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Responder Technology Alert (November 2015)

January 2016

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 Physiological

1.1.1 Chaotic Moon

Technology name: Biometric Tattoos

Description: Chaotic Moon is exploring biometric tattoos with conductive paint that can noninvasively measure a user's biometrics (sweat, heart rate, hydration, etc.) to determine stress levels, as well as track a user's location. The technology can be discretely worn on the skin and transmits information via Bluetooth. The company has developed a biometric tattoo kit prototype and has anticipated applications in military applications and location tracking.

Source: **Biometric Tattoos, From Wearables to Digital Health** https://wtvox.com/cyborgs-and-implantables/biometric-tattoos/

Photo source: https://wtvox.com/cyborgs-and-implantables/biometric-tattoos/

1.1.2 Check-My-Temp

Technology name: Check-My-Temp

Description: Check-My-Temp armband is a wearable medical device with sensors that continuously and noninvasively record a user's movements and temperature with clinical-grade accuracy, and it communicates the information to a smartphone or tablet as well as specified user groups. The sensors collect more than 30 data points every 30 seconds for continuous, comprehensive monitoring. The device also features an accelerometer to track patient movements to help caregivers know if a patient is in distress.

Source: **New wearable thermometer Check-my-Temp takes the fear out of fever** http://www.medgadget.com/2015/11/new-wearable-thermometer-check-my-temp-takes-the-fear-out-of-fever.html

Photo source: https://www.indiegogo.com/projects/check-my-temp-world-s-most-advanced-thermometer#/

1.1.3 FocusMotion

Technology name: Motion tracking

Description: Developers are exploring the use of motion tracking in physical therapy, combining FocusMotion's motion-tracking technology with Reflexion's experience in digital medicine and rehabilitation and FORCE's tools for arm musculoskeletal recovery. FocusMotion has also partnered with Kinetic and the National Institute for Occupational Safety and Health to explore the development of a wearable system for diagnosing lower back pain risk factors associated with manual lifting.

Source: **FocusMotion Announces Training, Physical Therapy and Workforce Monitoring Initiatives at Los Angeles Dodgers Accelerator Demo Day**
http://www.pharmiweb.com/pressreleases/pressrel.asp?ROW_ID=139060#.VlI2BGSrSb8#ixzz3sLyFN8Xn

1.1.4 Healbe™ Corp.

Technology name: Flow™

Description: Flow is an automatic hydration monitoring technology that will be integrated into Healbe's GoBe™ body manager technology. GoBe uses an impedance sensor to measure hydration and does not require users to manually enter their fluid consumption. The device alerts users to drink when hydration levels are low. Flow can also incorporate a user's physical activity and calorie burn into the measurement.

Source: **Healbe GoBe™ Becomes First Wearable Device To Automatically Track Daily Hydration Level** http://www.prweb.com/releases/2015/11/prweb13086832.htm

Photo source: http://healbe.com/us/

1.1.5 Honeywell, Intel

Technology name: Connected Worker Solution

Description: The Connected Worker system has a mobile hub with sensor fusion to collect data from a variety of sensors worn by the wearer to monitor the user's toxic gas exposure, breathing, heart rate, posture, and movement in order to provide a comprehensive profile of the user and what they may be experiencing. The device is intended to have applications in monitoring safety, reducing injuries, and improving the productivity of industrial workers and first responders. The device can gather data from a self-contained breathing apparatus, heart rate monitor, microcontroller-based devices (toxic gas monitor, activity detector, and gesture recognition device). The data is transmitted to and displayed visually on a cloud-based dashboard, creating a "centralized command center" that can connect multiple devices and data sources for easy access by managers or other users.

Source: **Honeywell And Intel Demonstrate Prototype Of Wearable IoT Connected Safety Solution For Industrial Workers And First Responders**
http://www.marketwatch.com/story/honeywell-and-intel-demonstrate-prototype-of-wearable-iot-connected-safety-solution-for-industrial-workers-and-first-responders-2015-11-03

1.1.6 InBody USA

Technology name: InBodyBAND

Description: The InBodyBAND measures body composition (fat, body fat, body fat percentage, muscle mass) and activity (steps, distance, calories) to provide a comprehensive profile of a user. The device uses bioelectrical impedance analysis and ECG. The device gathers body composition data via four electrodes tracking in under 20 seconds, and it also tracks activity in real-time. The device features automatic sleep monitoring, alarms, and phone notifications. The device is water-resistant, has an average 8-day battery life, features a micro-USB charging port, and its app is iOS and Android compatible. Data can be stored on the device for up to seven days and synced via Bluetooth to the app.

Source: **InBody USA Introduces First Fitness Wearable That Goes Beyond Steps to Track Body Composition** http://news.sys-con.com/node/3535472

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

1.1.7 iRhythm Technologies

Technology name: ZIO XT Patch cardiovascular monitor

Description: In a study of 6,100 patients, Scripps Translational Science Institute is using the iRhythm Technologies' single-lead, continuous ECG and cardiovascular monitoring wearable patch to detect asymptomatic atrial fibrillation, a heart arrhythmia indicative of several health complications.

