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Responder Technology Alert (August 2015)

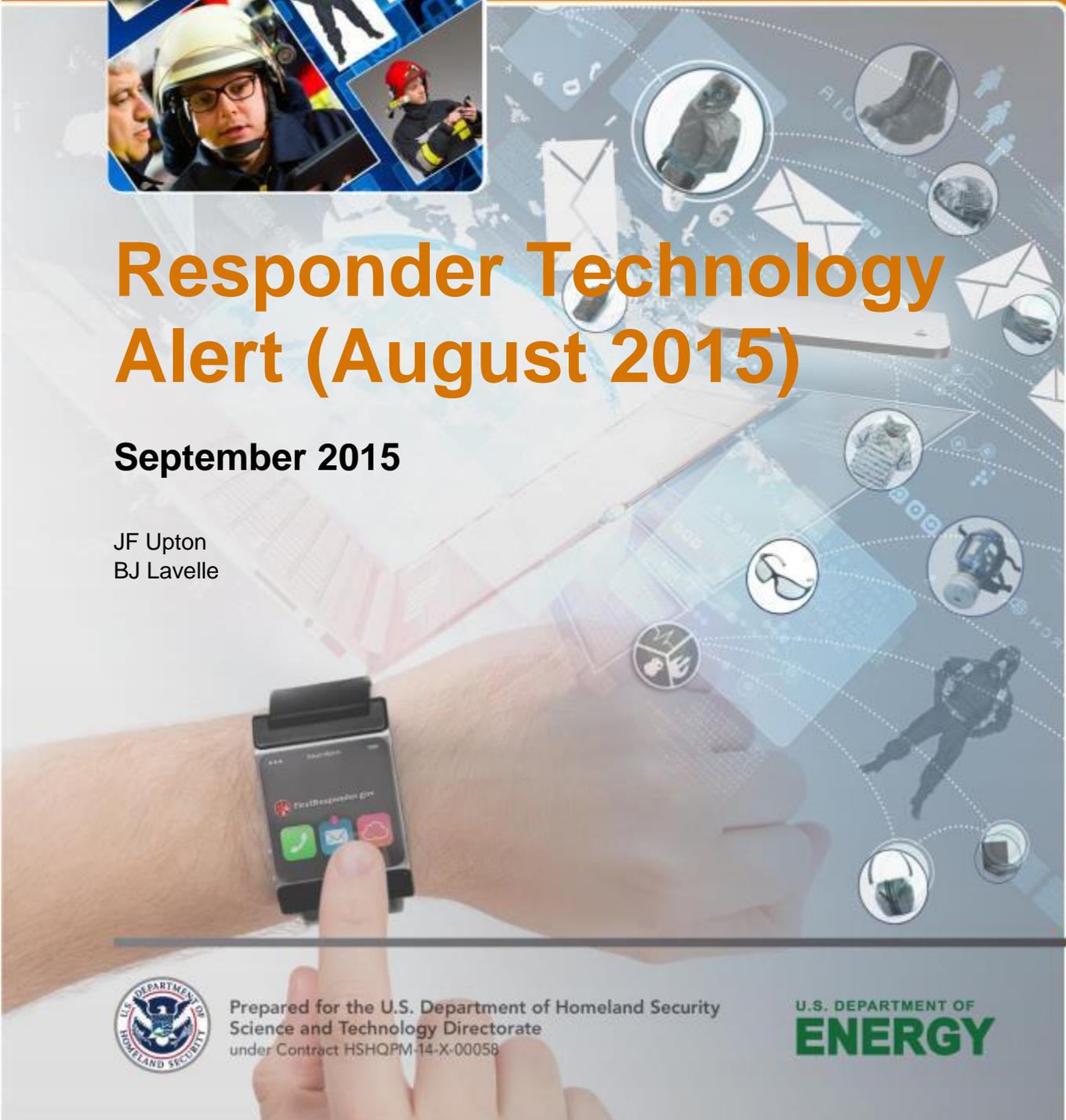
September 2015

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://nwrta.pnnl.gov>. A spreadsheet summarizing these technologies is available in Appendix A.



1.0 SENSORS

1.1 Physiological

1.1.1 Cambridge Design Partnership

Technology name: First Response Monitor

Description: The First Response Monitor is an affordable biometric device that clips to a user's nose, monitors vital signs (including pulse rate and respiration), and transmits data in real-time via Bluetooth to a smart device that will display the data and trend graphs of the measurements. The device was originally designed for first responders in situations of mass casualties but may have other applications in performance monitoring.

