The E-Textile eVolution

By Craig Crawford

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"Imagine if your aunt, who suffers from Alzheimer's, has wandered out the front door and you don't know when she left or how long she's been gone," begins 12-year-old Abbi Paul, a student at Argyll Scotland's Dunoon Grammar School, in her pitch to a panel of industry leaders in London earlier this summer. "Did you know that 50% of wandering dementia patients die if not found within 24 hours of leaving home alone?" she asks.

"What if your grandfather, who lives alone, has fallen and no one knows for a day, leaving him on the floor unable to get up?" continues her classmate, Rory Orland, also 12 years old.

These are real life problems for Orland, Paul, and their classmates Olivia Robertson and Caleb MacLeod who, drawing from personal experience, conceived Safe Step, the award-winning App in the Apps for Good 2017 Internet of Things (IoT) competition. Now entering its sixth year, Apps for Good is a charity that provides a curriculum framework for 9- to 16-year-olds to solve problems through smartphone apps. Sponsored by Samsung, the IOT category was launched this year.

The Safe Step team proposed the combined use of e-textiles and an app to alert caretakers when falls or departures occur. Sensory mats placed by the bed, the bath, or the front door determine movement and alert caregivers via a smartphone app.

E-textiles aren't new; heart monitoring sportswear has been on the market for nearly five years. However, e-textiles are evolving quickly. With the convergence of the Internet of Things, big data analytics, artificial intelligence (AI), and mobile technology, even teenagers see opportunity for e-textiles to positively impact the world around us.

"Imagine the Internet of Things with nodes across cities, streets, cars, homes, etc., and then imagine the human space," says Mark Hayward, senior technology analyst at IDTechEx, a market research, technology scouting, and events company covering emerging technology areas, including wearables and e-textiles.

"We need something ubiquitous to connect these. Enter textiles—creating the personal element, the ubiquitous fabric of life," he says. "We are in contact with textiles for up to 90% of our lives, and they are starting to become intelligent through the integration of electronics. From clothing to bandages, bed linen to industrial fabrics, new products integrating e-textiles are being created."

Opportunities

Necessary Medicine

"Medical applications are driving e-textiles from being a concept to becoming commercially viable," explains Mark Maltese product development engineer for Syscom Advanced Materials. Syscom develops, manufactures, and markets conductive metal fibers, including metal-clad fibers.

"Think of a garment that monitors a person's heart rate in a nursing home without being wired to equipment, or a conductive rug that indicates

