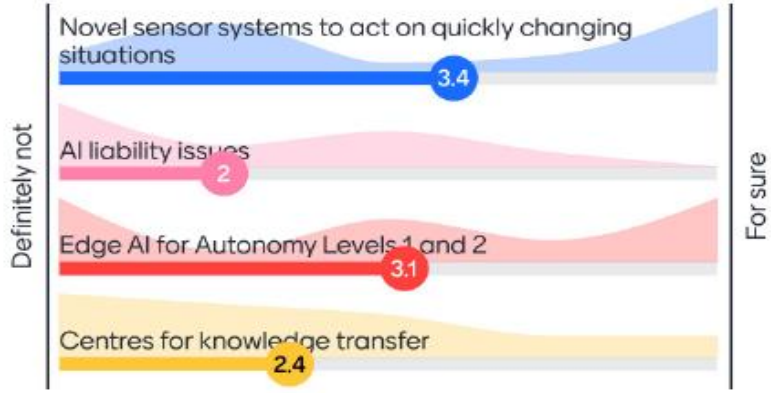


19

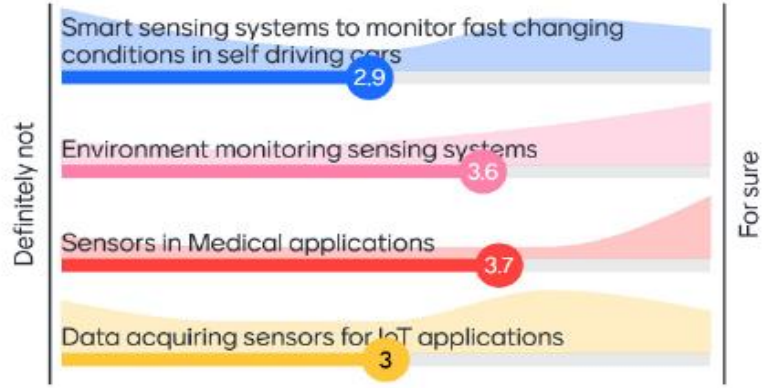
16. When the Meta-Roadmap recommendations are implemented: How likely are you to participate in the respective calls of the "Energy" module?

20

17. When the Meta-Roadmap recommendations are implemented: How likely are you to participate in the calls of the "Autonomous Operation" module?



18. When the Meta-Roadmap recommendations are implemented: How likely are you to participate in the respective calls of the "Sensing" module?



Further Reading & Contact

5E Website
https://5e-project.eu

Catalogue of 39 Opportunities
https://5e-project.eu/library/download-area/

Joint Vision
https://5e-project.eu/joint-vision/

Functional Electronics
https://5e-project.eu/functional-electronics/

Vision Papers
https://5e-project.eu/vision-papers/

Meta-Roadmap
https://5e-project.eu/meta-roadmap/

Digital Showcase
https://5e-project.eu/showcase/

LinkedIn: 5E Project

Twitter: @5E_Project

petra.weiler@vdivde-it.de

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113

THANK YOU! QUESTIONS?

The Coordination and Support Action 5E has received funding from the European Community's Programme Horizon 2020 under GA Number: 825113