Company link: <http://www.cambridge-design.co.uk/>

Source: Wearable device measures pulse and respiration

<http://www.newelectronics.co.uk/electronics-news/wearable-device-measures-pulse-and-respiration/88258/>



Photo source: <http://www.cambridge-design.co.uk/news-and-articles/news/connected-wearable-monitor-saves-lives>

1.1.2 EFD Sports

Technology name: StrikeTec

Description: Designed for boxing, StrikeTec sensors measure a wearer's punches, recording speed, type, and force, as well as fatigue, endurance, and calories burned. The data is monitored in real-time and synced to a cloud server. Users can monitor their performance real-time via a smart device and track their progress over time. The information can also be shared with another user (i.e., a coach) in real-time.

Product link: <http://efdstriketec.com/>



Source: StrikeTec's Wearable Sensors Give MMA Fighters Actionable Data Feedback

<http://www.sporttechie.com/2015/08/20/striketecs-wearable-sensors-give-mma-fighters-actionable-data-feedback/>



Photo source: efdstriketec.com

1.1.3 Google, Dexcom

Technology name: Glucose monitoring device

Description: Google partnered with Dexcom to develop a low-cost, disposable, bandage-sized wearable glucose monitoring device that will be connected to cloud storage and provide real-time information.

Source: Google to develop wearable glucose-monitoring device

<http://www.foxnews.com/health/2015/08/14/google-to-develop-wearable-glucose-monitoring-device/>

1.1.4 King Abdullah University of Science and Technology

Technology name: Wearable pressure sensor

Description: Researchers are developing a highly sensitive and affordable pressure sensor that detects minute blood pressure changes. The device also detects throat muscle movements to recognize deviations in human voices and track movements for different words. The device is anticipated to have potential applications in recognizing the onset of physiological anomalies such as cardiovascular disease and may include voice recognition.

Research link: <http://dx.doi.org/10.1039/C5NR03155A>

Source: Highly sensitive wearable sensors

<http://www.natureasia.com/en/nmiddleeast/article/10.1038/nmiddleeast.2015.151>

1.1.5 Laboratory of Movement Analysis and Measurement, Ecole Polytechnique Fédérale de Lausanne

Technology name: Wearable barometric pressure sensor

Description: Researchers are integrating barometric pressure and inertial sensor data to improve activity tracking and mobility monitoring by incorporating corresponding body elevation. The technology can



recognize body elevation (climbing stairs, standing, etc.), which researchers incorporated into their event-driven activity tracking.

Source: Improving activity recognition using a wearable barometric pressure sensor in mobility-impaired stroke patients <http://www.jneuroengrehab.com/content/12/1/72>

1.1.6 Misfit, Speedo

Technology name: Speedo Shine

Description: Speedo Shine features the Misfit Shine activity tracker designed for swimmers. The device is waterproof up to 50 meters, can sync with an Android or iOS device via Bluetooth, and offers a 6-month battery life with a coin-cell battery that does not require regular charging. The device will also sync with Speedo's Fit app.

Product link: <http://misfit.com/products/speedo-shine>

Source: Misfit unveils Speedo Shine, the water wearable for swimmers
<http://www.lidtime.com/misfit-unveils-speedo-shine-the-water-wearable-for-swimmers-8066/>

1.1.7 Multisensor Diagnostics, Johns Hopkins

Technology name: MouthLab

Description: MouthLab is a battery-powered wearable device that connects to a patient's lip or fingertip to track vital signs (blood pressure, heart rate, temperature, breathing rate, and blood oxygen). The device can also conduct an electrocardiogram through the mouth and fingertip sensors and transmit results via Wi-Fi. The hand-held device includes a mouthpiece with temperature, breath, and blood volume sensors as well as a fingertip area to measure the pulse and blood oxygen levels. It is anticipated that in the future the device may include the ability to measure saliva, blood, and other chemicals.

Product link: <http://www.multisensordiagnostics.com/>

Source: New Wearable Devices Collect Vital Signs in any Setting
<http://mhealthintelligence.com/news/new-wearable-devices-collect-vital-signs-in-any-setting>

1.1.8 North Carolina State University Nanosystems Engineering Research Center for Advanced Self-Powered Systems of Integrated Sensors and Technologies

Technology name: Smart medical sensors

Description: Researchers are developing wearable sensors powered by a user's body heat and capable of monitoring a patient's breathing; transmitting the data to a smart device where algorithms evaluate time, pitch, and magnitude/volume to interpret if a user is having difficulties; and sending notifications to the user. The sensor measures wheezing in a user's lungs and uses algorithms to help determine if there is an



issue and whether to notify the user or medical provider. Researchers are working to develop sensors that operate wirelessly and can perform the analysis and send notifications without the need for a smart device.

