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Responder Technology Alert (September 2015)

October 2015

JF Upton
BJ Lavelle

Prepared for the U.S. Department of Homeland Security
Science and Technology Directorate
under Contract HSHQPM-14-X-00058

U.S. DEPARTMENT OF ENERGY

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Pacific Northwest National Laboratory
Richland, Washington 99352

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Introduction

The Pacific Northwest National Laboratory (PNNL) is supporting the Department of Homeland Security (DHS) to advance technologies to enhance responder health and address complex and changing threat environments. The DHS Science and Technologies First Responders Group established the Responder Technology Alliance (RTA) to accelerate the development of solutions to first responder needs and requirements by identifying, analyzing, and recommending solutions that improve responder safety, enhance their ability to save lives, and minimize property loss. The end goal is for RTA to develop and implement strategies that will make effective solutions available to first responders.

As part of technology foraging for the RTA, this report summarizes technologies that are relevant in the area of "wearables," with the potential for use by first responders. The content was collected over the previous month(s) and reproduced from a general Internet search using the term wearables. Additional information is available at the websites provided. The content is organized by technology function including:

- Sensors – Devices that detect physiological, particle, and chemical activity
- Displays – Heads-up and body-worn visual displays
- Power – Wearable power systems including chargers, batteries, self-powering or harvesting technologies, and power supplies
- Communications – Voice and data communications systems utilizing Bluetooth, wireless, hands-free, ergonomically optimized systems, noise-filtering digital speakers or microphones, etc.
- Location tracking – Track users indoors or outside
- Cameras – Body-worn photo and video cameras
- Breathing Apparatus – Wearable air supply and monitoring devices
- Exoskeletons – Whole or partial body suit that enhances mobility and physical performance
- Wearable Computers – Body-worn data processing devices
- Other – Miscellaneous technologies as well as emerging trends or recent advances in the field of wearables.

This report is not meant to be an exhaustive list nor an endorsement of any technology described herein. Rather, it is meant to provide useful information about current developments in the area of wearable technology.

These reports are available online at http://nwrtc.pnnl.gov. A spreadsheet summarizing these technologies is available in Appendix A.

1.0 SENSORS

1.1.1 BrainScope

Technology name: Ahead 100 and 200

Description: BrainScope is developing devices to assess brain injuries. The device features a headpiece with electroencephalogram (EEG) leads that connect to an Android smartphone for analysis. BrainScope has developed two models, the Ahead 100 and Ahead 200; the Ahead 200 is smaller and more rugged than its predecessor. The technology does not replace a CT scan but has been FDA approved for prescription use by trained medical professionals.

Source: **BrainScope raises $2.5M for concussion assessment wearable and app**
http://mobihealthnews.com/46552/brainscope-raises-2-5m-for-concussion-assessment-wearable-and-app/

Photo source: http://mobihealthnews.com/46552/brainscope-raises-2-5m-for-concussion-assessment-wearable-and-app/

1.1.2 Halo Wearables

Technology name: H1 hydration monitor

Description: The Halo smartwatch features sensors to measure and monitor a user's hydration. The backside of the watch features optical sensors and electromagnetic pads that emit electrical signals and track sodium and potassium levels in a user's blood plasma, a thermistor to measure skin temperature, and humidity and air temperature sensors. The device displays red, yellow, or green to indicate the user's hydration level. While designed for the sports industry, the device may have applications in situations with extreme heat conditions.

Source: **Next Football Season, Suiting Up Could Include This Sweat-Tracking Wearable**
http://www.forbes.com/sites/jenniferelias/2015/09/04/startup-aims-to-heighten-athlete-performance-with-hydration-tracking-device/

Photo source: http://www.forbes.com/sites/jenniferelias/2015/09/04/startup-aims-to-heighten-athlete-performance-with-hydration-tracking-device/

1.1.3 IntellADAPT

Technology name: Adaptive learning headgear

Description: Developers are creating technologies to recognize and respond to brain signals and enable a more engaging learning experience. The measured brain signals are used to determine mental engagement. Initially designed for the classroom, the technology is anticipated to help a user better understand their students' mental engagement and learning style.

Source: **Mind-Reading Wearable Tech Underway To Help Improve Classroom Learning Experience** http://www.ischoolguide.com/articles/25221/20150910/mind-reading-wearable-tech-classroom-learning-experience.htm

1.1.4 Made in Sense

Technology name: Happic

Description: The Happic band tracks activity (steps, sleep, etc.), is Android and iOS compatible, and features an OLED display, vibration motors, and gesture control, which enables a user to control other devices with their hand/arm movements. For example, it can alert a user which direction to move based on user's mobile device's GPS. While operating a camera, the device's accelerometer can detect movements of the wrist to zoom or take a photo. The vibration motors are located around the wrist (two on top, one underneath) and provide programmable haptic notifications to the user. The device offers a battery life of up to seven days and charges via a USB connector.

Source: **This smart band vibrates around your wrist for screen-free navigation** http://www.wareable.com/wearable-tech/happic-smart-band-vibrates-wrist-navigation-1628

Photo source: https://www.happiclife.com/

1.1.5 Melomind

Technology name: Melomind

Description: Melomind is a headset that uses neurofeedback to help relax the mind. The user wears a headset and earphones connected to a smart phone. The device uses specially designed sensors to detect and measure the wearer's relaxation and the information is sent via Bluetooth to an app on the user's mobile device, where a user can monitor their performance and see visualizations to help understand their results. The app builds personalized meditation sessions based on the user's stress levels and offers brain training and audio tracks to help them relax. The technology is proposed to help a user relax in just 15 minutes.

