DIGITEX

Virtual tools for training

Innovation boosting based on creative knowledge mapping

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DIGITEX

Virtual tools for training
Innovation boosting based on creative knowledge mapping

General Framework

DigiTEX project aims to support innovative approaches and digital learning technologies to accelerate innovation, teaching and learning in the field of medical, protective, sensorial and smart 3D textiles design, testing and manufacturing of the innovative advanced products for healthcare (protective equipment, wearable monitoring devices) in the context of the digital economy.

Specific Objectives

Virtual tools for co-design and management of the product from idea-to end user are based on a new concept of involvement the end user in the co-design of products in the field of healthcare, security and industry through online tools and creative methods.

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STRUCTURE

MODULE 1 - Creative methods for co-design smart components

MODULE 2 – Wearable Devices

MODULE 3 - Eco Design for Smart Materials in the context of circular economy

MODULE 4 - Wearable System Integration and Algorithms

MODULE 5 - Market dynamic and opportunities

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Creative methods for co-design smart components

Authors: Aileni R.M.

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Creative methods for co-design smart components

Co-design and Creative Methods

Co-design can produce different results, from information in the form of data, and cognitive maps to models of a product or service. In advance, the participants must be prepared, they must think and reflect on the subject to be studied.

Creative methods are helpful in co-design and innovating products or services.

Co-design involves:

➔ the relevant stakeholders (end-user, academic partners, designers, industry);
➔ generate new ideas, and concepts by collaboration between stakeholders.

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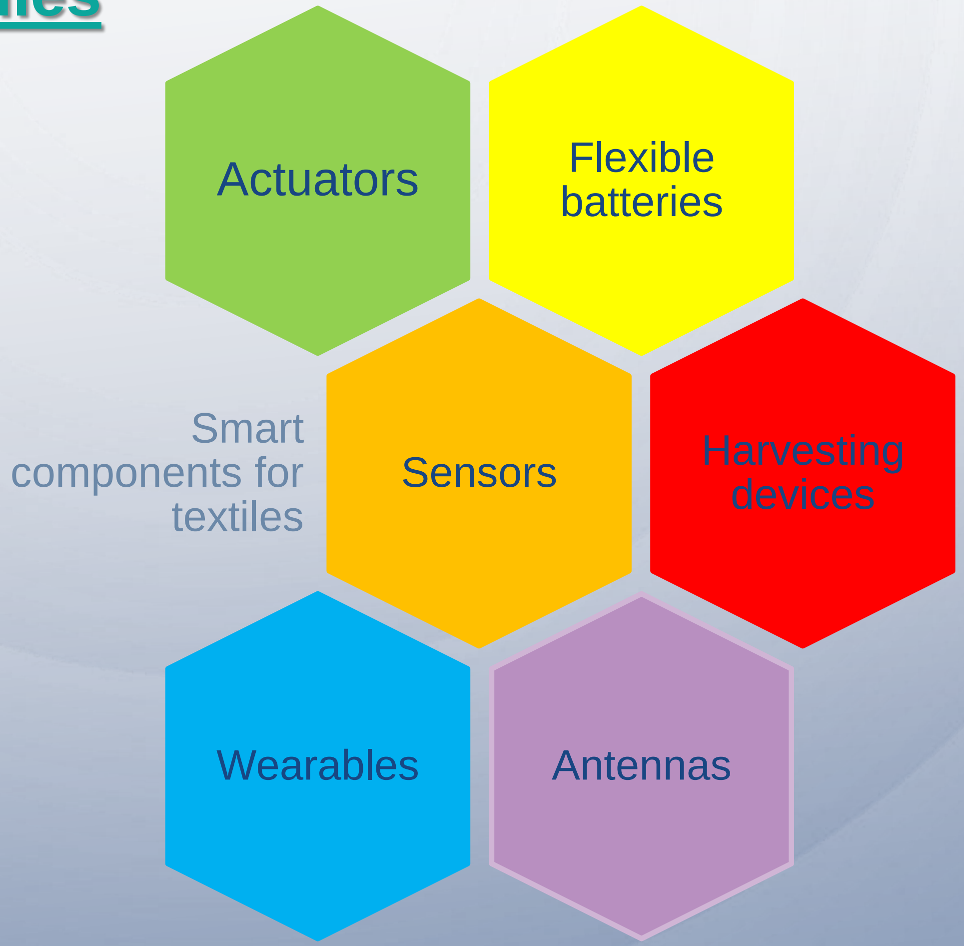
Creative methods for co-design smart components

Smart Components for Textiles



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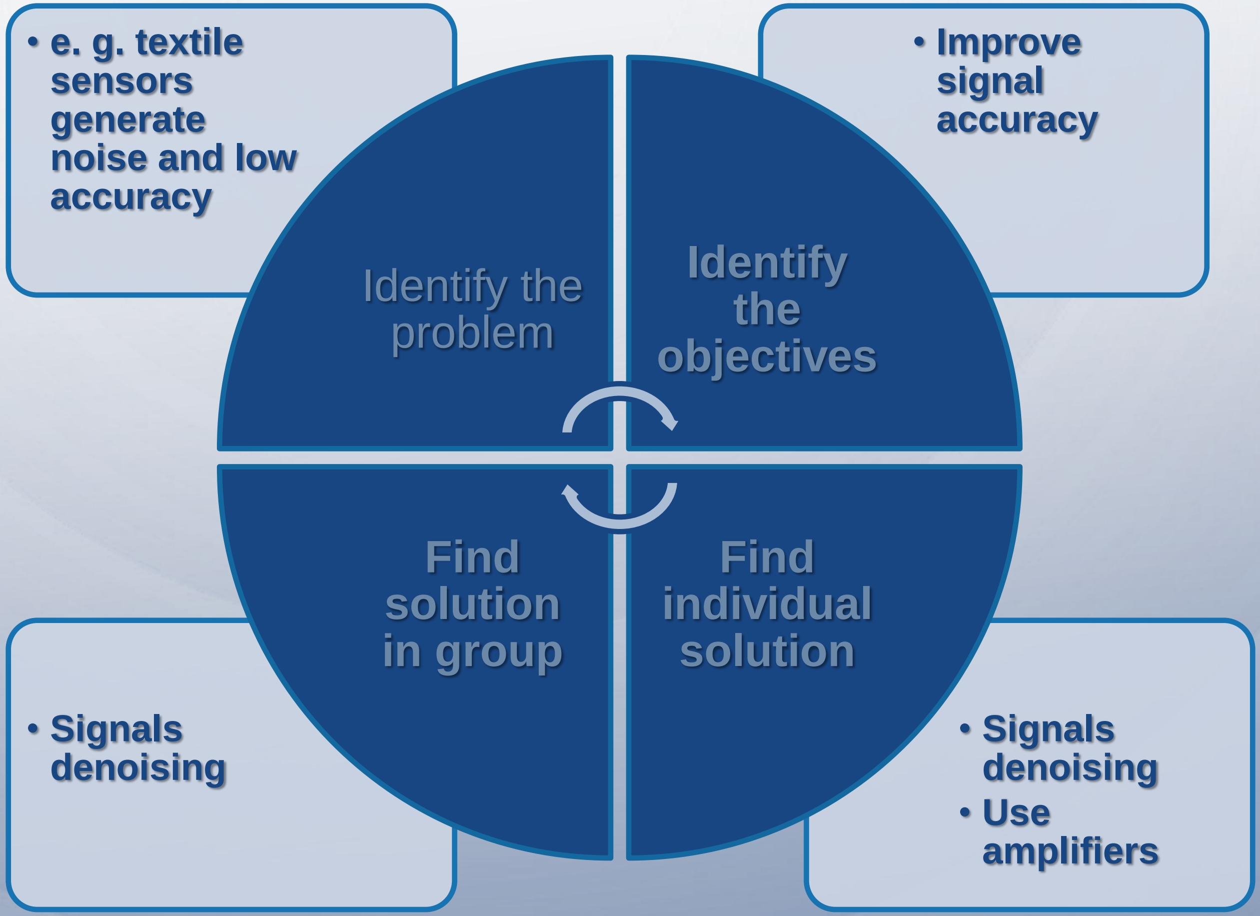
Creative methods for co-design smart components

Use case 1 ➔ Brainstorming



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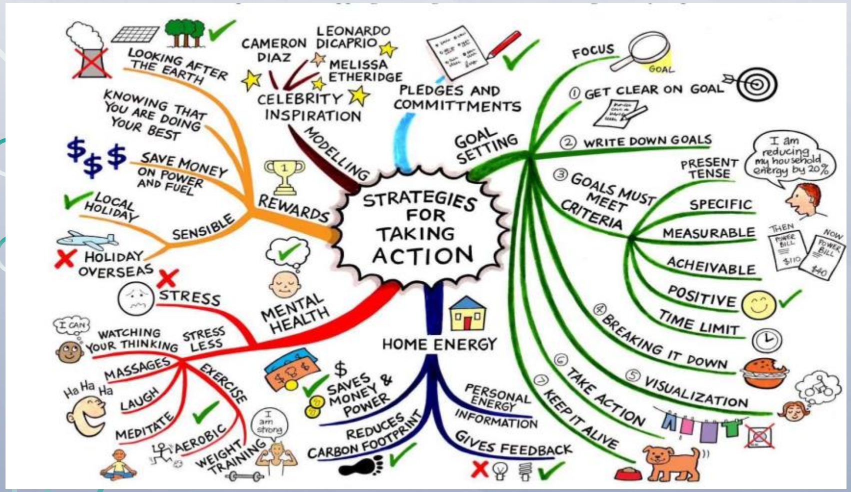
Creative methods for co-design smart components