Source: Wearable Sensors Monitor Patients' Wheezing Sounds Over Time

<http://www.azosensors.com/news.aspx?newsID=10078>

1.1.9 Nymi, TD Bank Group, MasterCard

Technology name: Biometric authentication

Description: Developers announced contactless, biometrically authentication functionality in a wearable. The technology recognizes users by their heartbeat and uses near-field communication capabilities to communicate with other devices.

Source: Nymi, TD and MasterCard Announce World's First Biometrically Authenticated Wearable Payment Using Your Heartbeat <http://www.marketwatch.com/story/nyimi-td-and-mastercard-announce-worlds-first-biometrically-authenticated-wearable-payment-using-your-heartbeat-2015-08-11>

1.1.10 Toshiba

Technology name: Silmee W20 and W21 wearable monitors

Description: The Silmee wearable monitors have sensors to measure skin temperature, pulse, ultraviolet light, and movement. The device offers Bluetooth connectivity, two-week battery life, an emergency button, and GPS. The sensors can reportedly track a range of "life logs" such as how long a user spends talking to others. Users can also transmit the information to another pre-selected user.

Source: Toshiba's new wearables take aim at senior needs

<http://www.mhealthnews.com/blog/toshibas-new-wearables-take-aim-senior-needs>

1.1.11 University of Waterloo Advanced Aging Research Centre, Pervasive Dynamics

Technology name: Rehabilitation sensor

Description: Researchers are developing body-worn sensors that attach to the user's legs, chest, and wrists and provide detailed information on heart rates, speed and direction of limbs, stress, and breathing. The data is sent to the clinician's office where it can be assessed in real time. Example applications include monitoring a user's gait or movements to identify and improve symmetry.

Source: Startup and research centre join forces to develop wearable technology to aid stroke recovery <http://www.therecord.com/news-story/5805637-startup-and-research-centre-join-forces-to-develop-wearable-technology-to-aid-stroke-recovery/>



Photo source: <http://www.therecord.com/news-story/5805637-startup-and-research-centre-join-forces-to-develop-wearable-technology-to-aid-stroke-recovery/>

1.2 Other

1.2.1 Flexible Hybrid Electronic Institute

Technology name: Flexible sensors

Description: Developers are working on printing technologies to create stretchable electronics with embedded sensors to be worn by soldiers and also used to monitor structural integrity of ships or warplanes. Flexible Hybrid Electronics Institute is part of a consortium of 162 high-tech companies, universities and other groups (including Boeing, Apple, Harvard), to which the Department of Defense recently awarded \$75 million to advance electronic systems with flexible sensors fit for soldiers and other military needs.

Source: Pentagon Teams With Apple, Boeing to Develop Wearable Tech

<http://www.reuters.com/article/2015/08/28/us-usa-defense-tech-idUSKCN0QX12D20150828>

1.2.2 Ollinfit

Technology name: Wearable sensors

Description: Ollinfit's wearable sensors and app act as a personal trainer, providing feedback on a user's activities, monitoring form, and providing live audio and vibration feedback. Users can also monitor the amount of weight the person using the device is lifting. The sensors detect motion and compare it to Ollinfit's database, which will grow as the user base grows and the app and algorithm gain more information (data from users with different body types, ages, genders, etc.).

Product link: <http://www.ollinfit.com/>

Source: Ollinfit Looks to Emulate Personal Trainer Experience with Wearable Tech

<http://www.techvibes.com/blog/ollinfit-2015-08-31>



2.0 DISPLAYS

2.1 Body-Worn (wrist, arm or chest)

2.1.1 AU Optronics Corp. (AUO)

Technology name: AMOLED display

Description: AUO is using AMOLED displays and transfective LCD technologies to create thin, lightweight, low-power consumption displays fit for wearable devices. The technology varies in size from 1.3 to 1.6 inches square and 0.45 millimeter thick, with a 1.3-inch transfective low-temperature polysilicon LCD (LTFS) display with Memory-in-Pixel technology, which reportedly requires less than 1% of the power of traditional LCDs and can be read easily in sunlight. AUO is also expected to debut a 5-inch bendable AMOLED technology, with special sensors so a user can bend the device to manipulate the size and direction of the display area.