Source: **Relax in Under 15 Minutes With a Mindfulness Wearable for Your Brain**
http://www.psfk.com/2015/09/connected-headset-mindfulness-wearable-melomind.html

1.1.6 Nemaura

Technology name: SugarBeat glucose-monitoring device

Description: SugarBeat is a non-invasive, wearable, continuous glucose-monitoring device. The system includes a small (1 millimeter) disposable, adhesive, daily-use sensor patch; smartphone app; and a Bluetooth-enabled, LCD-equipped, wrist-worn device. Fluid beneath the skin is painlessly extracted to the sensor patch and the device records glucose levels (up to four times a day) and streams the data to the phone app.

Source: **Dr. Chowdhury speaks about Nemaura Medical's Wearable Patch – WT | Asia 2015**
https://www.wearable-technologies.com/2015/09/dr-chowdhury-speaks-about-nemaura-medicals-wearable-patch-wt-asia-2015/

Photo source: https://www.wearable-technologies.com/2015/09/dr-chowdhury-speaks-about-nemaura-medicals-wearable-patch-wt-asia-2015/

1.1.7 PetPace Ltd., I4C Innovations Inc.

Technology name: PetPace, Voyce

Description: Designed for animals, the PetPace collar monitors the wearer's vital signs (temperature, pulse, respiration), notifying a user via phone/text/e-mail when it detects irregularities that may be a sign of pain or distress. A similar product, Voyce is available in a consumer model and Voyce Pro is available for prescription for pets. Battery life varies from two days to eight weeks depending on the amount of data requested to measure.

Source: **New collars monitor pets for pain, problems**
http://www.sacbee.com/entertainment/living/pets/article33374112.html

1.1.8 SMRT Mouth

Technology name: Sports Monitoring Responsive Technology (SMRT) mouth guard

Description: SMRT Mouth is a mouth guard that uses high-sensitivity biometric sensors to measure osmolality in a user's bio-fluid in order to monitor hydration, circulation, and exertion. The device sends that data via Bluetooth to a mobile device that provides real-time tracking and sends alerts if certain thresholds are surpassed.

Source: **SMRT Mouth Launches Indiegogo Campaign To Help Finance Innovative Smart Wearable**
http://www.prnewswire.com/news-releases/smrt-mouth-launches-indiegogo-campaign-to-help-finance-innovative-smart-wearable-300144451.html

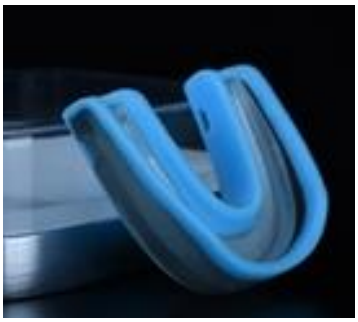

Photo source: http://photos.prnewswire.com/prnh/20150916/267302

1.1.9 University of Texas

Technology name: Vital-sign monitor

Description: Researchers created thin, wearable patches that adhere to the skin and use a patent-pending process to continuously monitor a user's vital signs (i.e., heart rate, hydration level, muscle movement, temperature, and brain activity). The goal is to create line of easy-to-manufacture disposable epidermal electronics, creating the devices in bulk and cutting the manufacturing process from days to less than half an hour. The technology employs affordable products (prefabricated, industrial-quality metal on polymer sheets) and processes to print electronics on polymer adhesives. In tests, researchers found that the patches detected body signals more effectively than existing medical devices and that the patches' conforming to the skin minimized motion-induced errors. In the future, developers hope to incorporate blood pressure and oxygen saturation sensors into the technology.

Source: **Wearable Electronic Health Patches May Now Be Cheaper and Easier to Make**
http://news.utexas.edu/2015/09/29/engineers-develop-new-method-for-making-wearable-electronics

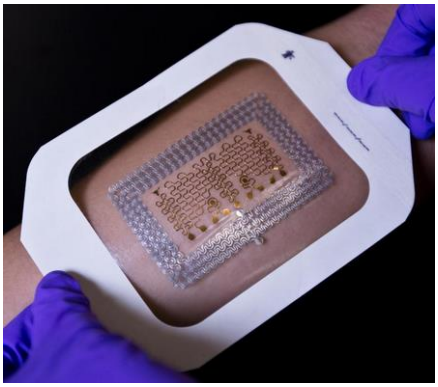

Photo source: http://news.utexas.edu/2015/09/29/engineers-develop-new-method-for-making-wearable-electronics

1.1.10 Whoop

Technology name: Whoop

Description: Whoop is a wrist-worn device that continuously measures biometrics to help a user optimize performance and reduce injury. It observes a user's heart rate, motion, skin moisture, and ambient

temperature, and the body's response to the environment, both observing variations and gathering up to 150 megabytes of physiological data per day. The data is sent via Bluetooth to an online database where it is analyzed and reported to a user in terms of intensity (strain), recovery (preparedness for strain/exertion), and sleep quality (how much the user got and how much they needed to ensure optimum performance that day). The data is also made available to a set of users (i.e., coaches and trainers) via a dashboard with customizable privacy settings. The U.S. military is reported to be currently using the device.

