Market Opportunities for Smart Textiles 2014

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White paper on smart textile garments and devices: a market overview of smart textile wearable technologies.

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Introduction

It is an interesting time in smart textiles development. As the industry matures and develops there is an increasing drive to turn research results into commercial opportunities. The surge in wearable technology is acting as a spur to the smart textile industry and smart garments are being perceived as a niche market within the fast growing wearable technology industry. The Smart Fabrics Conference 2014 has been re-named Smart Fabrics and Wearable Technology, Intel has launched a "Wearable" challenge and "wearable tech" has never been more talked about in the media.

This third Ohmatex White Paper on smart textile garments and devices, focuses on the intersection between smart textile technology and "wearable tech" – wearable technology on a textile platform. For those who have been working in the industry for almost 10 years we want to highlight what is new and where development is happening. For those in traditional textiles or wearable textiles who wish to begin to exploit the potential of smart textile garments and devices we aim to observe trends, track changes and highlight successes and opportunities in the field of smart textile technology.

Definitions

Smart textiles	Textiles with the ability to react to different physical stimuli; mechanical, electrical, thermal and chemical etc.
SFIT	Smart Fabrics and Interactive Textiles (also defined as smart textiles).
Wearable Technology	Any electronic device small enough to be worn on the body.
Interactive Textiles	Wearable technology that is integrated into a garment or controlled by an integrated panel or button.
E-textiles	Textile with electronic properties included in the textile fibres.

Market overview

A new study by Grand View Research, January 2014, confirms that the global market for smart textiles is continuing to see strong growth in a number of key markets. The overall size of the global smart textile market was estimated to be USD 289.5 million in 2012 and expected to exceed USD 1,500 million by 2020. The main growth sector in the last 3 years has been in the protection and military clothing sector and it is estimated to remain the largest market segment in the next six years. Sport and fitness applications are predicted to see the fastest growth along with health and medical applications.[1]

Cath Rogan, of Smart Garment People, UK, observed in her conference review of Smart Fabrics Europe 2013 that "in strong contrast to previous conferences, there was almost no mention of textile based wearable physiological monitoring" and instead there was a much stronger bias towards "lighted textiles".[2] However the programme for the Smart Fabrics and Wearable Technology 2014 conference in San Francisco shows a healthy number of presenters in the field of smart textile physiological monitoring devices and several presentations featuring of non-textile wearable monitoring devices.[3]

This may indicate differences in smart textile priorities and interests between Europe and the U.S, however the last 3 years have seen smart textile technologies coming to market in all of the above mentioned growth sectors: Military protective clothing, physiological monitoring for medical and sports applications, and lighted textiles.

Within the larger wearable technology sector smart texiles is clearly positioned as a segment within this market. An ABI Research report on Global Wearable Computing Devices, includes smart garments as a niche segment in the larger wearable technology industry.[4]

Wearable Technology consulting company, Vandrico, Canada is actively maintaining a Wearable Tech database, which is updated on an almost daily basis. At the time of writing there are currently 164 wearable devices listed. The majority are listed in the "lifestyle" and "sports" sector with an average cost of $378 (USD).[5] Of these devices the following smart textile devices/garments are listed: **Owlet Baby Monitor** (sock monitor), **Tjacket** (simulating hugs for ADHD application), **Beartek Bluetooth Gloves**, **Moticon** (motion analysis insole), **ElectricFoxy Move** (movement sensing garment with stretch sensors), **Xybermind Achillex** (monitoring insole and running vest), **Heapsylon Sensoria smart sock** (sock monitor for fitness), **4iiii Viiiva Heart rate monitor** (conductive textile strap). **OMSignal** and **Hexoskin** (smart biometrics t-shirts). This list is by no means exhaustive, but it gives some indication of the smart textile wearable devices currently being developed and coming to market.

Together with a growing smart textile market and an increased number of products moving from R&D to commercialisation, there has also been an increasing focus on the need for standardisation as a pre-requisite for market exploitation and commercialisation of smart textile research.

Smart textile networks and conferences

The smart textile industry has seen growing membership of online communities, networks, social media and conferences supporting the industry.

