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Responder Technology Alert (July 2015)

August 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. For an electronic copy, contact Jaki Upton at jaki.upton@pnnl.gov

1.0 SENSORS

1.1 Physiological

1.1.1 Baycrest Rotman Research Institute

Technology name: Muse wireless electroencephalography (EEG) headband

Description: Muse offers clinical-grade EEG with smartphone connectivity and provides users insight into their brain activity. Researchers used the Muse wireless EEG headband to collect neurofeedback, or brain data, of more than 500 adults. The device measured activity as the patients played collective neurofeedback games designed to manipulate their mental relaxation and concentration. The collective EEG signals were used to control lighting and imagery in an exhibit. The device can reportedly help users learn meditation, improve attention, and manage stress by providing real-time insight into their brains.

Product link: http://www.choosemuse.com/

Source: **'Wearable for the mind' launches new era of brain research**
http://www.greatreporter.com/content/2578/wearable-mind-launches-new-era-brain-research

Photo source: http://www.choosemuse.com/

1.1.2 BeneGear Inc.

Technology name: Heart-rate variability (HRV) monitor

Description: BeneGear Inc. employed ADI's single-lead heart-rate monitor applications into its HRV health wearables to measure HRV as a potential indicator of cardiovascular disease. The device is expected to go into high-volume manufacturing in August. The product is described as offering easy integration, low-noise, and low-power consumption.

Source: **BeneGear to Apply ADI's HRV Application into Wearables**
http://en.ctimes.com.tw/DispNews.asp?O=HJZ72B8MK3GSAA00N5

1.1.3 MOOV

Technology name: MOOV NOW fitness tracker

Description: MOOV NOW is a wearable fitness tracker that is an "artificial intelligence coach." The device uses a combination of sensors (magnetic meter, gyroscope, and accelerometer) to analyze performance (movement, poses, etc.) and provide real-time feedback to the wearer. For example, it can measure impact and advise a runner to run more or less gently. The device is waterproof and offers a six-month battery life.

Product link: http://welcome.moov.cc/

Source: **MOOV NOW, a new top of the line fitness wearable aka the next-gen Artificial Intelligence coach** http://www.vcpost.com/articles/79485/20150720/moov-now-new-top-line-fitness-wearable-aka-next-gen.htm

Photo source: http://welcome.moov.cc/

1.1.4 NimbleHeart Inc.

Technology name: Disposable electrode

Description: NimbleHeart is developing a disposable electrode capable of providing clinical-grade electrocardiogram (ECG) signals. The technology was designed for use with astronauts in space, where electrodes must be able to be applied without preparation (shaving, abrasion, gel application, etc.). The dry electrodes are designed to be comfortable and with a patent-pending 12-lead ECG harness that minimizes motion impacts. The harness is available in multiple sizes.

Product link: http://www.nimbleheart.com/

Source: **NimbleHeart delivers wearable 12 lead ECG harness to NASA for astronaut monitoring** http://www.prnewswire.com/news-releases/nimbleheart-delivers-wearable-12-lead-ecg-harness-to-nasa-for-astronaut-monitoring-300112648.html

Photo source: http://photos.prnewswire.com/prnh/20150710/235313

1.1.5 University of Michigan

Technology name: Wearable fluid status sensor

Description: The wearable device measures fluid status, the volume of blood pumping through a user's blood vessels, as a diagnostic measure for heart rate, blood pressure, or infection, for example. The device uses Dynamic Respiratory Impedance Volume Evaluation (DRIVE) to measure bioimpedance, or electrical conductivity. With the ability to simply attach to a patient's arm or leg, the device is proposed to reduce the need for invasive measuring techniques such as an ultrasound or catheter and to provide continuous real-time data.

Source: **Wearable fluid status sensor could lead to new 'vital sign'**
http://www.engin.umich.edu/college/about/news/stories/2015/july/wearable-fluid-status-sensor

1.2 Chemical/particulate

1.2.1 MyExposome

Technology name: MyExposome wristband

Description: Users wear the MyExposome wristband for a week, during which time a special material monitors for chemicals to which a wearer is exposed, such as pesticides, endocrine disrupters, and flame retardants. Users ship the wristband to the MyExposome laboratory, where it is analyzed for more than 1,400 different toxins. In addition to monitoring personal exposures, developers hope the device can be used to better understand toxins within a given area.

Product link: http://www.myexposome.com/

Source: **Innovation of the week: Toxin-detecting wearable**
http://theweek.com/articles/567865/innovation-week-toxindetecting-wearable

Photo source: https://www.kickstarter.com/projects/540997591/know-your-personal-chemical-exposure

1.3 Other

1.3.1 Cyrcadia, Inc.

Technology name: iTBraTM wearable breast cancer early detection device

Description: Cyrcadia, Inc. is beginning clinical trials for a wearable breast cancer early detection device. Cyrcadia has plans to produce a smart-phone-enabled wearable, iTBraTM that will employ a comfortable data collection device placed under a bra over 2-12 hours to collect breast cell data to detect the earliest stages of cellular variances. Data will be transmitted to a global cancer library for analysis that will then be communicated back to the patient and physician. Reportedly, "Previous trials comprised of 500 participants, using Cyrcadia Health's non-compressive, non-irradiative technology, demonstrated significant promise in addressing the dense breast tissue population by using machine-learning predictive algorithms."

Company link: http://cyrcadiahealth.com/

Source: **Cyrcadia, Inc. Enters Clinical Trials for Wearable Breast Cancer Detection Device**
https://www.elcaminohospital.org/newsroom/cyrcadia-health-enters-clinical-trials-wearable-breast-cancer-detection-device

2.0 DISPLAYS

2.1 Heads-up (on face or head)

2.1.1 CSIRO

Technology name: Guardian Mentor Remote

Description: Guardian Mentor Remote features a connected headset and glasses that connect to on-site operators and mechanics elsewhere to enable real-time assistance. The goal of the technology is to reduce costs by reducing the need to have engineers in person. The system has a helper station and operator station equipped with wearable computers, helmet-mounted camera, and near-eye display. The off-site expert then uses a "virtual pair of hands in a shared visual space" to demonstrate how to fix the equipment. The prototype has been in trials with Boeing and Aviation Australia.

