Introduction to EU-H2020 project WEARPLEX: Wearable multiplexed biomedical electrodes

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H2020-ICT-02-2018

Overview

- Introduction to WEARPLEX project and concept
- Project Partners
- What is FES and EMG?
- State of the art multi-electrode systems for FES and EMG
- Printed ink development
- Printed logic Demultiplexor
- E-textile integration
- Mass manufacturing
- Workshops
- Contacts

Introduction

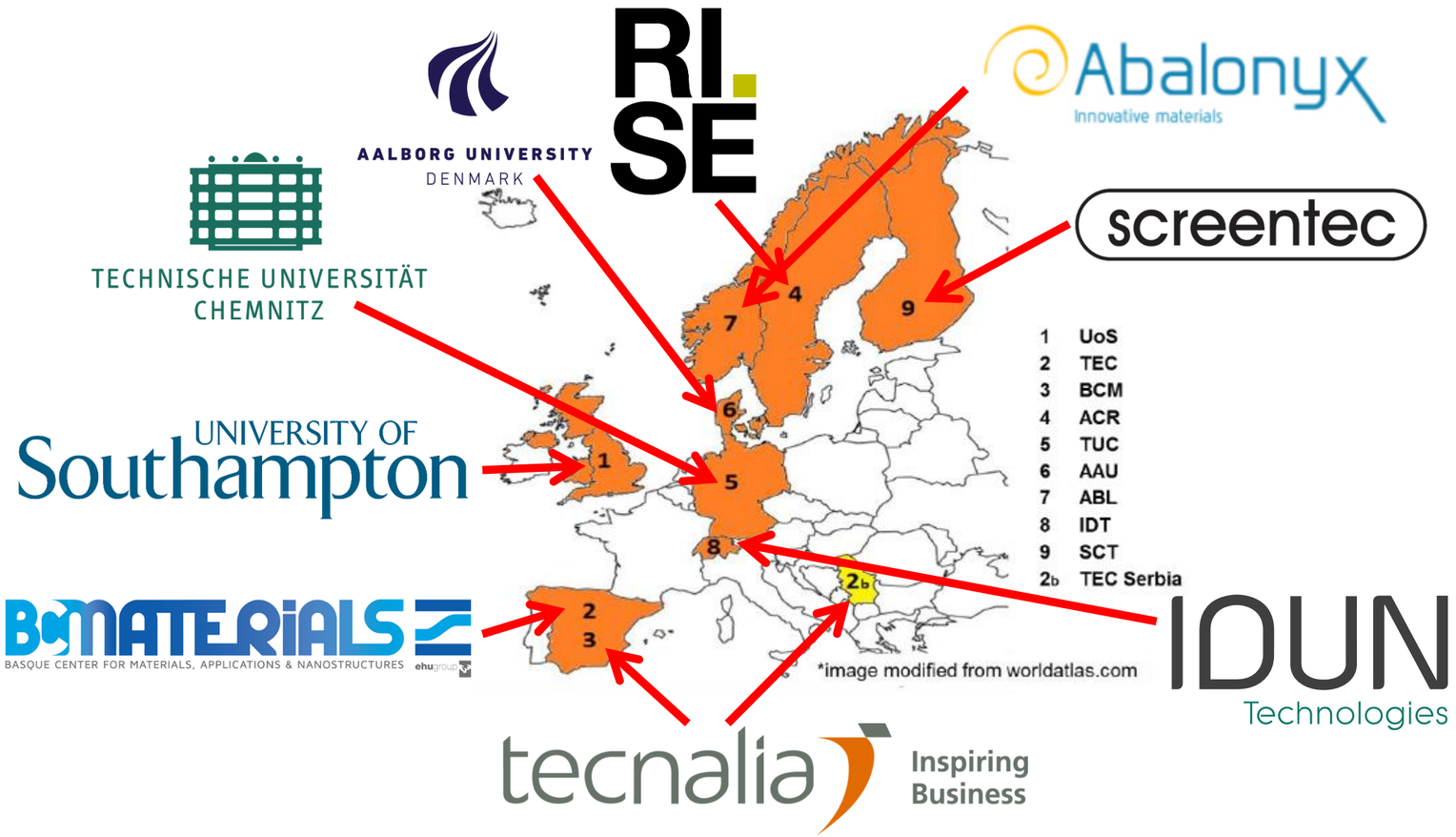
- WEARPLEX is a 3 year €3.7M multi-disciplinary research and innovation action, started January 2019.
- Submitted to the ICT-02-2018 - Flexible and Wearable Electronics call for proposals; focus on manufacturability, integration and demonstrators.
- **Aim:** Integrate printed electronics with flexible and wearable textile-based biomedical multi-pad electrodes.
- **Key Focus:** Printed electronics on textiles, printed multi-pad electrodes with integrated logic circuits to adjust the size and shape of stimulation and recording electrodes.
- **Key novelty:** Development of a smart electrode which can adapt to the subject but also to the recording/stimulation system, allowing an increase from 1 to N channels – flexibility of a matrix recording to ‘conventional’ recording/simulation systems.
- Printed electrode pads will be addressable into virtual electrodes.
- Software methods developed for automatic calibration of the virtual electrodes to adapt to individual users.
- Virtual electrodes allowing stimulation and recording from the same device.