Source: **Scripps starts massive study to find undiagnosed AFib using iRhythm wearable patch** http://www.fiercemedicaldevices.com/story/scripps-starts-massive-study-find-undiagnosed-afib-using-irhythm-wearable-p/2015-11-30

Photo source: http://www.irhythmtech.com/zio-services.php

1.1.8 Isansys Lifecare

Technology name: Lifetouch™

Description: The Real-time Adaptive and Predictive Indicator of Deterioration (RAPID) project at Birmingham Children's Hospital is combining biotelemetry and wireless sensors to gather vital signs (heart rate variability, breathing rate, oxygen levels) for analysis to understand a user's condition. The project is using the Isansys Lifecare Lifetouch™ sensors to analyze real-time ECG data and send the data via Bluetooth to a bedside Isansys gateway display. The Lifetouch sensor features a Patient Status Engine multi-vital-sign data capture and analysis system. Whereas vital signs are typically recorded every 1-4 hours, RAPID continuously monitors and analyzes data in real-time, providing a more accurate portrayal of patient's condition or deterioration.

Source: **Isansys wearable technology and wireless patient monitoring platform in at-scale deployment at Birmingham Children's Hospital** http://www.mhealthnews.com/press-release/isansys-wearable-technology-and-wireless-patient-monitoring-platform-scale-deployment-

1.1.9 Massachusetts Institute of Technology

Technology name: Ingestible sensor

Description: Researchers at MIT developed a small, ingestible sensor for measuring vital signs (heart rate, breathing rate, etc.) via sound waves detected from the gastrointestinal tract. It separates heart and lung sounds from background noise in the digestive track. The pill-size device features a microphone and

sound processing equipment and transmits information to an external receiver. The device typically remains in the digestive tract for a day or two. Anticipated applications include assessing trauma applications, monitoring soldiers, evaluating chronic illnesses, and improving athletic training.

Source: **MIT develops a wearable device you can swallow**
http://www.bizjournals.com/boston/blog/bioflash/2015/11/mit-develops-a-wearable-device-you-can-swallow.html

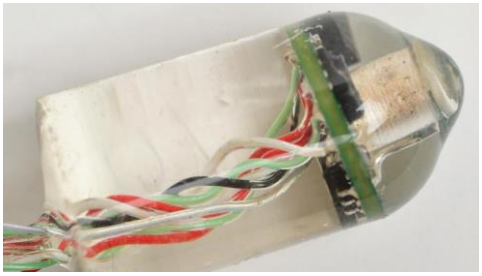

Photo source: http://news.mit.edu/2015/ingestible-sensor-measures-heart-breathing-rates-1118

1.1.10 Newdealdesign, VivaLnk

Technology name: Fever Scout

Description: Fever Scout is a soft, flexible thermometer that can wirelessly connect and communicate readings to a smartphone via Bluetooth. It can also save detailed charts and notes that can be exported to a medical provider. The device is rechargeable and reusable, with approximately a week-long battery life. The device's design places the Bluetooth and sensor technologies at a distance, increasing the connection range and efficiency. It displays colors to indicate optimal placement to ensure effective readings. It is iOS and Android compatible. It can alert the user when temperatures reach specific thresholds. The technology can accommodate multiple users and ad-hoc Wi-Fi networks as well as VivaLnk's cloud service.

Source: **newdealdesign rethinks the thermometer with fever scout wearable monitor**
http://www.designboom.com/technology/newdealdesign-vivalink-fever-scout-connected-thermometer-11-18-2015/

Photo source: http://www.designboom.com/technology/newdealdesign-vivalink-fever-scout-connected-thermometer-11-18-2015/

1.1.11 Samsung Electronics

Technology name: Bio Processor

Description: Samsung's new Bio Processor is a small (45 millimeter) system-in-package chip for wearables with an embedded ECG reader, application processor, and Bluetooth module. It can measure blood flow and bioelectrical impedance and other functions—all on the same chip. The technology is anticipated to help identify a patient's illness by monitoring ECG patterns. Samsung plans to expand its bio processor work with a smaller processor that will deliver improved battery efficiency and reduced form factor.

Source: **Samsung rolled a wearable chip of its own, and it's all about bio measurements**
http://www.phonearena.com/news/Samsung-rolled-a-wearable-chip-of-its-own-and-its-all-about-bio-measurements_id75488#zHtgqGCIRUr04h4i.99

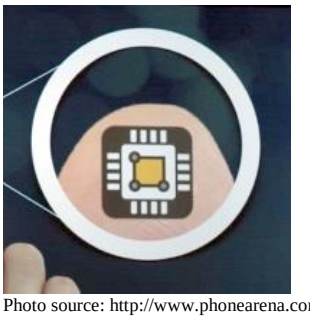

Photo source: http://www.phonearena.com/news/Samsung-rolled-a-wearable-chip-of-its-own-and-its-all-about-bio-measurements_id75488#zHtgqGCIRUr04h4i.99

1.1.12 Sarah Heimeier (Individual)

Technology name: Jana

Description: The Jana, initially designed for "personalized healthcare" in maternity, is a stomach-worn device that measures glucose and blood pressure as well as fetal heart rate via soundwaves reflecting off bodily tissue. The information is transmitted to a smart device app as well as to a medical provider.

Source: **Australian made wearable technology lifeline for rural mothers claims James Dyson Award**
http://www.news.com.au/technology/innovation/design/australian-made-wearable-technology-lifeline-for-rural-mothers-claims-james-dyson-award/news-story/988e676db22107c1a0f5aa998f06bc6e

Photo source: http://www.news.com.au/technology/innovation/design/australian-made-wearable-technology-lifeline-for-rural-mothers-claims-james-dyson-award/news-story/988e676db22107c1a0f5aa998f06bc6e

1.1.13 University of Massachusetts Medical School, Massachusetts Institute of Technology, Northeastern University, University of Connecticut

Technology name: Cardiac monitor

Description: Researchers are advancing noninvasive patient monitoring by developing a vest that detects subclinical cardiac dysfunction along with a smart watch that assesses cardiac rhythm abnormalities. The study will collect patient data in order to develop programs for analyzing data and identifying at-risk patients.