Use case 2 ➔ Mind Map

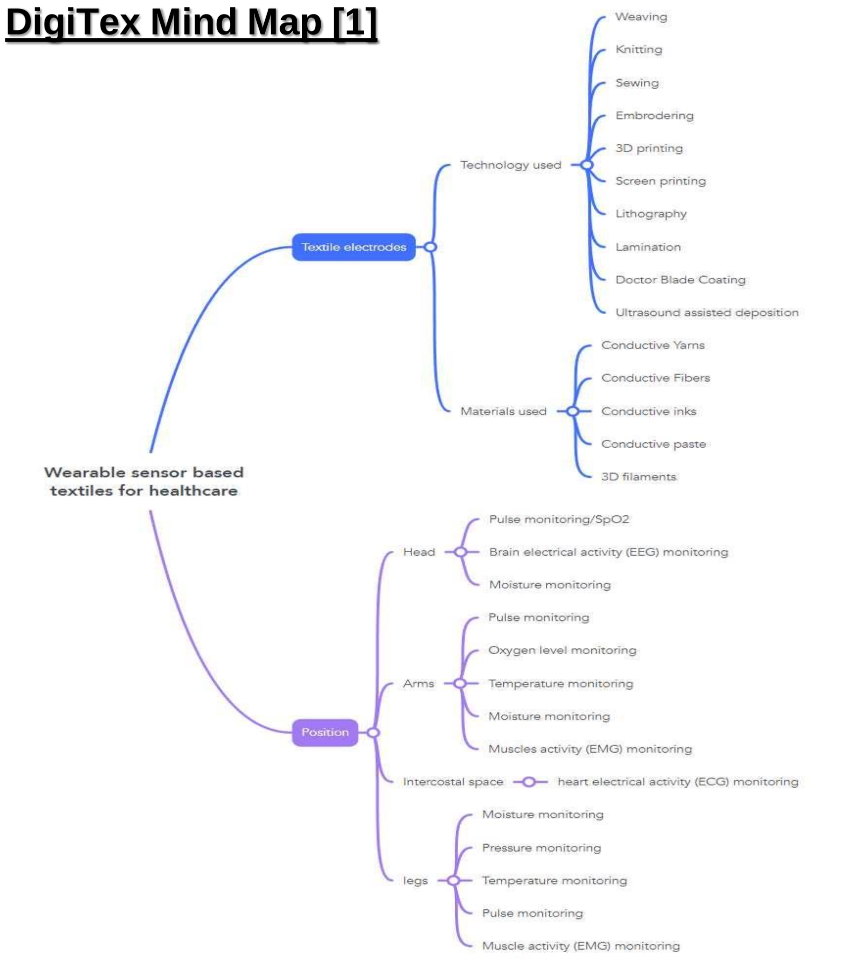
Mind mapping is a method for generating ideas by association.
The proposed mind map was generated from the central main idea (wearable sensors for healthcare) and expanded on secondary directions (textile electrodes, position on the human body) with the specific concepts about technology, materials used, and specific human body positions for integration sensors in textiles and finished with the specific sensors depending on the body area.

- *The Mind Map was generated by creative online web software [2]*



Mind Mapping ‘Strategies for Climate Change’ Essay Topic [3]

DigiTex Mind Map [1]



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Creative methods for co-design smart components

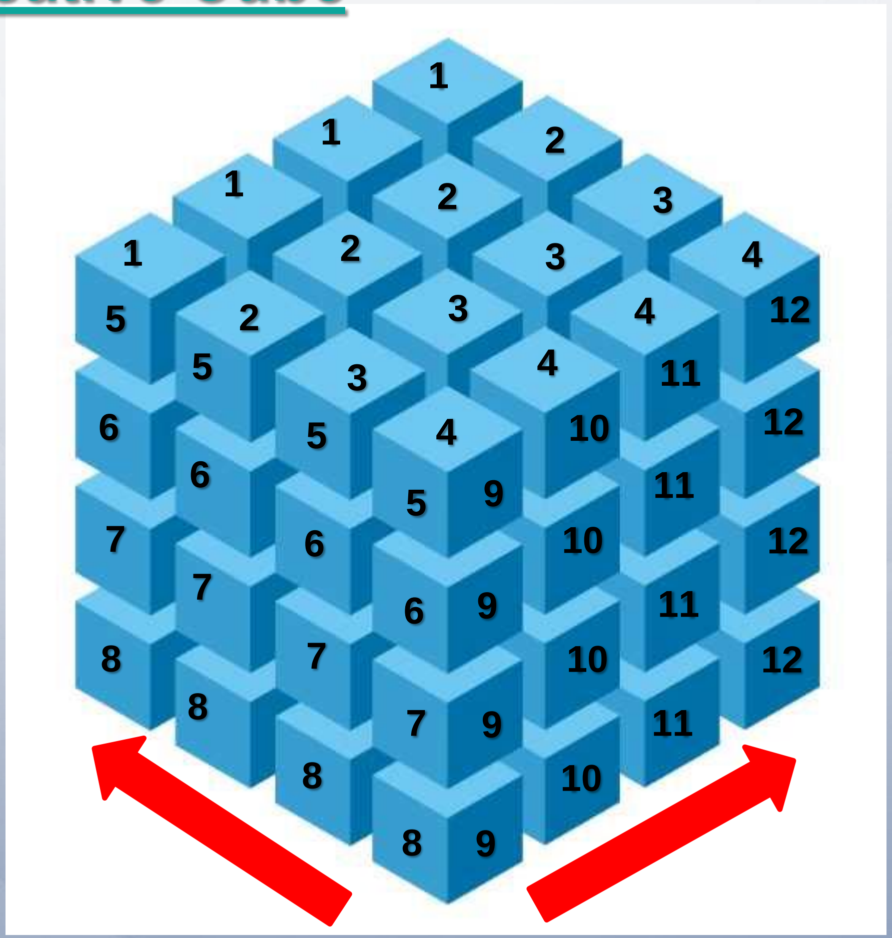
Use case 3 → Creative Cube

Numbers correspondence:

Technologies:
1-3D printing
2-lamination
3-ultrasound
4-screen printing

Components:
5-sensors
6-actuators
7-battery
8-harvesting device

Materials
9 – knit
10– woven
11 – nonwoven
12 –braided fabric



Pairs:
4-5-9 → Sensors obtained through the screen printing on the knitted fabric
1-5-9 → Sensors obtained through the 3D printing on the knitted fabric;
8-9-1 → Harvesting device obtained by 3D printing on the knitted structure;
7-9-3 → Battery obtained by assisted ultrasound technology on the knitted structure;

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Creative methods for co-design smart components

Use case 4 ➔ Interactive laboratory

➔using interactive laboratory facilities for virtual simulation
➔working in groups, e.g.:
Group 1: integration of monitoring components in personal protective equipment for firemen;
Group 2: integration of sensors in wearable monitoring system-based textiles;
Group 3: integration of monitoring components in personal protective equipment for chemical hazards;
Group 4: integration of monitoring components on the military suits.

Steps necessary for co-creation:

- ➔ Discussion about how it should be the final products (20 minutes)
- ➔ Discussion about constraints in product development (10 minutes)
- ➔ Discussion about benefits (10 minutes)
- ➔ Defining a sketch of the textile product with integrated electronic components (10 minutes)
- ➔ Perform a virtual simulation of the integrated components and products (45 minutes)
- ➔ Defining the limitations and weak points of the final product (15 minutes).
- ➔ Define the possibility to re-design and optimize the proposed product (10 minutes).

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Creative methods for co-design smart components

Use case 4 ➔ Six thinking hats

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References

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- [2] www.mindmeister.com
- [3] www.greendealsolutions.net/wp-content/uploads/2013/03/strategies-for-change.jpg
- [3] www.agile-moose.com/debonos-6-hats
- [4] www.innovolo-group.com/misc/how-you-can-use-edward-de-bonos-six-hats-method-for-exceptional-problem-solving

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DIGITEX

Wearable Devices

Authors: Ioannis Chronis, Georgios Priniotakis, Athanasios Panagiotopolous

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Table of contents

- Evolution of wearables
- Generations of wearables
- A model for efficient design of wearable
- Conclusion

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Types of wearables

Near-body electronics	On-body electronics	In-body electronics	Electronic Textiles
electronic devices and components intended to be located near an organism where it does not contact the external surface of the organism directly	electronic devices and components intended to be located on an organism where it contacts the external surface of the organism directly	electronic devices and components intended to be located internal to an organism	fabrics or textile-based electronic devices and components

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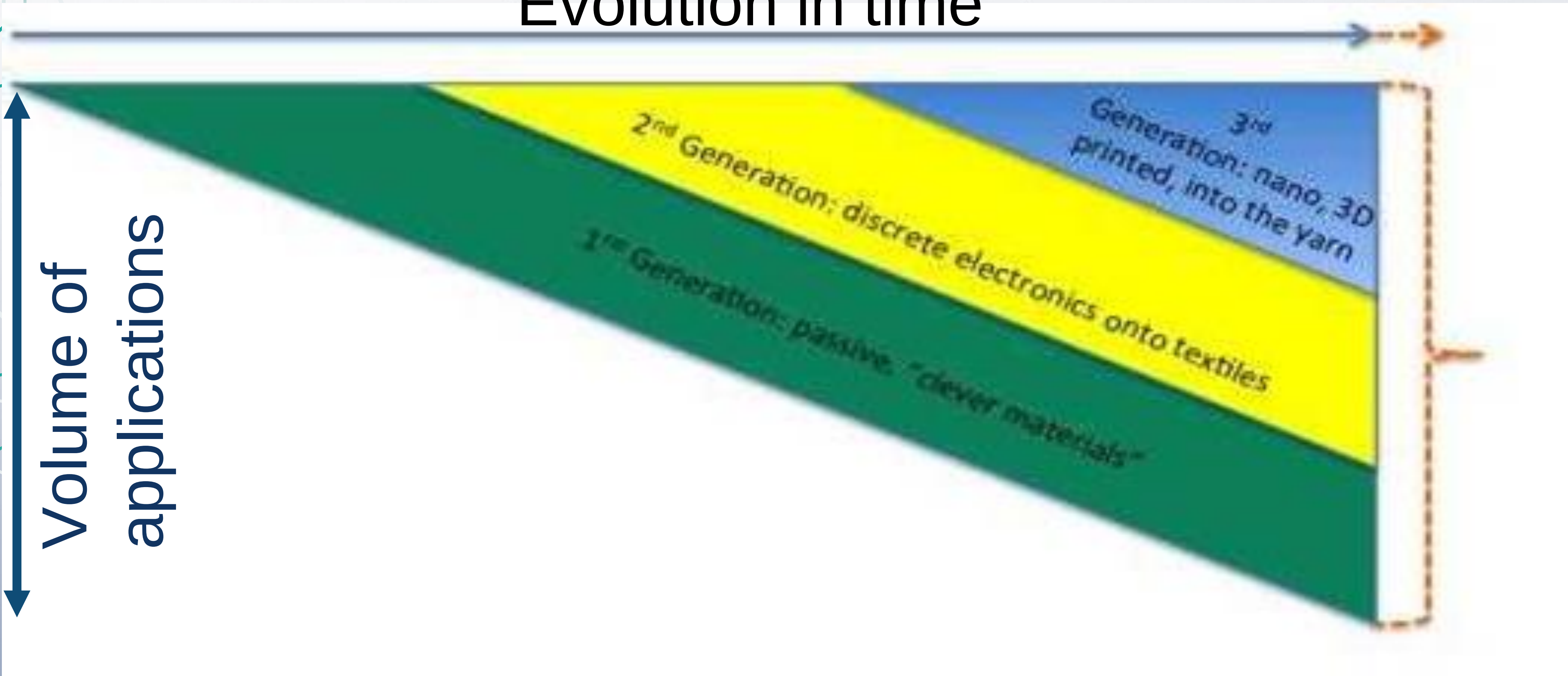
Evolution of smart textiles



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First Generation of Wearables

Plain chemical material, with unusual functionality, according to the environmental stimuli.

