



Seminar  
**Smart and Safe Work Wear**

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Rovaniemi*

## Electronics Integrated into Textiles

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# Why «smart»?

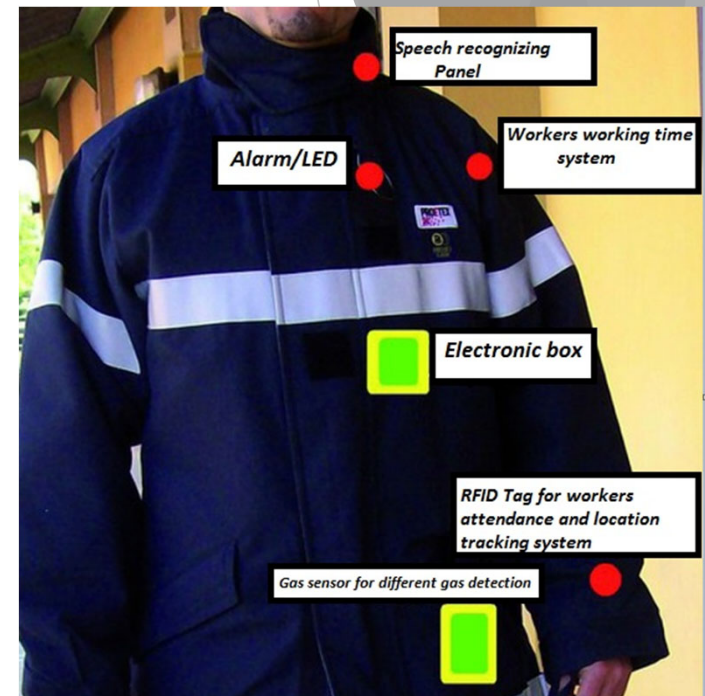
- ▶ “Smart materials and structures can be defined as the materials and structures that sense and react to environmental conditions or stimuli, such as those from mechanical, thermal, chemical, electrical, magnetic or other sources”

# Wearable technologies and needs of end-user segments

- ▶ The development of wearable intelligent textiles systems has changed the concept of clothing.
- ▶ **Smart clothes** make it possible not only to **identify, store and transmit data** about the basic values and activities of the **wearer's life, and environmental parameters**, but also to **adapt to the wearer's needs**.
- ▶ **Integrating electronics** in clothing so that the user does not need to perform unnecessary hand movements for mobile use is one of the main tasks [3].
- ▶ The introduction of intelligent textiles has revealed the need for integrated, invisible and convenient wireless communication systems in clothing [4], that are as light and wearable as possible [5].

# Wearable technologies and needs of end-user segments

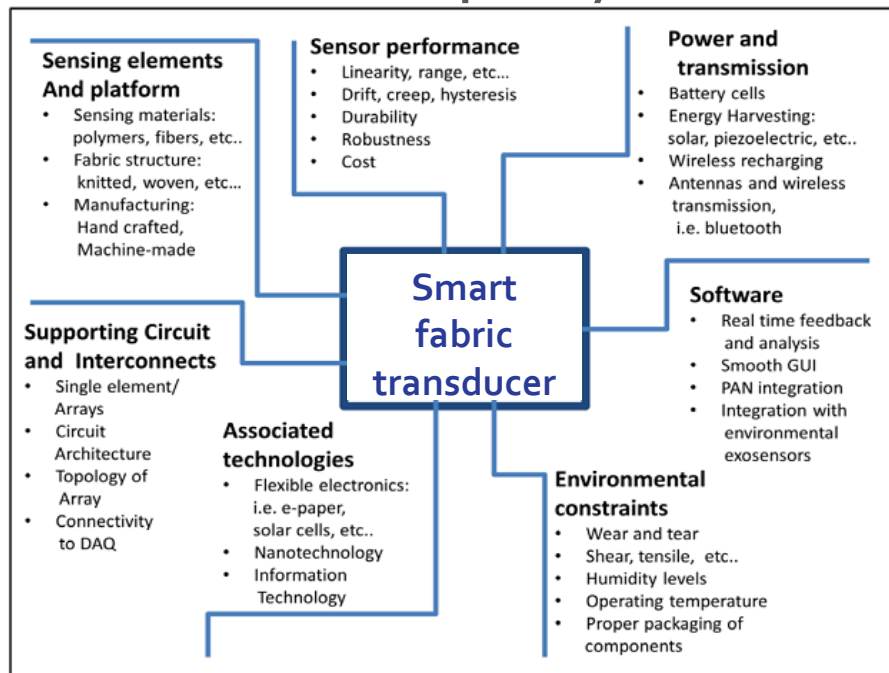
- Factors to be considered before implementing technological solutions :
  - ❑ comfortness of the users with integrated sensors and tags;
  - ❑ ability to withstand several washing cycles with integrated stretchable electronics technology;
  - ❑ compatibility to extreme environmental conditions including heat, water, different toxic gases, stretchable conditions etc.;
  - ❑ resistance to chemical industrial work environment;
  - ❑ wireless connectivity to some applications or control system.



Possible technological solutions in different parts of work wear [1]

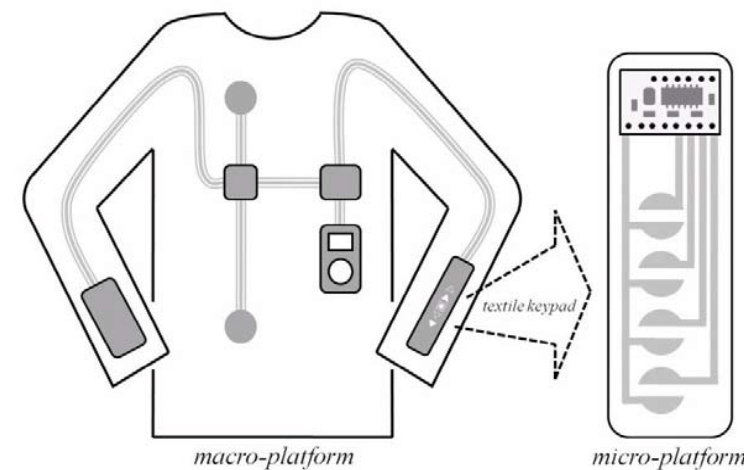
# Problems

- The development of a smart textile direction requires extensive interdisciplinary collaboration