Source: **Whoop Wearable Brings 24/7 Performance Tracking to Elite Athletes**
http://www.xconomy.com/boston/2015/09/22/whoop-wearable-brings-247-performance-tracking-to-elite-athletes/

Photo source: http://www.xconomy.com/boston/2015/09/22/whoop-wearable-brings-247-performance-tracking-to-elite-athletes/

1.1.11 Zoll Medical Corp.

Technology name: μ-Cor

Description: Zoll Medical Corp. acquired Kyma Medical Technologies, Ltd., to advance its wearable monitoring device for patients with chronic cardiac illnesses. Kyma's μ-Cor patient-monitoring technology is a chest-worn device that measures fluid trends in the mid- to upper-back area and reports the information to the patient's healthcare team. Kyma is also developing sensors and algorithms to support management for other chronic diseases.

Source: **Zoll Acquires Israeli Wearable Cardiac Monitor Startup for $35M**
http://hitconsultant.net/2015/09/18/zoll-acquires-israeli-wearable-cardiac-monitor-startup/

1.2 Biological

1.2.1 BIOdress

Technology name: BIOdress

Description: A series of designers and researchers created BIOdress, a garment that employs thermochromic dyes, conductive threads, and a memory alloy to measure and respond to air quality. The

garment responds to air quality in several ways. Its shoulder component "breathes"—expanding and contracting based on the surrounding air quality. The faster the movement, the poorer the air quality it is detecting. Additionally the leaves of the garment can move and the fabric can change color.

Source: **Smartly dressed: the future of wearable technology**
http://www.abc.net.au/radionational/programs/breakfast/smartly-dressed-the-future-of-wearable-technology/6744374

1.2.2 Raune Frankjaer

Technology name: Biological sensor fabric

Description: A German designer created knitwear with optical fibers and electronics that display light patterns in response to physical signals such as a user's heartbeat, as well as two jackets that communicate via light.

Source: **Smartly dressed: the future of wearable technology**
http://www.abc.net.au/radionational/programs/breakfast/smartly-dressed-the-future-of-wearable-technology/6744374

1.3 Other

1.3.1 National University of Singapore

Technology name: Liquid-based tactile sensor

Description: Researchers are developing a thin, flexible, and durable micro-fluid-based tactile sensor anticipated to have applications in biomedical sensors. Compared to conventional tactile sensors, which are rigid and restrictive, this liquid-based technology is fabricated on a flexible substrate and uses a "pressure-sensing element to recognize force-induced changes." The technology has been tested for extreme deformations (pressing, bending, stretching), and maintained its electrical output and functionality. Developers have applied for a patent.

Source: **Highly flexible and wearable tactile sensor**
http://www.printedelectronicsworld.com/articles/8456/highly-flexible-and-wearable-tactile-sensor

2.0 DISPLAYS

2.1 Heads-up (on face or head)

2.1.1 Samsung

Technology name: Glasses-style wearable computer

Description: Samsung has reportedly filed a patent for a "Google-Glass-like" method and device that can project a virtual input area in the user's line of vision or onto an object. The device features an image sensor that senses gestures and may also include a depth sensor.

Source: **Samsung Patent Reveals an In-Depth Glass Project that could be Miles Ahead of Google** http://www.patentlyapple.com/patently-apple/2015/09/samsung-patent-reveals-an-in-depth-glass-project-that-could-be-miles-ahead-of-google.html

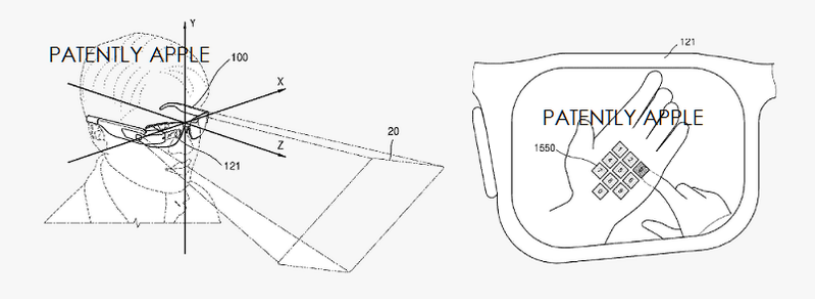

Photo source: http://www.patentlyapple.com/patently-apple/2015/09/samsung-patent-reveals-an-in-depth-glass-project-that-could-be-miles-ahead-of-google.html

2.1.2 University of ISFAHAN

Technology name: Human-computer interface

Description: Researchers are developing a headset to enable disabled individuals to type letters or communicate using their eye movements. The lightweight, wireless glasses feature a human-computer interface that recognizes eyes' electrical signals and turns them into communications (typing) or other responses (selecting an image).

Source: **Wearable interface to help disabled people** http://en.mehrnews.com/news/110053/Wearable-interface-to-help-disabled-people

2.2 Body worn (wrist, arm or chest)

2.2.1 Centre for Microsystem Technology, Holst Centre, Imec,

Technology name: Stretchable thin-film transistor

Description: Researchers are creating a thin fabric with a stretchable, conformable, thin-film transistor and stretchable LED display. The displays can be laminated into washable textiles and fabricated using common manufacturing approaches. The technology is anticipated to help advance the creation of responsive clothing.

