

TECH FOR FUTURE

Centre of Expertise HTSM Oost

SaxShirt

Competing product

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SaxShirt

Competing products

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1. Introduction

The project SaxShirt has been going on for about six months. In the meanwhile Saxion is not the only one working on smart textile solutions, in the degree that commercial products are popping up in the market everywhere.

Hereby an up-to-date overview of the commercially available products, to have a clear view on the current market, to learn from the existing solutions and be able to position the SaxShirt with respect to the existing developments.



2. Commercial products

Some of the products are close to the basics of the SaxShirt. Others measure and analyze different physiological aspects, but are still interesting for a complete view on the market, and possibilities for future applications. Three categories are defined:

- Commercial & Sports: existing commercial products, built around existing heart rate trackers (f.e. from Polar)
- ECG Integrated: products that go a step further; not only heart rate, but also ECG is measured; target group is widening: sports, health, safety etc. Most in line with SaxShirt
- EMG: first products measuring EMG are being released. Out of the SaxShirt scope, but possibly interesting developments.

2.1 Commercial & sports

The most commercial products are relatively simple coaching products with little technical info available. The technology is an extension to the existing heart rate monitors, integrating measurements of breathing, acceleration (activity) and/or GPS. The different products distinguish in software possibilities, apps and motivating feedback to the user (f.e. “will power” in the Armour39 [1]). The products are marketed with both straps or in a garment, however, in their shops and websites only the straps are found back, only on certain other websites the shirts can be bought (f.e. [2, 3]). Prices vary from 30 to 300 euros, dependent on the features, software, hardware etc.

1.1.1 Under Armour - Armour39 [1]

Measuring

- Heart rate
- Acceleration



1.1.2 Adidas – miCoach [4]

Measuring

- Acceleration
- Heart beat
- Breath rate





1.1.3 Spree Sports – Fitness monitor

2.2 ECG integrated

There are several products that do not only measure heart rate, but are also accurate enough to give ECG data using dry electrodes. The products are in a higher price class (400 – 800 euros), more is known about the specifications, and the products are not only aimed at the sports market, but also at care, rehabilitation, and work-safety. I.e. they are more in line with the SaxShirt purposes.

1.1.4 Hexoskin [5]

Hexoskin is wanting to offer more than just a fun tool for sports, but try to be better quality, more professional, and suitable for a wider range of applications. Their beta products have been used by athletes preparing for Sochi.

Informing about their unique selling points this is their answer:

"First, without wearing a mask, we are the only product on the market which provides you with true breathing and ventilation data. We discriminate between thoracic and abdominal breathing and provide you with a precise ventilation measurement in litres per minute in addition to breathing rate. We also record the full ECG which allows us to use our own algorithms to provide you with precise measurements of Heart Rate but also Heart Rate Variability which is a direct measurement of fatigue or anxiety as well as Heart Rate Recovery. Sleep analysis is also part of the reports we produce from your data.

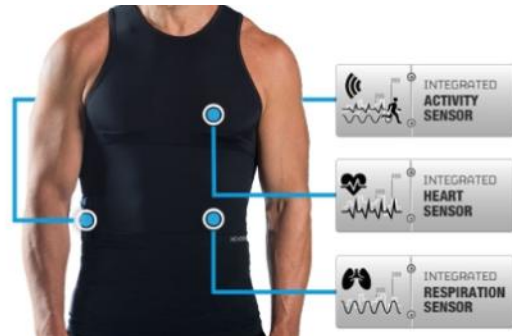
Another key element of our business model, we are "Open Data"; this means that not only can you provide access to your data to your coach or friends on the portal but you can also download all of it for use on 3rd party software.

Lastly but also very important is comfort; Hexoskin is not a strap, not some kind of kit you need to put together everytime you want to train or another bra. Hexoskin is a very comfortable light compression shirt built using the latest in advanced Italian fabric with 100% textile sensors, it looks good and fits well. I have been wearing mine sometimes more than 12 hours a day or night for work for the last 18 months. Hexoskin was built to be as easy to use as getting dressed in the morning; if you can slip-on a pair of jeans when you get up, you can use Hexoskin."