Why WEARPLEX?

- Medical electrodes market is $1B globally, despite being mostly lab or clinic use.
- Several markets for wearable EMG and FES devices:
  - Stroke Rehabilitation (1 every 2 seconds, expected to be 70 million survivors by 2030).
  - Haptic interfacing, e.g remote control, gaming, assisted living.
  - Posture correction and pain relief .
- Combining with textiles allows easier setup, home use, reduced clinician time, reduced healthcare costs.

Project Partners

- 9 Project partners across Europe, 3 Universities, 3 Research Institutes and 3 SME's.

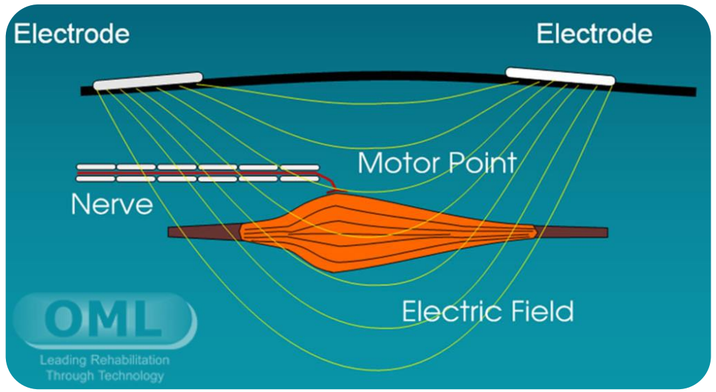


Project Partners

- *University of Southampton* (UoS) – Coordinator – expertise in printed electronics on fabric and e-textile fabrication.
- *Tecnalia Research and Innovation: Spain and Serbia* (TEC) – Expertise in multi-pad electrodes, FES and printed electronics.
- *Basque Centre for Materials, Applications and Nanostructures* (BCM) – Expertise in printed ink development.
- *Research Institutes of Sweden* (RISE) – Printed electrochemical transistors and logic devices.
- *Technical University of Chemnitz* (TUC) – Printed electronics mass manufacturing.
- *Aalborg University* (AAU) – Expertise in recording and analysis of EMG signals, application of FES and clinical assessment.
- *Abalonyx* (ABL) – Expertise in GO and rGO for printed electronics.
- *IDUN Technologies* (IDUN) – Expertise in electrode design and biopotential monitoring.
- *Screentec* (SCT) – Expertise in industrial printed electronics and medical devices.

What is FES?

- Functional Electrical Stimulation (FES) is used to electrically stimulate motor nerves in order to activate paretic muscles.
- The stimulation is controlled and targeted to specific nerves to provide useful movement of a limb (e.g grasping, stepping).
- Treatment for Stroke survivors for upper limb therapy, drop foot for Stroke and Multiple Sclerosis sufferers, muscle pain relief.
- Typical stimulation signal between 10 and 100 Hz, 5-50 mA, 200-500 µs.