# Technologies to incorporate electronic components into work wear

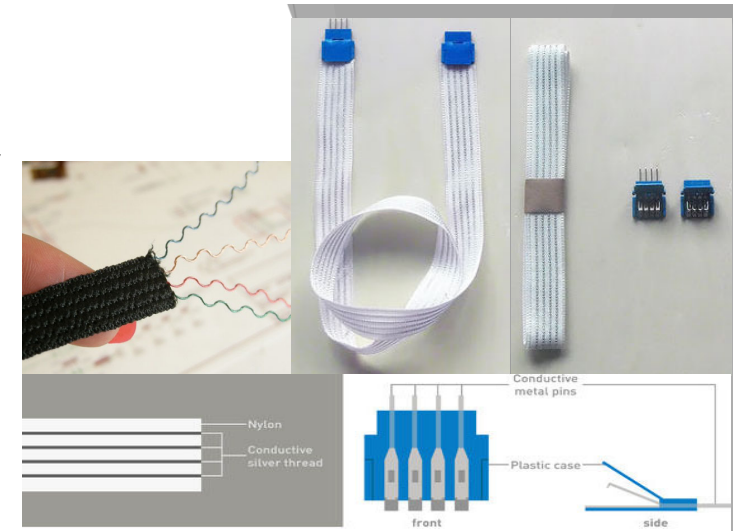
- ▶ The task of an electric circuit is to connect the electrical elements to form a functional system.
- ▶ Electronic elements can be:
  - ❑ sensors,
  - ❑ actuators,
  - ❑ transistors,
  - ❑ power supplies, etc. *that are integrated into smart textiles.*
- ▶ Electrotechnical platforms can be divided into two categories:
  - ❑ a microplatform (for connections between close-up electronics);
  - ❑ a macroplatform (for connections between each individual subsystem in one or more products) [6].



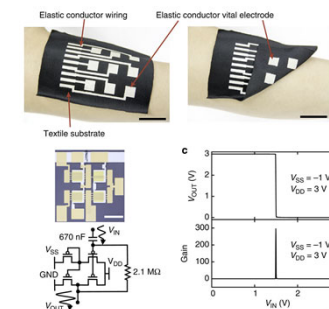
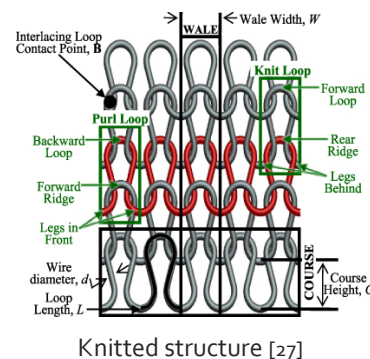
Electro-textile platforms [6]

# Methods used to design electrically conductive textile platforms

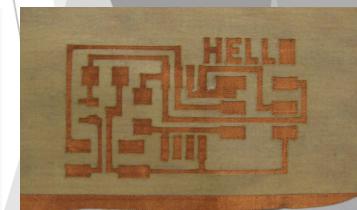
- ▶ 1. Sewing and embroidering
  - ❑ 1.1. Sewing
  - ❑ 1.2. Embroidering
- ▶ 2. Weaving
- ▶ 3. Knitting
- ▶ 4. Printing
  - ❑ 4.1. Screen-printing
  - ❑ 4.2. Inkjet printing
  - ❑ 4.3. 3D printing
- ▶ 5. Mordanting
- ▶ 6. Lamination
- ▶ 7. Embedding RFID chip in yarn



Electro-Textiles [8,9,10,11]



Printed textile electronic elements [39,40,41]