Product link: http://www.csiro.au/en/Research/DPF/Areas/Autonomous-systems/Guardian/ReMoTe

Source: **Wearable tech from CSIRO promises to end long airport delays**
http://www.afr.com/technology/wearable-tech-from-csiro-promises-to-end-long-airport-delays-20150723-giimil

Photo source: http://www.csiro.au/en/Research/DPF/Areas/Autonomous-systems/Guardian/ReMoTe

2.1.2 Samsung

Technology name: Wearable display

Description: The device is described as having a camera and transparent screen for each eye as well as sensors for tracking movement. The camera capability is suggested to allow for a 3D point of view. The screen will allow for augmented reality, overlaying visual information into the user's environment. The device will also feature LEDs and sensors for tracking motion as well as voice, gesture, and touch controls.

Source: **This is Samsung's hybrid of Google Glass and HoloLens**
https://www.wareable.com/samsung/google-glass-hololens-hybrid-1376

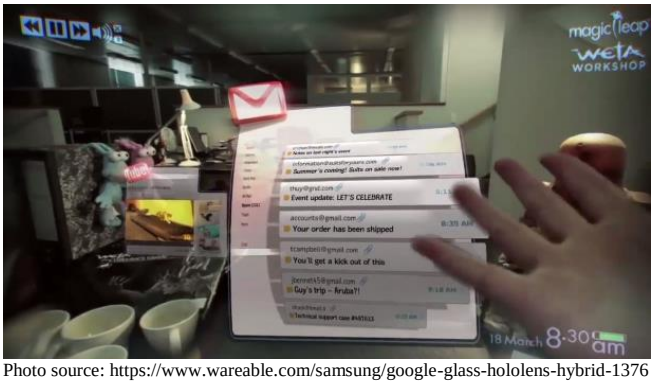

Photo source: https://www.wareable.com/samsung/google-glass-hololens-hybrid-1376

2.2 Body worn (wrist, arm, or chest)

2.2.1 Seoul National University, Samsung Advanced Institute of Technology and Pusan National University

Technology name: Light-emitting diodes (LEDs)

Description: Researchers are pursuing full-color, high-resolution wearable displays not previously achieve by conventional printing techniques by using "intaglio transfer printing ultrathin layers of colloidal quantum dots deposited on various substrates to form pixels of different shapes and sizes." According to researchers, "The subpixels are used in wearable white LEDs exhibiting stable electrical characteristics when bent."

Research link: http://doi.org/10.1038/nnano.2015.150

Source: **Wearable light-emitting diodes: Red–green–blue is in fashion**
http://www.nature.com/nnano/journal/v10/n7/full/nnano.2015.150.html

3.0 POWER

3.1 Chargers

3.1.1 Energous Corporation

Technology name: WattUp wire-free charger

Description: The WattUp wire-free charger creates a 15-foot range charging area for battery-powered devices. Similar to a Wi-Fi router, the WattUp transmitter sends energy via radiofrequency to WattUp-enabled devices, where the WattUp receiver translates the signal into power. The device can charge battery-operated devices requiring less than 10 watts. According to the WattUp website, "Highly targeted pockets of energy are delivered via multiple miniature antenna arrays and custom control chips in the transmitter, or Power Router. Energy harvesting of the micro energy beams from these pockets then takes place via paired antenna arrays and custom chips in the receiver devices." The customizable system is controlled via software, and up to 12 receivers can be managed simultaneously.

Product link: http://www.energous.com/

Source: **Power Unplugged: Product Review** http://www.energous.com/overview/

3.2 Self-powering (Harvesters)

3.2.1 Institute for Basic Science, Seoul National University, Pusan National University, Harvard University

Technology name: Battery-powered silver mesh heat wrap

Description: Researchers are developing a battery-powered silver mesh of insulating, breathable, conforming material that can apply heat to a wearer's particular body part. The material is suggested to have potential applications in ski jackets and heated seats.

Source: **Silver mesh lets users "wrap heat" around body parts** http://www.gizmag.com/silver-mesh-heat-wrap/38305/

Photo source: http://www.ibs.re.kr/

3.2.2 MicroGen Systems, Inc.

Technology name: SmartMesh IP Wireless Sensor Network

Description: Creators are using vibration energy harvesting BOLT Power Cells to create a live wireless sensor network (WSN) using Linear Technology's Dust Networks LTC5800-IPM SmartMesh IP mote-on-chip. The technology is powered by MicroGen's piezoelectric Micro Electro Mechanical Systems (piezo-MEMS) vibrational energy harvester or micro-power generator technology. The BOLT Power Cell uses vibrational energy, instead of chemical energy like typical batteries. The WSN comprises four self-powered motes enabled by electronic shakers. During a conference exhibit, developers demonstrated "the first fully MEMS energy harvesting powered WSN completed by a commercial company." The goal of the technology is to "eliminate or extend the lifetime of primary cells or rechargeable batteries in WSN industrial and building applications, where the labor to frequently change batteries is cost prohibitive for a WSN to be installed."

Source: **MicroGen's Piezo-MEMS Vibration Energy Harvesters Enable Linear Technology SmartMesh IP Wireless Sensor Network** http://www.linear.com/solutions/1837

Photo source: http://www.linear.com/solutions/1837

3.2.3 Ricoh, Tokyo University of Science

Technology name: Energy-generating rubber piezoelectric mat

Description: The piezoelectric mat uses the high-energy output of ceramic materials and the flexibility of polymeric materials to convert pressure and vibration into energy. This combination produces as much power as ceramics while exceeding the flexibility of polymeric materials. The material is reported to be soft, flexible, durable, and not requiring a high-temperature process like ceramics.

Press link: http://ricoh.com/release/2015/0518_1.html

Source: **Ricoh invents super-efficient power-producing rubber**
http://www.engadget.com/2015/05/18/ricoh-invents-super-efficient-power-producing-rubber/

Photo source: http://www.engadget.com/2015/05/18/ricoh-invents-super-efficient-power-producing-rubber/

3.2.4 SeeHorse

Technology name: SeeHorse physiological monitor

Description: Designed for horses, SeeHorse is a physiological monitor that stays powered by generating energy from the wearer's movements. The device records a horse's temperature and other vitals such as pulse, respiratory functions, and movements and sends the data to the owner's phone or computer.

Product link: http://seehorse.ca/

Source: **Wearable gadget monitors horse's health**
http://www.horseandcountry.tv/news/2015/07/07/wearable-gadget-monitors-horses-health.