Networks

Innovationintextile is an online smart textiles hub created by UK based textile specialists Orange Zero Ltd in 2009, and has enjoyed phenomenal growth. It is now established and highly regarded internationally in the field of technical textiles. It provides a daily updates email service which can be filtered to your areas of interest.

European Technology Platform: for the future of textiles and clothing is an industry-led initiative launched in 2004 and formed as a legal entity/membership organization to provide a network for the European textile industry. It is now the largest network for textile research and innovation in Europe, with 750 members.

COLAE – Commercialisation clusters of Organic and Large Area Electronics – promotes the commercial exploitation of large screen electronics.

SustaSmart – promotes the standardisation of smart textiles for various applications including personal protective equipment.

Conferences

Smart Fabrics (& Wearable Technology)
Energy Harvesting and Storage Europe
3F Talks – Functional Fibres and Films (Germany)
Flexible and Stretchable Electronics

LinkedIn Groups

Smart Fabrics – Formed Dec 2009, 680 members (Smart Fabrics conference group)
Smart Textiles – Formed Feb 2011, 1010 members (Lina Rambausek)
Smart Textiles (Smart Fabrics and Interactive Textiles, SFIT) – Formed Dec 2009, 2332 members

Segmentation and Stakeholders

Personal Protective Equipment & Military

According to the study by Grand View Research Inc, Protection and military accounted for 27% of the overall market share of smart textiles in 2012, and is expected to remain the largest segment in the next 6 years.

Personal Protective Equipment

Research and development is beginning to result in commercialisation of smart textile solutions for firefighters, allthough there is still a gap between prototype development and commercialisation.

In the US, Globe Firefighters "WASP" systems was made available for select training academies in 2013. This shirt includes a wireless firefighting tracking system which measures firefighter location and a physiological monitoring system.

In 2012 a number of EU funded projects resulted in various prototypes for smart textile PPE garments. **Prospie (completed 2012)** completed the development of a PPE with inbuilt cooling mechanism and physiological sensors to measure relevant, such as skin temperature, heat flux and heart rate, to assess the thermal status of the worker. **Safe@Sea (completed 2012)** developed advanced personal protective suit for the fishing industry. This includes the integration of sensors into protective outer garments to detect falling overboard in a fully waterproof smart textile garment.

safe@sea

Enprotex, a European foundation formed to provide a link between EU publically funded R&D PPE projects and public procurement organisations, acknowledges that despite the significant public funding in this area there have been very few direct commercial spin-offs. They are working on a new EU initiative **Smart@fire** to bridge the gap between prototypes and commercialisation.[6] The outcome of this project aims to be a smart PPE suit to be procured by EU fire and rescue services by 2015. The 3rd Enprotex conference will be held in Brussels on 18-19 November, 2014 and will specifically address issues of regulation, standardisation and public procurement in the PPE industry.[7]

Military and defence applications

A number of development projects are continuing to exploit opportunities for integration of electronics and communications equipment in military uniforms. Since 2011, Sagem's FELIN system has started volume production and is currently supplying the French Army.

The **Sagem FELIN system** developed for the French Soldier modernisation programme is now in volume production for the French Army and is the first of its kind in Europe. Delivery of the suits began in 2012,

equipping 4 regiments per year and 10 regiments have now been equipped. FELIN is a dramatically modernised combat suit with integrated rechargeable battery technology and the possibility to attach and run a range of electronics devices including weapon sights and radios. The weight is ergonomically positioned and the integrated communications reduces the burden of additional equipment as well as providing direct information to command staff. Based on feedback on the FELIN system and on-going development Sagem has now developed a Smart Vest with integrated wireless technology.[8]

The **US military** has been exploring opportunities for exploitation of smart textile technologies at the US Army Natick Soldier Research, Development and Engineering Center (NRSDEC) since at least 2006, and this work is ongoing in collaboration with Infoscitex Corp. Currently their focus is on wearable power to reduce weight from batteries and cabling for electronic devices. The main focus of the research is on two types of energy harvesting technologies – kinetic energy, generated by the soldiers movements and photovoltaic flexible solar cells which can be integrated onto external fabric surfaces to harvest solar energy. The aim is to integrate this technology into Army combat uniforms and tactical vests.[9]