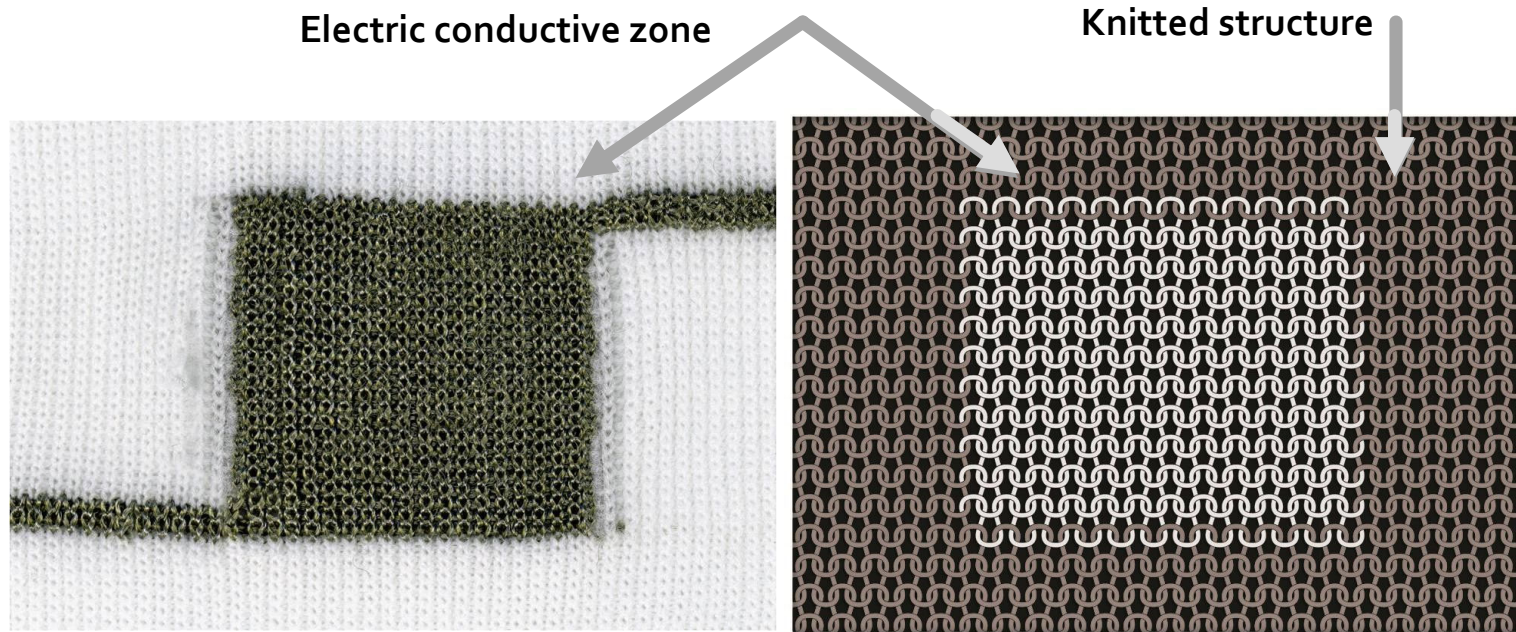


Mordanted textile scheme [43,44,45]



# Example: electrically active knit structures

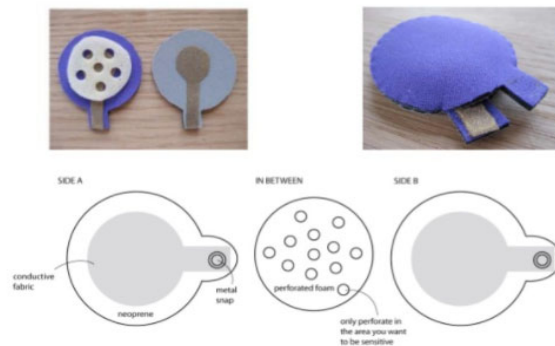
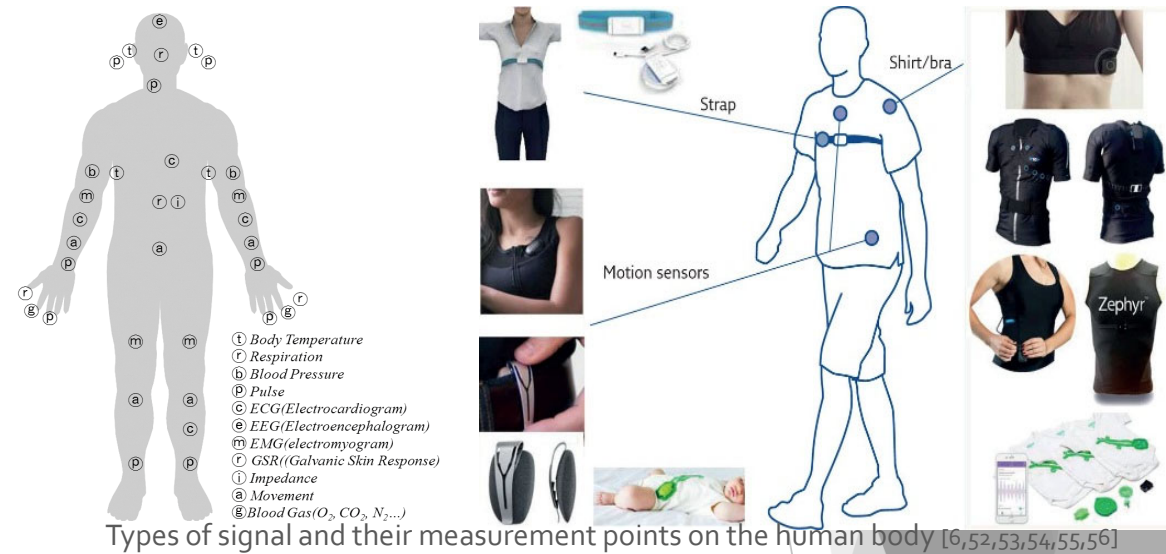
- Integrated electro conductive yarn in knitted structure





# Solutions

- ▶ Textile sensors and switches
- ▶ Pressure sensitive sensors
- ▶ Electric conductive connectors system
- ▶ Measurements of biomedical signals



Soft push switch [66,67,68]



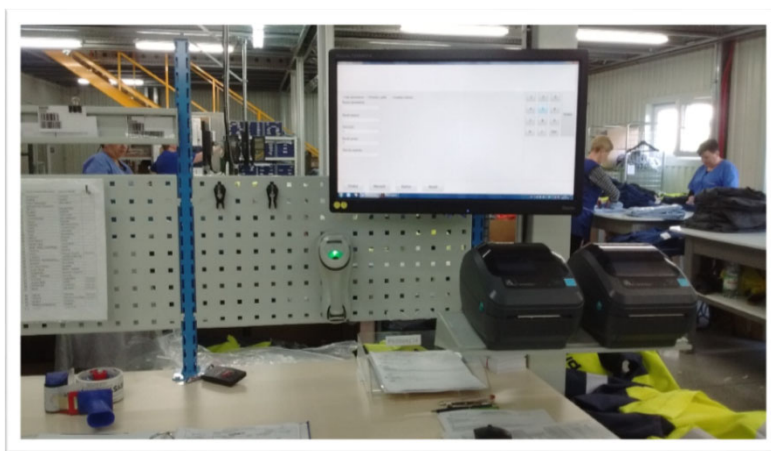
Zipper switches [73,74,75]



Textile electrodes [59,60,61,62,63]