3.2.5 SolePower

Technology name: Energy-harvesting insole

Description: SolePower is developing a patent-pending, waterproof, energy-harvesting, removable insole that would allow a user to store energy from their footsteps. Heel impacts spin a small generator that generates electricity that is transferred to a battery pack wired to the shoe or transferred via an ankle strap.

Product link: http://solepowertech.com/

Source: **Video: Shoe Inserts Harvest Energy to Power Devices**
http://www.designnews.com/author.asp?doc_id=267997&dfpPParams=ind_184,industry_alt,industry_consumer,aid_267997&dfpLayout=blog

Photo source: http://www.designnews.com/

3.3 Power supplies

3.3.1 Enfucell OY

Technology name: SoftBattery

Description: SoftBattery is designed to be a disposable, thin, flexible, 3D-printed power source that comes in three sizes and three voltages, fit for use in wearable bio-patches, wireless medical and logistic sensors, and more.

Product link: http://www.enfucell.com/softbattery

Source: **Super Skinny Batteries** https://www.wearable-technologies.com/2015/07/super-skinny-batteries/

Photo source: http://www.enfucell.com/softbattery

3.3.2 Nikola Labs, Ohio State University ElectroScience Laboratory

Technology name: Radiofrequency (RF) energy-harvesting smartphone case

Description: Nikola Labs is developing an energy-harvesting smartphone case that extends battery life by harvesting wasted RF energy. The RF to direct current (RF-to-DC) technology harnesses the RF waves (from Wi-Fi, Bluetooth, LTE) wasted during transmission to mobile devices to create direct current power. Nikola Labs announced the iPhone 6 case, with plans to bring the design to a Galaxy S6 case for Android. The technology will comprise built-in 'low-profile' antennas, a high-efficiency RF-harvesting circuit, and an integrated lightning port to feed power back into the phone. The technology is anticipated to slow the rate of the battery discharge without impacting data transmission or call quality, without supplemental batteries, and while adding a layer of physical protection to the phone.

Product link: https://www.kickstarter.com/projects/nikolalabs/nikola-phone-case-power-your-phone-with-wasted-ene

Source: **Nikola Labs RF Energy Harvesting Smartphone Case Launches on Kickstarter**
http://www.i4u.com/2015/06/92167/nikola-labs-rf-energy-harvesting-smartphone-case-launches-kickstarter

Photo source: https://www.kickstarter.com/projects/nikolalabs/nikola-phone-case-power-your-phone-with-wasted-ene

3.3.3 Varta Microbattery

Technology name: CoinPower Series lithium-ion rechargeable microbatteries

Description: The CoinPower Series of lightweight, lithium-ion rechargeable microbatteries reportedly offers up to 30% higher energy density than comparable products and is ideal for Bluetooth, medical, health, fitness, automotive, and wireless sensor applications. The technology features 3.7V and 50mAh and 100mAh capacities, as well as low-impedance, year-plus shelf life, and fast charging capability. The batteries can reportedly be recharged more than 500 full cycles and maintain 90% of their initial capacity.

Product link: http://www.varta-microbattery.com/en/products/batteries-cells-configurations/technology/rechargeable/lithium-button-cells/all/technology-description.html

Source: **Varta – Rechargeable Li-Ion micro batteries target Bluetooth, portable and wearable products** http://www.electropages.com/2015/07/varta-rechargeable-li-ion-micro-batteries-target-bluetooth-portable-wearable-products/

3.4 Power management

3.4.1 Intersil Corporation

Technology name: ISL9120 Buck-Boost Regulator

Description: ISL9120 is a high-efficiency, ultra-small form factor, buck-boost regulator for efficient power management of system power supplies and peripherals (Wi-Fi, Bluetooth, memory cards, LCD modules), fit for wearables and other devices that run on single-cell lithium-ion, lithium-polymer, 2-cell alkaline, NiCd, or NiMH batteries. The device reportedly offers "ultra-high efficiency up to 98% [that] reduces power drain and heat buildup," and "full protection for under-voltage, short-circuit and over-temperature."

Product link: www.intersil.com/products/isl9120

Source: **Intersil Announces Industry's Highest Efficiency Buck-Boost Regulator for Wearables and Other Mobile Devices** http://www.marketwatch.com/story/intersil-announces-industrys-highest-efficiency-buck-boost-regulator-for-wearables-and-other-mobile-devices-2015-07-06

3.4.2 Microsoft

Technology name: WearDrive

Description: The WearDrive platform extends the battery life of wearables by using Bluetooth to transfer energy-draining operations off the actual device and to the user's smartphone, requiring the wearable to only perform small tasks requiring limited battery consumption.

Research link: http://research.microsoft.com/apps/pubs/default.aspx?id=244461

Source: **New research on Microsoft's WearDrive could save your battery's life**
http://www.wearables.com/new-research-on-microsofts-weardrive-could-save-your-batterys-life/

3.4.3 National Aeronautics and Space Administration

Technology name: Wi-Fi reflector chip

Description: Researchers are exploring Wi-Fi-reflecting microchips that reflect wireless signals rather than using regular transmitters. Reflecting the signal, rather than generating it, reportedly results in data transmission up to three times faster than regular Wi-Fi while using 1,000 times less power. The chip "constantly senses a background signal and suppresses it, enabling actual Wi-Fi signals to be transmitted without any interference." However, researchers are still working to address challenges such as "while the wearable device will experience a low power drain, the device that it is communicating with must have good battery life or be plugged in [and] the wireless router will also experience more power use, which could mean a rise in a user's power bill."

Press link: http://www.jpl.nasa.gov/news/news.php?feature=4663

Source: **This Wi-Fi Reflector Chip Speeds Up Wearables And Improves Battery Life**
http://www.techtimes.com/articles/71438/20150723/wi-fi-reflector-chip-speeds-up-wearables-improves-battery-life.htm

4.0 COMMUNICATIONS

4.1 Short-range low-power Bluetooth

4.1.1 Doppler Labs

Technology name: Here Active Listening earbuds

Description: Here Active Listening earbuds are equipped with digital signal processors that allow users to customize sounds, control volume, and other effects as well as turn down background noise via a smartphone app. The earbuds contain a 4-6 hour lithium-ion battery life, Bluetooth radio, microphone, and speaker.