In the **UK** a light weight military uniform with a reduction in battery and cable weight is under development with conductive fabric integrated into the shirt, helmet, backpack, gloves and weapons platform. The Centre for Defense Enterprise (CDE) has awarded £234,000 to Intelligent Textiles, to find smart textile solutions for reducing the weight load for soldiers. Intelligent Textiles have patented a number of techniques for weaving conductive fabrics, but work still has to be done on the connectors used within the garment to prevent them from rusting and short circuiting. Intelligent Textiles is also working with BAE systems to integrate other equipment into the uniform. The uniform is expected to be available by 2015.[10]

The **Canadian Government** is currently evaluating bids for the "Integrated Soldier System Project" which will supply a suite of equipment including electronic devices and sensors. They intend to acquire up to 6,000 integrated suites of equipment and the contract is expected to be awarded in December 2014.[11]

Space

The European Space Agency (ESA) continues to invest in smart textile technology for astronaut space missions. The technology they are developing is designed to help counteract some of the health problems encountered by astronauts as a result of the effects of reduced gravitational forces in space.

Smart sock

ESA have invested in the development of a smart sock that can monitor the efficacy of astronaut training exercises in space, to help to reduce muscle degeneration experienced through loss of gravity in Space. The result is a sock with built-in sensors that record the electrical activity of muscle (EMG) and use light to detect oxygen content in and around the muscle (NIRS).They contracted Ohmatex to develop this in 2009 and the first phase and delivery of a prototype was completed in October 2012.

Smart T-shirt

Astroskin is T-shirt which has the potential to monitors astronaut's vital signs in real time and wirelessly transmits them to medical teams on Earth, who can interpret the data to evaluate how a crew is responding to their tasks and environment. It has been developed by **Carré Technologies,** featuring their **Hexoskin** technology and is currently being trialed by an Antarctica expedition team, who are being monitored remotely by researchers at the University of Quebec. The results from this trial will be shared with the Canadian Space Agency for possible use on future space missions.[12]

Telemedicine and sports health

We previously observed that despite the strong predictions for the growth of telemedicine, the number of smart garment medical devices to assist with this was developing more slowly than might be expected. To some extent this is still the case however there are a number of devices due to come to market in 2014. Multi-sensor garments which have been underway for several years are now becoming commercially available. Some have launched their products through successful pre-order crowdfunding campaigns in 2013 designed to support their first production runs.

Currently the main garments being developed for physiological monitoring with medical and sports applications are T-shirts and socks/stockings and insoles. The main biometrics being monitored are heart rate, temperature, movement and respiration, and muscle activity. All of the devices being developed have potential for both medical/telemonitoring and sports applications, however there has been a shift towards marketing them more agressively at the sports and fitness markets to encourage early adoption of the technology, and an increasing focus on fashion and design elements in the finished garments.

We will track the progress that has been made from what is now considered the standard basic heart rate, monitor to more complex multi-sensor smart textile garments and platforms currently being developed.

1. The heart rate monitor

One of the most successful smart textile developments in healthcare devices, has been the medical heart rate sensor, mounted on a textile conductive strap, developed by Clothing + in Finland. They developed the first heart rate sensor in cooperation with Polar Elektro and they now mass produced in high volume in China, supplying Suunto, Adidas, Garmin, Philips and Timex. They currenty manufacture more than 3 million belts each year, which is half of the total global heart rate monitor market for both health and sport. These currently retail at around $80 for both strap and electronics. Today heart rate monitors typically allow for measurement of heart rate, acceleration, deceleration, speed and distance.