# Textronic clothing

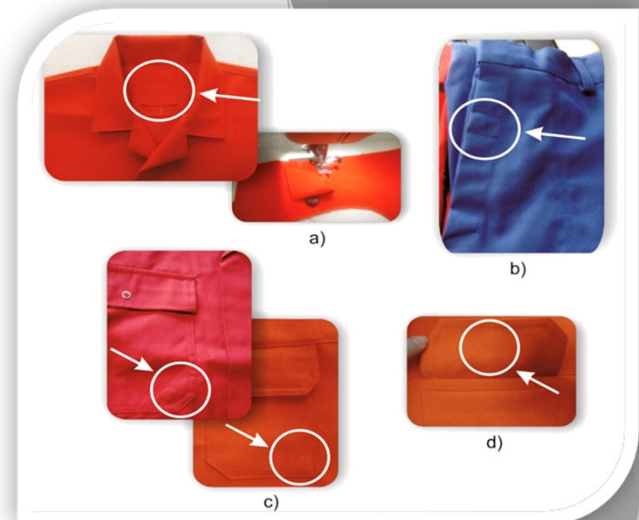
## *RFID Tags*



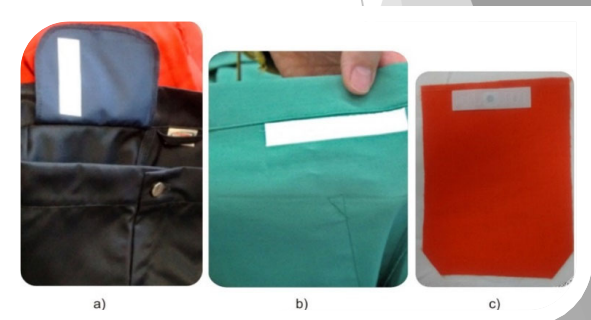
# Clothes with RFID tags

## Benefits of the TAG GUARD (that have been selected):

- ▶ Quick and easy get information about product
  - ❑ name and type product
  - ❑ date of production
  - ❑ size and sex
  - ❑ name and number of the employee
- ▶ Information how many times the employee washed his clothes
- ▶ Information when the last time clothes was washed
- ▶ All information saved in a secure place in the cloud
- ▶ Information available only to privileged user
- ▶ Application available on iphone, android and windows phone and www



RFID tags in the form of capsules - TAG GUARD



RFID tags in the form of tapes

# Practise Experiments

## *washing and drying processes*

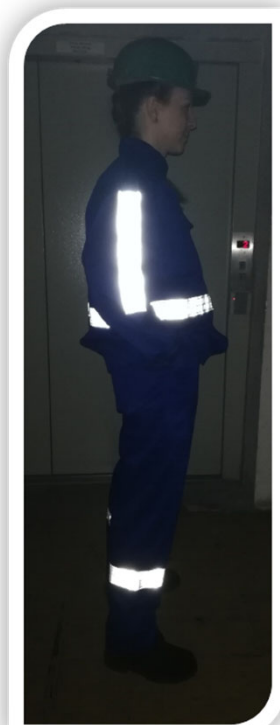
FABRIC	TAGGUARD AFTER WASHING AND DRYING IN TEMP 60°C		RESULTS
	5X	50X	
KG308/ BG1003 (K-121)	3 samples	3 samples	ACTIVE

Tests of washing and drying resistance were carried out for 5 washing and drying cycles and 50 washing and drying cycles for fabrics with sewn in tags and for fabrics with ironed RFID tags. After the maintenance process, the samples were transferred to Krystian to check the activity of the tags. All trials received the positive evaluation after the maintenance processes.



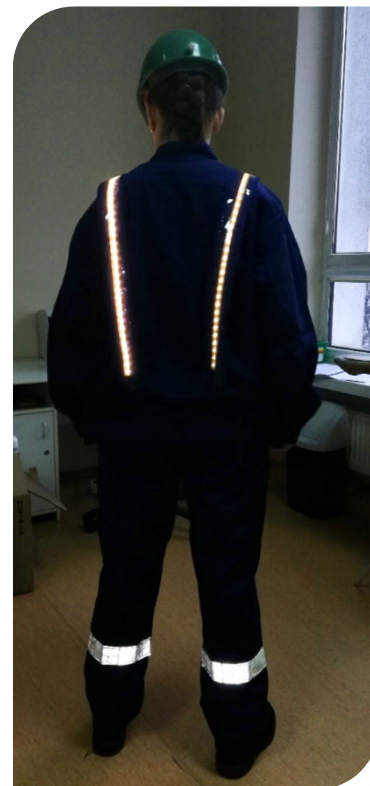
# Clothing with self-lighting tapes

*the applied tapes increase visibility without a light source*





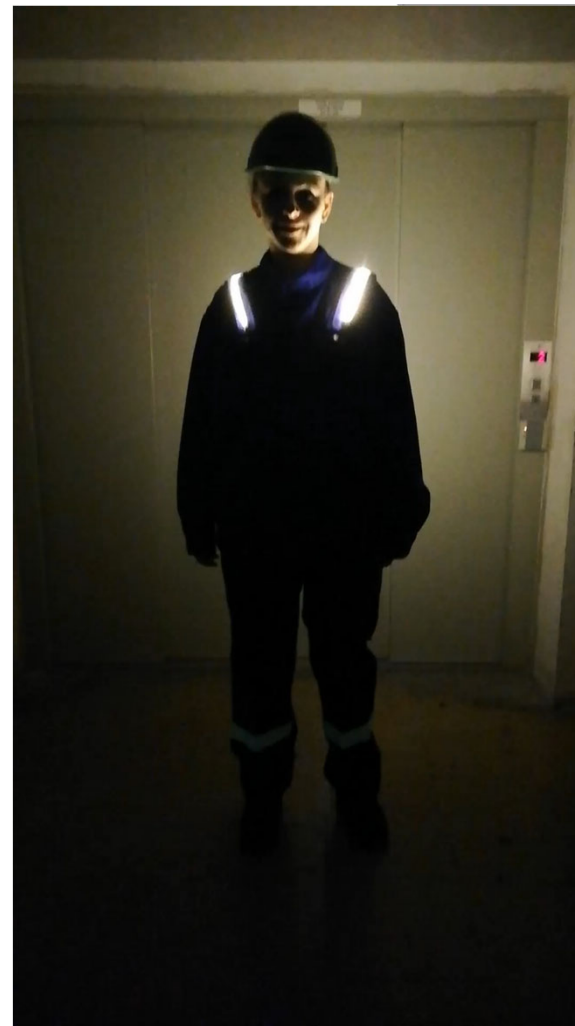
# Clothing with enhanced visibility through the implementation of a strip with LED lighting powered by batteries



The battery lasts for 8 hours.