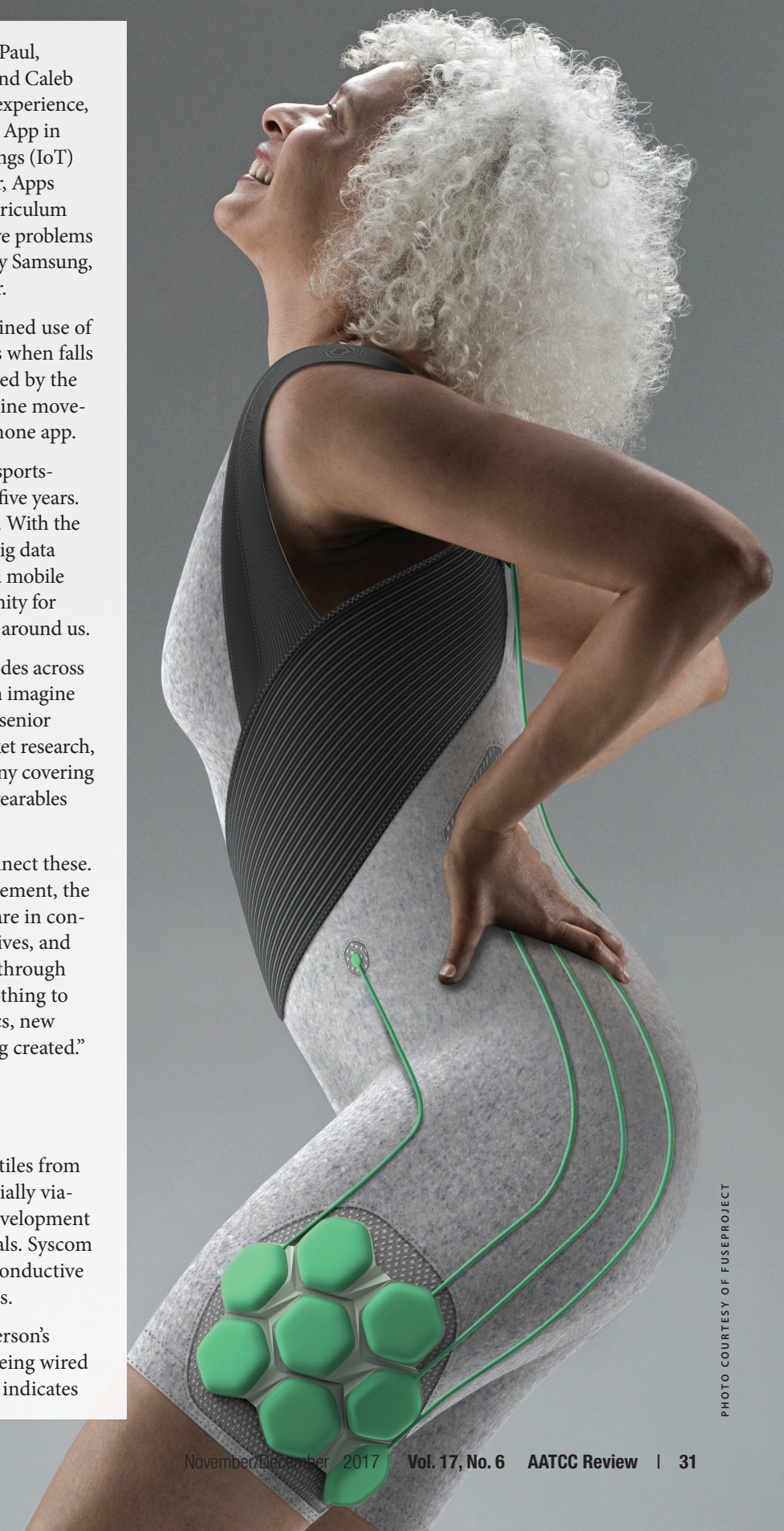

PHOTO COURTESY OF FUSEPROJECT

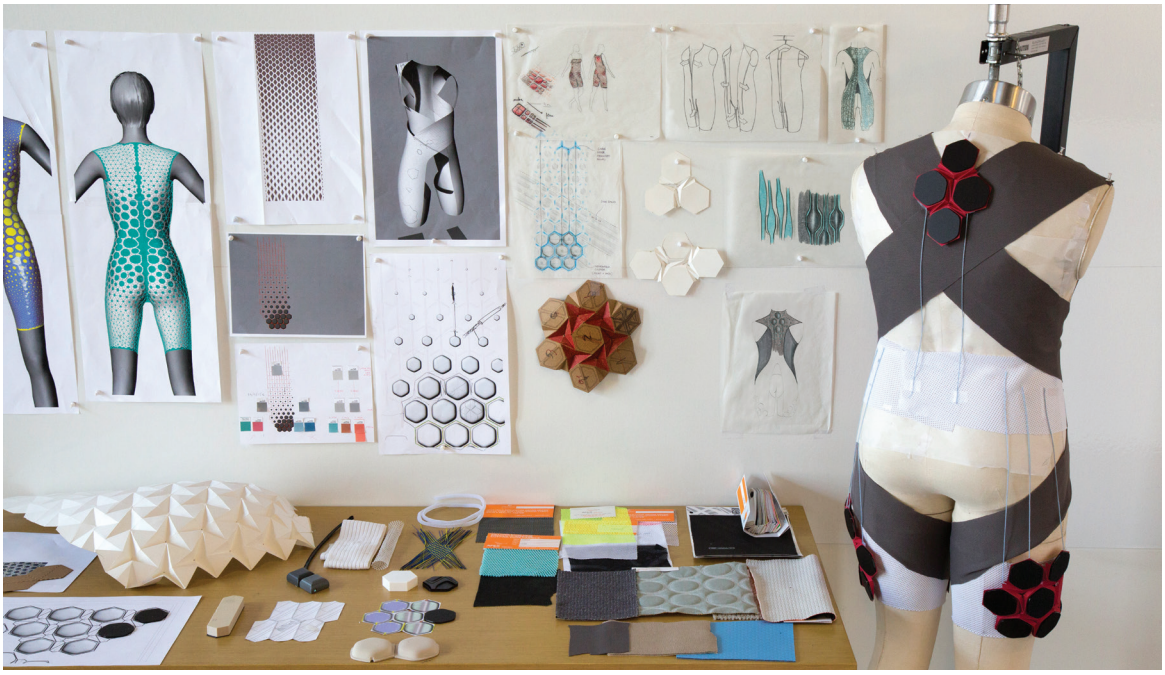

PHOTO COURTESY OF FUSEPROJECT

a fall, or a mattress that tells a nurse when it's time to turn a bed ridden patient," says Maltese. All of these things are in development.

Tech start-up Neopenda has developed a smart hat for prematurely born infants that can measure heart rate, temperature, respiratory rate, and blood oxygen saturation. Up to two dozen baby hats can be synched to one tablet to provide doctors and nurses the ability to check on an entire nursery at a glance via Neopenda's app. Deployment in Uganda is underway.

"As military usage moves into civilian adoption, this gets more exciting," says Hayward. The military exoskeleton technology created by research think tank SRI International (and made famous in video games like *Call of Duty)* was designed to reduce injury and enhance solider endurance while hauling heavy loads. Now through an SRI start up, Superflex, the technology has been modified to help the world's ageing population.

Smart hat by Neopenda

"We are trying to create a new category of powered clothing that delivers movement assistance," explains Rich Mahoney Superflex CEO. "We think of this as the first supersuit. It's not a video game or science fiction. It's real, and will provide mobility assistance for people."

Partnering with Designer Yves Béhar and his industrial design team from Fuseproject (a firm that creates strategic partnerships, design ventures, and civic works to create innovative products), Superflex introduced the Aura Powered Suit prototype in January of 2017 at London's Design Museum.

Lightweight and outfitted with electric muscles, the suit is designed to provide core wellness support to a wearer's torso, hips, and legs, providing strength when getting up, sitting down, or standing.