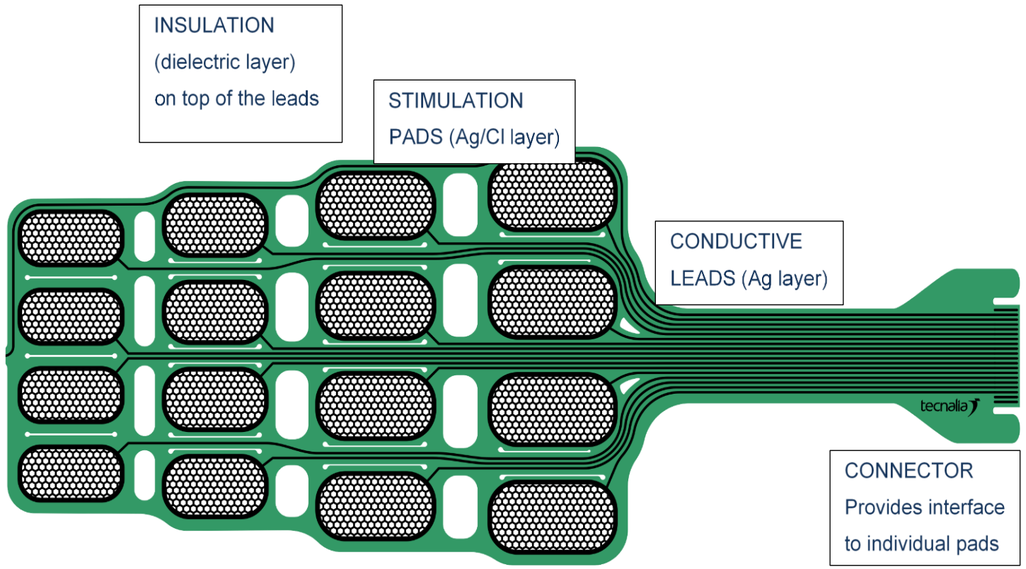
Electrical stimulation of nerve to drive muscle contraction

What is EMG?

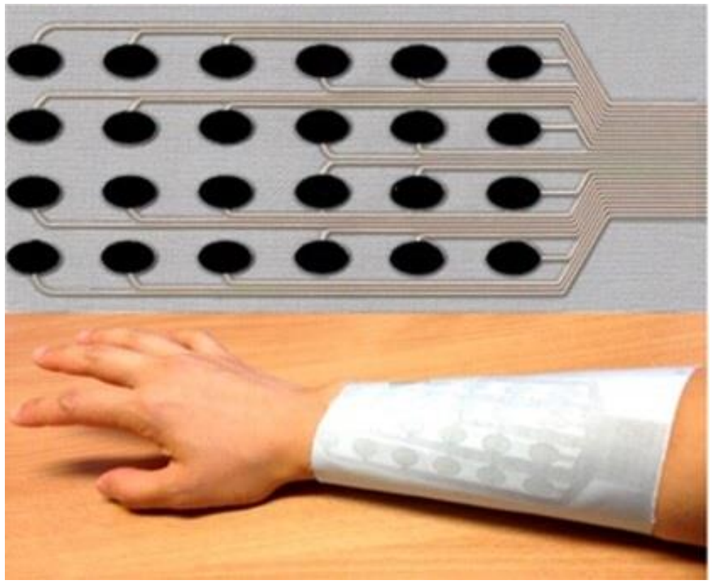
- EMG is Electromyography – a process for measuring the electrical potential generated by muscles.
- We specifically look at surface EMG, measuring the electrical activity at the skin closest to the muscle.
- By measuring EMG we can determine the health of muscles and their control nerves.
- EMG can also be used to estimate the motor intention of the subject for the purpose of myoelectric control.
- Signal is typically in the mV range with useful frequency content up to 150-200 Hz.
- More electrodes provides more muscle specific information for a given movement or gesture.
- This allows increased selectivity and quality of EMG recording and electrical stimulation delivery; leads to improved assessment and motor intention estimation (EMG) and better movement generation (FES).

State of the Art Electrode Technology

- Existing multi-pad electrode structure using printed electronics on flexible plastic and FES electrode array printed directly on fabric.



Printed FES electrode array on plastic (TEC)