Product link: https://www.kickstarter.com/projects/dopplerlabs/here-active-listening-change-the-way-you-hear-the

Source: **Audio Wearable Startup Doppler Labs Raises $17 Million**
http://www.forbes.com/sites/aarontilley/2015/07/07/audio-wearables-startup-doppler-labs-raises-17-million/

Photo source: http://www.dopplerlabs.com/

4.2 Wearable, hands-free operation

4.2.1 Aring

Technology name: Aring finger-worn remote

Description: Aring is a finger-worn ring that provides users a wireless interface for their smart phone and acts as a wireless, hands-free remote. Aring features a built-in microphone, a single button, and Bluetooth connectivity. Users press the button then announce commands or whisper reminders. The waterproof device features a 10-meter range and a rechargeable battery lasting for 300, 30-second sessions or 3 days on standby.

Product link: https://www.indiegogo.com/projects/aring-the-first-ring-that-listens-to-your-command

Source: **Ring Listens to All Your Phone Commands** http://www.psfk.com/2015/07/smart-ring-wireless-phone-commands-the-aring-hands-free.html

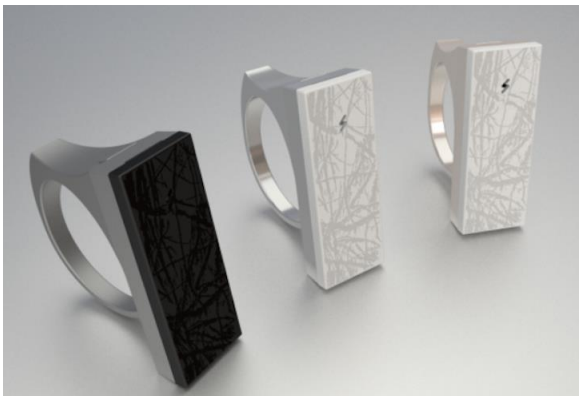

Photo source: https://www.indiegogo.com/projects/aring-the-first-ring-that-listens-to-your-command

4.2.2 Makitronics, LLC

Technology name: Gyropalm

Description: Gyropalm is an open-source system allowing users to control devices using wrist gestures, with up to 48 hours of continuous usage. The patent-pending device comprises a wristband and a receiver base, as well as an optional accessory that magnetically snaps onto the receiver base. The device reportedly recognizes "16 simple gestures for normal commands and can offer up to 48 customizable gestures," "long-distance, low-latency range of up to 3,000 feet" and "encrypted protocol on 2.4g Hz." With an additional wristband, the device allows for simultaneous control.

Product link: http://gyropalm.com/

Source: **Introducing the World's First Long-Distance Wearable Universal Remote Designed to Control Your Digital Life, IoT Devices, Appliances, and Robotics**
http://www.benzinga.com/pressreleases/15/07/r5668705/introducing-the-worlds-first-long-distance-wearable-universal-remote-de

5.0 LOCATION TRACKING

5.1.1 Argodesign

Technology name: RFID wristband

Description: Designers are expanding the concept of Disney's MagicBand to create a similar technology for hospitals. The technology would feature an RFID chip to communicate patient data and help track patients and doctors. Kiosks in the hospital could also scan the chip and direct users to a destination or connect via smartphone.

Company link: http://www.argodesign.com/

Source: **How Tech From Disney World Could Make Hospitals Better**
http://wearables.reviewed.com/features/how-tech-from-disney-world-could-make-hospitals-better

Photo source: http://www.argodesign.com/

5.1.2 Athentek

Technology name: Circo location-tracking wearable

Description: Circo features the MediaTek Labs' LinkIt ONE developer board to create a wearable location tracker. LinkIt ONE connects to a cloud-based application that allows users to locate the device. It offers a battery life of a few days, small size (37x32x11 mm), and light weight (18 grams), and can be worn around the neck or wrist. Positioning data is sent to a secure cloud, available via a smartphone app that also features a social chat room, activity history, geo-fencing, and real-time positioning. The device supports GSM 900/1800/850/1900 frequencies and uses GPS, AGPS, Wi-Fi, and cellular ID.

Source: **Smart wearable helps you track your kids** http://www.fudzilla.com/news/wearables/38149-smart-wearable-helps-you-track-your-kids

5.1.3 BluAzu

Technology name: Scout personal GPS tracking device

Description: Scout is a personal GPS tracking device that combines with GPS, cellular, and Bluetooth LE to provide 24/7 real-time location tracking where cellular service exists. The device sends notifications to a smart phone app if the user leaves a designated area and users can follow Scout in real-time on a map. The device's "Safety Tether" allows users to designate the distance at which the device can travel before they receive a notification.

Product link: http://findmyscout.com/

Source: **BluAzu Announces the Launch of SCOUT - A New Personal GPS Tracking Device**
http://www.newswiretoday.com/news/153936/BluAzu-Announces-the-Launch-of-SCOUT-A-New-Personal-GPS-Tracking-Device/

6.0 CAMERAS

6.1.1 Google

Technology name: Google Glass gesture controls

Description: A new patent awarded to Google is described as allowing a user to operate a head-mounted camera using their fingers in the view field. When the user's fingers, making the shape of a rectangular picture frame, come into the camera's view, it takes a photo. The patent suggests that users can orient their fingers into different shapes (i.e., circular) to take differently shaped photos.

Patent link: U.S. Patent 9,098,741

Source: **Google wants you to use your fingers to take photos on the next Google Glass** http://qz.com/447068/google-wants-you-to-use-your-fingers-to-take-photos-on-the-next-google-glass/

6.1.2 Google

Technology name: Wearable long-term camera and display

Description: A new patent filed by Google is anticipated to allow users to record longer videos, potentially up to 24 hours, that would then be uploaded to cloud storage and accessible via voice control.

Source: **Google Potentially Working on Wearable That Allows Users to Replay a Lifetime of Memories** http://www.craveonline.com/lifestyle/tech-and-gadgets-news/881233-google-potentially-working-wearable-allows-users-replay-lifetime-memories

Photo source: http://www.craveonline.com/design/881233-google-potentially-working-wearable-allows-users-replay-lifetime-memories

6.1.3 WearWise

Technology name: WearWise

Description: WearWise comprises a small, clip-on camera (1.6 x. 1.6 x 0.8 inches) with a 120-degree-angle, 8 megapixel camera capable of taking 1080p resolution video. The device can take up to 60

minutes of interrupted video or 2,048 photos per charge. The device uses Wi-Fi instead of Bluetooth, allowing users to livestream video to a smartphone or preview pictures at full resolution without lag or interruptions.