They are characterized by a passive and simple function

Typical examples:

Phase change materials

Chromic materials

Shape memory polymers

Optical Fibers

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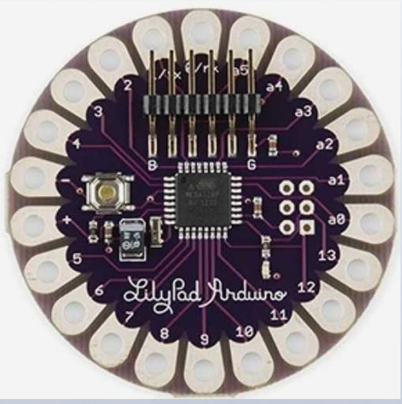
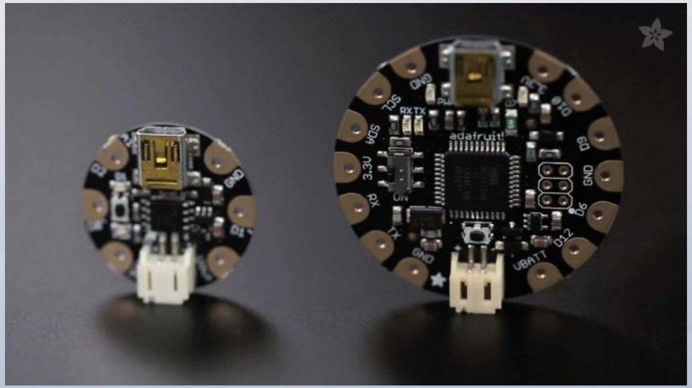
Second Generation of Wearables



adafruit®



ARDUINO™ ®

shimmer™ ®
DISCOVERY IN MOTION

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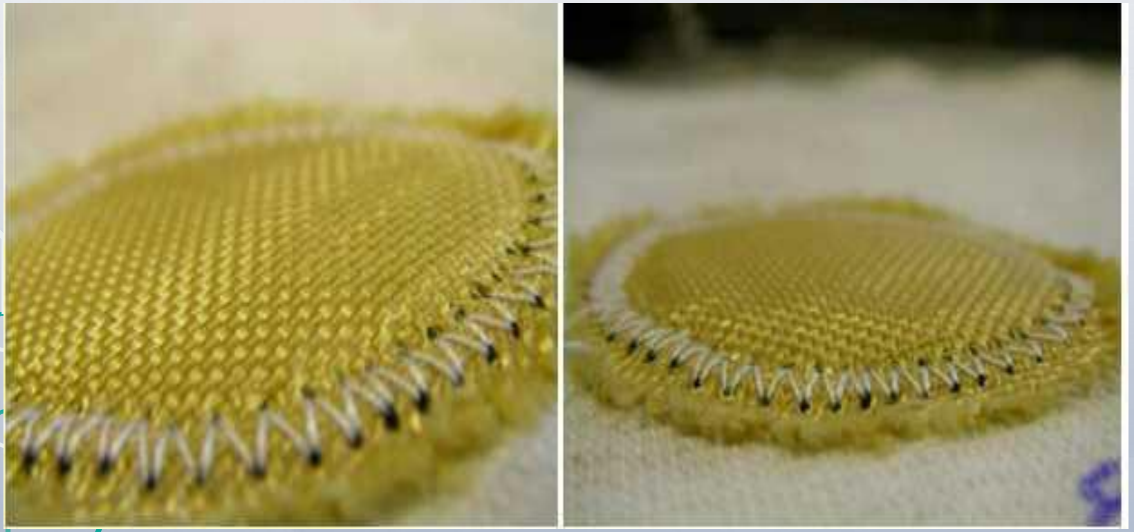
Third Generation of Wearables

Textile electrodes (gold coated)



Microscope pictures

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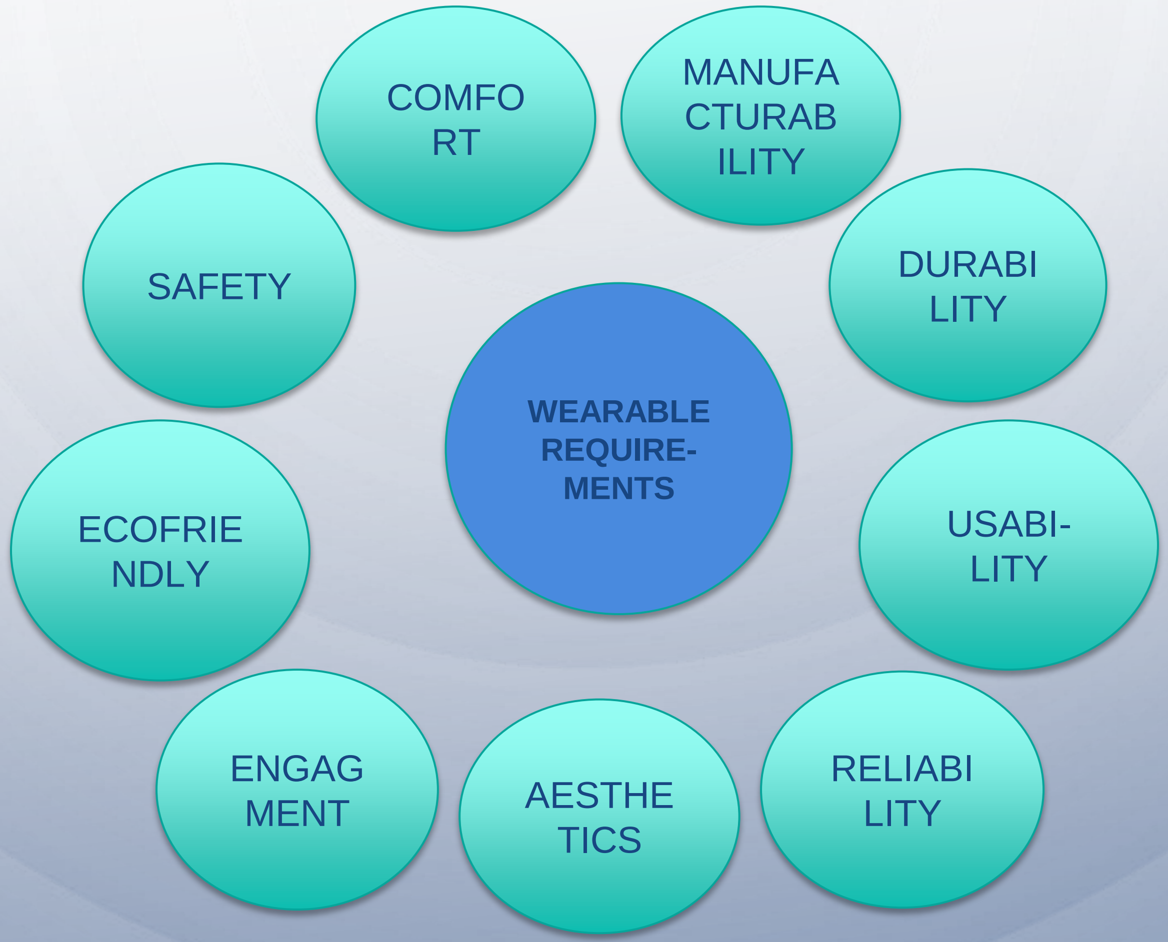
The Integration Problem



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Conclusions

- Wearables are expected to become a mature market, although the efficient integration of the garment and the functioning element is still not very well addressed.
- The applications are very promising and attractive to the users
- The design model of wearables is a complicated one and requires a multidisciplinary approach. Fashion and electronics designers, should have a common vision and common understanding about the products.
- The third generation of wearables is expected to fix this discrepancy.