The next generation of heart rate monitors are those where the sensors are integrated into T-shirts as a more comfortable alternative to wearing a strap whilst exercising, with data captured and transmitted wirelessly in a removable electronic device attached to the shirt. T-shirts and sports bras with a sensor woven into the fabric of the garment are available as part of the **Adidas miCoach** range (via **Numetrex**). The transmitter and compatible electronics are sold separately. Similar products are available from **Heapsylon's Sensoria** fitness range. Both brands are currently retailing for between $60.00 - $80 and are machine washable. **GOW Trainer** produced by Weartech (Spain) is another system which includes the full package of T-shirt/bra with sensors (hand washable), plus the electronics/communication device and associated apps. It is retailing at €120.

Adidas have also entered the professional sports market with their **miCoach Elite** soccer system launched in 2012. It consists of Adidas heart rate monitor t-shirts, relaying information in real time to coaches during training. It has currently been adopted by Major League Soccer in North America, costing $100,000 USD per team.

However for the average non-professional consumer there is still a big difference between the cost of a running shirt, and the cost of a shirt with an integrated sensor. Kim Scheffler, responsible for product development and commercialisation of the Adidas miCoach brand is aware that it is necessary to educate consumers that "it is not a Garment with Sensors in it .....it's a garment built around the sensors".[13] This is echoed by Davide Vigano, CEO of Heapsylon (Sensoria Fitness) who's company mission statement is "The Garment is the computer".[14]

2. Multi-sensor physiological monitoring: heart rate, respiration, temperature, oxygenation, plantar pressure

Developments in multi-sensor garments which have been underway for several years are now becoming commercially available. A number are now accepting pre-orders for release later this year. These are significantly more expensive than heart rate sensoring devices, and are being priced between $200 - $400. The products can be differentiated by the biometrics that they measure, their smart phone and blue tooth compatability (i.e. which smart phones) and the quality of the data monitoring platforms supporting them (apps and software).

Heapsylon has developed an **e-textile smart sock (Sensoria Smart Sock)** for medical and sports applications. This is based on their e-textile sensor technology which is also used in their heart rate T-shirt range. The textile plantar pressure sensors allow measurements which can be valuable information for preventing falls, weight monitoring and monitoring for patients with diabetic foot ulcers. Sensoria raised $115,000 in pre-orders in a two month crowdfunding campaign in 2013. They are currently available for pre-order (socks plus electronic anklet) for $199.00, with an expected release date of 31 March 2014. Heapsylon is currently interested in attracting investors to further their e-textile developments.

Carré Technologies (Canada) are curently launching **Hexoskin,** a smart textile garment with 3 integrated sensors: heart rate, respiration and activity sensors. Their full pack of machine washable shirt and electronics is avaliable for $399.00. Hexoskin raised $165,000 USD in pre-orders in a crowdfunding campaign in Sept 2013, and their first orders are expected to be ready for delivery in March 2014.

OMSignal is also developing a shirt using Hexoskin technology. They have attracted investment from several seed stage venture capital funds. They are not yet accepting pre-orders.

Owlet baby monitor – smart sock measuring heart rate, oxygen levels, skin temperature and sleep quality. The sensor is waterproof, but is removed from the sock for washing. $130,000 in pre-orders was raised in a 3 week crowd funding campaign in September 2013. Their first batch is now sold out and orders for a second production run are now being taken. The current retail price is $250.

The German **Moticon insole** measures plantar foot pressure for motion analysis, accelaration and temperature and is aimed at athletes during rehabilition following injuries/surgery. It is possible to order the product, although no price is currently given.

The **MYWEAR** EU FP7 development project is due to be completed in November 2014. The project has developed a textile based integrated data monitoring platform which allows data from several wearable sensors (Heart rate, respiration and plantar pressure) to be displayed on smart phones and retransmitted to medical professionals or caretakers to follow and oversee the user's data. This development is aimed at four target groups: elderly, obese, diabetic and disabled, enabling wearers to carry on their daily life while being comfortably monitored by health professionals.

3. Stretch sense sensors: monitoring volume and muscle activity

Textile strain gauge or stretch sensors measure increases or decreases in a fabric as it is stretched. These can be used to measure muscle activity during exercise or changes in volume as a result of increased fluid in a part of the body (plethysmography).