Source: **Turning clothing into information displays** http://www.nanowerk.com/nanotechnology-news/newsid=41199.php

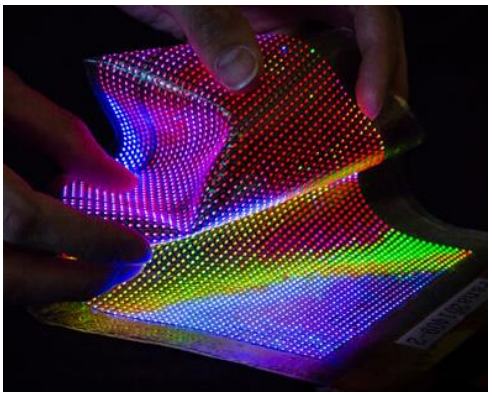

Photo source: http://www.nanowerk.com/nanotechnology-news/newsid=41199.php

2.2.2 Dot

Technology name: Dot

Description: Dot is a smartwatch that offers a Braille module with proprietary haptic technology that can share raised bumps for up to four characters at a time and can display scrolling messages at speeds up to 100hz. The smartwatch offers Bluetooth and smartphone connectivity to display messages from a range of apps (text messaging, Twitter, etc.) using voice commands.

Source: **Dot is bringing wearable tech to the visually impaired** https://www.techinasia.com/dot-braille-wearable/

3.0 POWER

3.1 Chargers

3.1.1 Dark Energy

Technology name: Poseidon

Description: Poseidon is a military-grade power source and light that is "drop proof, crush proof, 100 percent waterproof and 100 percent dust proof." The technology features a water-resistant cable, 10,000 mAh portable power, dual charging capability, and a built-in LED light and lantern.

Source: **Dark Energy brings wearable tech to hunting** http://siliconslopes.com/blog/2015/09/10/dark-energy-brings-wearable-tech-to-hunting/

Photo source: https://darkenergy.com/product/poseidon/

3.2 Self-powering (Harvesting)

3.2.1 Bionic Power

Technology name: PowerWalk

Description: The PowerWalk device resembles carbon-fiber shin guards equipped with an energy harvester for converting the user's mechanical work into electricity. The device features an orthopedic knee brace such that "knee motion drives a gear train through a one-way clutch, transmitting only knee extension motion at speeds suitable for a DC brushless motor that serves as the generator." The device weighs 850 grams and can generate 8-14 watts of power from a 1.5 m/s walking speed, supposedly enough to charge a cell phone on a 15-minute walk, and up to 25 watts on a down-hill walk.

Source: **Energy Harvesting Digs Into Human Motion and Wearable Materials**
http://www.designnews.com/author.asp?section_id=1386&doc_id=278538&dfpPParams=ind_182,industry_gov,industry_medical,kw_robotics,kw_motors,kw_41,aid_278538&dfpLayout=blog

Photo source: http://www.bionic-power.com/

3.2.2 Drayson Technologies

Technology name: Freevolt

Description: Freevolt turns ambient radio energy into small amounts of power, harvesting the energy to run low-energy devices (i.e., sensors, beacons, wireless communications). The device is pocket- and smartphone-sized and credit-card-thin. The technology advanced due to a multi-band antenna that harvests energy across radio bands, a rectifier that turns energy into current, and an optimized power management system. Drayson will license the technology to companies.

Source: **Startup hopes energy harvested from the air will power smart homes and wearables**
http://www.cnet.com/news/energy-harvested-from-air-will-power-smart-homes-and-wearables/

4.0 COMMUNICATIONS

4.1 Wearable, hands-free operation

4.1.1 Mind Solutions

Technology name: NeuroSync

Description: The NeuroSync headset enables a user to control smart devices by the "power of thought." Electrical signals from the brain travelling through the inner ear canal are received by a sensor on the device.

Source: **San Diego Startup Shipping Wearable Brain-Computer Interface**
http://timesofsandiego.com/business/2015/09/04/mind-solutions-shipping-wearable-brain-computer-interface/

4.1.2 Motorola, VivaLnk

Technology name: Digital Tattoo

Description: Digital Tattoo is a near-field communication skin tag that allows a user to interact with their smartphone (currently only Moto X) with a tap of the finger. The tattoo can be worn up to five days and endure showers and sweat.

Source: **You can now unlock your Motorola phone with a 'digital tattoo'**
http://www.engadget.com/2014/07/22/digital-tattoo-phone-unlock/

Photo source: http://motorola-blog.blogspot.ca/2014/07/-unlock-your-moto-x-with-a-digital-tattoo.html

4.1.3 MSA

Technology name: MSA Gallet F1 XF

Description: MSA Gallet F1 XF "jet style" helmet offers eye and face protection with quality optics, clear vision, and wide field of view as well as integrated radio communications with reduced interference from noisy environments and customizable loudspeakers and hearing protection. It also features a bone-conductive headset with various microphone positions and the ability to operate with or without the SCBA. The visor also offers maximum inner space and gap-free protection.