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DIGITEX

Ecodesign for smart materials in the context of circular economy

Author: David Gómez i Maurel, AEI Tèxtils

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Introduction

Sustainability concepts

Smart textiles

Common relationship

Conclusions

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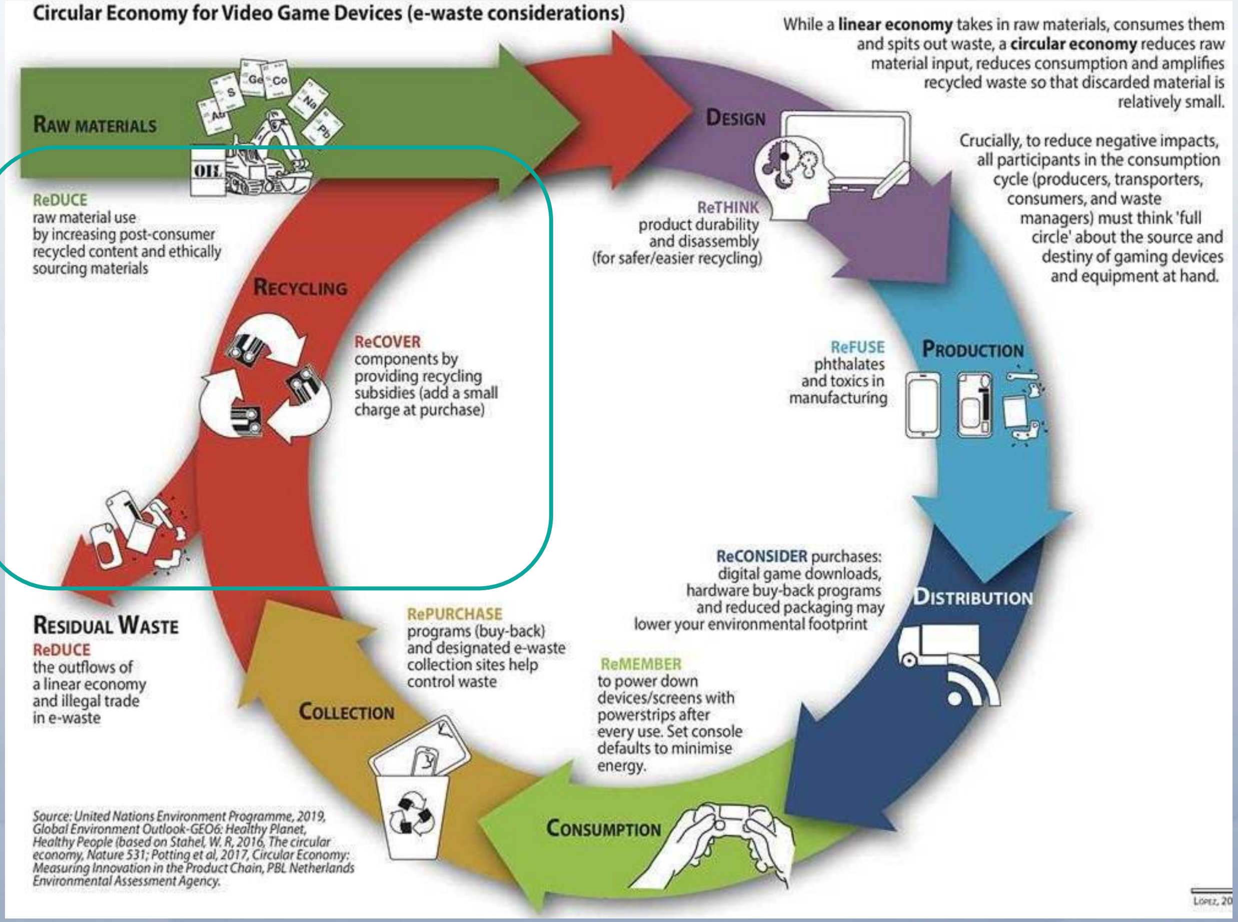
Circular economy



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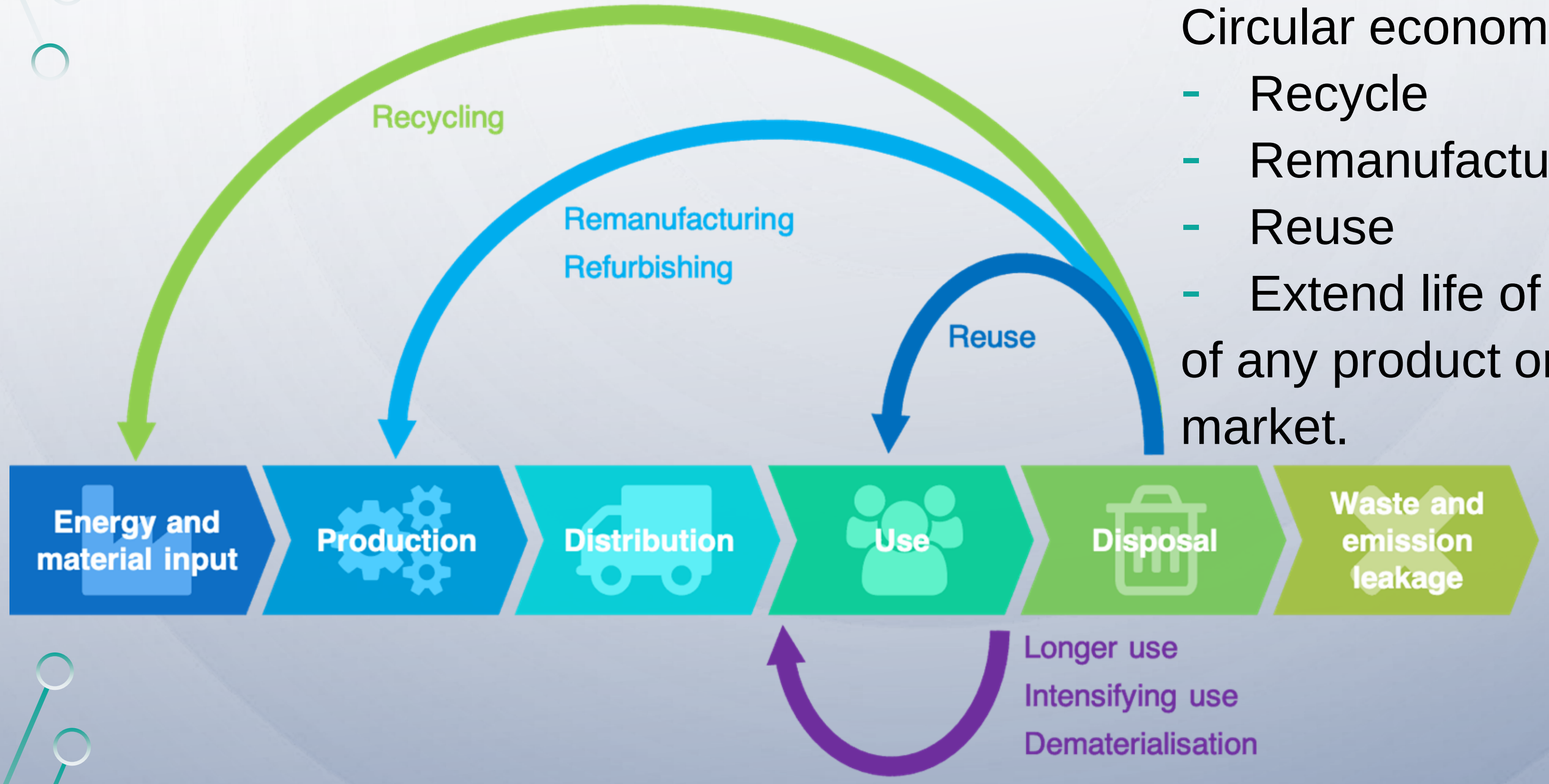
Circular economy



Circular economy consists mainly in:

- Recycle
- Remanufacture
- Reuse
- Extend life of products

of any product or service chain in the market.

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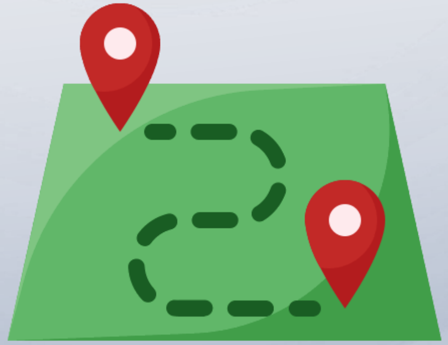
Ecodesign

Principles of ecodesign

Performance in origin



Internalization of costs

Comprehensive view of the life cycle

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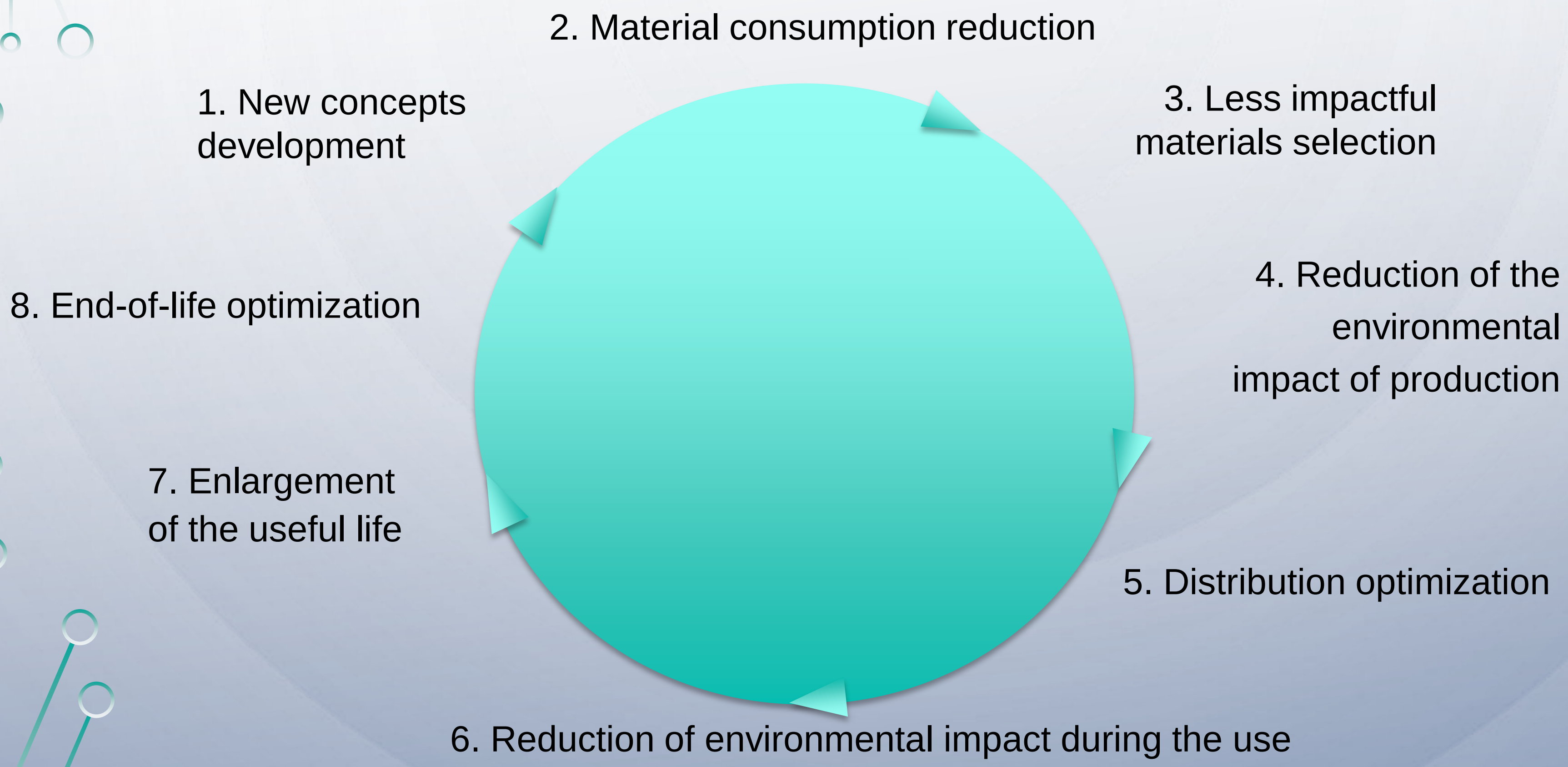
Ecodesign