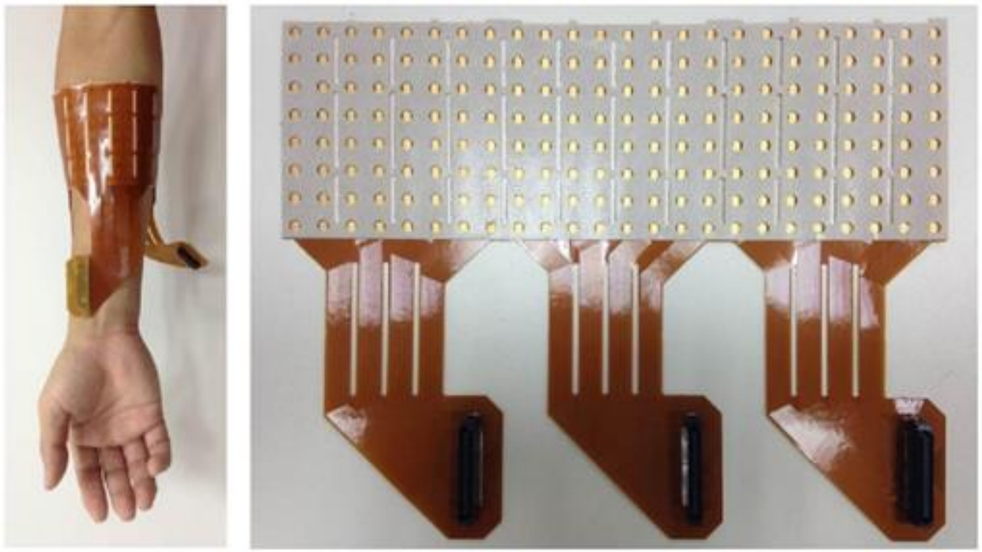


Printed FES electrode array on fabric (UoS)

- For each device, the electronics is connected separately and is not integrated within the electrode structure.

State of the Art Electrode Technology

- High density EMG electrodes exist (192 channels) but all switching is performed using external electronics and flat cables.



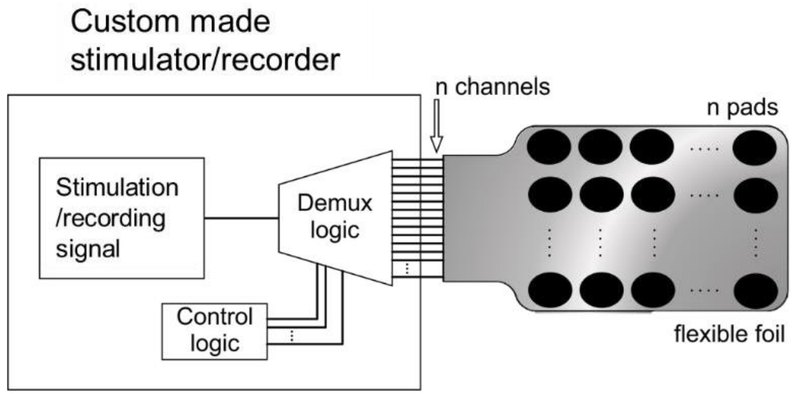
Etched copper EMG electrode array on plastic

Extensive cabling required

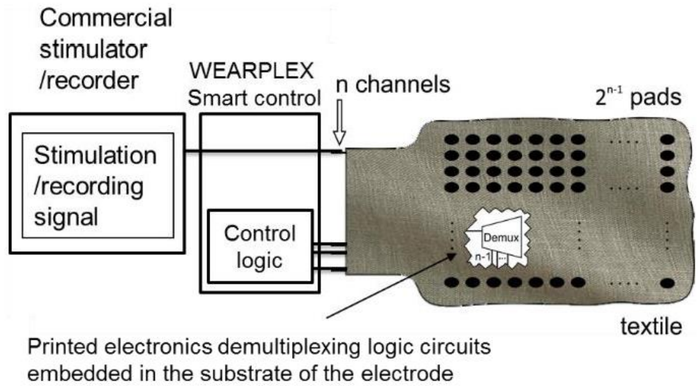
- No commercially available devices combining EMG and FES and no fully printed examples in the literature.

State of the Art Electrode Technology

- Proposed WEARPLEX solution combining EMG and FES electrode structure and recording/stimulating circuitry on one smart textile device.
- AAU and TEC have extensive experience in using multi-electrode systems for EMG and FES use.