Measuring

- Heart rate
- ECG
- Acceleration
- Breath rate



1.1.5

HEXOSKIN™		Traditional Watch + Chest Strap Product
Price	399	399
Sensor form factor	Undershirt / Tank	Chest strap
Interface	Smart phone / Smart watch	Wrist watch
Battery life	14 hours	8 hours
Logging Memory	Infinite laps	1000 laps
Weight	41g	71g
Dimensions	4.1 x 6.8 x 1.3cm	5.4 x 6.1 x 1.5cm
Waterproof for swimming	✓	✓
Sensors		
Heart Rate	✓	✓
ECG Monitor	✓	✗
RR Intervals	✓	✗
HRV ratio	✓	✗
Breathing Rate	✓	✗
Breathing Volume	✓	✗
Breathing Monitor	✓	✗
3-Axis accelerometer	✓	✗
Step Counter	✓	foot pod sold separately 85\$
Cadence	✓	
Speed	✓	✓
Altitude	✓	✓
Open Raw Sensor Data	✓	✗
Bluetooth	iOS/Android	✗
USB	✓	✓
GPS features	✓	✓



1.1.6 Zephyr – Bioharness [6]

Zephyr promotes a high level product for sports, research, defense, safe work and wellness purposes. If I understood well (Lennart should be able to confirm this information) Zephyr started off measuring body temperature as we plan to in the SaxShirt, however, they took this functionality out of their product, being too inaccurate. Next, they started of measuring breathing rate by measuring resistance in an elastic sensor, however, changed to measuring breathing rate with a pressure sensor. N.B. the shirt has two sensor housings on the strap/shirt: in front and on the side (measuring breathing rate?).

The product is at Saxion, ask Lennart about it.

Measuring

- Heart rate
- Breath rate (pressure)
- GPS



Features*

- Uses Bluetooth to provide heart rate, RR Interval, speed & distance to your Android devices
- Machine Washable strap that offers both comfort and accuracy
- Long transmission range (~300ft up to ~1000ft)
- Water Resistant up to 1m
- Logs and stores up to 20 days of data
- Available GPS module provides speed, distance and location

Measurements

- | | |
|------------------|--------------------|
| ▪ Heart Rate | ▪ Activity Level |
| ▪ R-R Interval | ▪ Peak |
| ▪ Breathing Rate | ▪ Acceleration |
| ▪ Posture | ▪ Speed & Distance |

Specifications

HR Range:	25 – 240 BPM
BR Range:	4-70 BPM
Acc. Range:	±16g
Battery Type:	Rechargeable Lithium Polymer
Battery Life:	26 Hours per charge
Charge Cycles:	300
Transmit Range:	To ~300ft, ~1000ft w/Antenna & Amplifier
Frequency:	2.4 – 2.4835GHz
Garment Washes:	80
Operating Limits:	
Temperature:	-10 – 60°C
Humidity:	5 – 95%



- GPS

1.1.7 Nuubo [7, 8, 9]

Nuubo has put of effort in their ECG-measurements. This is the main function of their shirt, and also the market they focus on: professionals in care that are helped by replacing cardiologic analysis to the home environment.

If I remember correctly (I saw the shirt half a year ago) their electrodes are not ‘just’ conductive yarns in a garment, but a silicon layer was below and between the electrodes, covering up the electrodes and the connection in between. The current product integrates two electrodes, multiple electrodes could be a next step.

Measuring

- ECG
- GPS
- Accelerometer



“Nuubo provides a new perspective on cardiac wireless remote monitoring. Nuubo’s nECG platform allows for the capture of a dynamic ECG via an innovative system that is cost-effective, wearable, remote, continuous and non-invasive. In addition to this, it can be used simultaneously for both individuals and large numbers of patients.