Source: Brezet, H; van Hemel, C. 1997

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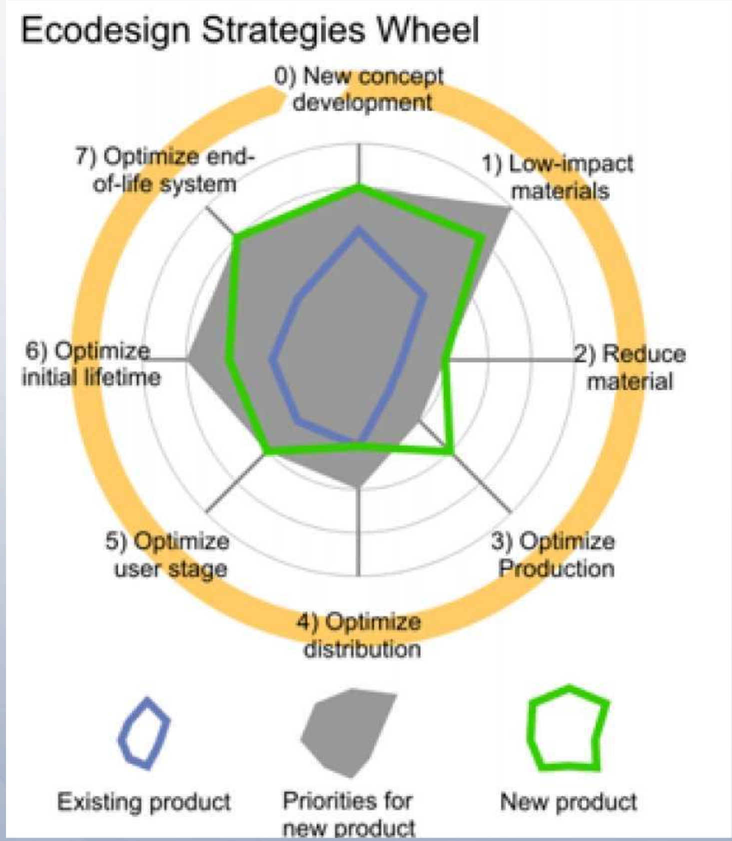
Ecodesign

LCA



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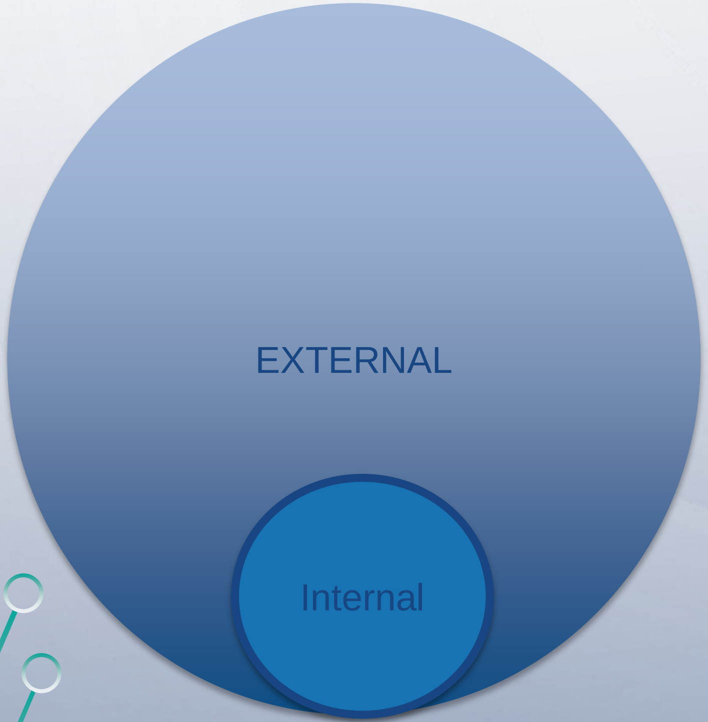
Ecodesign

Ecodesign benefits



- Reduction of manufacturing and distribution costs
- Satisfy consumer demands
- Requirement required in different countries for the import of certain products
- Compliance with environmental legislation, anticipation of future changes
- Show the company's commitment to the environment and sustainability
- Increased added value and product quality (durability, functionality...)
- Possibility to access eco labeling systems
- Possibility of accessing new green purchase markets

- Reduction of manufacturing and distribution costs
- Internal evaluation of the entire product life cycle
- Analysis of alternative configurations based on the life cycle of the products
- Point of reference for the reduction of product impacts
- Obtaining quantified results following standardized methodologies:TRANSPARENCY

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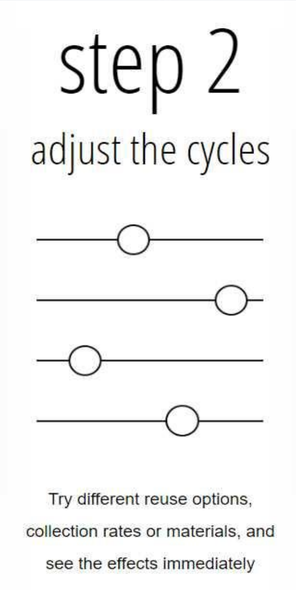
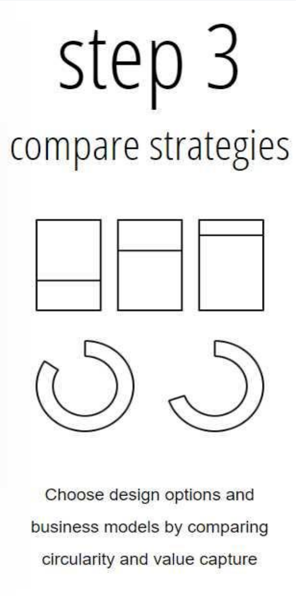
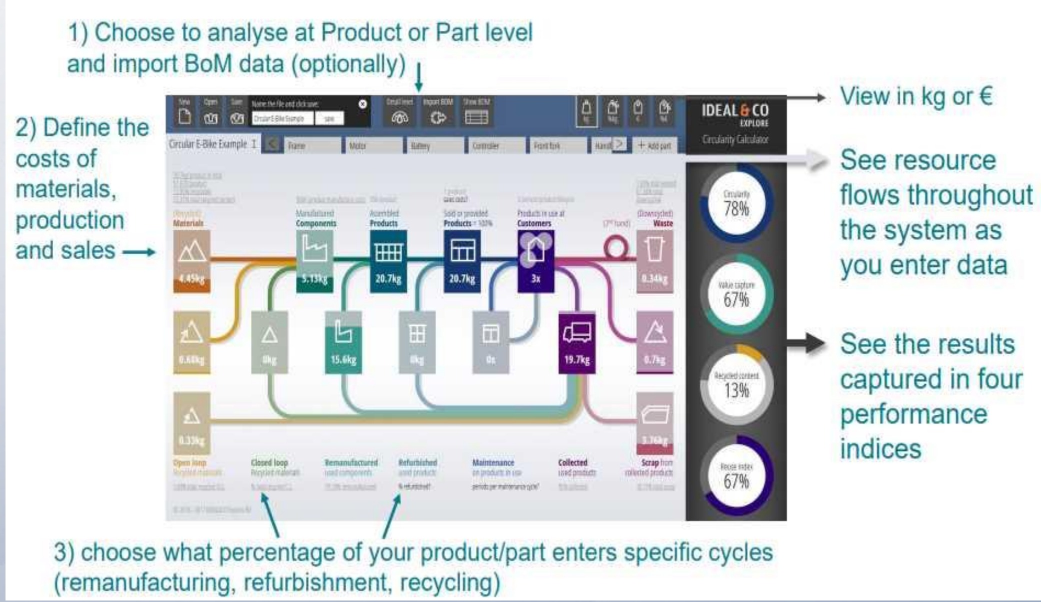
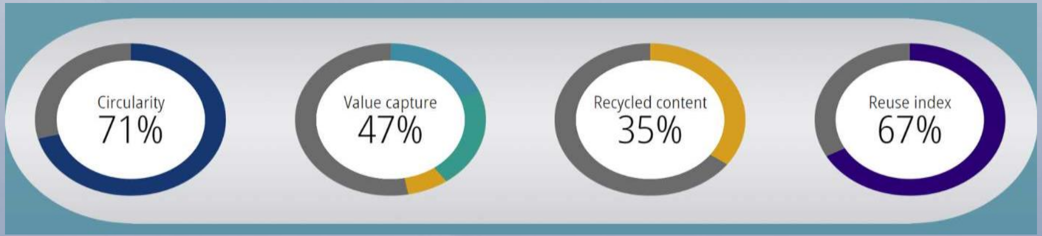
Ecodesign - digital tools

Circularity calculator









[Circularity calculator]

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Ecodesign - digital tools

Hoskins - ***A free Calculator for the Materials Circularity Indicator***

Hoskins tool

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Ecodesign’s role in circular economy

Source: [A Circular Ecodesign Approach to Improve the Circular Economy]

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Conclusions

- Circular economy is key to optimise all kind of resources (material, energy, natural resources & environment)
- Many contributions and initiatives complement and expand circular economy system
- The end-of-life of a product is the key step for its reintroduction to a circular system
- Ecodesign is essential to facilitate the products reintroduction
- Ecodesign is essential to enlarge products’ life
- Current system is not yet properly prepared, meaning some limitations for ecodesign
- Digital tools become very essential to analyse and improve products’ circularity

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DIGITEX

Wearable System Integration and Algorithms

Authors: Aileni R.M.