Current state of the art multi-electrode system



Proposed WEARPLEX solution

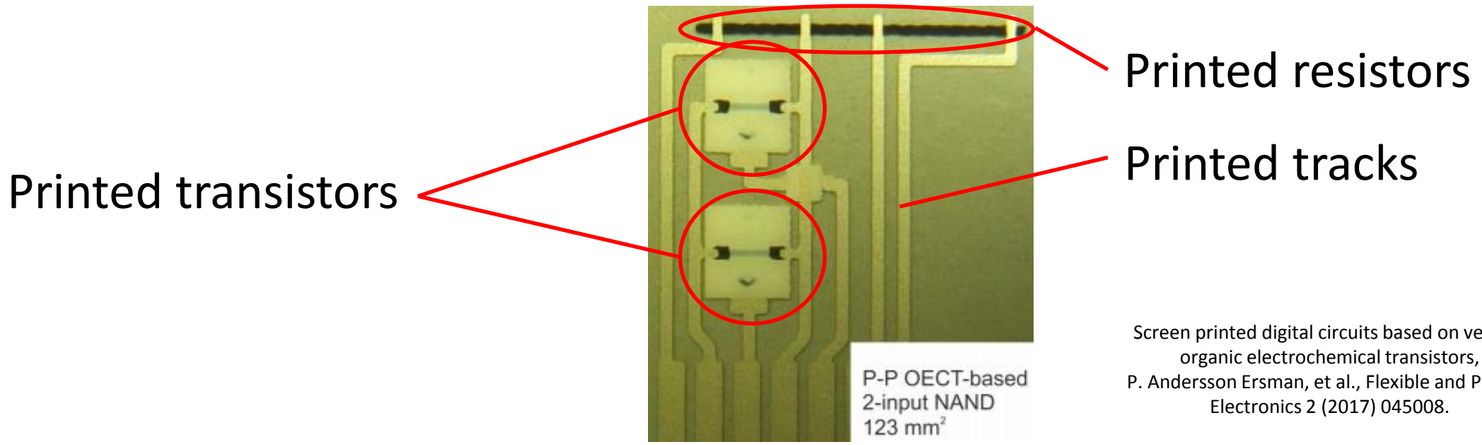
WEARPLEX concept of 'virtual' electrodes

Printed Ink development

- BCM, TEC, IDUN and ABL focused on developing improved performance materials.
- The printed electrodes and devices will consist of several printed layers each requiring a new material tailored for this application.
- Interface ink - provides smoothing layer on the fabric; printed only where required to minimise loss of fabric properties.
- Conductive inks – used for conductive tracks between electrodes and interconnects with printed logic circuits.
- Dielectric inks – used as insulator layers for printed logic circuits.
- Skin interface – used to interface between the WEARPLEX system and the skin.
- Semiconductor inks – used to achieve high definition printed logic circuits.

Printed Logic - Demultiplexor

- To achieve the full WEARPLEX concept it is necessary to achieve a printed demultiplexor circuit.
- RISE Acreo has developed OECT-based logic devices.

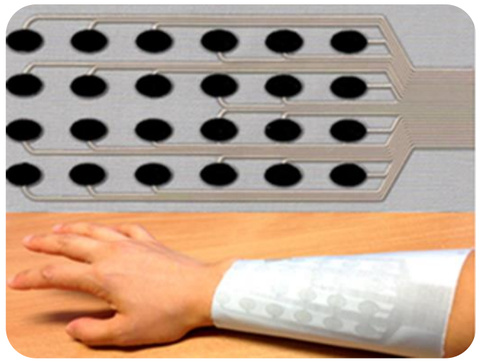


Screen printed digital circuits based on vertical organic electrochemical transistors, P. Andersson Ersman, et al., Flexible and Printed Electronics 2 (2017) 045008.

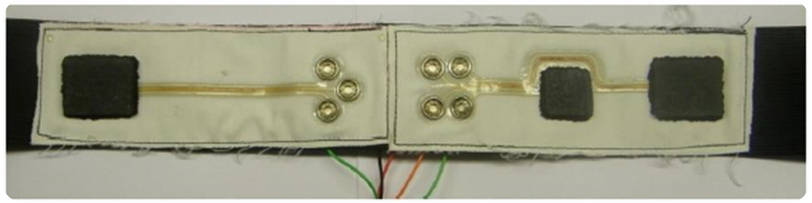
- Currently able to achieve much higher currents than OFETs but much slower switching times, ~10ms+ - an issue in more complex circuits.
- Significantly less sensitive to layer thickness (1-10 µm) compared to OFETs (100nm), making them the only viable option for printing directly on textiles (interface surface roughness is 1-5 µm).

E-Textile Integration

- WEARPLEX combines printed electronics with textiles to create e-textiles.
- UoS has developed a number of printed electrode devices on textiles.