A strip with LED lights can be connected to a powerbank.

Clothing with enhanced visibility through the implementation of a strip with LED lighting powered by batteries



# Potential development areas for military uniforms

- ▶ **Protective clothing** (protection against injuries and hazards in the battlefield)
- ▶ **Wound detection** (with integrated sensors)
- ▶ **Health/stress monitoring** (with integrated sensors)
- ▶ **Energy harvesting** (in order to maintain the communication)
- ▶ Creating the “**future super soldier**” (exosuits)



<http://www.zephyr->

Heart Rate  
Heart Rate Recovery  
Heart Rate Variability  
Accelerometry  
Intensity & Load  
GPS Sensors (GPS Receiver sold separately)

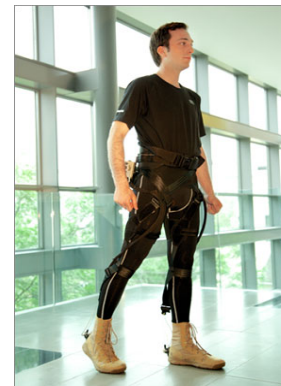
#### Features:

Smooth fabric provides complete comfort without restriction  
Compression fit bolsters muscle support and increases circulation  
Moves moisture away from the body for ultimate comfort  
Machine Washable



<http://www.dupont.com/products-and-services/fabrics-fibers-nonwovens/fibers/brands/kevlar/products/kevlar-km2-plus.html>

Kevlar® fiber for Military - KM2 Plus – the most protective DuPont fiber for the most hazardous duty. Highest grade protective fiber for military use offers increased processability for conversion to woven fabrics and structures for ballistic fabric weavers and body armor manufacturers.



<https://wyss.harvard.edu/technology/soft-exosuit/>

Soft exosuits offer a new way to ease the physical burden of soldiers, firefighters, paramedics, farmers and others whose jobs require them to carry extremely heavy loads.

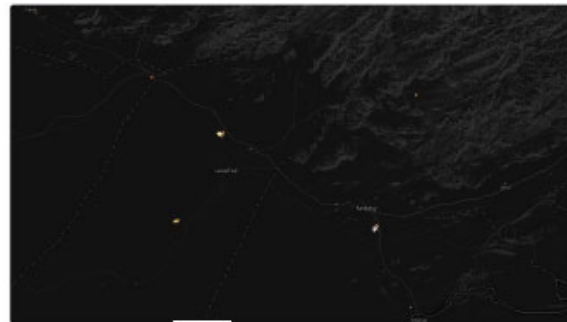
# Threats of electronics integration into army uniforms

## ► GPS tracking!



Nathan Ruser @Nrg8000 · Jan 27

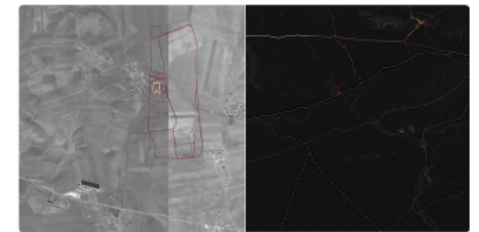
If soldiers use the app like normal people do, by turning it on tracking when they go to do exercise, it could be especially dangerous. This particular track looks like it logs a regular jogging route. I shouldn't be able to establish any Pattern of life info from this far away



Nathan Ruser  
@Nrg8000

Follow

Strava released their global heatmap. 13 trillion GPS points from their users (turning off data sharing is an option). [medium.com/strava-engineer](https://medium.com/strava-engineer) ... It looks very pretty, but not amazing for Op-Sec. US Bases are clearly identifiable and mappable



10:24 AM · 27 Jan 2018

1,764 Retweets 1,940 Likes



Not just US bases. Here is a Turkish patrol N of Manbij





# Integration of RFID into clothing

- ▶ In manufacturing textiles and clothing, RFID technology is widely used both during the production process, in monitoring stocks and raw materials, and in warehousing, as well as in distribution of finished products, in logistics, in tracking goods and in supply chain management.
- ▶ Radio Frequency Identification (RFID) technology employs electromagnetic waves to read information on labels, tags. RFID system consists of three key components – microchip tags, an antenna and a reader that provide a unique identity for each product.