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Wearable System Integration and Algorithms

- Gaming Armbands
- Smart Shoes
- Fitness Tracker
- Smart Clothing
- Smart Glasses
- GPS tracking Band
- Smart Gloves
- Smart Jewelry

Smart Glove [7]

Myo armband for gesture control [1]

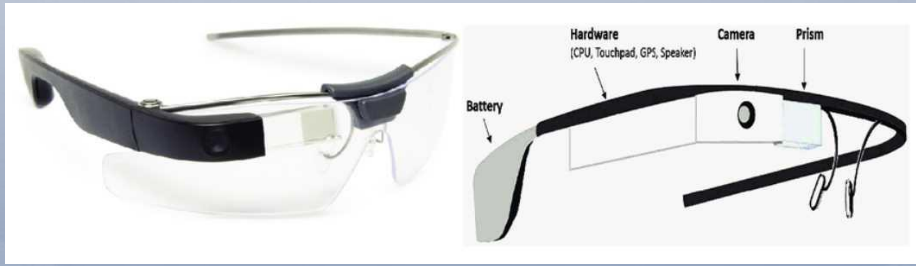
Smart shoes (pressure sensors, GPS) [2]

Garmin GPS tracking band, pulse [6]

Smart ring [8]

Fitness (Pulse, SPO2, Temperature, Steps)

Smart glasses [5]



Smart Cloth (ECG) [4]

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Wearable System Integration and Algorithms

Wearable integration:

1. using PCB with all hard components integrated and textile support (Hard Integration)
2. using textiles with conductive yarns or conductive coatings (having the role of electrodes) + microcontrollers + Bluetooth (Soft-Hard Integration)

Algorithms for smart systems:

-data acquisition using low-power computing;

-signal preprocessing

-extract valuable information from digital data using algorithms, data mining and artificial intelligence (machine learning, deep learning)

-analyzing correlations between different signals in order to establish patterns for medical condition recognition

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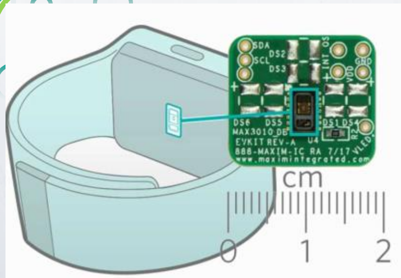
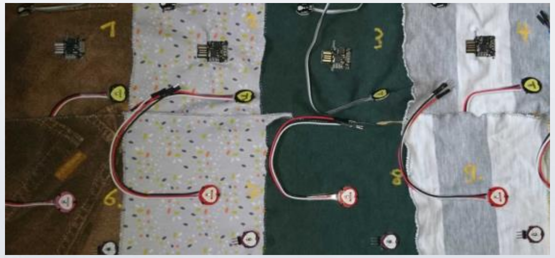
Wearable System Integration and Algorithms

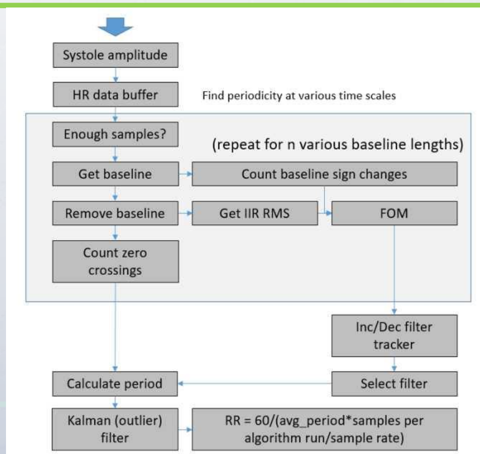
Use case 1 ➔ Pulse /SPO_2 monitoring wearable



Pulse oximeter integration [9]



Pulse/SPO2 sensors integration [10]



SPO_2 Algorithm flow [11]

Integration

➔ In textiles can be integrated hard components (Pulse/SPO_2 sensors by sewing or bonding with adhesives)

Algorithms

Raw signals ➔ Data preprocessing using Savitsky-Golay (SG) filter for denoising signal
➔Heart Rate Algorithm using the following methods:

1. Threshold-Crossing Method
2. Window Method for Heart Rate
3. Fusion Method

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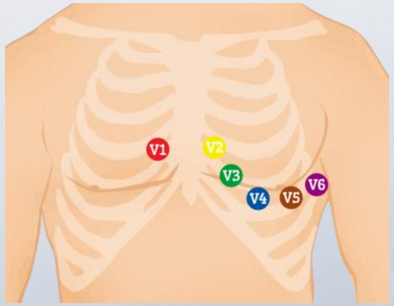
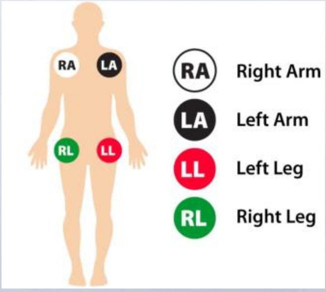
Wearable System Integration and Algorithms

Use case 2 ➔ Heart electrical activity (ECG) monitoring wearable

The garment with ECG leads integrated [12]





The 12-Lead ECG - Chest and Limb Electrodes and Placement [13]

Integration

➔ In textiles can be integrated flexible components (ECG electrodes made by conductive yarns integration in support textile (knit, woven structure) and conductive coating based metallic microparticles.

Algorithms

The electrical activity of the human heart (ECG) consists of several waveforms (P, QRS, and T) [14].

- Algorithms for peak detection (PEAK), slope detection (SQRS) and Length-Transform (WQRS) [15].
- Algorithms such as TERMA that exploit two-event-related moving averages and fractional-Fourier-transform are proposed [14].

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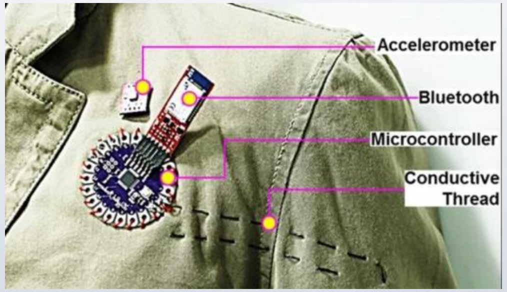
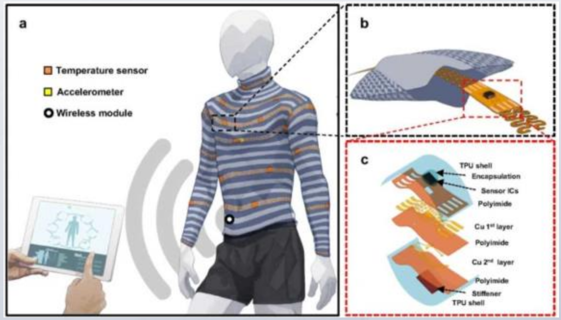
Wearable System Integration and Algorithms

Use case 3 ➔ Fall detection monitoring wearable



Garment with accelerometer integrated [16]



Electronic textile conformable suit (E-TECS) for distributed sensing wirelessly [17].

Integration

➔ In textiles can be integrated hard components such as 3-Axis accelerometer, magnetometers.

Algorithms

Fall-Detection Algorithm Using 3-Axis Acceleration can use:
-a combination with Simple Threshold and Hidden Markov Model [18];
-the k- Nearest Neighbors' algorithm [19];
-Deep Learning Fall Detection Algorithm [20].

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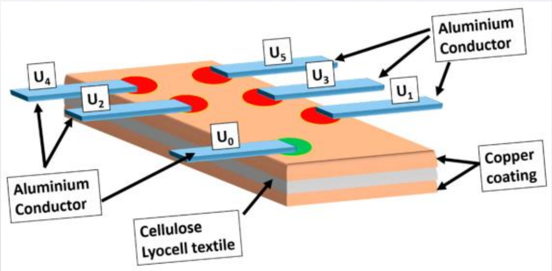
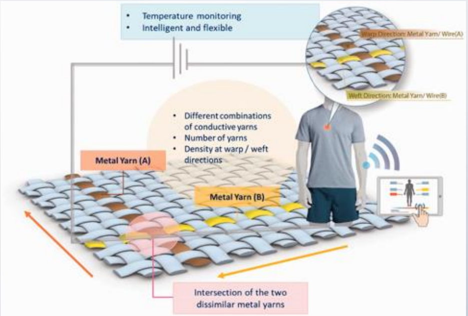
Wearable System Integration and Algorithms

Use case 4 ➔ Temperature monitoring wearable



Copper-coated cellulose textiles obtained by magnetron sputtering are used as a conductor matrix for temperature measurement [21].



Weaved thermocouple [22]

Integration

In textiles can be integrated thermocouples made by interconnecting 2 yarns or surfaces (A, B) from different metals (e.g., A copper and B constantan (Cu/Ni)) obtained by weaving, knitting, sewing, or magnetron sputtering.