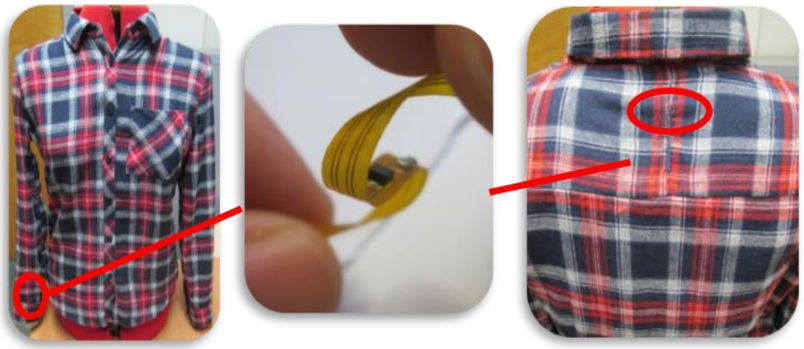
Printed FES array on fabric



Printed ECG electrodes on fabric

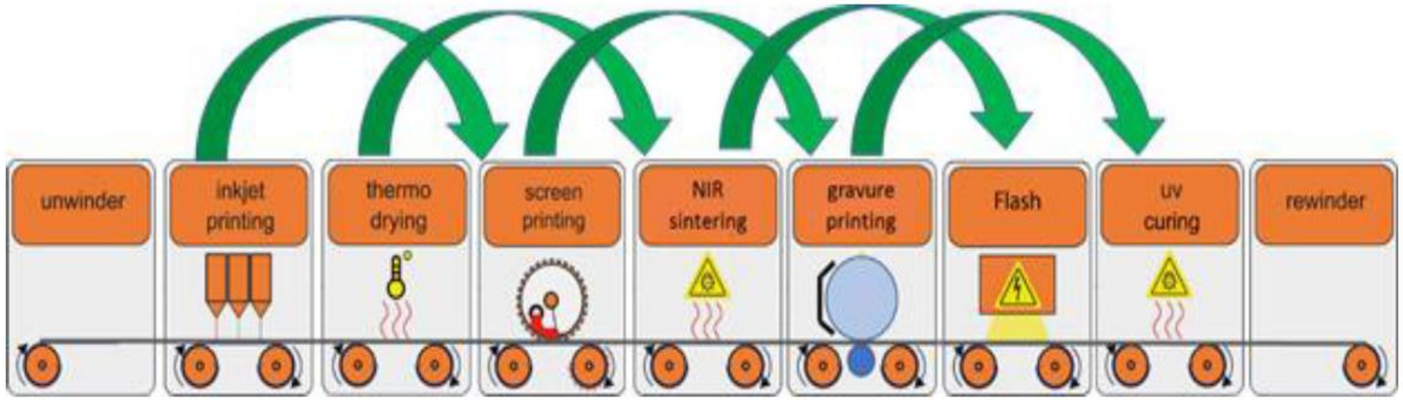
Printed Full Frank configuration

- And integration of flexible electronic circuits into textiles.



Mass Manufacturing

- Screentec and Technical University of Chemnitz are leading this work.
- Have significant experience in developing large scale roll to roll and sheet to sheet printed electronic applications.
- Aim is to achieve processes necessary to achieve scale up of production for WEARPLEX system.
- Delivery is at the end of the project for Gamma prototype



Modular roll to roll process machinery concept from TUC

Stake Holders Board and Workshop

- Seeking members for a Stake Holders Board for the project.
- Representatives from the relevant industries, health and sports professionals, patient associations.
- 3 workshops to be held during the project:
  - WS1 – Alpha demonstrators - Specifications: 1 day event during 2019, planned to be linked with 13th International Workshop on FES in Vienna, September 23-25th - https://fesworkshop.org/13th-workshop-2019
  - WS2 – Beta demonstrators – Technological leap: 1 day event adjacent to a Wearable electronics international conference in 2020.
  - WS3 – Gamma demonstrator – WEARPLEX powered products: 1 day event at Medica fair or Wearable electronics international conference in 2021.

Website and Social Media

http://wearplex.soton.ac.uk

https://uk.linkedin.com/company/wearplex-project

https://twitter.com/wearplex @wearplex

https://www.instagram.com/wearplexproject/

https://www.youtube.com/channel/UCER_bp0sOqU3N5j0CW-B9dA

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- Thanks to other colleagues also working on the WEARPLEX project: Abiodun Komolafe, Kai Yang, Helga Nunes-Matos, Monika Glanc-Gostkiewicz, Matija Strbac, Goran Bijelic, Raquel Gonzalez, Nikola Perinka, Arvad Hubler, Maxim Polomoshnov, Erika Spaich, Azadeh Moteallah, Siamek Eqtesadi, Simon Bachmann, Jenni Isotalo, Roelof Aalpoel.

Some of the consortium at the WEARPLEX kick-off meeting in Brussels – Jan ‘19

Call to Action

- Volunteers for the Stakeholder Board and Attendees to WEARPLEX Year1 Workshop.
- Alpha demonstrators shown, technical, clinical and business discussion.
- 1 day event – Provisional date **Wednesday 25th September**, Vienna, Austria.

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