Source: **UMMS researcher to develop wearable devices for monitoring of cardiac patients** http://www.umassmed.edu/news/news-archives/2015/11/umms-researcher-to-develop-wearable-devices-for-monitoring-of-cardiac-patients/

1.1.14 University of New South Wales

Technology name: Head tracker

Description: The wearable system attaches to a baseball cap and tracks and analyzes the movement of the user's head to determine the intensity of activities and elicit responses. For example, if it detects a user is reading, the technology could turn their phone to silent and provide notifications to suggest when to take breaks. During demanding tasks, the technology could notify the user to pay attention. The current prototype can be worn on glasses where it can track head and eye movement and speech.

Source: **Head tracker knows what you're doing and helps you multitask** https://www.newscientist.com/article/dn28560-head-tracker-knows-what-youre-doing-and-helps-you-multitask/

1.2 Chemical/particulate

1.2.1 Atmotube

Technology name: Atmotube

Description: Atmotube is a wearable air pollution monitor that can detect in real-time volatile organic chemicals and harmful gases (e.g., carbon monoxide) as well as temperature and humidity. The device calculates the data into an Air Quality Score and alerts the user via smart phone when the air becomes unsafe. Users can also use the device to conduct a "spot check" to help determine the source of the problem.

Source: **Atmotube is a wearable air pollution monitor** http://www.trustedreviews.com/news/atmotube-is-a-wearable-air-pollution-monitor#WzdkWVPqq6Q4mMBx.99

Photo source: http://atmotube.com/

1.2.2 Konkuk University

Technology name: Textile gas sensor

Description: Scientists developed a gas sensor that can be embroidered into clothing and alert wearers if they are exposed to high concentrations of nitrogen dioxide. The material uses a reduced graphene oxide wrapped around cotton and polyester fibers. As nitrogen dioxide levels rise, the graphene becomes more electrically conductive and LED lights illuminate to notify a user. The material is flexible and strong and does not require special treatment for washing. The material can be regenerated for reuse by irradiating it with heat or ultraviolet light.

Source: **Graphene-Coated Wearable 'E-Textile' Can Alert Wearer To Presence Of Dangerous Gases** http://www.forbes.com/sites/sujatakundu/2015/11/30/graphene-coated-wearable-e-textile-can-alert-wearer-to-presence-of-dangerous-gases/

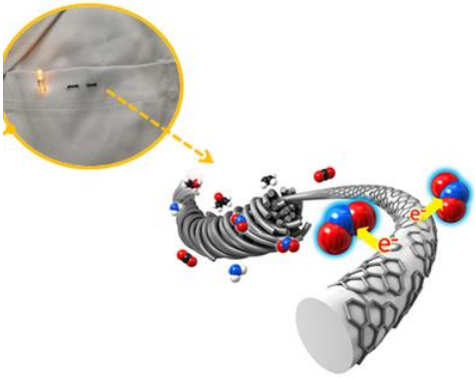

Photo source: http://www.nature.com/articles/srep10904

1.3 Radiation

1.3.1 FLIR Systems

Technology name: Portable nuclear threat detector

Description: DHS awarded a contract to FLIR Systems to create portable devices to aid in the detection of nuclear or radioactive materials. The work is part of the “Human Portable Tripwire” program developed to provide Customs, Coast Guard, and Transportation Security officers with passive environmental monitors to assist in nuclear or radioactive material detection.

Source: **DHS INVESTS IN WEARABLES THAT CAN DETECT NUCLEAR THREATS**
http://www.nextgov.com/emerging-tech/2015/11/dhs-investing-wearables-can-detect-nuclear-threats/123474/

1.4 Other

1.4.1 Georgia Institute of Technology

Technology name: Ear and tongue speech recognition system

Description: Researchers are creating a system that uses tongue, jaw, and ear canal movements to recognize speech and possibly to control wearable devices. Different words generate different movements in the jaw, tongue, and ear canal, and those are detected by the system. The technology uses a magnetic tongue control system, like that used to assist disabled users in navigating a powered wheelchair. The earpieces feature a proximity sensor that uses infrared light to map changes in the ear canal, which reflect changes in the jaw and thus different words. In tests, software detected what the user was saying 90% of the time (slightly lower when using only the ear trackers). Researchers have considered building a phrasebook of recognizable words and sentences, and they are also exploring how to recognize and use jaw movements to control wearables.

Source: **Ear and tongue sensors combine to understand "silent speech"**
https://www.newscientist.com/article/dn28504-ear-and-tongue-sensors-combine-to-understand-silent-speech/

2.0 DISPLAYS

2.1 Heads-up (on face or head)

2.1.1 Evena Medical

Technology name: Eyes-On

Description: Eyes-On is a hands-free ultrasound and near-infrared device that uses Epson's Moverio technology to assist with vein viewing. The glasses project infrared light and ultrasound on the patient's skin, allowing for both peripheral and deep targeting of veins. The information collected is captured by sensors and translated into an image that is overlaid on the patient's skin in real time.