Product link: https://www.kickstarter.com/projects/1762451800/wearwise-the-new-generation-of-cameras?ref=category_newest

Source: **WearWise Life Logging Wearable Camera Uses WiFi Rather Than Bluetooth (video)** http://www.geeky-gadgets.com/wearwise-life-logging-wearable-camera-10-07-2015/

Photo source: https://www.kickstarter.com/projects/1762451800/wearwise-the-new-generation-of-cameras?ref=category_newest

7.0 EXOSKELETONS

7.1.1 202 Institute of China Ordnance Industry Group

Technology name: Exoskeleton

Description: The 202 Institute continues to update its exoskeleton, presenting in June its larger battery pack, strengthened legs, and hip-mounted hydraulic pumps. The device reportedly allows a user "to carry over 100 pounds, with enough charge to walk 20 kilometers at a speed of 4.5 km per hour." Its flexibility also allows for lateral ground movement.

Source: **Updated Chinese exoskeletons could one day go into combat** http://www.popsci.com/updated-chinese-exoskeletons-could-one-day-go-combat

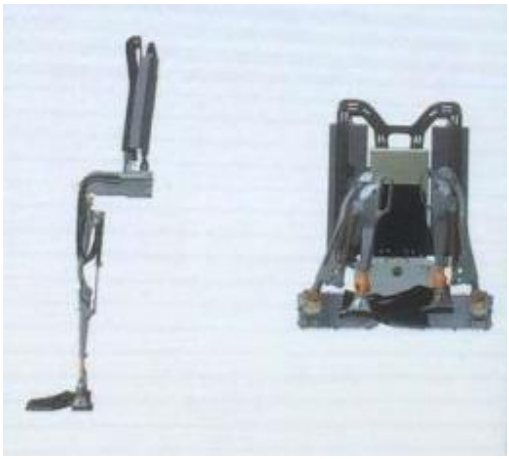

Photo source: http://www.popsci.com/updated-chinese-exoskeletons-could-one-day-go-combat

7.1.2 Bionik Laboratories Corp.

Technology name: ARKE lower-body exoskeleton

Description: ARKE is a robotic lower-body exoskeleton. According to the Bionik Laboratories web site, "ARKE™ functions by externally mounting to the patient's lower body and through a serious of sensors and algorithms, the system is able to learn and anticipate an individual's walking gait. This information is routed through the onboard monitor system that activates a series of motors to artificially create a walking pattern and enable the wheelchair bound individual to walk."

Product link: http://www.bioniklabs.com/arke/

Source: **Bionik Laboratories Completes US$13.1 Million Private Placement** http://www.prnewswire.com/news-releases/bionik-laboratories-completes-us131-million-private-placement-300109372.html

7.1.3 Lockheed Martin

Technology name: Fortis exoskeleton

Description: The Fortis exoskeleton reduces the weight on the wearer, supporting up to 36 pounds of weight, and it does not require batteries. Instead of attaching to the arms or using hydraulics and motors, Fortis uses "an articulated swing arm attached to the exoskeleton at the waist (Lockheed Martin calls this the 'zeroG' arm). At the end of this arm is a mounting point for the tool. The worker operates the tool normally, but it's attached to the exoskeleton via the swing arm. Instead of the weight of the tool being transferred to the wearer's arms, it's borne entirely by the aluminum/carbon fiber frame of Fortis and transferred to the ground." In demonstrations, "A worker was able to hold this [16-pound] tool over his head unaided for only three minutes before needing to rest his arms. Using Fortis, the worker was able to use the grinder continuously for 30 minutes with no problems. Lockheed estimates Fortis can improve productivity by up to 27x, depending on the task. At the same time, it also reduces the risk of injury and makes manual labor much less tiring." The exoskeleton is described as being designed "with human movement and biomechanics in mind. There are joints at the ankle, knee, and hip to ensure you can actually move while wearing the device. The weight of the payload gets to the ground through the stirrup, which is also attached to the ankle and allows the foot to rest on the ground normally."

Product link: http://www.lockheedmartin.com/us/products/exoskeleton/FORTIS.html

Source: **The Fortis exoskeleton let you lift heavy tools indefinitely – and it's unpowered!**
http://www.extremetech.com/extreme/191959-the-fortis-exoskeleton-let-you-lift-heavy-tools-indefinitely-and-its-unpowered

Photo source: http://www.lockheedmartin.com/us/products/exoskeleton/FORTIS.html

7.1.4 Panasonic

Technology name: Assist Suit AWN-03

Description: The Assist Suit reduces the physical burden on a user when lifting/lowering heavy loads. The device weighs about 6 kg (not including battery and harness) and offers a 15-kg force. The device

"straps around the user's shoulder, waist and one thigh, and embedded sensors send signals to engines in the suit that automatically move to reduce the energy the human needs to use in order to lift a heavy object and decrease the amount of stress placed on the lower back."

Press link: http://news.panasonic.com/global/topics/2014/28635.html

Source: **Panasonic to mass produce Alien style robot exoskeleton suit to help workers with heavy lifting** http://www.ibtimes.co.uk/panasonic-mass-produce-alien-style-robot-exoskeleton-suit-help-workers-heavy-lifting-1509593

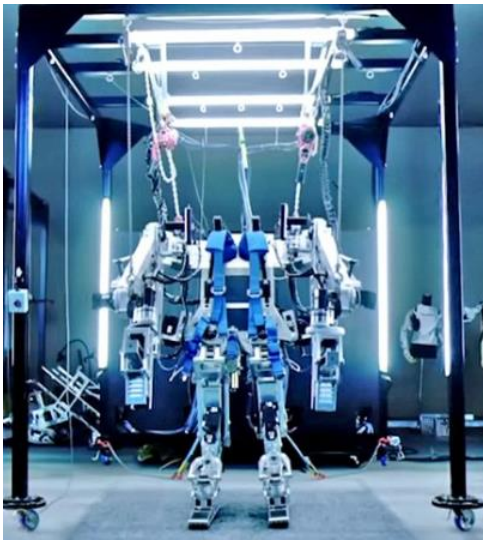

Photo source: http://www.ibtimes.co.uk/panasonic-mass-produce-alien-style-robot-exoskeleton-suit-help-workers-heavy-lifting-1509593

7.1.5 Taiwan's Industrial Technology Research Institute

Technology name: Walking Assistive Exoskeleton Robot

Description: The Walking Assistive Exoskeleton Robot is a 20-kilogram aluminum and carbon fiber device with four battery-powered motors that can last up to three hours.