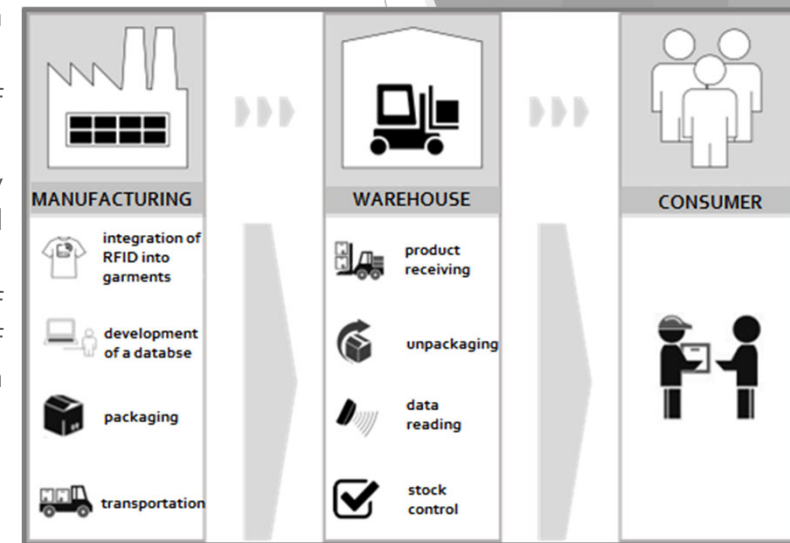
*Functioning principles of RFID*



# Integration of RFID into clothing

## ► Benefits for implementing RFID system:

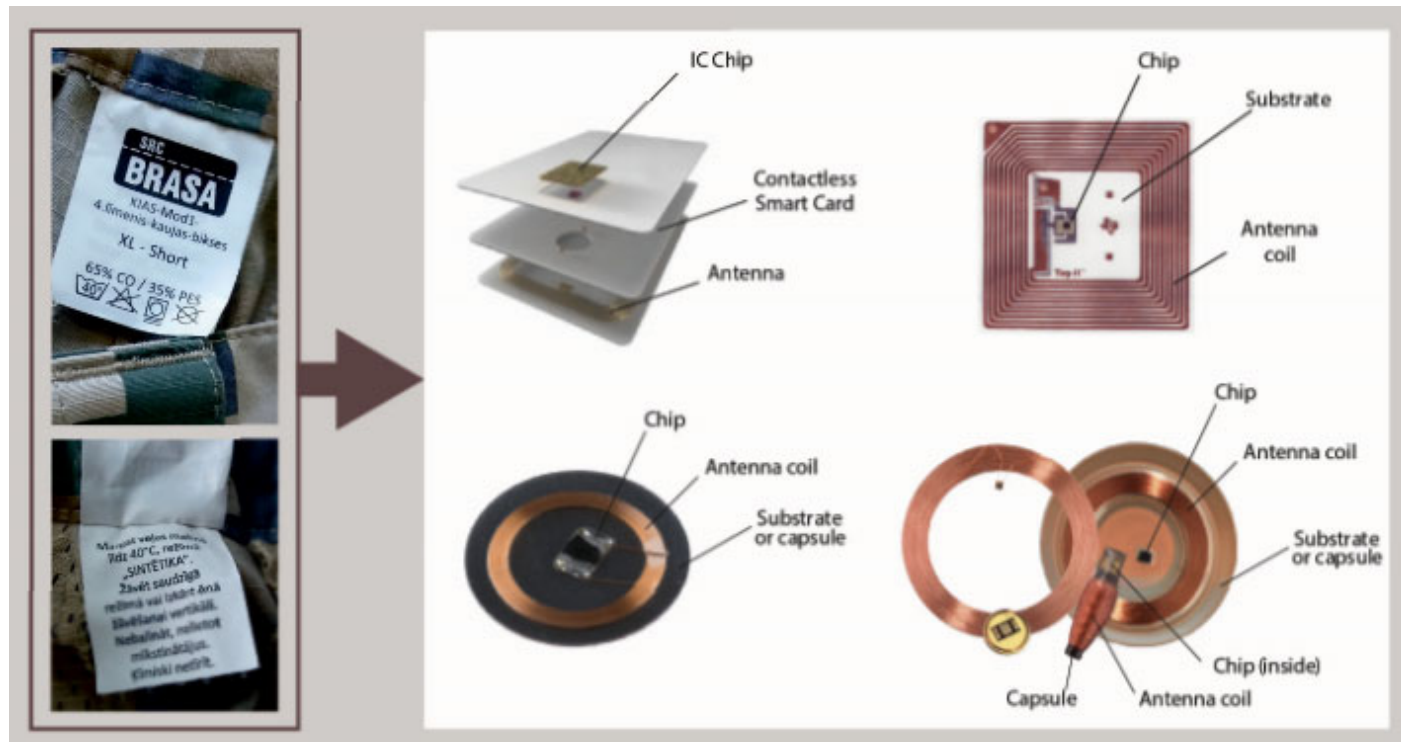
- ❑ **Effective inventory management** – optimization of stocks, rational use of space, reduction of labour costs.
- ❑ **Improved supply chain management** – high accuracy, determinable precise location of product in real time, transparent stock monitoring, efficient planning of orders.
- ❑ **Increased productivity** – rational use of time and assets, reduced volume of unnecessary and inadequate production, increased accountability, adequate and rational planning and tracking of stocks, optimizing their storage and use of space.
- ❑ **Centralized product care** – RFID labels store information on proper handling and storage of product, its history of use and its owner. Provision of proper care extends wearing life of product. Integrated RFID tags can be washed and they preserve data transfer functions for a long time.
- ❑ **Increased consumer satisfaction.**
- ❑ **Improved security level in a warehouse.**
- ❑ ***When integrating RFID system into military clothing, traceability is one of the main drawbacks. Consequently, attention should be paid to the fact that RFID labels should be easily deactivated in discharge of duties or their signal should be easily locked by integrating textile materials specially developed for this purpose in clothing.***