Source: **Eyes-On Wearable Ultrasound and IR Glasses for Easy Venipuncture, Maybe Much More**
http://www.medgadget.com/2015/11/eyes-wearable-ultrasound-ir-glasses-easy-venipuncture-maybe-much.html


Photo source: http://evenamed.com/eyes-on-glasses/

2.1.2 Google

Technology name: Google Glass

Description: A new patent suggests a new Google Glass-type device will fit onto the user's ear and wrap around their head with an adjustable band. The device will have image-generating capabilities viewable from the display and include a touch-based input surface.

Source: **Google Files Patent For What Could Be Next Version Of Glass**
http://www.techtimes.com/articles/111386/20151127/patent-shows-new-version-google-glass-being-developed.htm

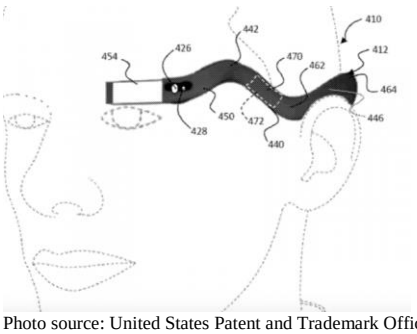

Photo source: United States Patent and Trademark Office

2.1.3 Institute of Cardiology

Technology name: Virtual reality

Description: A team of cardiologists used a virtual reality device to guide a surgical procedure to clear a clogged artery. The team used a Google Glass-like virtual reality device with a hands-free computer and head-mounted display that projects a 3D computed tomographic reconstruction in a mobile app equipped with zoom and hands-free voice recognition. The head-mounted display captured images and video while allowing the user to interact with the environment. The technology was developed for this purpose to allow the operators to visualize the vessel and direct the guide wire to address the occlusion.

Source: **First-in-man use of virtual reality imaging in cardiac cath lab to treat blocked coronary artery** http://www.eurekalert.org/pub_releases/2015-11/ehs-fuo111815.php

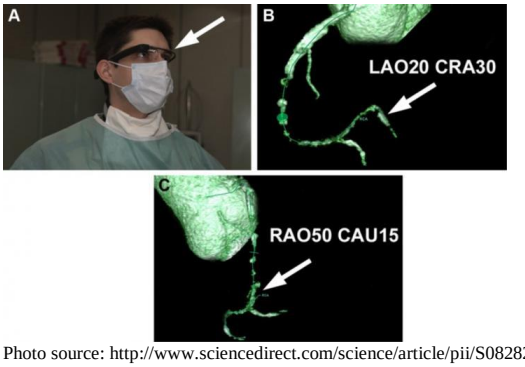

Photo source: http://www.sciencedirect.com/science/article/pii/S0828282X15013070

3.0 POWER

3.1 Self-powering (Harvesters)

3.1.1 Pauline Van Dongen, Wadden Sea Society

Technology name: Solar Parka

Description: Dongen's Wearable Solar Parka use solar cells to capture and convert solar light into energy. The cells feature a layered structure similar to a human cell, which interacts with sunlight. The garment's pockets feature detachable solar panels for charging devices. One pocket also features a thin, bendable, waterproof solar panel. The jacket's photo-voltaic cells generate enough power to charge a smartphone in two hours of sunlight. When not in use, the solar panels can be stored in a zip pocket in the parka.

Source: **Wearable Solar Innovation: Parka Offers Shelter, Comfort and Energy**
http://inventorspot.com/articles/wearable-solar-innovation-parka-offers-shelter-comfort-and-energ#sthash.MgcskjS1.dpuf

Photo source: http://inventorspot.com/articles/wearable-solar-innovation-parka-offers-shelter-comfort-and-energ#sthash.MgcskjS1.dpuf

3.1.2 Tekcapital

Technology name: Moje

Description: The device currently referred to as Moje aims to harvest energy from a human motion. According to recently filed patents, the device includes a dual-mode, low-frequency technology that generates enough current to recharge mobile devices.

Source: **Tekcapital applies for new wearable tech patents**
http://www.proactiveinvestors.co.uk/companies/news/117217/tekcapital-applies-for-new-wearable-tech-patents-117217.html

3.2 Power Supplies

3.2.1 Graphene 3D Lab

Technology name: Graphene Flex Foam

Description: Graphene Flex Foam combines a conductive elastomer composite and ultra-light grapheme foam, which forms a highly conductive and lightweight material anticipated to have benefits in the manufacture of lithium-ion batteries, supercapacitors, and wearables. The Flex Foam provides increased energy storage, catalyst support in organic synthesis reactions, gas sensors, and flexible acoustic devices.

Source: **Graphene Flex Foam: Graphene 3D Lab Introduces New Lightweight, Flexible Graphene Material** http://3dprint.com/107252/graphene-flex-foam/

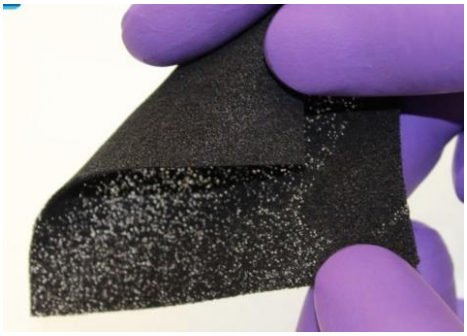

Photo source: http://3dprint.com/107252/graphene-flex-foam/

4.0 COMMUNICATIONS

4.1 Wearable, hands-free operation

4.1.1 Microsoft

Technology name: Wearable Control System

Description: A recent patent application by Microsoft describes a wearable technology to control smart devices (TV, smartphone, etc.). The technology, which could be a wristband or ring, has a small footprint and does not include a touch display, but it does include a microphone and the ability to use unique sound waves to control devices. One potential example could be changing TV channels via the noise produced from scratching a leather couch.