"When we talk about designing for an ageing population, the standard approach has been to provide aid in the home—completing tasks, welfare modules, accommodating lack of mobility, which results in a life lived more statically," explains Béhar. "But what if technology could help us continue to move about the world and engage with it, physically, socially, and emotionally?"

Using biomimicry, the suit is anatomically aligned with the wearer. For comfort, the hard technology components such as motors, batteries, and control boards are designed into hexagonal low-profile pods that are attached to fabric origami pouches allowing movement as the hardware expands, contracts, and moves with the wearer. The hardware pods

are removable for garment cleaning. The design is modular and scalable, and therefore adaptable to different muscular needs and heights.

"Superflex's new powered clothing technology means that people will lead fuller, healthier, and more rewarding lives," says Mahoney.

Fuseproject and Superflex plan to launch the consumer version in 2018 as they refine ease of use, care and cleaning, and price.

Reducing Stress

Last month, Nottingham Trent University announced that its Advanced Textiles Research Group, led by Professor Tilak Dias of the School of Art and Design, will explore how smart textiles embedded in cockpit seats and pilot clothing can measure anxiety in airline pilots. Project ASCENT (Active Simulator Cockpit Enhancement) is part of a wider research effort with SerTec Engineering and Paragon SA, and aims to enhance cockpit simulators.

Stress indicators such as variable heart rate, perspiration, and body temperature, as well as fatigue and alertness, will be monitored through sensors embedded in the yarns used to make textiles and clothing.