The product platform is based on a proprietary biomedical etextile BlendFix® sensor electrode technology that is easy-to-use (low physician involvement), with minimal impact on patient lifestyle, and capable of being used in real-time and for continuous recording. The sophisticated and highly automated analysis software uses beat-by-beat QRS detection and an artificial intelligence algorithm to classify and detect ECG anomalies. This provides a new opportunity in the cardiac space: remote ECG monitoring in environments with high levels of physical activity, such as sports.”



1.1.8 Sense core [10]

Sense core is measuring body temperature, ECG, true respiration and more. The product is aimed at the sports market, but does not only focus on the data during sports, but has the philosophy of looking the full picture involved in becoming a better athlete (sleep, nutrition etc.). Sense core is also a basic fabric with 2 small sensors, unobtrusively tracking all the system needs to know.

Measuring

- ECG
- Heart rate
- Breath rate
- Acceleration



"sense-pro team

revolutionary dry electrodes for the elite sports team

Technology developed for astronauts, and fine-tuned for everyday and active life use. Ten pairs of two small sensors that weigh only 19 grams each, and without requiring gel, adhesives, or foot and arm pods, record the following parameters, for your entire team:

// medical grade ECG

// heart rate

// calories

// EPOC excess post-exercise oxygen consumption

// true respiration

// breath rate

// body temperature

// 3-axis acceleration

// speed/pace

// distance

// forward acceleration

// cadence

// total steps

// activity classification

The sense-pro team product features a robust charger which has been designed in order to allow charging of all units at the same time, but also to provide a handy and robust carrier of our precious sensors during your team's frequent travels."



1.1.9

1.1.10 Smartex – wearable wellness system [11, 12]

Smartex is a research institution in smart fabrics, possibly similar to the knowledge centre Smart Functional Materials. Their aim is also to show a fully unobtrusive, textile solution for measurement of all kinds of physiological parameters. Their website refers to quite some research, certainly interesting for us to have a look at as well. Shame on the big box...

Wearable wellness system

- ECG
- Breathing
- Accelerometer
- Heart rate



“The electronic device is equipped with a powerful processor that, through the use of complex signal processing algorithms, elaborates the acquired signals to extract several parameters like:

- *Heart rate and respiration rate*
- *Quality indexes for ECG and respiratory signals*
- *Heart rate variability (simpato-vagal index)*
- *Posture and/or activity classification (lying, standing, walking, running)*
- *Estimation of energy expenditure*
- *step/minute*

The ECG and respiratory signal are obtained by means of sensors made of yarns that are fully integrated into the textile structure that compose the garment. Posture and movements are monitored through the use of a tri-axial accelerometer, which is embedded into the small electronic device, and several sophisticated classification algorithms.

The WWS system offers an high level of comfort which make it a perfect solution for long term monitoring of physiological parameters.”



2.3 EMG integrated

Another very interesting development is the integration of EMG-measurements in textiles. This is a different application, and still to be developed more. At the same time EMG has always been difficult and complicated to measure well, done in labs only, but in the mean time of high interest in rehabilitation and sports (NB this is the impression I have from some biomechanical researchers I spoke to in the past, I would need to confirm this). If this solution does what it proves it can create access to a large amount of new possibilities.

1.1.11 Athos [13]

I like how they position/fix/integrate the sensor in the garment. It's there, but it's finished. And it also needs to attach the electrodes to the skin well. I would like to check out the look and feel and details of this solution.