Source: **Optimum communications the next level of PPE for oil and gas emergency response** http://www.manmonthly.com.au/news/sponsored-content/optimum-communications-the-next-level-of-ppe-for-o

4.1.4 Texas A&M University, Texas Instruments

Technology name: Inertial and electromyographic sensors for gesture detection

Description: Researchers are combining inertial (motion) and electromyographic (electrical muscle activity) sensors to measure muscle activity in a user's hand gestures. Prototypes demonstrated the ability to recognize 40 American Sign Language words with approximately 96 percent accuracy. The inertial sensors measure acceleration and angular velocities of the user's hand/arm, while the electromyographic sensors measure electrical activity in the muscles and can distinguish between hand and finger movements. The sensors are placed on the right wrist where they detect gestures and send the data via Bluetooth to a laptop where complex algorithms are used to interpret and display the word for the gesture. Compared to existing technologies, this novel approach does not require a camera but rather interprets the user's muscle activity.

Source: **Wearable Technology Combines Inertial and Electromyographic Sensors for Detecting Gestures** http://www.azosensors.com/news.aspx?newsID=10137

4.1.5 University of California San Diego

Technology name: Magnetic field human body communication

Description: Researchers are developing an ultra-low-power, secure wireless communications system for wearables by sending magnetic signals through the human body, as opposed to transmitting through Bluetooth or other means, which often require an additional "boost" to pass through the body. Researchers hope to create an application for a "wireless sensor network for full-body health monitoring." Leveraging the fact that magnetic fields easily pass through biological tissue, the "magnetic field human body communication" technique uses the human body as a field to deliver magnetic energy between devices without significant power loss or consumption. The technique's losses are reported an "upwards of 10 million times lower than those associated with Bluetooth radios." The technique may also result in preserved battery life and possibly offering increased security.

Source: **Magnetic Fields Provide a New Way to Communicate Wirelessly**
http://gadgets.ndtv.com/wearables/news/magnetic-fields-provide-a-new-way-to-communicate-wirelessly-734866

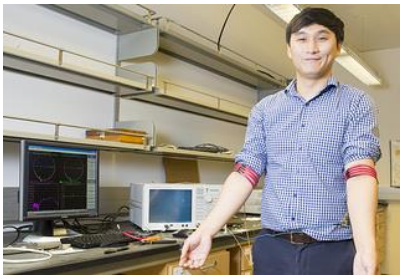

Photo source: http://jacobsschool.ucsd.edu/news/news_releases/release.sfe?id=1807

5.0 LOCATION TRACKING

5.1.1 AlertGPS

Technology name: AlertGPS

Description: The AlertGPS wearable device offers GPS location information and 2-way voice communication and can issue an alert and dispatch help at the push of a ONEtouch button. It is accompanied by a dashboard the enables a user to see real-time location information. AlertGPS is currently being used by the Forza Futbol Club.

Source: **AlertGPS Safety Wearable and Forza FC Revolutionize Tournament Safety**
http://newswire.net/newsroom/pr/00090185-alert-gps-safety-wearable-and-forza-fc-revolutionize-tournament-safety.html

Photo source: http://newswire.net/newsroom/pr/00090185-alert-gps-safety-wearable-and-forza-fc-revolutionize-tournament-safety.html

5.1.2 BeSpoon

Technology name: BeSpoon Sport Edition

Description: The BeSpoon Sport Edition features the BeSpoon RFID tags and receivers in combination with Mac-lloyd's Sport-Tracking Fusion software to create an ultra-wideband (UWB), RFID-based, real-time location tracking system. The technology records a user's movements and heart rate and transmits that data to a server for analysis using Sport Tracking's Fusion software. The software can determine speed, jump height, players' proximity to each other, as well as produce a map of the court and each player's location. BeSpoon teamed with French research center CEA-LETI to design the system to be smaller and lower cost than many of the existing systems. The device features a battery-powered, button-sized (1.2 cubic inch) RFID tag that features BeSpoon's UWB chip and a heart rate sensor by Sport Tracking combined in a tank-top worn under or over the player's uniforms. The chip can transmit data up to 984 feet and offers precision tag location within several inches, but receivers must be installed surrounding the area of use.

Source: **French Handball Team Trains With Wearable RFID Sensors**
http://www.rfidjournal.com/articles/view?13492/

5.1.3 Broadcomm

Technology name: Global Navigation Satellite System (GNSS) Location Hub Microcontroller with Integrated GNSS BCM47748 chip

Description: Broadcomm's new GNSS chip enables low-power accurate location detection for Internet of Things and wearable devices. The technology delivers its power savings by removing the signal processing from the multicontroller unit, and instead calculates position, velocity, and time on the chip, which also lowers the cost for original equipment manufacturers and reduces footprint. It also uses intelligent firmware to extend the device's battery life and adapts to the user's activity and context for more precise location tracking.

Source: **New GNSS Chip for IoT Market and Wearable Devices**
http://en.ctimes.com.tw/DispProduct.asp?O=HJZ9EC54BXASAA00P4

Photo source: https://www.broadcom.com/products/wireless-connectivity/gps/bcm47748

5.1.4 OnGarde

Technology name: SiteZone Proximity Warning System

Description: SiteZone's wearable RFID transponder affixes to a user (on a hard hat, sleeve, etc.) and another unit is attached to a vehicle, creating a safety zone between the two. If the user enters the field of the vehicle, the driver and the user receive a vibration, audio, and visual alert and Site Zone's proximity warning system logs the incident. SiteZone can "see" through dust, smoke, and other low-visibility conditions. OnGarde, creator of SiteZone, also created the OverSite product that transfers the logged data to a secure website, where users can review and learn from the results (i.e., target training and recognize repeat offenders). OnGarde is testing and refining the technology with several of its clients to identify additional practical applications, such as the Zone Selector, which allows a user to switch between preset ranges for specific tasks, and the BucketZone, which establishes a detection zone around working equipment (e.g., excavators, shovels).