Press link: <http://www.auo.com/?sn=107&lang=en-US&c=9&n=1816>

Source: AUO to Exhibit Special-Sized AMOLED Displays for Wearables
<http://en.ctimes.com.tw/DispNews.asp?O=HJZ8O9UWG0ISAA00ND>



Photo source: <http://www.auo.com/?sn=107&lang=en-US&c=9&n=1816>

2.1.2 Korea Advanced Institute of Science and Technology

Technology name: Bendable display

Description: Researchers are developing a bendable, fiber-like display that can be woven into fabric. Researchers are using a more efficient process than standard heat-treating methods that can speed up the creation of wearable displays with LED fibers that can be mass-produced similarly to nylon or polyethylene fiber.

Source: Brace yourselves, bendy wearable displays are coming
<http://www.itproportal.com/2015/08/13/brace-yourselfes-wearable-displays-are-coming/>

2.1.3 National Chiao Tung University

Technology name: White LEDs for wearable/flexible displays



Description: Researchers are developing flexible, white LEDs for use in wearable and curved or flexible displays. The device builds on existing technologies, making it affordable and efficient, and also features a common silicon-based polymer renowned for its transparency, stability, and flexibility. In test runs, “researchers ran the device for a standard 1,000 hours, to test its durability, finding that its emission decayed by only 5%. Its potential for use in wearables was demonstrated when subjected to bending tests. It held its power output when bent to a curvature with a 1.5-cm radius. It also exhibited a light efficiency of 120 lumens per watt.”

Research link: <http://dx.doi.org/10.1364/OE.23.0A1167>

Source: A new design for an easily fabricated, flexible and wearable white-light LED
http://www.eurekalert.org/pub_releases/2015-08/tos-and082015.php



Photo source: <https://www.osapublishing.org/oe/fulltext.cfm?uri=oe-23-19-A1167&id=324488>

2.1.4 Polyera

Technology name: Wove wristband

Description: The Wove flexible display wristband features Polyera’s flexible, thin-film transistors in a wearable that can show a range of data (email previews, news headlines, weather forecasts, etc.) and features a touch-screen interface. The device uses electronic paper and offers zero-power standby mode.

Product link: <http://www.polyera.com/>

Source: Polyera Wove wearable previews true flexible display <http://www.slashgear.com/polyera-wove-wearable-previews-true-flexible-display-17397771/>



Photo source: <http://www.polyera.com/>



3.0 POWER

3.1 Chargers

3.1.1 Joe's Jeans

Technology name: #Hello smart fabric

Description: This denim clothing features a back pocket fit to charge smartphones (iPhone 5, 5S, or 6) and a waistband with a portable battery pack and USB cord. The battery pack reportedly charges the devices to limited capacities (70-85 percent) and must be removed before washing.

Product link: <http://www.joesjeans.com/Hello/-1571864922823424774/Product?sku=S26AR35143-23-AR3>

Source: Wearable Technology: Jeans That Charge Your Smartphone
<http://www.idigitaltimes.com/wearable-technology-jeans-charge-your-smartphone-464210>



4.0 COMMUNICATIONS

4.1 Hands-free Operation

4.1.1 Gadia Power

Technology name: Gadia Power

Description: Gadia Power offers bio-sensing technology in a small (1-inch), lightweight, durable micro device that allows the user to control smart devices (and potentially nano-drones and virtual reality helmets) using hand gestures. The device offers 16-hour battery life and Bluetooth connectivity. The device tracks electrical activity in a user's muscles and recognizes six distinct hand gestures. The device is supported by open-source documentation and user support community.

Product link: <https://www.indiegogo.com/projects/gadia-power-bio-sensing-gesture-control-wearable--2>

Source: Gadia Power, the Bio-Sensing Gesture Control Wearable, now on Indiegogo

<http://www.prnewswire.com/news-releases/gadia-power-the-bio-sensing-gesture-control-wearable-now-on-indiegogo-300118840.html>

4.1.2 QuickLogic

Technology name: Programmable, logic-based system-on-chip voice interface

Description: The “multicore programmable logic-based [system-on-chip] chip” was designed as a sensor interface that supports hardware flexibility and always-on voice processing applications for wearables and other Internet of Things devices. The voice trigger functionality offers voice recognition of up to 20 phrase commands, reduced current consumption and ultra-low power sound detector, and reduced need for cloud support. The device can work in quiet and noisy environments.