Measuring

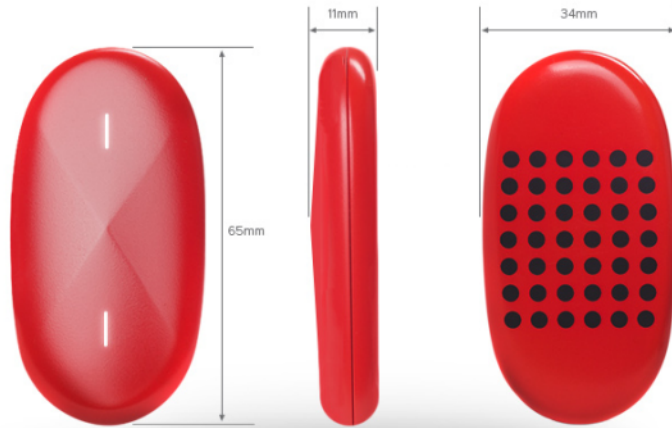
- Heart rate
- EMG
- Breath rate
- Acceleration





Tech Specs

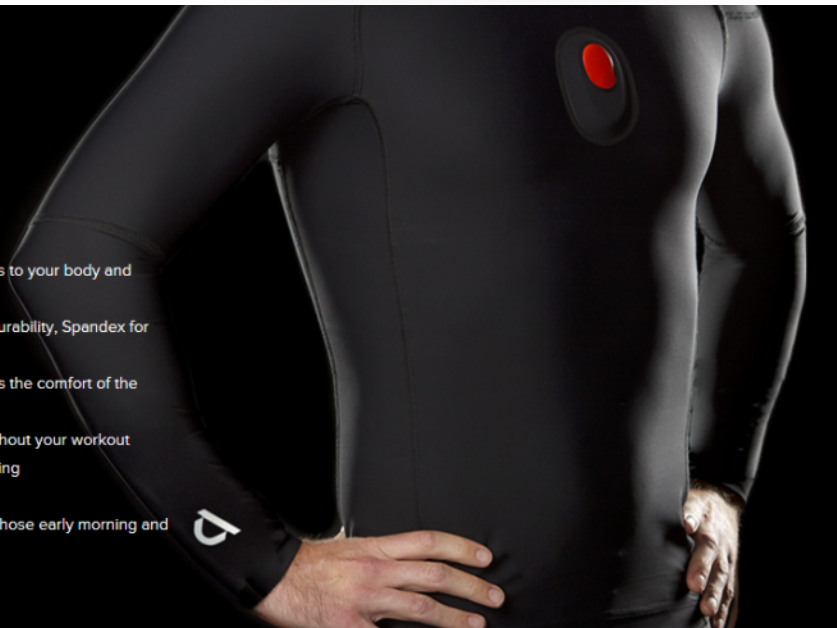
- Up to 16 body metrics:
 - Measure effort from up to 14 muscles
 - Heart Rate
 - Breathing Rate
- 3-axis accelerometer helps us understand motion
- 2 multi-color LEDs show workout progress, achievements, and device status
- Bluetooth 4.0
- 10+ hour battery life
- Waterproof, safe from sweat and the elements, not for swimming
- 20g, lighter than a pack of gum



The Apparel

Tech Specs

- Compression/form fitting design, contours to your body and provides support
- 4-way stretch nylon/spandex; Nylon for durability, Spandex for comfort and excellent recovery
- Sleek and durable sensor design matches the comfort of the apparel
- Wicking fabric helps keep you dry throughout your workout
- Flatlock seam construction prevents chafing
- Welded Core pocket
- Reflective logo keeps you visible during those early morning and late evening workouts
- Imported



1.1.12 MBody [14]

It would be great to find out how they integrated the electrodes and connections in their garments. The structure of the shiny lines seems to be functional in keeping the electrode close to the skin as well.



Measuring

- Heart rate
- EMG



“Measurement device for processing the muscle data

- *Gathering and processing of muscle data*
- *Internal memory*
- *Bluetooth®-data transfer*
- *Rechargeable battery, recharge with USB-power cable*
- *Easy-to-use, light & compact*

THE MUSCLES – “THE ENGINE”

Muscles produce the force and movement output of the performance.

MUSCLE LOAD represents the level of muscle work during the exercise. Thus, it gives direct and instant information about the level of loading and performance of the working muscles.