"This will enable the collection of data which will indicate the psychological experiences a pilot goes through while navigating a plane, potentially through unknown situations," Dias explains. "By using smart textiles we're able to provide new prognostic and diagnostic techniques for pilot monitoring in a completely non-intrusive way."

Smart Coaching

According to the team at Polar, listening to your body is one thing, but understanding what it is telling you is a different story. Through a combination of sports expertise, physiology, and electronics, Polar is launching a smart compression shirt with heart rate capture points on the front and a GPS sensor back pocket, allowing wearers to track motion and heart rate in real time. Through Polar's Team Pro System, coaches can monitor live training data via broadcast from the athlete and guide the athlete to an optimal workout.

Meanwhile, Wearable X has launched the Nadi X yoga pant. Sensors pulse at the hips, knees, and ankles to help wearers master yoga positions, while a companion smartphone app provides additional feedback—even playlists—to make yoga perfect.

Lumo Bodytech, creators of an artificial intelligence coaching platform, have teamed up with Puma and announced this month that they plan to introduce a new Puma product powered by Lumo's MotionScience Platform for runners, who they claim run faster, farther, and more efficiently through AI and wearables.

Samsung also is investing heavily in e-textiles: their Body Compass workout clothes measure biometric data, their Bean Pole Golf shirt monitors the weather and UV rays, and their newly-launched Human Fit smart suit (a collaboration with Rogatis) allows a wearer to unlock a smartphone and swap business cards digitally through NFC connectivity.

E-textiles offer help even for the less-active who are just interested in working on their tans. Spinali Design offers the Neviano UV Protect swimsuit collection, which contains a removable waterproof sensor that tells users when it's time to turn over, reapply sunscreen, or retreat to the shade through a companion smart app.

Show Me the Way

Levi's Commuter Jacket is the first piece of connected clothing to launch from Google's Project Jacquard platform. The aim of the platform is to weave touch and gesture interactivity into any textile using standard, industrial looms to transform clothes and furniture into interactive surfaces via conductive threads.

Aimed at the urban cyclist, the jacket (more than two years in the making) is promoted as a co-pilot—touch and gestures allow the cyclist to get map directions, play music, and dismiss phone calls through interactions on the sleeve—enhancing their awareness as a cyclist instead of distracting from the riding. The jacket encourages cyclists to use their sleeve, not their phone while driving.

A smart tag (removable for laundering) houses the electronics on the jacket sleeve. A beta product is out, with the goal of offering consumer purchase this year. The jacket will be on display at London's Museum of Design in October.

Clearly, the world is not lacking good ideas for e-textiles. So what are the challenges that are keeping most of these products from the mainstream?

Challenges

Durability

"The main issue today is durability," Maltese says. "When e-textiles are washed, they diminish. We aim to improve productivity, conductivity, and durability."

Zach Adams, Syscom product development engineer and Maltese's colleague, agrees, "We'd like to

PHOTO COURTESY OF LEVI'S

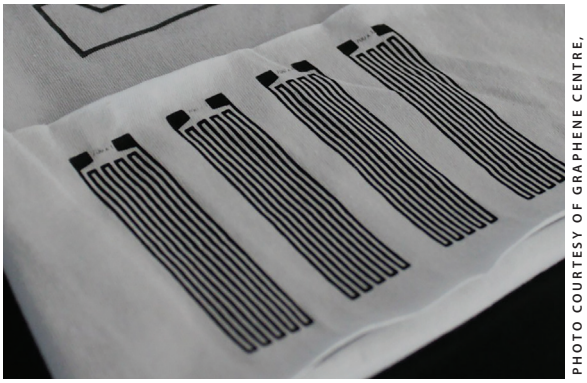

PHOTO COURTESY OF GRAPHENE CENTRE, UNIVERSITY OF MANCHESTER

Levi's detachable tag

see e-textiles you can wash and dry 150 times—treat them like normal garments. That's our work and goal."