Source: **Health and safety innovation: wearable tech changing hearts and minds**
http://www.shponline.co.uk/health-and-safety-innovation-wearable-tech-changing-hearts-and-minds/

Photo source: http://www.shponline.co.uk/health-and-safety-innovation-wearable-tech-changing-hearts-and-minds/

5.1.5 Revolar

Technology name: Revolar

Description: Revolar is a small (1-inch x 1-inch x 1/8-inch), water-resistant device that, upon the push of a button, sends an alert with the user's GPS location to the user's contact list entered into the Revolar App on the user's smart device. Revolar features a replaceable battery that reportedly lasts for months.

Source: **Revolar personal safety device sends your GPS location** http://www.slashgear.com/revolar-personal-safety-device-sends-your-gps-location-27380892/

Photo source: http://www.slashgear.com/revolar-personal-safety-device-sends-your-gps-location-27380892/

5.1.6 Tencent

Technology name: QQ watch

Description: The QQ watch features a 1.12 inch, 128 x 128 pixel OLED display; a 2G radio as well as GPS, Wi-Fi, and cellular triangulation; a five-day battery life; IP265 ruggedness; and an SOS call button. The device also features a 0.3 megapixel camera compatible with WeChat, which enables the user to take a photo of their location or nearby landmark and send to other users. The device was designed to help parents locate their children.

Source: **Tencent's Kids Smartwatch Helps Parents Keep Track of Their Children**
http://au.idigitaltimes.com/tencents-kids-smartwatch-helps-parents-keep-track-their-children-106757

6.0 EXOSKELETONS

6.1.1 University of Pittsburgh

Technology name: Hybrid exoskeleton

Description: Researchers are developing a "hybrid" mechanical exoskeleton. The technology combines functional electrical stimulation (FES) (low-level electrical currents that activate muscles), and powered exoskeletons (electric motors on an external frame). The combination results in extended use time by supplementing mechanical operations with a user's own muscle power. The research will investigate adaptive control algorithms for optimal input to the different systems as well as control algorithms to enable synergy between the systems in order to deliver optimal single and multi-joint movement. The goal of the research is to "examine the efficiency of exoskeleton technology for manufacturers hoping to develop new hybrid models that take advantage of FES technology, powered frames, and robotics."

Source: **Hybrid walking exoskeleton research at Pitt receives NSF funding**
http://www.eurekalert.org/pub_releases/2015-09/uop-hwe092215.php

7.0 OTHER

7.1.1 Behnaz Farahi (Individual)

Technology name: Caress of the Gaze

Description: Caress of the Gaze is a 3D-printed garment with a camera with a facial-tracking algorithm so that it can detect when it is being observed, which causes the garment to ripple in response. The device's microcontroller can reportedly detect the gender and age of the person looking at the device. The technology was developed by an architect and interaction designer using a 3D printer to fabricate composite materials in varying flexibilities, densities, and combinations.

Source: **3D-printed interactive wearable reacts to ogling**
http://www.networkworld.com/article/2986982/software/3d-printed-interactive-wearable-reacts-to-ogling.html

7.1.2 Behnaz Farahi (individual)

Technology name: Synapse

Description: Synapse is a 3D-printed cyber helmet that moves in response to brain activity. The developer modified a Mindflex headset with a Neurosky electroencephalogram chip to monitor electrical activity of the brain and use that activity to move the device.

Source: **Shape-changing Synapse helmet tanslates brainwaves into movement [sic]**
http://neurogadget.com/2015/01/26/shape-changing-helmet-tanslates-brainwaves-movement/10874

Photo source: http://behnazfarahi.prosite.com/204244/5572755/gallery/synapse

7.1.3 Fhoss Technology

Technology name: Light-powered personal protective equipment

Description: Fhoss Technology developed rechargeable, water-resistant, light-powered protective clothing equipped with battery-powered strips atop reflective material that increase visibility of the wearer in low-light conditions. The clothing's hidden battery pack offers approximately 12 hours of continuous operation. Fhoss was awarded the 2015 New Product Innovation Award by Frost & Sullivan and was shortlisted for Innovation of the year in the North Somerset Business Awards.

Source: **Weston-super-Mare high viz clothing firm Fhoss Technology shortlisted for eighth award** http://www.westernmorningnews.co.uk/Weston-super-Mare-high-viz-clothing-firm-Fhoss/story-27844820-detail/story.html#ixzz3nA45sWx0

7.1.4 Google

Technology name: Self-adjusting glasses

Description: According to a recent patent application, Google is pursuing a self-adjusting system for glasses. Motion detectors and motors in the frame automatically adjust the tension of the arms (tighten, loosen, etc.) to keep the glasses in place.

