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Responder Technology Alert (May 2015)

June 2015

JF Upton
SL Stein



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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1.0 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
- Integrated Communications – Voice and data communications systems utilizing Bluetooth, wireless, hands-free, ergonomically optimized systems, noise-filtering digital speakers or microphones, etc.
- 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
- General – 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.

A spreadsheet summarizing these technologies is available in Appendix A. For an electronic copy, contact Jaki Upton at jaki.upton@pnnl.gov

2.0 Sensors

2.1 Physiological

2.1.1 Atlas Wearables

Technology name: Atlas Wristband activity tracker

Description: The Atlas Wristband uses machine learning and analytics to track more than 50 activities and relevant metrics (reps, calories, heart rate, etc.). The device allows users to log workouts, analyze data, and suggest new exercise routines. The device is waterproof to 50m and uses Bluetooth to share data with a smart device.

Status: Evolving – available for preorder

Funding: In-Q-Tel

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

Source: In-Q-Tel Strategically Invests in Atlas Wearables Technology
<http://www.virtual-strategy.com/2015/05/18/q-tel-stragecially-invests-atlas-wearables-technology#axzz3aoEd4YUf>

2.1.2 California State University, iRythm

Technology name: iRythm ECG monitor

Description: Researchers are pursuing a wearable ECG monitor patch that is small (5cm), waterproof, and comprising a system-on-chip, sensor, microprocessor, and Bluetooth connectivity. The device is intended to be able to be worn for longer periods of time than typical ECG monitors.

Status: Evolving

Funding:

Product link:

Source: Skin-Like Wearable Device Monitors Heart Health
<http://www.emdt.co.uk/daily-buzz/skin-wearable-device-monitors-heart-health>

2.1.3 Cambridge Cognition

Technology name: Cognitive testing

Description: Cambridge Cognition filed a patent for technology to assess cognitive function and neurological conditions. Cambridge Cognition is exploring the use of physiological health data from wearables to trigger cognitive tests for users to establish a record of and better understand a user's mental

function. Such information, Cambridge Cognition suggests, could shed light on conditions such as Alzheimer's, depression, stress, anxiety, etc.

Status: Evolving

Funding:

Product link:

Source: Wearable cognitive assessment devices a step closer as Cambridge Cognition file new patents
<http://www.news-medical.net/news/20150507/Wearable-cognitive-assessment-devices-a-step-closer-as-Cambridge-Cognition-file-new-patents.aspx>

2.1.4 Chinese Academy of Sciences

Technology name: E-skin physiological sensor

Description: This research explores e-skin the uses flexible electronics and nanotechnology in a thin film of carbon nanotubes and graphide oxide that can be worn close to the skin. The sensors monitor and transmit a user's blood pressure, pulse, etc., to provide real-time diagnostics.

Status: Evolving

Funding:

Research link:

Source: Card-sized diagnostics, e-skin are future of wearable medicine
<http://www.computerworld.com/article/2922118/healthcare-it/health-sensing-e-skin-card-sized-diagnostics-are-future-of-wearable-medicine.html>



Photo source: http://english.sinano.cas.cn/rh/rp/201412/t20141229_133731.html

2.1.5 Colorado University Boulder

Technology name: Skin temperature sensor

Description: Students are developing a wearable that measures skin temperature and allows a user to indicate their comfort, with a goal that the device could eventually recognize a user's thermal state and automatically adjust the heating/cooling. For example, a user swipes left or right to indicate if it is too hot or too cold. The current prototype comprises a skin temperature sensing platform and the data acquisition module.

Status: Evolving

Funding:

Product link:

Source: Wearable Skin Temperature Logger

<http://www.instructables.com/id/Wearable-Skin-Temperature-Logger/>



Photo source: <http://www.instructables.com/file/FW11IEJ9I98BKUXZ>

2.1.6 Echo Labs

Technology name: Blood-monitoring wristband

Description: Echo Lab's health-monitoring wristband uses optical signals to measure oxygen, CO₂, pH, hydration, and blood pressure. Various industries have inquired about the device for its ability to monitor blood composition. The device shines electromagnetic waves into the skin and uses a proprietary algorithm to measure the reflection of the waves and measure molecules in the blood, given that different molecules will have different wave frequencies. Echo Labs suggests their algorithm can measure blood composition of a user that is in motion or at rest.