Product link: <http://www.quicklogic.com/platforms/sensor-processing/eos/>

Source: Programmable logic based voice interface for IoT wearables and mobiles

<http://www.eeherald.com/section/new-products/owns20150802001j.html>

4.1.3 University of Texas

Technology name: Wearable American Sign Language Recognition system

Description: Researchers are developing gesture-recognition wearables to recognize American Sign Language words. The system comprises a wrist-mounted device to measure hand motion and an arm-mounted device to measure muscle activity. The information is sent wirelessly to a computer for



translation into text or speech. The technology reportedly recognizes about 40 words with 96 percent accuracy.

Source: Dallas university team develops sign language recognition system using TI parts, partly TI funded <http://bizbeatblog.dallasnews.com/2015/08/87419.html/>

Location tracking



5.0 LOCATION TRACKING

5.1.1 Corrisoft

Technology name: Alternative to Incarceration (AIR)

Description: AIR comprises a Bluetooth- and GPS-equipped ankle bracelet that tethers to a smartphone and offers 4G capabilities for improved speed, accuracy, and volume of information. The device offers real-time GPS tracking of the user that is displayed on a map and two-way real-time communication through voice text or e-mail.

Product link: <http://www.corrisoft.com/air/>

Source: This Wearable Tech Could Keep Teens Out of Jail <http://www.psfk.com/2015/08/wearable-tech-teen-offenders-alternative-to-incarceration-via-rehabilitation-corrisoft.html>



Photo source: <http://www.corrisoft.com/air/>

5.1.2 PolyOne Corporation, Filip Technologies

Technology name: FiLIP™ 2

Description: The FiLIP 2 wearable phone and user locator combines cell tower location, Wi-Fi triangulation, and GPS data to locate a user and deliver the information to a smartphone app. The device also enables two-way voice communication and calling functionality.

Product link: <http://www.polyone.com>

Source: PolyOne Enables the Next Generation Wearable Phone & Locator for Kids by Filip Technologies <http://www.marketwatch.com/story/polyone-enables-the-next-generation-wearable-phone-locator-for-kids-by-filip-technologies-2015-08-03>



6.0 EXOSKELETONS

6.1.1 Chinese Academy of Science Advanced Manufacturing Technology

Technology name: Exoskeleton

Description: This flexible, controllable, robotic exoskeleton can assist a user's climbing and fighting ability while bearing up to a 30-kg load. The device features a series of sensors that recognize and respond to a user's neuromuscular signals with the appropriate action.

Source: China's exoskeleton can help climb mountains with heavy weight http://www.business-standard.com/article/pti-stories/china-s-exoskeleton-can-help-climb-mountains-with-heavy-weight-115082401244_1.html

6.1.2 Defense Science and Technology Organization

Technology name: Operations Exoskeleton (formerly NoREx)

Description: The Operations Exoskeleton uses a “minimalist approach” to reduce physical strain, and possibly fatigue and injury, by bearing more than 60% or 50 kg of a user's load using a system of flexible cables and passively transferring part of the carried weight to the ground. Cables to attach to a rigid backpack frame, run down the back/legs to the boot, and transfer approximately two thirds of the backpack load to the ground. The device is does not require a power source and weighs approximately 3 kg.

Press link: <http://www.dsto.defence.gov.au/news/2015/07/31/flexible-skeleton-takes-weight>

Source: This Is The Australian Defence Force's Take On Exoskeleton Technology <http://www.gizmodo.com.au/2015/08/this-is-the-australian-defence-forces-take-on-exoskeleton-technology/>



Photo source: <http://www.gizmodo.com.au/2015/08/this-is-the-australian-defence-forces-take-on-exoskeleton-technology/>



6.1.3 Hyundai Motor Group's Central Advanced Research and Engineering Institute

Technology name: Life-Caring Exoskeleton

Description: The Life-Caring Exoskeleton features robotic controllers and a system-on-module circuit board with an aluminum case that is lightweight but rugged. The device uses NI's LabVIEW software and RIO hardware to offer a number of sensors and actuators assigned to perform complex tasks, using a series of control algorithms that work in real time to respond to user's movement and provides mobility assistance with the optimal amount of power. The software is described as being quicker to use and intuitive. The device also features a lithium-ion battery in a compact backpack and the entire system weighs less than 10 kg.

Product Link: <http://sine.ni.com/cs/app/doc/p/id/cs-16749>

Source: Hyundai Demos Robotic Exoskeleton at NIWeek 2015

http://www.designnews.com/author.asp?section_id=1386&doc_id=278446&dfpPParams=ind_182,industry_consumer,industry_medical,kw_robotics,kw_motors,kw_2,aid_278446&dfpLayout=blog



Photo source: <http://sine.ni.com/cs/app/doc/p/id/cs-16749>

7.0 OTHER

7.1.1 ActiveProtective

Technology name: Wearable air bag

Description: Developers are creating a wearable air bag that is worn in a belt over a user's clothing, with clip-together ends equipped with motion sensors that deploy the airbag in the event of a fall. Designed for hip protection, the device will protect the user's side and rear, deploying a 2-inch-thick air cushion within 60 milliseconds.