Source: **Is Google working on self-adjusting glasses? Patent hints at sensors and motors that tighten the arms to stop them falling off** http://www.dailymail.co.uk/sciencetech/article-3227633/Is-Google-working-self-adjusting-glasses-Patent-hints-sensors-motors-automatically-tighten-arms.html#ixzz3mP9AHZJE

7.1.5 Hillcrest

Technology name: MotionEngine™ Wear

Description: MotionEngine Wear is a small-footprint, low-power software designed to be a low-cost, flexible, energy-efficient solution for wearable developers. The software offers a foundation for activity tracking, sleep monitoring, and more. It can sense for context awareness (whether a user is in a car or on a bicycle for example), orientation (compass bearing), and gesture controls. The software is compatible with popular system architectures, deployable on various platforms, and employs power-reduction algorithms and always-on sensing.

Source: **Wearable Device Makers to Enjoy Higher Performance and Faster Time to Market Thanks to Hillcrest Labs** http://www.marketwatch.com/story/wearable-device-makers-to-enjoy-higher-performance-and-faster-time-to-market-thanks-to-hillcrest-labs-2015-09-29

7.1.6 Lumenus

Technology name: Lumenus

Description: Lumenus is creating LED-equipped smart clothing that pairs with a user's smart phone via Bluetooth and, with an Android or iOS app running Google Maps servers, it uses the GPS and accelerometer to light up the clothing's LEDs to indicate to the user which way to go. The device also has lights to warn others when the user is braking or turning. It offers the typical Google Maps functions of automatically rerouting, manual location entry, and route suggestions.

Source: **This Cycling Jacket Offers Turn-by-Turn Directions** http://www.bicycling.com/bikes-gear/interbike-2015/cycling-jacket-offers-turn-turn-directions

Photo source: http://www.bicycling.com/bikes-gear/interbike-2015/cycling-jacket-offers-turn-turn-directions

7.1.7 Stanford University

Technology name: Color-changing artificial electronic skin

Description: Researchers are developing an "e-skin" that, in addition to mimicking natural skin's flexibility, stretchability, and pressure capabilities, features an electrochromic polymer creating the chameleon-like ability to change color. The application of varying pressure causes a change in voltage, which causes the material to change color from red to blue. Production of the material is simple, cost-effective, and easily scalable.

Source: **Artificial Chameleon Skin Promises New Developments In Wearable Tech** http://inventorspot.com/articles/artificial-chameleon-skin-promises-new-developments-wearable-tec

7.1.8 University of Exeter

Technology name: Nano-chemical vapor deposition

Description: Researchers from the University of Exeter are exploring a new method for producing graphene called Nano-chemical vapor deposition (nanoCVD), in which graphene is grown in an

“industrial cold wall Chemical Vapor Deposition (CVD) system” developed by Moorfield. Graphene has properties appealing to the wearable industry—it is thin, flexible, strong, lightweight, and conductive—but current production processes are costly. This proposed method is reported to grow graphene an estimate 100 times faster, with improved electronic quality, and at nearly 1 percent of the cost of traditional methods. The method has been used to produce a transparent, flexible, graphene-based touch sensor; transparent, lightweight, flexible conductive material; and transparent, flexible, graphene-embedded textiles. Additionally, the method allows for mass production with current facilities.

Source: **Breakthrough with New Technique for Graphene Production**
http://science.dodlive.mil/2015/09/23/22601/

Photo source: http://science.dodlive.mil/2015/09/23/22601/

Appendix A

Technology Summary

Technology summary

The table below provides a summary of the technologies compiled in this report. This information is not meant to be an exhaustive list nor an endorsement of any technology described herein.

Company	Technology	Description
Sensor		
Physiological		
BrainScope	Ahead 100 and 200	Devices to assess brain injuries; features a headpiece with electroencephalogram leads that connect to an Android smartphone for analysis.
Halo Wearables	H1	Smartwatch with sensors to measure and monitor a user's hydration.
IntellADAPT	Adaptive learning headgear	Recognizes and responds to brains signals to enable a more engaging learning experience
Made in Sense	Happic	Tracks activity (steps, sleep, etc.), is Android and iOS compatible, and features an OLED display, vibration motors, and gesture control, which enables a user to control other devices with their hand/arm movements.
Melomind	Melomind	Headset that uses neurofeedback to help relax the mind
Nemaura	SugarBeat	Wearable continuous glucose-monitoring device featuring a small (1 millimeter) disposable, adhesive sensor patch; smartphone app; and a Bluetooth-enabled, LCD-equipped watch-like device.
PetPace Ltd., I4C Innovations Inc.	PetPace, Voyce	Collars that monitors the wearer's vital signs (temperature, pulse, respiration), notifying a user via phone/text/e-mail when it detects irregularities that may be a sign of pain or distress.
SMRT Mouth	Sports Monitoring Responsive Technology (SMRT) Mouth	mouth guard that uses high-sensitivity biometric sensors to measure concentrations in a user's body fluid in order to monitor hydration, circulation, and exertion.
University of Texas	Vital-sign monitor	Thin, wearable patches that adhere to the skin and use a patent-pending process to continuously monitor a user's vital signs
Whoop	Whoop	Wrist-worn device that continuously measures biometrics to help a user optimize performance and reduce injury.
Zoll Medical Corp., Kyma Medical Technologies, Ltd.	µ-Cor	Chest-worn device that measures fluid in the mid- to upper-back area and reports the information to the patient's healthcare team
Biological		
BIOdress	BIOdress	Garment employs thermochromic dyes, conductive threads, and a memory alloy to measure and respond to air quality.
Raune Frankjaer	Biological sensor fabric	Knitwear with optical fibers and electronics that display light patterns in response to physical signals such as a user's heartbeat, as well as two jackets that communicate via light.
Other		
National University of Singapore	Liquid-based tactile sensor	Thin, flexible, and durable micro-fluid-based tactile sensor anticipated to have applications in biomedical sensors.
Displays		
Heads-Up		
Samsung	Glasses-style wearable computer	"Google-Glass-like" method and device that can project a virtual input area in the user's line of vision or onto an object
University of ISFAHAN	Human Computer Interface	Lightweight, wireless glasses featuring a human-computer interface that recognizes eyes' electrical signals and turns them into communications (typing) or other responses (selecting an image).