Status: Evolving

Funding:

Product link: <https://angel.co/echo-labs>

Source: This Wearable Prototype Can See Through Skin To Scan Your Blood
<http://www.forbes.com/sites/parmyolson/2015/05/27/wearable-tech-blood-monitoring-echo-labs-standford/>

2.1.7 Ecole Polytechnique Federale de Lausanne (EPFL)

Technology name: Sweat nanosensor

Description: This sensor in an adhesive electronic stamp, with microscopic transistors, attaches to the skin to analyze sweat (ions, protons, pH, proteins, calcium, sodium, potassium, etc.) and measure hydration, stress, or fatigue.

Status: Evolving

Funding: Funded by the Swiss national program Nano-Tera within the project “NanowireSensor.”

Research link: <http://pubs.acs.org/doi/abs/10.1021/nn5064216>

Source: Soon, wearable device that assesses your health via sweat
http://www.business-standard.com/article/pti-stories/soon-wearable-device-that-assesses-your-health-via-sweat-115051801150_1.html

2.1.8 Fujitsu: FEELytm

Technology name: Feelythm

Description: Designed for drivers, Feelythm comprises an ear-worn and neck-worn wearable pulse sensor and mountable receiver for inside the vehicle. The wearable uses a Fujitsu Laboratories algorithm to assess the user’s pulse and gauge drowsiness, sending an alert to the neck device, which vibrates and makes noise to alert the driver. The data is stored in the cloud and also transmitted to the driver’s command center. The device features a 5-day battery life. Fujitsu also developed a band that collects a user’s vitals (pulse rate, temperature, location, humidity) and uses algorithms to interpret the data to monitor stress, fatigue, and even falls or accidents. Developers propose the module could help users recognize signs of heat stroke, hypothermia, and other conditions.

Status: Evolving

Funding:

Product link: <http://www.fujitsu.com/global/about/businesspolicy/business/ubiquitous/>

Source: Fujitsu’s new wearables might not be sexy, but they could save your life
<https://www.techinasia.com/fujitsu-enterprise-wearable-tech/>



Photo source: <https://www.techinasia.com/fujitsu-enterprise-wearable-tech/>

2.1.9 Fujitsu: Ubiquitous

Technology name: Ubiquitousware vital-sensing band

Description: Fujitsu developed a band that collects a user's vital signs (pulse rate, temperature, location, humidity) and uses algorithms to interpret the data to monitor stress, fatigue, and even falls or accidents. Developers propose the module could help users recognize signs of heat stroke, hypothermia, and other conditions.

Status: Evolving – scheduled for debut in December

Funding:

Product link: <http://www.fujitsu.com/global/about/businesspolicy/business/ubiquitous/>

Source: Fujitsu's new wearables might not be sexy, but they could save your life
<https://www.techinasia.com/fujitsu-enterprise-wearable-tech/>

2.1.10 MC10, University of Rochester: BioStamp

Technology name: BioStamp

Description: Researchers are collaborating to combine physiological sensing and pattern recognition algorithms with clinical expertise and big data analytics for possible healthcare applications. The goal is to identify how biometric data from physiological sensors can inform disease-specific algorithms and predictive health analytics. The work utilizes MC10's BioStamp biometric sensing device, software, cloud storage, and computing platform. As one potential application, researchers propose the work can benefit monitoring the progression of neurological conditions and impact of subsequent therapies.

Status: Evolving

Funding:

Product link:

Source: Rochester Researchers to Test MC10's Biostamp Wearable Biometric Sensing Sticker
<http://www.azosensors.com/news.aspx?newsID=9648>

2.1.11 McLaren Applied Technologies

Technology name: Wearable to reduce jet lag

Description: The proposed device would analyze vital signs over time then analyze that data to predict the best time for the user to travel.

Status: Evolving

Funding:

Product link:

Source: McLaren wearable gadget to end jet lag
<http://www.itproportal.com/2015/05/15/mclaren-wearable-gadget-to-end-jet-lag/>

2.1.12 Osram Opto Semiconductors: SFH 7051 BioMon Sensor

Technology name: SFH 7051 BioMon Sensor

Description: Osram Opto's energy-efficiency, green LED optical sensors products measure heart rate by shining light on the skin and measuring the volume of blood passing through by amount the light absorbed by blood and the surrounding tissue. The device features energy-efficient green emitter chips that result in extended battery life. The device is the next in Osram Opto's line of health-monitoring technologies.