Source: **Microsoft invents new Wearables Control System that's driven by Surface Sound & Action Gestures** http://www.patentlyapple.com/patently-apple/2015/11/microsoft-invents-new-wearables-control-system-thats-driven-by-surface-sound-action-gestures.html

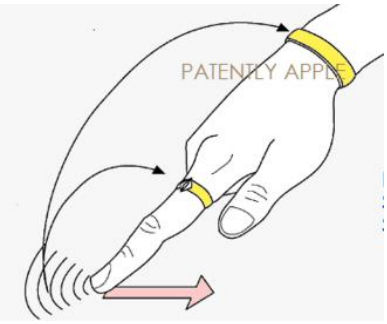

Photo source: http://www.patentlyapple.com/patently-apple/2015/11/microsoft-invents-new-wearables-control-system-thats-driven-by-surface-sound-action-gestures.html

4.1.2 NEC Corp.

Technology name: ARmKeypad

Description: NEC created virtual keyboard software that works with smart glasses and a smart watch to project a keyboard on a user's arm that connects wirelessly with common smart devices. Potential applications include use in factories and hospitals.

Source: **NEC turns arm into virtual keyboard with wearable tech** http://asia.nikkei.com/Tech-Science/Tech/NEC-turns-arm-into-virtual-keyboard-with-wearable-tech

Photo source: http://jpn.nec.com/press/201511/20151105_04.html

4.1.3 Qeexo

Technology name: FingerAngle

Description: The FingerAngle algorithm allows for the detection and response to a user's finger angles, such that a user can rotate a single finger to zoom a display, scrolls, etc. The system detects the angle the finger points as well as its angle relative to the display.

Source: **FingerAngle revolutionises wearable interactions** http://www.wearabletechnology-news.com/news/2015/nov/16/fingerangle-revolutionises-wearable-interactions/

5.0 CAMERAS

5.1.1 3RDiTek

Technology name: 3RDi

Description: The 3RDi (third eye) is a head-worn camera prototype that shoots high-definition photos and video. Users can switch between video and photo functions by tapping the device. In picture mode, users tap the device to take a picture. The current device prototype syncs to a smartphone via Bluetooth and its camera includes auto focus, LED flash, microSD storage, build-in microphone, and social-media-friendly capabilities.

Source: **3RDi Wearable Camera Launches on Indiegogo**
http://techgadgetcentral.com/2015/11/05/3rdi-wearable-camera-launches-on-indiegogo/

Photo source: https://www.indiegogo.com/projects/3rditek-capture-your-life#/

6.0 EXOSKELETONS

6.1.1 B-Temia Inc., Sagem

Technology name: Exoskeleton

Description: B-Temia Inc. and Sagem are working together to create a next-generation exoskeleton based on B-Temia's Dermoskeleton™ and intended for industrial and military use. The partnership brings together B-Temia's experience in human robotics and artificial intelligence with Sagem's work in actuators and stabilization technology.

Source: **B-Temia and Sagem Sign a Partnership Agreement in the Field of Exoskeletons for Industrial and Military Applications** http://www.newswire.ca/news-releases/b-temia-and-sagem-sign-a-partnership-agreement-in-the-field-of-exoskeletons-for-industrial-and-military-applications-543588362.html

6.1.2 Daiya Industry Co. Ltd., Hiroshima University

Technology name: Unplugged Power Suit

Description: The Unplugged Power Suit assists human movement using a specially designed Pneumatic Gel Muscle (PGM) rather than electronics or tanks. The PGM is flexible and lightweight and exerts support via low air pressure. The pneumatic muscle assistive equipment comprises the PGM drive parts, an air pressure pump, and pipework. The pump, located in the sole, transmits force to the PGM via human body weight. The device covers the hip while the pump is positioned on the opposite sole, enabling the device to support human hip movement, specifically the swing motion. Users can adjust the amount of muscle activation by changing the positions of the PGM and pump. Anticipated benefits include reduced muscle activity during jogging and increased pitch speed.

Source: **Wearable equipment supports human motion where and when needed** http://medicalxpress.com/news/2015-11-wearable-equipment-human-motion.html

Photo source: http://www.hiroshima-u.ac.jp/news/show/lang/en/id/1923/dir_id/0

7.0 WEARABLE COMPUTERS

7.1.1 Google

Technology name: Screen-free wearable

Description: Project Aura is anticipated to create a screenless, audio-based wearable that will rely on bone conduction and respond to voice commands in the ears, enabling screen-free interaction with the device.

Source: **Alphabet Inc. To Launch New "Screenless" Google Glass Wearable**
http://www.bidnessetc.com/57661-alphabet-inc-to-launch-new-screenless-google-glass-wearable/

7.1.2 Neptune Pine

Technology name: Rufus Cuff

Description: The Android-based Rufus Cuff features a 3.2-inch screen, TI Cortex A9 processor, photo/video camera, built-in speaker, dual microphone, GPS, Wi-Fi and Bluetooth connectivity, and a 1,175 mAH battery a well as 16, 32, or 64 gigabytes of storage.