Supply chain management using RFID technology

# Identification and maintenance

## RFID



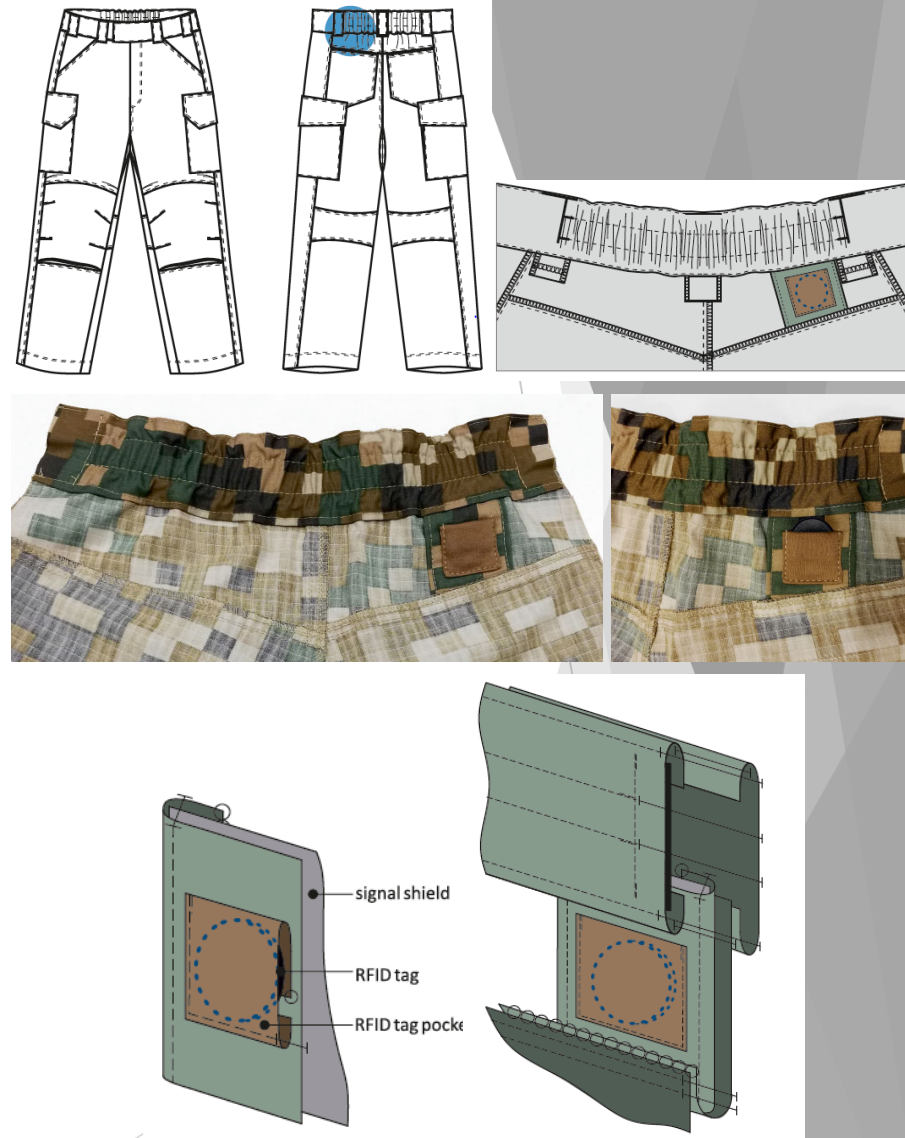
# Smart Solutions for Uniforms

## RFID integration



### IDENTIFYING AND MAINTENANCE

- ▶ RFID tags (chips) integrated into each item of the uniform thereby providing the individualization of the uniform, centralized cleaning and accurate tracking system of the inventory units.
- ▶ RFID tags can be directly integrated into and/or removable from the apparel and are washable.
- ▶ Benefits:
  - ❑ Identifying and maintenance of uniforms;
  - ❑ Effective inventory management;
  - ❑ Improved supply chain management;
  - ❑ Increased consumer satisfaction;
  - ❑ Improved security level in a warehouse.



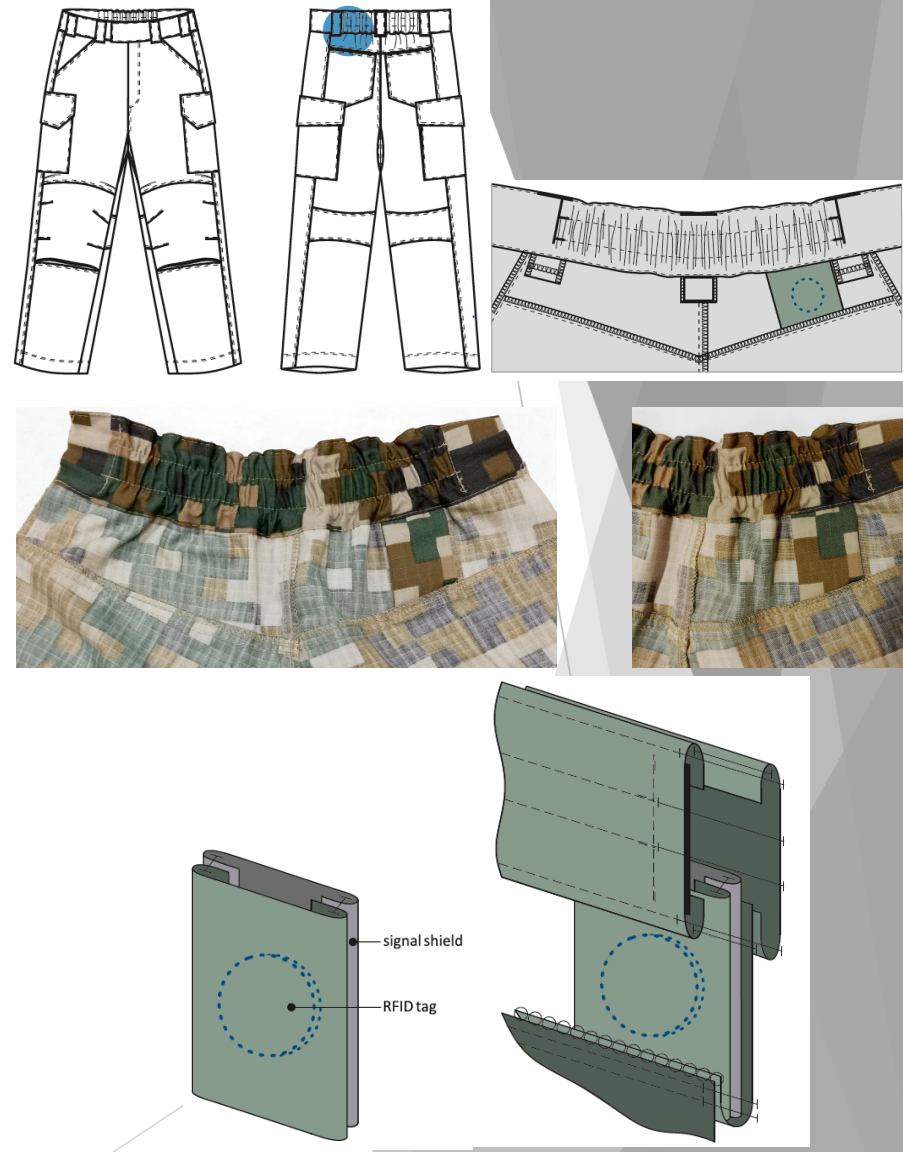
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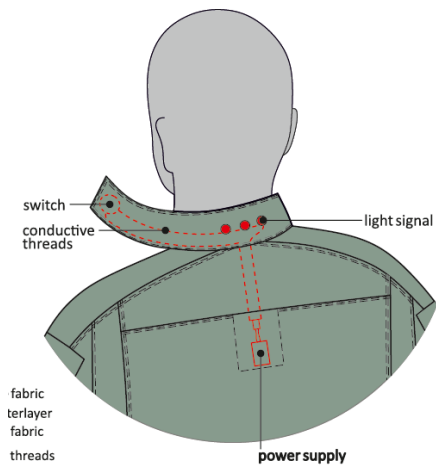
# Smart Solutions for Uniforms