Product link: http://walkagain.itri.org.tw/English/index.html

Source: **Powered Exoskeletons Give Assistance in Walking, Lifting**
http://www.voanews.com/content/powered-exoskeletons-assistance-walking-lifting/2846703.html

Photo source: https://www.itri.org.tw/eng/Content/MsgPic01/Contents.aspx?SiteID=1&MmmID=620651711475751171&MSid=621024014611372453

8.0 WEARABLE COMPUTERS

8.1.1 OrCam

Technology name: OrCam smart camera

Description: The OrCam smart camera mounts to eyeglasses to help users recognize objects and texts (signs, labels, computer screens, smartphones) as well as faces. It features a bone-conduction earpiece with the ability to "speak what it sees." It also responds to gestures, such as finger pointing, to focus on an area of interest to the user. Users can personalize the camera to store and recognize items in the device's internal memory without the need for an internet connection.

Product link: http://www.orcam.com/

Source: **Wearable of the Week: OrCam Smart Camera** http://www.humavox.com/blog/wearable-week-orcam-smart-camera/

9.0 OTHER

9.1.1 AnteNova

Technology name: Weii miniature ceramic antenna

Description: The Weii miniature ceramic antenna is a small (1 mm x 0.5 mm x 0.5 mm) "omni-directional, SMD mounted dielectric antenna [that] provides low dielectric losses and high isolation and can be used to add wireless connectivity to any small electronic device." The device is described as performing well over indoor ranges and when close to the human body.

Product link: http://www.antenova-m2m.com/

Source: **Tiny ceramic antenna suits all wireless, wearable apps**
http://www.ept.ca/pressroom/ProductDetail.aspx?id=15242&er=NA.

9.1.2 Elliott Data Systems, MotionQR, Inc.

Technology name: Emergency First Responder identification and certification management

Description: Elliott Data Systems is using motionQR's secure cloud-based platform and software development kits (SDKs) to equip first responder clients with digital identification in the form of motionQR codes. This will reportedly allow responders to digitally verify identities and credentials to gain access to a site in an emergency.

Source: **motionQR Unites with Elliott Data Systems to Create the Next Generation in Emergency First Responder Digital Identification and Credential Management** http://www.pr.com/press-release/628235

9.1.3 Kingii

Technology name: Kingii wearable flotation device

Description: Kingii is a wrist-worn device that inflates to prevent drowning. The device features an inflatable component and a carbon dioxide cartridge with compressed air. It is designed to support individuals up to 275 pounds. Users trigger a lever to inflate the device. The device also features a compass and whistle.

Product link: http://kingii.us/

Source: **Amazing Wearable Wrist Device Inflates To Stop Drowning Instantly**
http://yournewswire.com/amazing-wearable-wrist-device-inflates-to-stop-drowning-instantly/

Photo source: http://kingii.us/

9.1.4 Korea University

Technology name: Stretchable acoustic device

Description: Researchers are developing a wrist-worn stretchable acoustic device that can record and playback audio. The speaker features a liquid metal coil and a magnet, providing for more mechanic stability. The liquid metal coil offers excellent conductivity, low vapor pressure, and a low-melting point, which helps prevent degradation of the speaker.

Research link: http://www.nature.com/srep/2015/150716/srep11695/full/srep11695.html

Source: **THIS STRETCHY LOUDSPEAKER COULD BE USED IN WEARABLES AND BIOPRINTING** http://www.wired.co.uk/news/archive/2015-07/16/stretchable-loudspeaker-wearables-bioprinting

Photo source: http://www.nature.com/srep/2015/150716/srep11695/full/srep11695.html

9.1.5 Lauren Bowker (individual)

Technology name: The Unseen

Description: Designer Lauren Bowker is developing "Chameleon clothing" that would have the ability to change colors via smartphone controls.

Source: Chameleon-Like Clothing is Next Wave of Wearable Technology
http://sourcingblog.magiconline.com/content/chameleon-clothing-next-wave-wearable-technology

9.1.6 Naval Research Laboratory

Technology name: Transparent Spinel ceramic

Description: Spinel is part of the Naval Research Laboratory's effort to create transparent, light-weight, bulletproof material for high-energy laser windows and lightweight armor. Spinel is made from synthetic power to be shapeable into strong, transparent sheets and shapes and penetrable by infrared cameras.

Product link: http://www.nrl.navy.mil/techtransfer/available-technologies/materials/transparent-spinel-ceramic

Source: **Researchers Have Created A Bulletproof Material That Can Be Moulded Into Any Shape**
https://wtvox.com/2015/04/researchers-have-created-a-bulletproof-material-that-can-be-moulded-into-any-shape/?utm_source=dlvr.it&utm_medium=twitter

Photo source: http://www.nrl.navy.mil/PressReleases/2015/37-15r_dome_3000x1994.jpg

9.1.7 Novalogy

Technology name: Ayo energy-boosting glasses

Description: Ayo glasses use a special frequency of blue light to improve sleep and energy levels, reduce jet lag, and fight seasonal affective disorder. Blue light reportedly "tells the brain to stop producing melatonin." The device can be customized using a free app. Users wear the device for 20 minutes several times a day to normalize energy levels.

Product link: https://www.indiegogo.com/projects/ayo-light-based-energy-boosting-wearable

Source: **Glasses That Help You Sleep Better** http://www.ozy.com/good-sht/glasses-that-help-you-sleep-better/61074

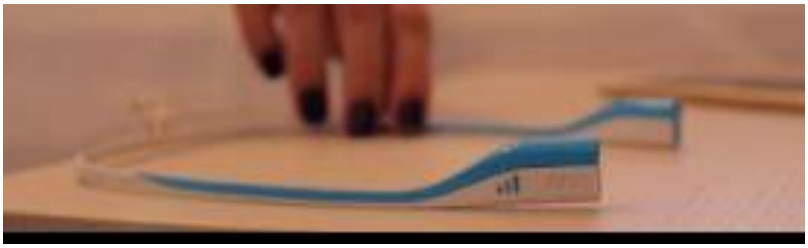

Photo source: https://www.indiegogo.com/projects/ayo-light-based-energy-boosting-wearable

9.1.8 Novartis

Technology name: ViaOpta application

Description: ViaOpta is an application designed to help visually impaired users through a navigation function that helps users recognize common objects. The app has a camera function that provides feedback to the user via audio feed. The app also offers navigation assistance and location tracking and sharing. The app operates in multiple languages, allows for vibration alerts (in addition to audio), and is available on Apple and Android devices.