Product link: <http://www.activeprotect.co/>

Source: Allentown company invents air bags for your hips <http://www.mcall.com/news/local/mc-hip-air-bag-20150802-story.html>



Photo source: <http://www.seniorvoicealaska.com/story/2015/02/01/health/gelpad-armor-and-airbags-you-can-wear/670.html>

7.1.2 Massachusetts Institute of Technology

Technology name: HERMES robot

Description: A user wears an exoskeleton suit and LCD goggles to control the robot with dexterity and balance. The robot provides force feedback to the human controller, allowing the user to feel what the robot feels and respond accordingly; additionally, the goggles let the user see what the robot sees. The device can help in emergency situations offering increased dexterity and balance and allowing responders to operate a robot in places where a human may not access. The robot is completely depended on the human for operation.

Product link: <http://news.mit.edu/2015/bipedal-robot-with-human-reflexes-0811>

Source: MIT researchers create robot controlled by exoskeleton wearing human <http://www.slashgear.com/mit-researchers-create-robot-controlled-by-exoskeleton-wearing-human-10396197/>

7.1.3 Max Planck Institute, Saarland University

Technology name: iSkin

Description: iSkin is a touch-sensitive silicon rubber that allows a user to control a smartphone from a body part without having to look at their phone. The material affixes to the skin with medical-grade adhesive. The stretchable, bendable material is “0.3 and 0.7 mm thick and supports both taps and firm presses, as well as multiple presses in different locations at once. In testing, iSkin was found to be 92% accurate for taps and over 98% accurate for firm presses.” Example applications include a user tapping their arm to answer a call. It is proposed that future functionality may include energy-harvesting capabilities.

Product link: <https://embodied.mpi-inf.mpg.de/research/iskin/>

Source: Wearable iSkin silicone controls your smartphone with a tap of your arm
<http://www.ibtimes.co.uk/wearable-iskin-silicone-controls-your-smartphone-tap-your-arm-1514961>



Photo source: <https://embodied.mpi-inf.mpg.de/research/iskin/>

7.1.4 Microsoft

Technology name: Wearable with skin-simulating interface

Description: Microsoft was reportedly awarded a patent for a wearable interface that will electrically stimulate the skin to alert the user to e-mails, text messages, and other notifications. Patent documentation suggests the sensor can be sewn into clothing such as a shoe or t-shirt and that it may also notify the user of a physical change in posture, performance, etc.

Patent link: <http://www.freepatentsonline.com/y2015/0235529.html>

Source: Microsoft has a weird idea for clothes that shock you when you get an email
<http://www.businessinsider.com/microsoft-wearable-computer-clothes-patent-2015-8>

7.1.5 MSA (Australia)

Technology name: Gallet F1 XF structural fire helmets

Description: Designed for firefighters, the helmets feature a full-face visor, proximity lights (instead of beam lights), built-in radio technology, and greater protection from heat and falling debris. The helmets work in conjunction with a breathing apparatus, with a speaker and microphone nearer the user's ear and mouth, respectively, for improved communication.

Source: **Firefighters ahead of the pack with new helmets**

<http://www.dailyliberal.com.au/story/3265057/firefighters-ahead-of-the-pack-with-new-helmets/>

7.1.6 NeuroMetrix

Technology name: Quell

Description: Quell is a lightweight, wearable pain relief device that uses non-invasive neurostimulation to relieve pain. The device can communicate to smart devices using the Quell Relief app to monitor and control their pain therapy. The device is FDA-cleared, available over the counter, and wearable during activity or rest.

Product link: <https://www.quellrelief.com/>

Source: **NeuroMetrix Reports Expanding Media Exposure for Quell™ Wearable Pain Relief Technology** <http://www.businesswire.com/news/home/20150803006056/en/NeuroMetrix-Reports-Expanding-Media-Exposure-Quell%E2%84%A2-Wearable#.Vc-DnixViko>



Photo source: <https://www.quellrelief.com/>

7.1.7 Zonda, Astec

Technology name: Self-heating gloves and insoles

Description: These battery-free, lightweight, self-heating gloves and insoles use heat-reflecting technology to maintain body temperature—polymer metal-coated fibers circulate heat round a user's hand or foot. The device can be controlled via smart phones, features a grip finish, and can be cut to fit any

Other

shoe size. The gloves feature touchscreen pads allowing a user to interact with their mobile device. The fleece in the gloves reflects radiation from the body that is then used to control body temperature.