Truly washable e-textiles promise better smart clothes without rigid components or expensive manufacturing with removable parts. Challenges around reliability, performance, and comfort are being addressed through new e-textile research that focuses on improved washability, stretchability, and in some cases new functionalities, Hayward says.

"The result is a complex ecosystem of different material, component, and connection options that are now available for product designers," he says.

Scientists from the University of Cambridge's Graphene Centre in partnership with Jiangnan University have developed conductive cotton fabric laced with graphene ink. Tests on a wearable motion sensor revealed that the textile can detect up to 500 motion cycles after more than 10 machine washings.

Graphene, a single atom-thick sheet of carbon, is flexible, conductive, and biocompatible—making it suitable for computer chips, electric cars, batteries, and e-textiles. Nanometer-thick graphene flakes chemically modified to attract to cotton are placed in a water-based dispersion and applied to cotton in a process similar to that used in dyeing.

I've Got the Power

"Most power sources today are snap-button connection," explains Adams. "You simply tie off the yarn at the snap button and then snap on the power or transmitter source. This will be the next hurdle."

This year, researchers at the University of Manchester demonstrated flexible battery-like devices printed directly onto textiles using a simple screen-printing technique with graphene. Development of graphene printed supercapacitors could turn the vast potential of wearable technology into the norm.

Cost and the Value Chain

"Aerospace-grade e-textiles are simply cost prohibitive in the commercial space," says Adams. "We have had to find ways to make this more commercially viable."

"When we started in aerospace, our goal was to save weight," explains Maltese. "Think copper wire, remove the core, and replace that with fiber. This offers an 80% weight savings, which is extremely important for satellites, the defense industry, even commercial aircraft," he says.

"Adhering metal to a polymer for aerospace is a complex process, and it takes time," Maltese explains. "We are competing with normal fiber manufactures, and yet we have the added costs of metal and other processes that ordinary textiles don't have."

Hayward agrees. "An e-textile compression shirt, for example, is competing with a traditional compression shirt that is made for less than $10 and sold for under $100," he says. "E-textile garments can be more than double that. Smart products contain electronics and that's a different value chain," he explains.

"The e-textile supply chain is different from the textile supply chain, and it is also different from an electronics supply chain," he says. "For example, there are different geographic locations, milestones, and lead times, for electronics and for e-textiles. The challenge is to build a mass manufacturing value chain," Hayward says.

The combination of the two chains to create e-textiles and smart garments requires coordination, shipping, assembly, and testing, he says.

At Google's I/O announcement in May 2016, Ivan Poupyrev, head of Google's Advanced Technology and Projects (ATAP) walked the audience through the supply chain challenges and successes when producing the Levi's Commuter jean jacket.

Poupyrev—described by *Fast Company* magazine as "one of the best interaction designers in the world"—pointed out that the e-textile denim needed to be produced within Levi's existing supply chain, and great care was taken to make this feasible. Additionally, the denim needed to be wash durable. First and foremost, the jacket had to be a jacket, he says.

For mass production and consumption across all e-textiles and smart garments, we still have a long way to go, Hayward says, but added, "While the market has been slow to start due to many challenges, with large companies investing heavily and releasing early products, this industry is poised to change very quickly."

Hayward is also the author of IDTechEx's extensive industry report *e-textiles: 2017-2027* and predicts that by 2027 the e-textile market will approach US$5 billion.

Earnings call statements like the one from Under Armour CEO Kevin Plank seem to support Hayward's prediction.

"We will continue to over-invest in connected fitness. We're doing so because we believe strongly that it will prove an important differentiator in our relationship with the consumer. With nearly 190 million registered users in our community, we continue to gather critical information to help us change the way athletes live. We firmly believe that going forward, brands without substantive communities will be at a deficit when it comes to building a relationship with our consumer," says Plank.

Google's continued investment in their Jacquard platform to create smart connected clothes is another indicator. In a connected world, perhaps e-textiles will truly become the fabric of our lives.

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