A number of stretch sensors using DEAP (Dielectric Electro Active Polymers) sensing technology are currently available for inclusion in sports or medical garments: **Danfoss Polypower**, Denmark and **Stretchsense** in New Zealand, which won two science awards for innovative technology in 2013.

The **Edema stocking** developed by Ohmatex, Denmark, uses a strain gauge sensor to measure changes in leg volume, as excess fluid accumlation is a symptom of edema. It is a telemedicine monitoring device for patients with congestive heart failure or pre-eclampsia in pregnancy. The stocking is now available for purchase by medical researchers.

Fashion

A number of designers are continuing to make their mark within wearable technology fashion, using LED light and colour to enhance garments for many stage performances and high profile events and occasions. The special effects for these performances are becoming increasingly advanced as the LED lights are being programmed with increasing sophistication. LED fashion garments which have now become commercially available and also other applications of smart textiles within fashion lines are being designed which incorporate inbuilt solar panels for charging technology on-the-go.

Rainbow Winters uses interactive textiles in her garments which allow for changes in colour and pattern in response to sound, sunlight, water and stretch. Her sound reactive Thunderstorm dress was featured at the Made in Future Exhibition in Milan in 2012. As volume increases the dress illuminates.

Pauline van Dongen merges traditional textiles with smart textile technology in her creations. In 2013 she created a wearable solar dress as part of the Wearable Solar project, incorporating solar cells into a dress which would be capable of charging a typical smart phone up to 50%.

Moritz Waldemeyer demonstrated some fantastic lighted garment displays at the closing ceremonies of the London 2012 Oympics and Paraympics. For the Olympic closing ceremony 140 LED-encrusted carnival outfits were created which were programmed to pulse to the beat Brazilian drummers. Other innovations by Waldemeyer have been LED video jackets worn on tours by Take That and Will.i.am (Blackeyed Peas) in 2011. Both jackets included video capable full colour LED pixels, especially designed by Waldemeyer for the display of animation at video speed on fabric surfaces, transmitted from a built in SD card.

London based **Cute Circuit** continues to design combine fashion and smart textile technology. In 2013 they again designed a number of haute couture lighted dresses for Katy Perry, and a "space" dress for Sarah Brightman's international tour. They now have a range of technology enhanced dresses available on their website, some of which include embedded LED lights, averaging around £300.00. They also have a K-Dress available commercially, based on the dress she wore at MET Gala New York in 2010. The dress retails at £1500.00.

Light Emitting Textiles

In addition to fashion, other applications for light emitting textiles are also emerging as wearable devices for phototherapy, safety lighting in garments, and lighting on various thin conductive substrates (textile, flexible and foil). Research is continuing to solve issues of robustness, seamless integration and washability.

The EU funded FP7 PLACE-it project (Platform for Large Area Conformable Electronics by InTegration), led by Dutch electronics giant Philips, focused on true integration of LED technology with flexible, stretchable and textile substrates. It resulted in the development and launch of the Philips **BlueTouch** Pain Relief Patch in 2012 and the **Ohmatex washable connector**.

Philips Blue Touch Pain Relief Patch

Ohmatex washable connector

The BlueTouch device incorporates special blue LED lights within a flexible substrate and is designed to offer non-invasive pain relief for muscular back pain. It is currently retailing at €250.00. The Ohmatex connector is fully washable and provides robust connectivity on textile and thin flexible substrates.

In 2013 Badger Gear launched their **360 LED Jacket**, a sportswear jacket with LED lights incorporated, designed for high visibility at night. It is currently retailing at $149.99 and is hand washable.

Foster Rohner and Danish design company **Diffus** are continuing to collaborate on research projects in the fields of embroidered optical fibres and integration of LED lights in embroidery. In 2012-13 they worked on **Hollowlight** which combines two lampshades in one installation, one has surface embroidered LED lights and the other has embroidered optical fibres. Diffus is also a partner in **Light.Touch.Matters**, an EU funded project which for the first time engages both designers and engineers in the development of smart materials that can sense touch and movement and respond with light.

Audio Entertainment

While smart garments with integrated controls for iPod and Mp3 players previously attracted media attention, such solutions are no longer newsworthy. As a result, standard type solutions are beginning to emerge that existing brands can integrate as a feature in their own products.