Product link: https://www.kickstarter.com/projects/1503544150/world-s-first-natural-heat-generating-gloves-and-i?ref=category_location

Source: Fashion Tech We Like – Battery Free, Self Heating Gloves and Insoles

<https://wtvox.com/3d-printing-in-wearable-tech/fashiontech-we-like-battery-free-self-heating-gloves-and-insoles/>



Photo source: <https://www.kickstarter.com/projects/1503544150/world-s-first-natural-heat-generating-gloves-and-i/description>

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
Sensor		
Physiological		
Cambridge Design Partnership	First Response Monitor	Biometric device that clips to a user's nose, monitors vital signs (including pulse rate and respiration), and transmits data in real-time via Bluetooth to a smart device that will display the data and trend graphs of the measurements.
EFD Sports	StrikeTec	Sensors measure a wearer's punches, recording speed, type, and force, as well as fatigue, endurance, and calories burned. The data is monitored real-time and synced to a cloud server.
Google, Dexcom	Glucose monitoring device	Disposable, wearable glucose monitoring device that will be connected to cloud storage and provide real-time information.
King Abdullah University of Science and Technology	Wearable pressure sensor	Highly sensitive and affordable sensor that detects minute blood pressure changes. The device detects throat muscle movements to recognize deviations in human voices and track movements for different words.
Laboratory of Movement Analysis and Measurement, Ecole Polytechnique Fédérale de Lausanne	Wearable barometric pressure sensor	Barometric pressure and inertial sensor data integrated to improve activity tracking and mobility monitoring by incorporating corresponding body elevation.
Misfit, Speedo	Speedo Shine	Speedo featuring the Misfit Shine activity tracker. The device is waterproof up to 50 meters, can sync with an Android or iOS device via Bluetooth, and offers a 6-month battery life with a coin-cell battery that does not require regular charging.
Multisensor Diagnostics, Johns Hopkins	MouthLab	Battery-powered wearable device that connects to a patient's lip or fingertip to track vital signs. The device can conduct an electrocardiogram and transmit results via Wi-Fi.
North Carolina State University Nanosystems Engineering Research Center for Advanced Self-Powered Systems of Integrated Sensors and Technologies	Smart medical sensors	Wearable sensors powered by a user's body heat and capable of monitoring a patient's breathing; transmitting the data to a smart device where algorithms evaluate time, pitch, and magnitude/volume to interpret if a user is having difficulties; and sending notifications to the user.
Nymi, TD Bank Group, MasterCard	Wearable credit card payment	Contactless, biometric authentication that recognizes users by their heartbeat and uses near-field communication capabilities to complete transactions.
Toshiba	Silmees W20 and W21 wearable monitors	Wearable monitors with sensors to measure skin temperature, pulse, ultraviolet light, and movement. The device offers Bluetooth connectivity, two-week battery life, emergency button, and GPS.
University of Waterloo Advanced Aging Research Centre, Pervasive Dynamics	Rehabilitation sensor	Body-worn sensors attach to the user's legs, chest, and wrists and provide detailed information on heart rates, speed and direction of limbs, stress, and breathing
Other		
Flexible Hybrid Electronic Institute	Flexible sensors	Printing technologies to create stretchable electronics with embedded sensors to be worn by soldiers and used on ships or warplanes to monitor structural integrity.