Press link: https://www.novartis.com/news/media-releases/novartis-pharmaceuticals-launches-first-app-visually-impaired-people-use-apple

Source: **Big Pharma company steps into wearable devices market** http://www.digitaljournal.com/technology/viaopta-app-guides-the-blind-via-the-apple-watch/article/437430

9.1.9 Qore Performance

Technology name: HydraQore Inserts

Description: HydraQore Inserts provide targeted pulse-point cooling to keep a wearer hydrated and cool. According to the Qore Performance website, “these lightweight and extremely durable Inserts weigh approximately 1.8 ounces and have anti-sweat technology to eviscerate condensation, while also resisting UV and bacteria.” The device can be used in shirts and shorts.

Product link: http://www.qoreperformance.com/products/pac-insert

Source: **Wearable Hydration (video available)** http://www.qoreperformance.com/pages/wearable-hydration

Photo source: http://www.qoreperformance.com/pages/wearable-hydration

9.1.10 Wild Acre Metals, Nuheara Pty Ltd.

Technology name: Wearable audio technology

Description: Wild Acre Metals is acquiring wearable hearing technology company Nuheara Pty Ltd., which is developing "multi-functional audio wearable technology that augments a user's hearing and facilitates cable free connection to smart devices."

Source: **Wild Acre Metals acquiring wearable hearing technology company**
http://www.proactiveinvestors.com.au/companies/news/63267/wild-acre-metals-acquiring-wearable-hearing-technology-company-63267.html

Appendix A

Technology Summary

Technology summary

The table below provides a summary of the technologies compiled in this report. For an electronic copy, please contact Jaki Upton at jaki.upton@pnnl.gov. This information is not meant to be an exhaustive list nor an endorsement of any technology described herein.

Company	Technology	Description	Category	Reported
Sensor				
Physiological				
Baycrest Rotman Research Institute	Muse wireless electroencephalography (EEG) headband	Clinical-grade EEG with smartphone connectivity, providing users insight into their brain activity	Sensor: Physiological	Jul-15
BeneGear Inc.	Heart-rate variability (HRV) monitor	Wearable with single-lead heart-rate monitor to measure HRV as a potential indicator of cardiovascular disease	Sensor: Physiological	Jul-15
Moov	MOOV NOW fitness tracker	Uses a combination of sensors (magnetic meter, gyroscope, and accelerometer) to analyze performance (movement, poses, etc.) and provide real-time feedback to the wearer	Sensor: Physiological	Jul-15
NimbleHeart Inc.	Disposable electrode	Disposable electrode capable of providing clinical-grade electrocardiogram (ECG) signals.	Sensor: Physiological	Jul-15
University of Michigan	Wearable fluid status sensor	Measures fluid status, the volume of blood pumping through a user's blood vessels, as a diagnostic measure for heart rate, blood pressure, infection, etc.	Sensor: Physiological	Jul-15
Chemical/Particulate				
MyExposome	MyExposome wristband	Users wear MyExposome wristband and it monitors for chemicals to which the user is exposed. Users then ship the wristband to the MyExposome laboratory, where it is analyzed for more than 1,400 different toxins	Sensor: Chemical/Particulate	Jul-15
Other				
Cyrcadia Inc.	iTBraTM wearable breast cancer early detection device	Smart-phone-enabled wearable that will employ a comfortable data collection device placed under a bra over 2-12 hours to collect breast cell data to detect the earliest stages of cellular variances. Data will be transmitted to a global cancer library for analysis that will then be communicated back to the patient and physician	Sensor: Other	Jul-15

Displays				
Heads-Up				
CSIRO	Guardian Mentor Remote	A connected headset and glasses that connect to on-site operators and mechanics elsewhere to enable real-time assistance	Displays: Heads-Up	Jul-15
Body-worn				
Seoul National University, Samsung Advanced Institute of Technology and Pusan National University	Light-emitting diodes (LEDs)	Full-color, high-resolution wearable displays using intaglio transfer printing ultra-thin layers of colloidal quantum dots deposited on various substrates to form pixels of different shapes and sizes.	Displays: Body-worn	Jul-15
Power				
Chargers				
Energous Corporation	WattUp wire-free charger	Wire-free charger that creates a 15-foot range charging area for battery-powered devices (up to 10 watts)	Power: Chargers	Jul-15
Self-Powering/Harvesting				
Institute for Basic Science, Seoul National University, Pusan National University, Harvard University	Battery-powered silver mesh heat wrap	A battery-powered silver mesh of insulating, breathable, conforming material that can apply heat to a wearer's particular body part	Power: Self-Powering/Harvesting	Jul-15
MicroGen Systems, Inc.	SmartMesh IP Wireless Sensor Network	Vibration energy harvesting BOLT Power Cells used to create a live wireless sensor network (WSN) using Linear Technology's Dust Networks LTC5800-IPM SmartMesh IP mote-on-chip	Power: Self-Powering/Harvesting	Jul-15
Ricoh, Tokyo University of Science	Energy-generating rubber piezoelectric mat	Piezoelectric mat uses the high-energy output of ceramic materials and the flexibility of polymeric materials to convert pressure and vibration into energy	Power: Self-Powering/Harvesting	Jul-15
SeeHorse	SeeHorse physiological monitor	Physiological monitor that stays powered by generating energy from the wearer's movements	Power: Self-Powering/Harvesting	Jul-15
SolePower	Energy-harvesting insole	Waterproof, energy-harvesting, removable insole that would allow a user to store energy from their footsteps	Power: Self-Powering/Harvesting	Jul-15
Power Supply				
Enfucell OY	SoftBattery	Disposable, thin, flexible, 3D-printed power source that comes in three sizes and three voltages, fit for use in wearable bio-patches, wireless medical and logistic sensors, and more.	Power: Power Supply	Jul-15