What is new is that developments in textile cabling are introduing new light weight, noise reducing, fashion cabling options to headset manufacturers. Currently several braided fabric options are on the market (**House of Marley** headphones and **One Good** earbuds). Ohmatex will be the first to offer textile conductive ribbon as head set audio cabling with the ability to integrate audio controls and fashion elements (colour, patterns, logo print).

Market drivers

Professional sports

Within the world of sport, there is an infinite need for improved athletic performance. Technological developments in physiological monitoring and motion supervision are starting to be exploited to facilitate new training tools allowing athletes and trainers to evaluate the efficiency of training programmes and fine tune them to optimise performance.

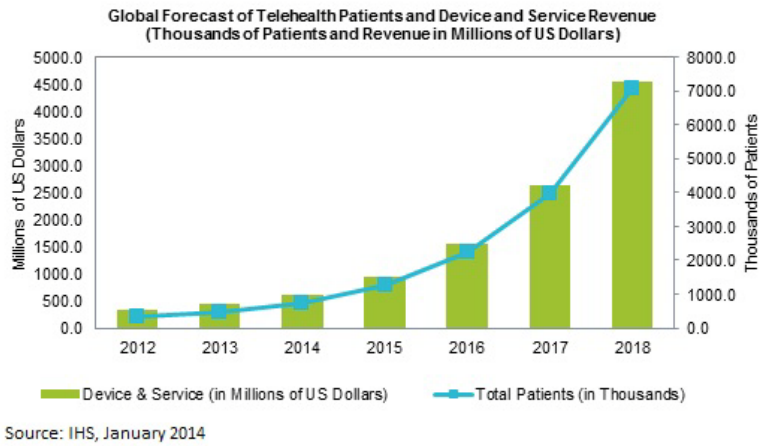
As the amateur health and fitness market adopts monitoring devices to improve their personal fitness levels, the professional sports market is beginning to adopt the technology on a much larger scale (e.g. North American Major League Soccer adopting Adidas miCoach Elite sensing shirts)[15], particularly where team sports are concerned, with the potential to collect and optimise data for every player. In this market it is the coaches and trainers who are the purchasers and managers of the data. For them it is not about the garment, but about the data that the garment can produce.

Ageing population/healthcare trends

According to an IHS report, "World Market for Telehealth- 2014 Edition", the number of patients using telehealth services will rise to 7 million in 2018, increasing dramatically from the current 350,000 patients. This will involve a corresponding increasing in medical devices and public spending to support this trend.[16]

One of the biggest driver of market growth in this field is the need to reduce health care costs, in particular hospital re-admissions of patients. This is a global trend and governments in the U.K., France, China and Denmark are also supporting telemedicine programmes to help address the cost of hospital admissions. According to the report, telemonitoring is most often prescribed to patients with congestive heart failure because of the need to reduce readmissions of this group of patients, and because of strong evidence that telemonitoring is effective in monitoring this condition remotely.[17]

The Whole System Demonstrator programme was conducted in the UK (2008 -10) to explore the impact of adopting telehealth. The results published at the end of 2011 reported a 20% reduction in emergency admissions, a 15% reduction in A&E visits and a 14% reduction in bed days in the patients studied. As a result the NHS launched an initiative in 2012 with the aim that by 2017, 3 million people with long-term health conditions would be receiving telehealth care.[18]



Source: IHS, January 2014

Publically (EU, NASA / ESA) funded research and development

A number of SFIT research projects have already been funded within the EU FP6 and FP7 programmes with the aim of revitalising the European textile industry and increasing competitiveness through high-tech innovation. These have focused on the major growth areas for Smart Textiles: Health care solutions (physiological monitoring), Advanced thin, organic and Large Area Electronics (lighted textiles), innovation in protective clothing, and energy harvesting and storage in fibre form. NASA, and its European counterpart ESA, are also extensively involved in exploiting and maturing the latest wearable technologies. A new round of EU funding (Horizon2020) is now underway where there will be an increasing focus on the commercialisation of research results in these areas.

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