Source: **The 'tablet' for your wrist has arrived** http://www.engadget.com/2015/11/02/rufus-cuff/

Photo source: https://www.indiegogo.com/projects/rufus-cuff-more-than-a-smartwatch#/

7.1.3 University of Tennessee

Technology name: Guide Glass

Description: Researchers are using Google Glass to explore wearable navigation technology to assist visually impaired users. The prototype features a tiny camera, computer, and sensors that work together to recognize an object near the user, calculate its distance and movement, and communicate it to the user.

Source: **UT researcher is developing Guide Glass**

http://www.wbir.com/story/tech/2015/11/04/ut-researcher-developing-guide-glass/75174434/

7.1.4 Zebra

Technology name: Zebra WT41N0 Wearable Terminal

Description: The Zebra WT41N0 Wearable Terminal is a rugged voice and data wrist-worn computer with Wi-Fi connectivity, voice-enabled applications, a dual-core processor, and mobile compatibility. The device can be loaded with software specific to the user and industry. The device was designed for warehouse workers to assist with scanning and managing inventory and instantly accessing shipping information.

Source: **The Pip-Boy is real, and warehouse workers use it every day**
http://www.dailydot.com/technology/fallout-pip-boy-real-life/

Photo source: http://www.dailydot.com/technology/fallout-pip-boy-real-life/

8.0 OTHER

8.1.1 Buffalo Armory, LLC

Technology name: Star Armor® 555

Description: Designed for first responders, Star Armor 555 delivers improved ballistic performance with multi-hit capability and protects against NIJ Level 3 and NIJ Level 3+ ballistic standards and M193 and M855 threats. The technology can withstand abuse, moisture, and heat, and its plates are thinner than typical ceramic alternatives. Buffalo Armory is also working toward lighter NIJ3/NIJ4 technologies with perforated armor and other metals.

Source: **Buffalo Armory Announces Star Armor® 555 Protects First Responders from Active Shooter, High Velocity Rifle Threats** http://www.prweb.com/releases/2015/11/prweb13057861.htm

8.1.2 Carnegie Mellon University

Technology name: EM-Sense

Description: EM-Sense uses body capacitance, or the body's natural conductivity, to enable a smart watch to interact with electrical devices, such as to unlock a recognized device without a password. An electrode attached to the wrist allows electromagnetic signals to travel through the wearer's body, essentially turning the user into an antenna. When the user connects with a recognized device, the smartwatch can be programmed for specific functions.

Source: **Recognition Software Could Let Smartwatches Enable Context-Aware Apps** http://www.techtimes.com/articles/104727/20151109/carnegie-mellon-disney-research-create-context-aware-software-em-sense.htm

Photo source: http://www.cs.cmu.edu/news/system-recognizes-objects-touched-user-enabling-context-aware-smartwatch-apps

8.1.3 Commonwealth Scientific and Industrial Research Organization, RMIT University

Technology name: Personal Protective Equipment of Things

Description: A team of RMIT University students and CSIRO created the Personal Protective Equipment of Things (PPE of Things) that uses Bluetooth sensors to track whether PPE is being worn and operated properly and to send real-time alerts. For example, the sensors can be attached to helmets or protective glasses and when removed, the user would receive a warning and management would receive a notice of breach of procedure.

Source: **Miner indiscretions: Hackathon winner sends out clothes and equipment misuse alerts**
http://www.startupsmart.com.au/growth/start-up-profiles/miner-indiscretions-hackathon-winner-sends-out-clothes-and-equipment-misuse-alerts/2015111215923.html

8.1.4 CuteCircuit, EasyJet

Technology name: LED- and sensor-equipped uniforms

Description: New airline uniforms have LED lights, built-in sensors, and a built-in microphone. The uniform allows pilots and crews to talk to each other, and the LEDs display a flight number and destination as well as provide extra lighting during emergency situations. Reflective panels and LED lights in the hood provide extra light to the wearer. Built-in video cameras can stream images to engineers. Lastly, air quality sensors and a barometer monitor the wearer's environment.

Source: **Wearable tech takes flight as UK airline EasyJet debuts LED and sensor-studded uniforms**
http://www.cnet.com/news/wearable-technology-takes-flight-as-uk-airline-debuts-led-and-sensor-studded-uniforms/

Photo source: http://www.cnet.com/news/wearable-technology-takes-flight-as-uk-airline-debuts-led-and-sensor-studded-uniforms/

8.1.5 MADLAB.CC

Technology name: Tactum

Description: The Tactum augmented modeling tool is a 3D printing concept that allows the user to manipulate images on their body via gestures and then create ready-to-print and ready-to-wear products, such as Moto 360 watch bands and medical braces. The technology recognizes typical gestures, such as

pinching. Via depth sensing and projection mapping, users interact with on-skin projections to manipulate designs. Trial runs included creating wearables from different material modes, and fabrication machines including nylon, rubber, and furry prints.

Source: **Design 3D-Printed Wearables by Pinching and Poking On-Skin Projections**
http://www.psfk.com/2015/11/design-3d-printed-wearables-autodesk-research-madlabcc-tactum-design-process.html

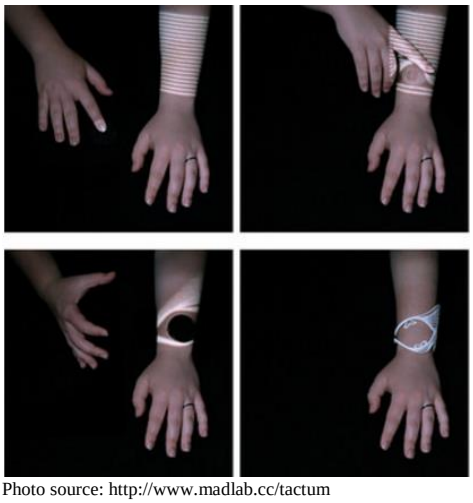

Photo source: http://www.madlab.cc/tactum

8.1.6 Massachusetts Institute of Technology

Technology name: LineFORM

Description: The MIT Media Lab is testing a proof-of-concept called LineFORM. The device is a "serpentine robot" flexible interface with actuators that can arrange into different shapes and configurations and accommodate a range of functions and interactive capabilities based on the attached module. For example, when worn around a wrist it can provide notifications via haptic feedback or when used as a smart cable, it can transform into a phone, lamp, or exoskeleton.