Algorithms

Raw signals ➔ Data preprocessing ➔ Signal sampling [10-15 minutes for temperature control]

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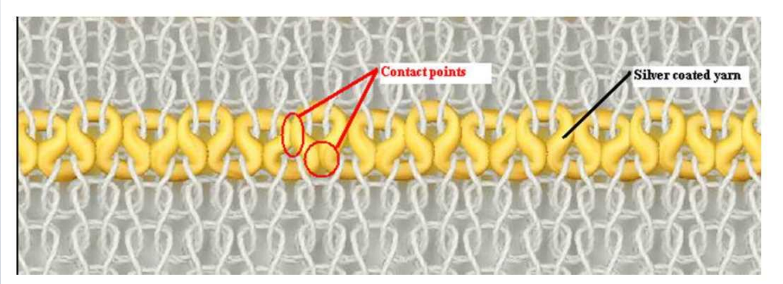
Wearable System Integration and Algorithms

Use case 5 ➔ Respiratory rhythm monitoring wearable


Respiratory Belt Transducer [23]



Knitted sensor for respiration monitoring [24]

Integration

➔ In textiles can be integrated flexible components (belts for respiration rate monitoring) using integration by sewing, knitting

Algorithms

- raw data filtering in order to remove baseline drift, using median filtering, wavelet transform, and morphological filtering [25];
- respiratory data analysis by evaluating the ratio of the inspiratory time to the expiratory time in one breathing cycle [25];
- classification by support vector machine of the respiratory data as normal or abnormal [25].

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DIGITEX

Market Dynamic and opportunities

Author: Silvana Laudoni, Ciape, Rome Italy

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Introduction

Smart textile represents a rapidly growing market. Even if this is a complex sector, where both technological and not technological issues need to be solved, potentials far outweighs challenges. The increasing demand for wearables, technological advancements, nanotechnology progresses and manufacturing developments are among the main drivers determining the growth of the sector.

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Breakup of Smart Textile market

TYPE

- Passive Smart Textile
- Active Smart Textile

FUNCTION

- Sensing
- Energy Harvesting
- Luminescence and Aesthetics
- Thermoelectricity

END-USE SECTOR

- Military and Protection
- Healthcare
- Sport and fitness
- Fashion
- Transportation
- Architecture

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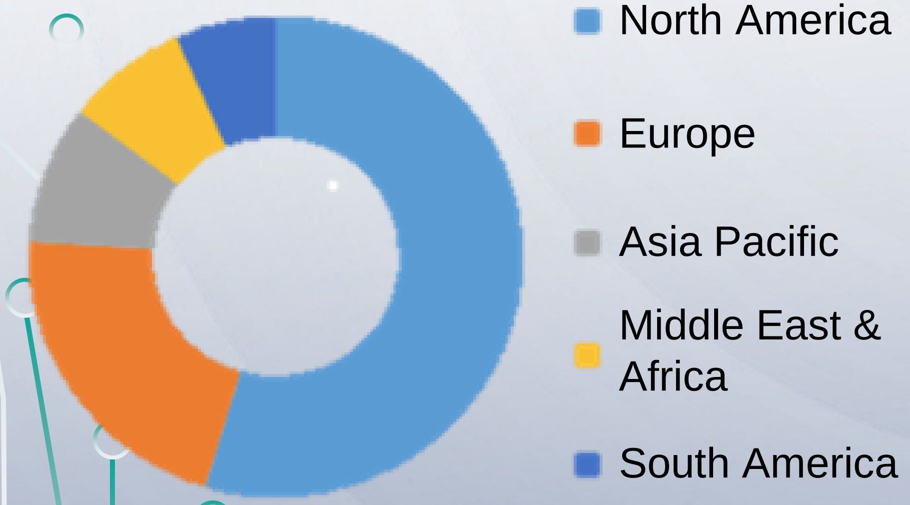
Market shares by Region



Regional Analysis in 2021 (%)

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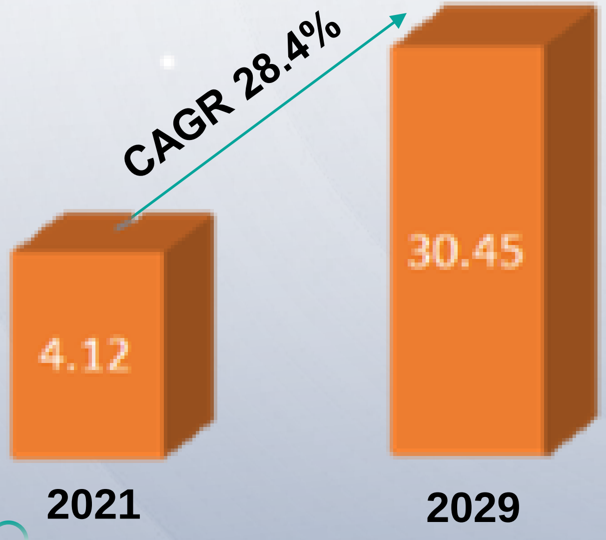
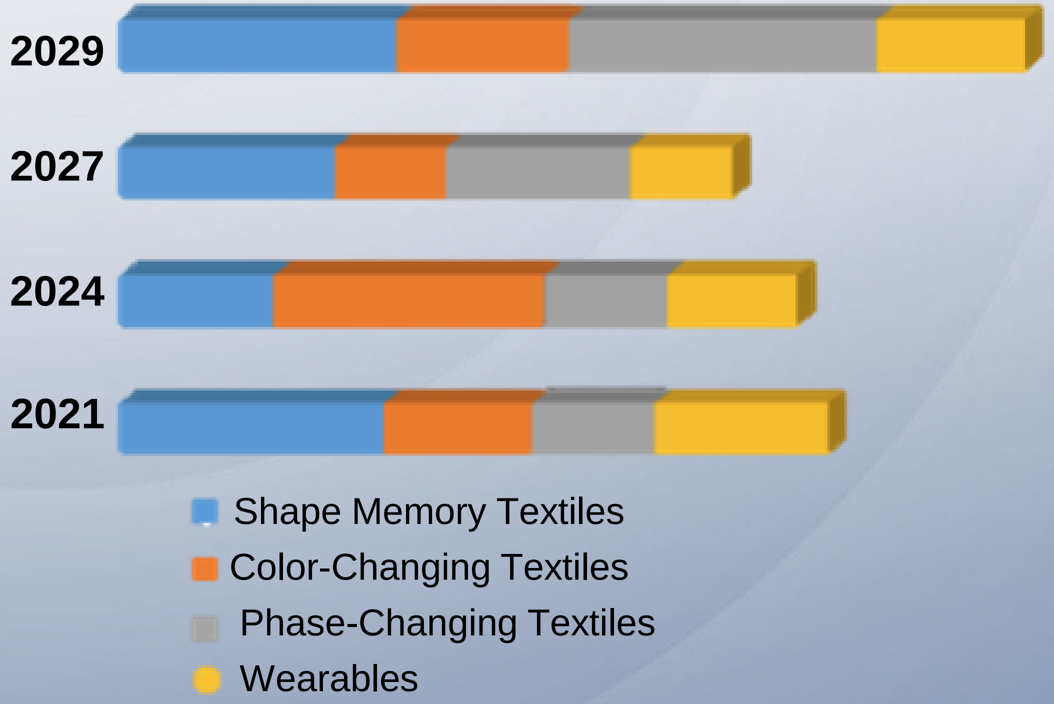
Market growth forecasts



Market Size in US$ Billion



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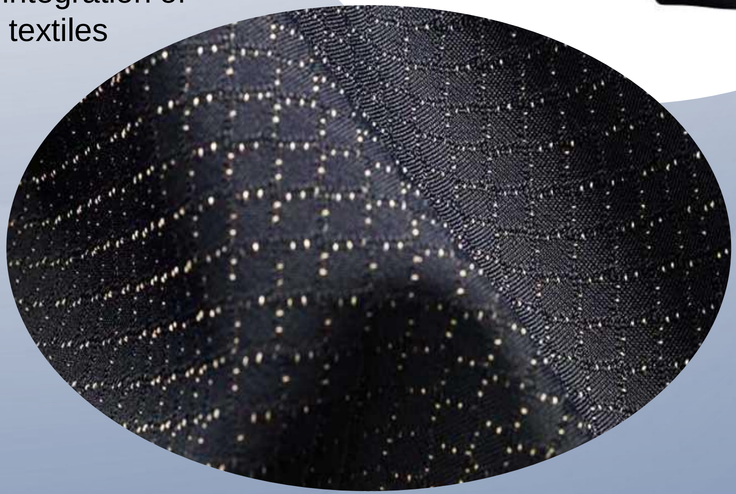
Key market players

- DuPont
- Alphabet
- Jabil
- AIQ Smart Clothing
- Sensoria
- Adidas
- Schoeller Textil AG
- Interactive Wear AG
- Google LLC
- Ohmatex A/S

Intexar by DuPont: integration of conductive inks into textiles

Sensoria Smart Socks: textile sensors detecting parameters important to the running performance



Scholler e-soft: hearable fabric lining with an integrated network of conductive yarns

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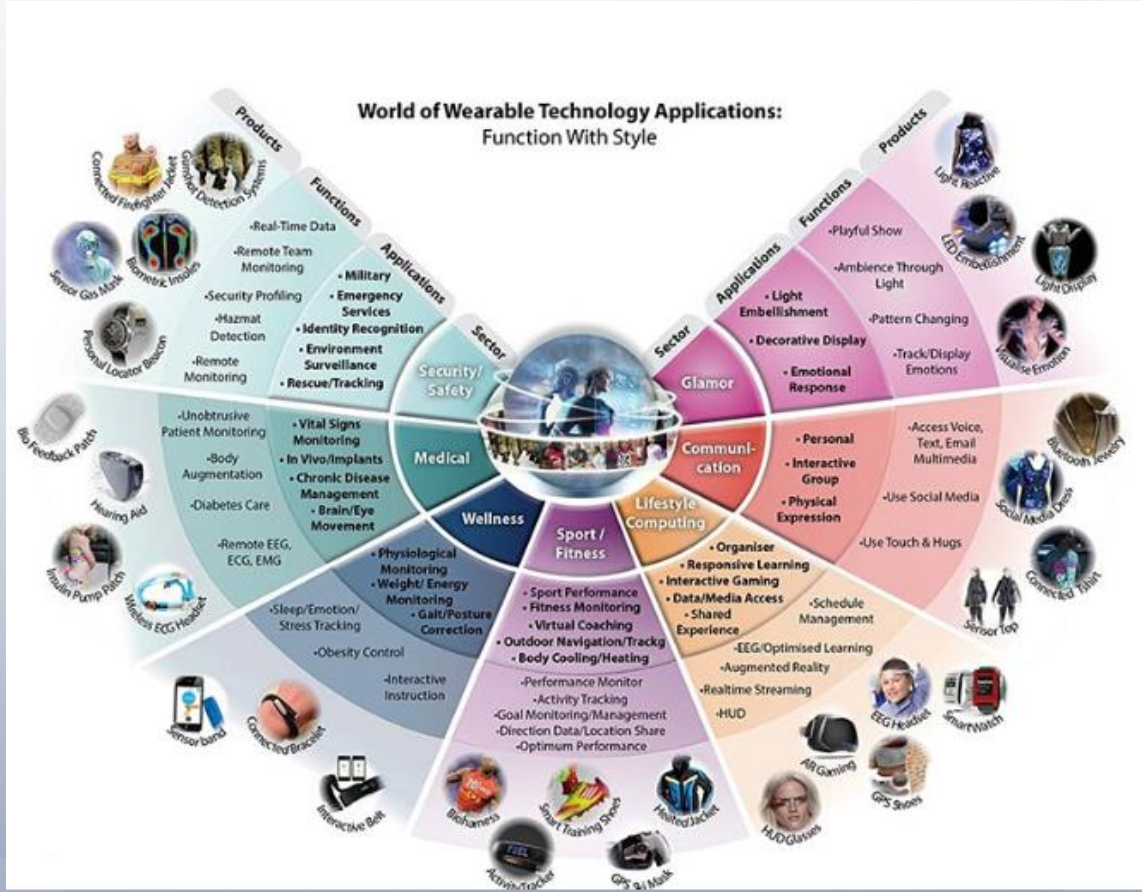
Main applications