Body-Worn		
Centre for Microsystem Technology, Holst Centre, Imec	Stretchable thin-film transistor	Fabric with a stretchable, conformable, thin-film transistor and stretchable LED display.
Dot	Dot	Smartwatch that offers a Braille module with proprietary haptic technology that can share raised bumps for up to four characters at a time and can display scrolling messages at speeds up to 100hz.
Power		
Chargers		
Dark Energy	Poseidon	Military-grade, rugged power source and light.
Self-Powering/Harvesting		
Bionic Power	PowerWalk	Resembles carbon-fiber shin guards equipped with an energy harvester for converting the user's mechanical work into electricity
Drayson Technologies	Freevolt	Turns ambient radio energy into small amounts of power, harvesting the energy to run low-energy devices.
Communications		
Hands-Free		
Mind Solutions	NeuroSync	Headset that enables a user to control smart devices by the "power of thought." Electrical signals from the brain travelling through the inner ear canal are received by a sensor on the device.
Motorola, VivaLnk	Digital Tattoo	Near-field communication skin tag that allows a user to interact with their smartphone with a tap of the finger
MSA	MSA Gallet F1 XF	"Jet style" helmet offers eye and face protection with quality optics, clear vision, and wide field of view as well as integrated radio communications with reduced interference from noisy environments and customizable loudspeakers and hearing protection
Texas A&M University, Texas Instruments	Inertial and electromyographic sensors for gesture detection	Combines inertial (motion) and electromyographic (electrical muscle activity) sensors to measure muscle activity in a user's hand gestures.
University of California San Diego	Magnetic field human body communication	Ultra-low-power, secure wireless communications system for wearables by sending magnetic signals through the human body.
Location Tracking		
AlertGPS	AlertGPS	Wearable device that offers GPS location information and 2-way voice communication and can issue an alert and dispatch help at the push of a ONEtouch button.
BeSpoon	BeSpoon Sport Edition	Features the BeSpoon RFID tags and receivers in combination with Mac-lloyd's Sport-Tracking Fusion software to create a UWB, RFID-based, real-time location tracking system. Records a user's movements and heart rate and transmits that data to a server for analysis using Sport Tracking's Fusion software.
Broadcomm	GNSS Location Hub Microcontroller with Integrated GNSS BCM47748 chip	Provides low-power accurate location detection and delivers power savings by removing the signal processing from the multicontroller unit, and instead calculates position, velocity, and time on the chip.
OnGarde	SiteZone Proximity Warning System	Wearable RFID transponder affixes to a user (on a hard hat, sleeve, etc.) and another unit is attached to a vehicle, creating a safety zone between the two, and sends alerts when the field is breached.
Revolar	Revolar	Small, water-resistant device that, upon the push of a button, sends an alert with the user's GPS location to the user's contact list entered into the Revolar App on the user's smart device.
Tencent	QQ watch	Features a 1.12 inch, 128 x 128 pixel OLED display; a 2G radio as well as GPS, Wi-Fi, and cellular triangulation; a five-day battery life; and an SOS call button. Features a 0.3 megapixel camera compatible with WeChat.

Exoskeletons		
University of Pittsburgh	Hybrid exoskeleton	Exoskeleton that brings together functional electrical stimulation (FES) (low-level electrical currents that activate muscles), and powered exoskeletons (electric motors on an external frame).
Other		
Behnaz Farahi (Individual)	Caress of the Gaze	3D-printed garment with a camera with a facial-tracking algorithm so that it can detect when it is being observed, which causes the garment to ripple in response.
Behnaz Farahi (Individual)	Synapse	3D-printed cyber helmet that moves in response to brain activity.
Fhoss Technology	Light-powered personal protective equipment	Rechargeable, water-resistant, light-powered protective clothing equipped with battery-powered strips atop reflective material that increase visibility of the wearer in low-light conditions.
Google	Self-adjusting glasses	Self-adjusting system glasses with motion detectors and motors in the frame that automatically adjust the tension of the arms (tighten, loosen, etc.) to keep the glasses in place.
Hillcrest	MotionEngine™ Wear	Small-footprint, low-power software designed to be a low-cost, flexible, energy-efficient solution for wearable developers
Lumenus	Lumenus	LED-equipped smart clothing that pairs with a user's smart phone via Bluetooth and, with an Android or iOS app running Google Maps servers, it uses the GPS and accelerometer to light up the clothing's LEDs to indicate to the user which way to go
Stanford University	Color-changing artificial electronic skin	An "e-skin" that mimics natural skin's flexibility, stretchability, and pressure capabilities and also features an electrochromic polymer creating the chameleon-like ability to change color.
University of Exeter	Nano-chemical vapor deposition	Method for producing graphene in a Chemical Vapor Deposition system.

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