Source: **MIT's shape-shifting bot can be a phone, lamp or exoskeleton**
http://www.engadget.com/2015/11/09/mit-media-lab-lineform-robot/

Photo source: http://tangible.media.mit.edu/project/lineform/

8.1.7 University of Auckland

Technology name: Flexible keyboard

Description: Researchers developed a flexible keyboard made of dielectric elastomer rubber. The device features two sensing layers between a single laminated structure and its surface is separated into nine sensing regions or programmable keys. The device can be wrapped around an object to essentially turn it into a keyboard or used as a "sensing skin" for motion capture. The keys/sensing areas can be modified by reprogramming the rubber keyboard.

Source: **Stretchable, programmable keyboard is tailor-made for wearable tech**
http://www.gizmag.com/auckland-scientists-create-rubber-programmable-stretchable-keyboard/40593/

Photo source: http://iopscience.iop.org/article/10.1088/0964-1726/25/1/015012

8.1.8 VTT Technical Research Centre

Technology name: Air-conditioned fabric

Description: Researchers developed a way to create clothes with smart-phone-controlled air-conditioning. Microscopic channel structures are embossed onto plastic film and these can be filled with hot or cold liquid. VTT is seeking sports and outdoor recreation partners to advance the project.

Source: **Air-Conditioned Fabric Is Coming and You Can Control It With Your Phone**
http://www.details.com/story/air-conditioned-fabric-is-coming-and-you-can-control-it-with-your-phone

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		
Chaotic Moon	Biometric Tattoos	Biometric tattoos and biowearables with conductive paint that can noninvasively measure a user's biometrics (sweat, heart rate, hydration, etc.) as well as track a user's location. The technology can be discretely worn and transmits information via Bluetooth.
Check-My-Temp	Check-My-Temp	Arm-worn medical device with sensors that continuously and noninvasively record a user's movements and temperature with clinical-grade accuracy and it communicates the information to a smartphone or tablet as well as specified user groups.
FocusMotion	Motion tracking	Using motion tracking in physical therapy, combining FocusMotion's motion-tracking technology capabilities with Reflexion's experience in digital medicine and rehabilitation and FORCE's tools for arm musculoskeletal recovery.
Healbe Corporation	Flow	Automatic hydration monitoring technology that will be integrated into Healbe's GoBe™ body manager technology.
Honeywell, Intel	Connected Worker Solution	Mobile hub with sensor fusion to collect data from a variety of sensors worn by a worker to monitor the user's toxic gas exposure, breathing, heart rate, posture, and movement in order to provide a comprehensive profile of the user and what they may be experiencing.
InBody USA	InbodyBAND	Measures body composition (fat, body fat, muscle mass) and activity (steps, distance, calories) to provide a comprehensive profile of a user. The device uses bioelectrical impedance analysis and ECG.
iRhythm Technologies	ZIO XT Patch cardiovascular monitor	Single-lead ECG cardiovascular monitoring technology used to detect asymptomatic atrial fibrillation, a heart arrhythmia indicative of several health complications.
Isansys Lifecare	Lifetouch	Sensors that analyze real-time ECG data and send the data via Bluetooth to a bedside Isansys gateway display. The sensor features a Patient Status Engine multi-vital-sign data capture and analysis system.
Massachusetts Institute of Technology, Northeastern Univ., Univ. of Connecticut	Cardiac monitor	Noninvasive patient monitoring with a vest that detects subclinical cardiac dysfunction along with a smart watch that assesses cardiac rhythm abnormalities.
Massachusetts Institute of Technology	Ingestible sensor	Small, ingestible sensor for measuring vital signs (heart rate, breathing rate, etc.) via sound waves detected from the gastrointestinal tract. It differentiates sounds from background noise of the digestive tract
Newdealdesign, Vivalnk	Fever Scout	Soft, flexible thermometer that can wirelessly connect and communicate readings to a smartphone via Bluetooth.
Samsung Electronics	Bio Processor	Small (45 millimeter) system-in-package chip for wearables with an embedded ECG reader, application processor, and Bluetooth module. It can measure blood flow and bioelectrical impedance and other functions—all on the same chip.
Sarah Heimeier (individual)	Jana	Stomach-worn device that measures glucose and blood pressure as well as fetal heart rate via soundwaves reflecting off bodily tissue.
University of New South Wales	Head tracker	Wearable system that attaches to a baseball cap and tracks and analyzes the movement of the user's head to determine the intensity of activities and elicit responses.
Chemical/Particulate		
Atmotube	Atmotube	Wearable air pollution monitor that can detect in real-time volatile organic chemicals and harmful gases (e.g., carbon monoxide) as well as temperature and humidity.