Technology summary

Ollinfit	Wearable sensors	Wearable sensors and app that act as a personal trainer, providing feedback on a user's activities, monitoring form, and providing live audio and vibration feedback.
Displays		
Body-Worn		
AU Optronics Corp. (AUO)	AMOLED display	AMOLED displays and transfective LCD technologies used to create thin, lightweight, low-power consumption displays fit for wearable devices. The technology is approximately 1.5-16 inches square and 0.45 millimeter thick, with a 1.3-inch transfective LTPS display with Memory-in-Pixel technology.
Korea Advanced Institute of Science and Technology	Bendable display	Bendable, fiber-like display that can be woven into fabric.
National Chiao Tung University	White LEDs for wearable/flexible displays	Flexible, white LEDs for use in wearable and curved or flexible displays.
Polyera	Wove wristband	Wristband features Polyera's flexible, thin-film transistors in a wearable that can show a range of data (email previews, news headlines, weather forecasts, etc.) and features a touch-screen interface.
Power		
Chargers		
Joe's Jeans	#Hello smart fabric	Denim with a back pocket fit to charge smartphones (iPhone 5, 5S, or 6) and a waistband with a portable battery pack and USB cord. The battery pack reportedly charges the devices to limited capacities (70-85 percent) and must be removed before washing.
Communications		
Hands-Free		
Gadia Power	Gadia Power	Bio-sensing technology in a small (1-inch), lightweight, durable micro device that allows the user to control smart devices using hand gestures. The device tracks electrical activity in a user's muscles and recognizes six distinct hand gestures.
QuickLogic	Programmable, logic-based system-on-chip voice interface	A sensor interface that supports hardware flexibility and always-on voice processing applications for wearables and other Internet of Things devices. The voice trigger functionality offers voice recognition of up to 20 phrase commands, reduced current consumption and ultra-low power sound detector, and reduced need for cloud support.
University of Texas	Wearable American Sign Language Recognition system	Gesture-recognition wearables to recognize American Sign Language words. The system comprises a wrist-mounted device to measure hand motion and a rest-mounted device to measure muscle activity. The information is sent wirelessly to a computer for translation into text or speech.
Location Tracking		
Corrisoft	Alternative to Incarceration (AIR)	Bluetooth- and GPS-equipped ankle bracelet that tethers to a smartphone and offers 4G capabilities for improved speed, accuracy, and volume of information. The device offers real-time GPS tracking of the user that is displayed on a map, two-way real-time communication, and smartphone camera capabilities for virtual searches.
PolyOne Corporation, Filip Technologies	FILIP™ 2	Wearable phone and user locator that combines cell tower location, Wi-Fi triangulation, and GPS data to locate a user and deliver the information to a smartphone app. The device also enables two-way voice communication and calling functionality.

Technology summary

Exoskeletons		
Chinese Academy of Science Advanced Manufacturing Technology	Exoskeleton	Flexible, controllable, robotic exoskeleton can assist a user's climbing and fighting ability while bearing up to a 30-kg load. The device features sensors that recognize and respond to a user's neuromuscular signals.
Defense Science and Technology Organization	Operations Exoskeleton	Bears more than 60 percent or 50 kg of a user's load using a system of flexible cables and passively transferring part of the carried weight to the ground. Cables attach to a rigid backpack frame, run down the back and legs to the base of the boot, and transfer approximately two thirds of the backpack load to the ground.
Hyundai Motor Group's Central Advanced Research and Engineering Institute	Life-Caring Exoskeleton	Exoskeleton with robotic controllers and a system-on-module circuit board with an aluminum case that is lightweight but rugged. The device uses NI's LabVIEW software and RIO hardware to offer a number of sensors and actuators assigned to perform complex tasks. The software is described as being quicker to use and intuitive. The device also features a lithium-ion battery in a compact backpack.
Other		
ActiveProtective	Wearable air bag	Wearable air bag worn in a belt over a user's clothing, with clip-together ends equipped with motion sensors that activate in the event of a fall. The device will protect the user's side and rear, deploying a 2-inch-thick air cushion within 60 milliseconds.
Massachusetts Institute of Technology	HERMES robot	A user wears an exoskeleton suit and LCD goggles to control the robot with dexterity and balance. The robot provides force feedback to the human controller, allowing the user to feel what the robot feels and respond accordingly; additionally, the goggles let the user see what the robot sees.
Max Planck Institute, Saarland University	iSkin	Touch-sensitive silicon rubber that allows a user to control a smartphone from a body part without having to look at their phone
Microsoft	Wearable with skin-simulating interface	Wearable computer that stimulates the skin to alert the user to e-mails, text messages, and other notifications; can be sewn into clothing such as a shoe or t-shirt; and can notify the user of a physical change in posture, performance, etc.
MSA (Australia)	Gallet F1 XF structural fire helmets	Helmets with proximity lights, built-in radio technology, and greater protection from heat and falling debris. The helmets work in conjunction with a breathing apparatus, with a speaker and microphone nearer the user for improved communication.
NeuroMetrix	Quell	Lightweight, wearable pain relief device that uses non-invasive neurostimulation to relieve pain. The device can communicate to smart devices using the Quell Relief app to monitor and control their pain therapy.
Zonda, Astec	Self-heating gloves and insoles	Battery-free, lightweight, self-heating gloves and insoles use heat-reflecting technology to maintain body temperature—polymer metal-coated fibers circulates heat round a user's hand or foot. The device can be controlled via smart phones, features a grip finish, and can be cut to fit any shoe size.



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