THE HEART – “THE FUEL PUMP”

Heart-circulatory system delivers oxygen and nutrients to the organs and carry out the metabolic waste.

HEART RATE gives you implicit information about the overall loading level and energy consumption of the whole body.”



3. Conclusions and recommendations

First, there are some basic commercial products that are available. They worked with shirts or straps and are based on existing products, avoiding startup-problems and keeping development and product costs low. Those products could be considered the maximum in 'bulkiness' acceptable. Remarkably is the fact that the shirts cannot be found back on their websites or in their own shops. Possibly they failed in functionality?

In the second category we see 'different versions of the SaxShirt'. Whether they work as you would expect from a commercial product is questionable, since they are all before, during, or right after their launch. For ECG purposes it may be interesting to order and have a look at the Nuubo-system, since they are focussing on the medical market, where accuracy and reliability are highly required.

Zephyr is interesting to learn from, since they already had some development cycles. Possibly papers can be found to find out why they took out temperature measurements, and why they changed their method of measuring breathing rate.

The other three products –from Smartex, Sensecore and Hexoskin- are interesting to have a look at from the textile point view. Smartex seems to be a smart-textile-research institute like the SFM-department, so it is interesting to see what they ended up with. Their literature should be looked at to learn from.

Sensecore really focuses on putting on a compression shirt, not realising you're actually wearing a bunch of measuring technology. However, this could just be marketing, and disappointing in real life. They release in the summer of 2014. Hexoskin is a similar story. Both focus on sports, but also sleeping, working etc.

Lastly we have the EMG products, a challenging technology for application in the consumer market. These products also have the requirement to stick the trackers to the skin well. Both products appear to offer their own very specific interesting solution, worth to check out in detail. NB If the technology is proven, it would pair up greatly with the SaxShirt?

Product	Advantages	Disadvantages	Position w.r.t. SaxShirt
Adidas MiCoach	Known technology	No textile innovations	Negative reviews shirt Accepted size/bulkiness
Armour39	Known technology	No textile innovations	Negative reviews shirt Accepted size/bulkiness
Hexoskin	Very textile-like	First release	Same basics
Nuubo	ECG measurements, shirt, medical focus, in sales stage; should be promising	Limited to ECG	Should have found a way to get good signal from dry electrodes in shirt
Sensecore	Very textile-like	First release	Same basics
Smartex	Very textile-like	Research product	Same basics project, same kind of (smart textile) organization
Zephyr	Proven and working product, measuring same parameters as SaxShirt	More focus on strap	Available at Health & Technology, 'known' strap-solution



Athos	Interesting attachment sensors	Other parameters (EMG)	Also need sensors to stick to skin well.
MBody	Interesting smart textile structure Interesting structure to keep the measurement surface close to the skin	Other parameters (EMG)	Also need sensors to stick to skin well. Integration conductivity in textile

Tabel 1

It would be interesting to make an order on one (or more) of the second-category products, however, delivery times and costs are tricky.

For the SFM department it would also be interesting to purchase both EMG products, to learn from their integration of electrodes and connections in the garment (MBody), and also from their attachment of the electrodes (Athos).

Product	Product release/delivery	Costs	Remarks
Adidas MiCoach	Available	€107,83	With strap
Armour39	Available	€107,78	With strap
Hexoskin	8 wks delivery time	€400	Starter kit. Easiest (though seems least interesting) buy
Nuubo	? They are visiting potential customers, in the medical area	?	
Sensecore	Summer?	?	
Smartex	Research product only?	?	
Zephyr	Available @ research center health & technology	?	
Athos	Pre-order (summer?)	€298	Excl software?
MBody	Not sure, seems available	€890	Starter kit

Tabel 2



1. Sources

1. <http://www.underarmour.com/shop/us/en/armour39>
2. <http://www.sil.it/clothes/shirts/adidas-techfit-micoach-shortsleeve-t-shirt.html>
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5. <http://www.hexoskin.com/en>
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14. <http://www.mbody.fi/frontpage#story>