Konkuk University	Textile gas sensor	Gas sensor that can be embroidered into clothing and high concentrations of hazardous gas cause its light-emitting diode to shine and alert the wearer.
Radiation		
FLIR Systems	Portable nuclear threat detector	Portable devices to aid in the detection of nuclear threats.
Other		
Georgia Institute of Technology	Ear and tongue speech recognition system	Uses tongue and ear canal movements to recognize speech and possibly to control wearable devices
Displays		
Heads-Up		
Google	Google Glass	Google Glass-type device that will fit onto the user's ear and wrap around their head with an adjustable band. The device will have image-generating capabilities and include a touch-based input surface.
Evena Medical	Eyes-On	Ultrasound and near-infrared device that uses Epson's Moverio technology to assist with vein viewing.
Institute of Cardiology	Virtual reality device	Cardiologists used a virtual reality device to guide a surgical procedure to clear a clogged artery. The team used a Google Glass virtual reality device with a hands-free computer and head-mounted display that projected a 3D tomographic reconstruction in a mobile app equipped.
Power		
Self-Powering/Harvesting		
Paula Van Dongen, Wadden Sea Society	Solar Parka	A one-size-fits-all hooded jacket equipped with various solar panels and photo-voltaic cells and created using yarn recycled from jeans.
Tekcapital	Moje	Piezoelectric electro-mechanical device that aims to harvest energy from a user's everyday activities.
Power Supplies		
Graphene 3D Lab	Graphene Flex Foam	Provides increased energy storage, catalyst support in organic synthesis reactions, gas sensors, and flexible acoustic devices. The material combines conductive elastomer composite with ultra-light graphene foam, which is highly conductive and lightweight.
Communications		
Hands-Free		
Microsoft	Wearable Control System	Wearable technology to control smart devices (TV, smartphone, etc.), with small form-factor and a microphone and the ability to use unique sound waves to control devices.
NEC Corp.	ARmKeypad	Virtual keyboard software that works with smart glasses and a smart watch to project a keyboard on a user's arm that connects wirelessly with common smart devices.
Qeexo	FingerAngle	Algorithm that allows for the detection and response to a user's finger angles, such that a user can rotate a single finger to zoom a display, scrolls, etc.
Cameras		
3RDiTek	3RDi	Head-worn camera that shoots high-definition photos and video, syncs to a smartphone via Bluetooth and its camera includes auto focus, LED flash, microSD storage, build-in microphone, and social-media-friendly capabilities.
Exoskeletons		
B-Temia Inc., Sagem	Exoskeleton	Developing a next-generation exoskeleton for industrial and military use. The partnership brings together B-Temia's experience in human robotics and artificial intelligence with Sagem's work in actuators and stabilization technology.

Daiya Industry Co. Ltd., Hiroshima University	Unplugged Power Suit	Assists human movement using a specially designed Pneumatic Gel Muscle (PGM). The pneumatic muscle assistive equipment comprises the PGM drive parts, an air pressure pump, and pipework. The pump, located in the sole, transmits force to the PGM via human body weight. The device covers the hip while the pump is positioned on the opposite sole, enabling the device to support human hip movement and swing motion.
Wearable computers		
Google	Screen-free wearable	Screenless, audio-based wearable that relies on bone conduction and responds to voice commands in the ears, enabling screen-free interaction with the device.
Neptune Pine	Rufus Cuff	Features a 3.2-inch screen, TI Cortex A9 processor, photo/video camera, built-in speaker, dual microphone, GPS, Wi-Fi and Bluetooth connectivity, and a 1,175 mAH battery a well as 16, 32, or 64 gigabytes of storage.
University of Tennessee	Guide Glass	Designed to provide navigation assistance to visually impaired users. The prototype features a tiny camera, computer, and sensors that work together to recognize an object near the user, calculate its distance and movement, and communicate it to the user.
Zebra	WT41N0 Wearable Terminal	A rugged voice and data wrist-worn computer with Wi-Fi connectivity, voice-enabled applications, a dual-core processor, and mobile compatibility.
Other		
Commonwealth Scientific and Industrial Research Organization, RMIT University	Personal Protective Equipment of Things	Uses Bluetooth sensors to track whether PPE is being worn and operated properly and to send real-time alerts.
Buffalo Armory, LLC	Star Armor 555	Delivers improved ballistic performance with multi-hit capability and protects against NIJ Level 3 and NIJ Level 3+ ballistic standards and M193 and M855 threats. The technology can withstand abuse, moisture, and heat, and its plates are thinner than typical ceramic alternatives.
Carnegie Mellon University	EM-Sense	Uses body capacitance, or the body's natural conductivity, to enable a smart watch to interact with electrical devices.
CuteCircuit, EasyJet	LED- and sensor-equipped uniforms	Uniforms with LED lights, built-in sensors, and built-in microphone.
MADLAB.CC	Tactum	Augmented modeling 3D printing concept that allows the user to manipulate images on their body via gestures and then create ready-to-print and ready-to-wear products.
Massachusetts Institute of Technology	LineFORM	Flexible interface that features a series of actuators that can arrange into different shapes and configurations and accommodate a range of functions and interactive capabilities.
University of Auckland	Flexible keyboard	Flexible keyboard made of dielectric elastomer rubber, featuring two sensing layers between a single laminated structure and its surface is separated into nine sensing regions or programmable keys
VTT Technical Research Centre	Wearable cooling fabric	Method to create clothes with smart-phone-controlled air-conditioning. Microscopic channel structures are embossed onto plastic film and these can be filled with hot or cold liquid.

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