Nikola Labs, Ohio State University ElectroScience Laboratory	Radiofrequency (RF) energy-harvesting smartphone case	Energy-harvesting smartphone case that extends battery life by harvesting wasted RF energy	Power: Power Supply	Jul-15
Varta Microbattery	CoinPower Series lithium-ion rechargeable microbatteries	Lightweight, lithium-ion rechargeable microbatteries reportedly offers up to 30% higher energy density than comparable products and is ideal for Bluetooth, medical, health, fitness, automotive, and wireless sensor applications	Power: Power Supply	Jul-15
Power Management				
Intersil Corporation	ISL9120 Buck-Boost Regulator	High-efficiency, ultra-small form factor, buck-boost regulator for efficient power management of system power supplies and peripherals of wearables and other devices that run on single-cell lithium-ion, lithium-polymer, 2-cell alkaline, NiCd, or NiMH batteries	Power: Power Management	Jul-15
Microsoft	WearDrive	Extends the battery life of wearables by using Bluetooth to transfer energy-draining operations off the actual device and to the user's smartphone, requiring the wearable to only perform small tasks requiring limited battery consumption	Power: Power Management	Jul-15
National Aeronautics and Space Administration	Wi-Fi reflector chip	Reflects wireless signals rather than using regular transmitters, reportedly resulting in data transmission up to three times faster than regular Wi-Fi while using 1,000 times less power	Power: Power Management	Jul-15
Communications				
Short-range low-power Bluetooth				
Doppler Labs	Here Active Listening earbuds	Earbuds equipped with digital signal processors that allow users to customize sounds, control volume, and other effects as well as turn down background noise via a smartphone app	Communications: Bluetooth	Jul-15
Hands-Free				
Aring	Aring finger-worn remote	Provides users a wireless interface for their smart phone and acts as a wireless, hands-free remote	Communications: Hands-Free	Jul-15
Makitronics, LLC	Gyropalm	Open-source system allowing users to control devices using wrist gestures, with up to 48 hours of continuous usage	Communications: Hands-Free	Jul-15

Location Tracking				
Argodesign	RFID wristband	Wristband with an RFID chip to communicate patient data and help track patients and doctors.	Location Tracking	Jul-15
Athentek	Circo location-tracking wearable	Features the MediaTek Labs' LinkIt ONE developer board to create a wearable location tracker that connects to a cloud-based application and allows users to locate the device.	Location Tracking	Jul-15
BluAzu	Scout personal GPS tracking device	Personal GPS tracking device that combines with GPS, cellular, and Bluetooth LE to provide 24/7 real-time location tracking where cellular service exists	Location Tracking	Jul-15
Cameras				
Google	Google Glass gesture controls	Allows a user to operate a head-mounted camera using their fingers in the view field. When the user's fingers, making the shape of a rectangular picture frame, come into the camera's view, it takes a photo	Cameras	Jul-15
Google	Wearable long-term camera and display	Allows users to record longer videos, potentially up to 24 hours, that would then be uploaded to cloud storage and accessible via voice control	Cameras	Jul-15
WearWise	WearWise	Small, clip-on camera (1.6 x. 1.6 x 0.8 inches) with a 120-degree-angle, 8 megapixel camera capable of taking 1080p resolution video	Cameras	Jul-15
Exoskeletons				
202 Institute of China Ordnance Industry Group	Exoskeleton	Allows a user to carry more than 100 pounds, with sufficient charge to walk 20 kilometers at a speed of 4.5 km per hour, as well as allow for lateral ground movement	Exoskeletons	Jul-15
Bionik Laboratories Corp.	ARKE lower-body exoskeleton	Robotic lower-body exoskeleton that externally mounts to the patient's lower body and through a serious of sensors and algorithms, the system is able to learn and anticipate an individual's walking gait	Exoskeletons	Jul-15
Lockheed Martin	Fortis exoskeleton	Reduces the weight on the wearer, supporting up to 36 pounds of weight, does not require batteries, and uses an articulated swing arm attached to the exoskeleton at the waist	Exoskeletons	Jul-15
Panasonic	Assist Suit AWN-03	Reduces the physical burden on a user when lifting/lowering heavy loads, weighs about 6 kg (not including battery and harness), and offers a 15 kg force	Exoskeletons	Jul-15

Taiwan's Industrial Technology Research Institute	Walking Assistive Exoskeleton Robot	20-kilogram aluminum and carbon fiber device with four battery-powered motors that can last up to three hours	Exoskeletons	Jul-15
Wearable Computers				
OrCam	OrCam smart camera	Smart camera that mounts to eyeglasses to help users recognize objects and texts (signs, labels, computer screens, smartphones) as well as faces	Wearable Computers	Jul-15
Other				
AnteNova	Weii miniature ceramic antenna	Miniature ceramic antenna that provides low dielectric losses and high isolation and can be used to add wireless connectivity to any small electronic device	Other	Jul-15
Elliott Data Systems, MotionQR, Inc.	Emergency First Responder identification and certification management	Uses motionQR's secure cloud-based platform and software development kits (SDKs) to equip first responder clients with digital identification in the form of motionQR codes	Other	Jul-15
Kingii	Kingii wearable flotation device	Wrist-worn device that inflates to prevent drowning. The device features an inflatable component and a carbon dioxide cartridge with compressed air	Other	Jul-15
Korea University	Stretchable acoustic device	Wrist-worn stretchable acoustic device that can record and playback audio	Other	Jul-15
Lauren Bowker (individual)	The Unseen	Chameleon clothing with the ability to change colors via smartphone controls	Other	Jul-15
Naval Research Laboratory	Transparent Spinel ceramic	Made from synthetic power to be shapeable into strong, transparent sheets and shapes, and penetrable by infrared cameras	Other	Jul-15
Novalogy	Ayo energy-boosting glasses	Glasses that use a special frequency of blue light to improve sleep and energy levels, reduce jet lag, and fight seasonal affective disorder	Other	Jul-15
Novartis	ViaOpta application	Application designed to help visually impaired users through a navigation function that helps users recognize common objects	Other	Jul-15
Qore Performance	HydraQore Inserts	Provide targeted pulse-point cooling to keep a wearer hydrated and cool	Other	Jul-15
Wild Acre Metals, Nuheara Pty Ltd.	Wearable audio technology	Multi-functional audio wearable technology that augments a user's hearing and facilitates cable-free connection to smart devices	Other	Jul-15

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