Credit: Beecahm Research
Source: SMART TEXTILES IN EUROPE: THE NEXT TECH DISRUPTION – SMARTX EUROPEAN SMART TEXTILE ACCELERATOR

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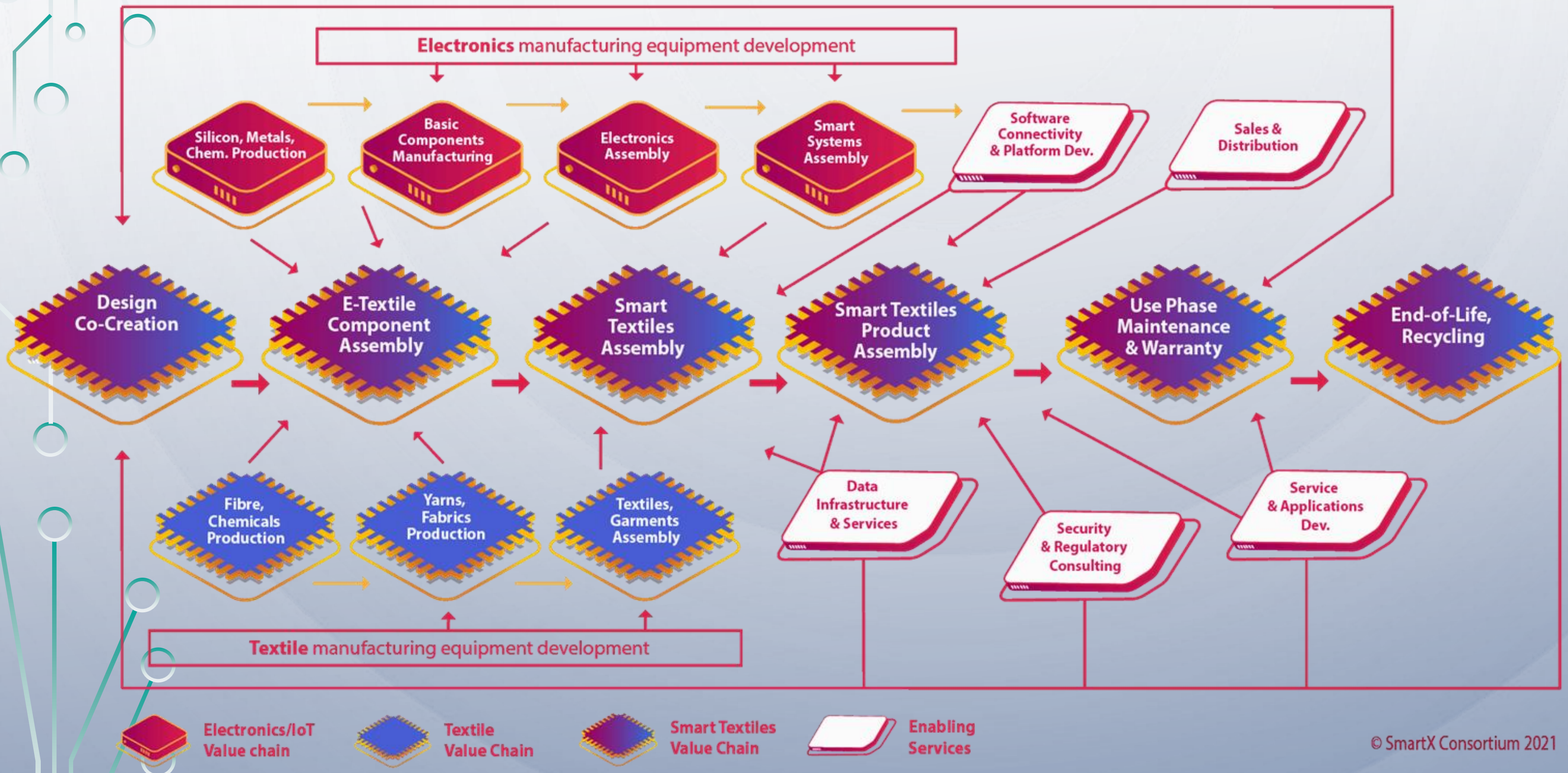
Smart Textile value chain



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Market development challenges

Technical	Non-Technological
• Lack of fully automated processes for integrating electronics into textiles in an affordable way • Need for scalable and cost-effective manufacturing technology for flexible and printed electronics • Need to speed up the development process in key areas, such as 3D Printing of conductive materials and incorporation polymer semiconducting materials onto textile • Maintenance and recycling • Data processing	• Lack of standards and test methods • Lack of effective cooperation methods between ecosystem actors • Lack of clear regulatory frameworks • Lack of sufficient education • Low consumers’ level of awareness

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Market drivers / opportunities

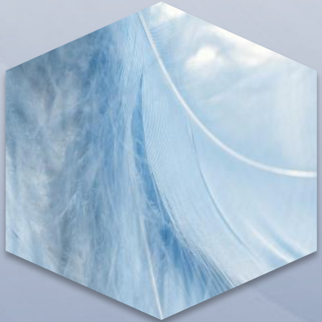
Internet of Things

Rise of wearables applications

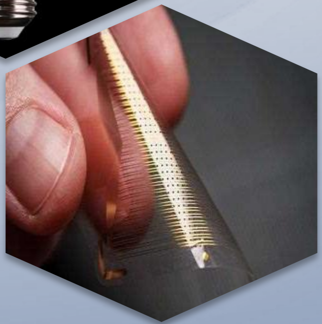
5 G and broadband enabled devices

Lower energy consumption

Demand for lightweight and durable fabrics



New composites



Flexible electronics and hybrid applications

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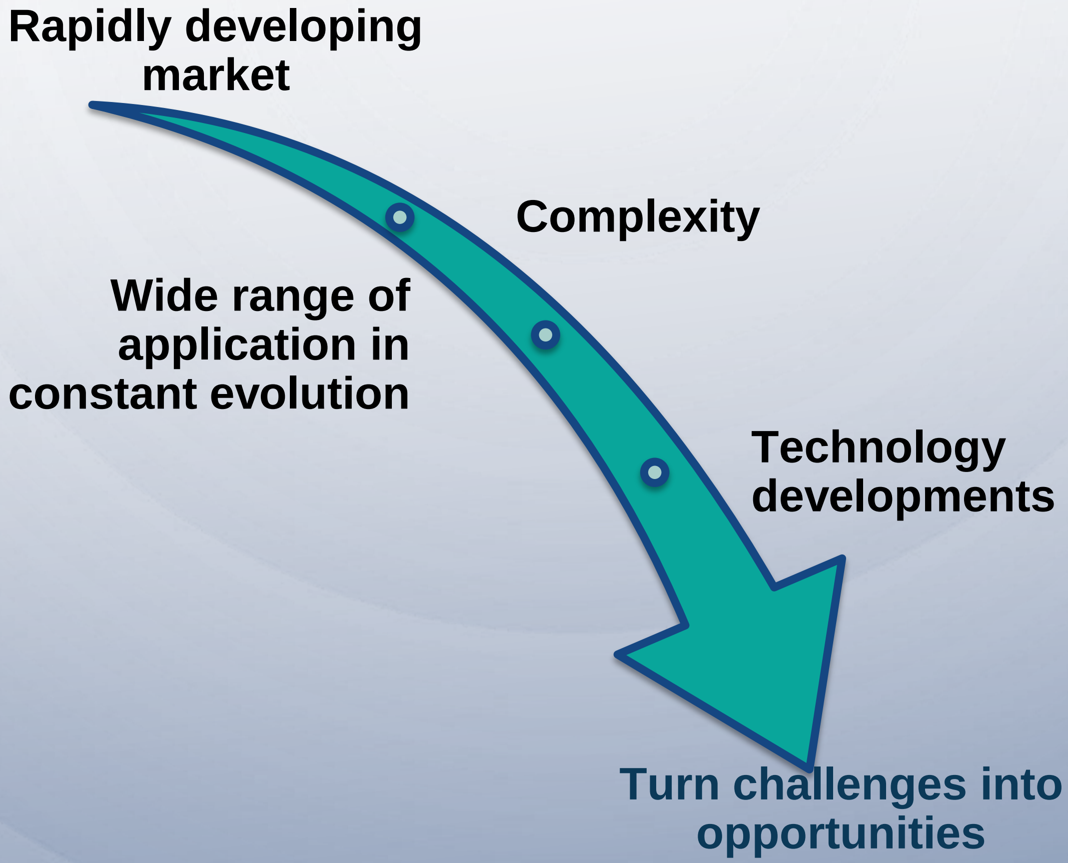
Key points



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