## Light Signal integration



**DON'T FOLLOW ME!**

- ▶ Light signal integration into the back side of the uniform jacket – in order to provide the soldiers visibility and to alert to other group members about the possible threats in deteriorated visibility conditions

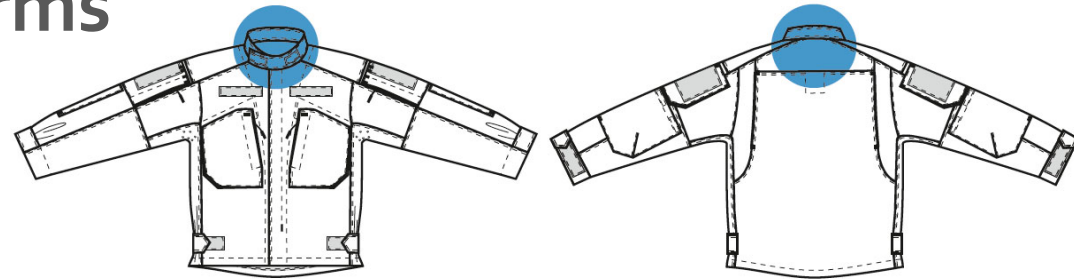
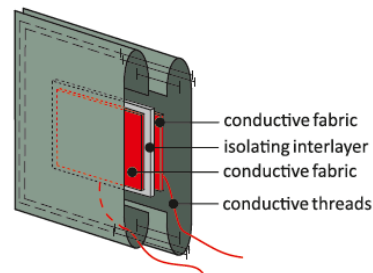


**Interreg**  
Baltic Sea Region



**SWW**  
smart & safe  
work wear

Switch





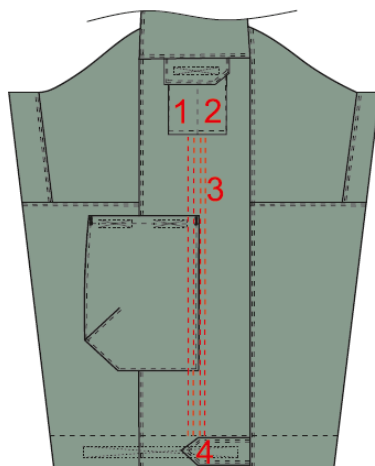
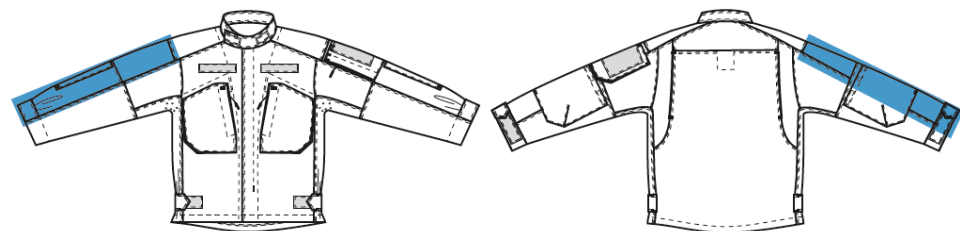
# Smart Solutions for Uniforms

## Electromagnetic Field Sensor integration



**LOOK OUT! ELECTRICITY!**

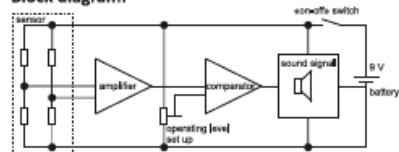
- Electromagnetic field sensor integration into the sleeve of the uniform jacket – in order to alert (signal) the soldiers about the existing electrical threats.



Location of electronic components:

- 1) power supply;
- 2) electronic unit (with a switch and alerting signal sensor);
- 3) conductive threads with metal snap buttons;
- 4) DC electromagnetic sensor.

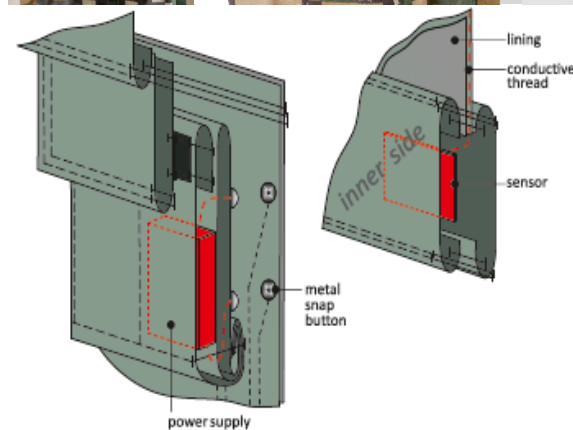
Block diagram:



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Baltic Sea Region



**SW**  
smart & safe  
work wear



# Thank You!

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