Status: Available

Funding:

Product link: http://www.osram-os.com/osram_os/en/products/product-catalog/infrared-emitters%2c-detectors-and-sensors/optical-sensors/health-monitoring-sensors/sfh-7051/index.jsp

Source: Osram Opto Vying Wearable Device Market with New Green LEDs for Heart Rate Monitoring.
http://www.ledinside.com/news/2015/5/osram_opto_vying_wearable_device_market_with_new_green_leds_for_heart_monitoring



Photo source: 1 <http://www.osram-os.com/>

2.1.13 Pursuit Enterprises

Technology name: Sleep technology

Description: Targeted at pilots and train or truck operators, the device alerts users who become drowsy while driving or working. It may also have applications for users with sleep-related disorders. The device uses miniature sensors near the user's eye and delivers alerts to an earbud-type device in the ear. The device also sends alerts to other users, such as a command center.

Status: Evolving

Funding:

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

Source: Newly patented device intends to solve sleep deprivation crises using wearable sensor technology <http://www.prweb.com/releases/2015/05/prweb12721526.htm>

2.1.14 Snowcookie

Technology name: Snowcookie skin sensor

Description: Designed for skiers, Snowcookie monitors a user's body position, fatigue, muscle reaction, and movement, then alerting the user to trends in performance and making recommendations for a break. The device can also detect falls and call for help. The device uses artificial intelligence to wirelessly aggregate the user's data with others and make recommendations, such as for a specific trail matched to the user's skill level.

Status: Evolving

Funding:

Product link: <http://snowcookie.eu/>

Source: Snowcookie is a wearable device which makes you a better, safer and connected skier <http://icrowdnewswire.com/2015/05/24/snowcookie-is-a-wearable-device-which-makes-you-a-better-safer-and-connected-skier/>

2.1.15 toSense: CovVa™ Monitoring System

Technology name: CoVa Monitoring System

Description: toSense is a remote heart-monitoring device designed to detect issues up to two weeks earlier than existing techniques. The device tracks a user's heart rate, fluid buildup, respiration, stroke volume, cardiac output and other data and transmits the data to the cloud, where it will be available to doctors.

Status: Evolving

Funding: \$3 million in funding from an investor

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

Source: ToSense receives clearance for heart monitoring necklace
<http://www.utsandiego.com/news/2015/may/27/evoNexus-perminova-eric-topol-scripps-health/>



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

2.1.16 University of British Columbia: Reveal

Technology name: Reveal

Description: Reveal's embedded sensors measure indicators of anxiety, including sweat, heart rate, and skin temperature, and transmit the data to a smart phone, with a goal to identify meltdowns before they happen.

Status: Evolving

Funding:

Product link: <http://awakelabs.com/reveal/>

Source: UBC students develop wearable device that monitors anxiety in autistic children
<http://news.ubc.ca/2015/05/19/ubc-students-develop-wearable-device-that-monitors-anxiety-in-autistic-children/>

2.1.17 University of California San Diego

Technology name: Biomedical sensor

Description: Researchers are developing "a seamless, compact and non-intrusive, high-sampling-speed biomedical sensor for health monitoring." The "smart skin" device comprises thin, multi-model electronic sheets with readout circuitry on flexible substrates that affix to the skin and record, process, and transmit electrophysiological data.

Status: Evolving, patent pending

Funding:

Product link:

Source: Monolithic Integration of Ultra-Scaled High Performance Pin-Size Wearable Electronics
<http://techtransfer.universityofcalifornia.edu/NCD/25044.html>

2.1.18 University of Strathclyde

Technology name: Skin-worn hydration monitoring sensors

Description: The University of Strathclyde is developing a transdermal sensor to analyze electrolytes in sweat and provide real-time analysis of fluid loss during exercise. The device uses Bluetooth to send data to a smart device, which provides hydration information to the user, allowing them to analyze their performance. The device focuses on hydration as a key element of physical performance that, when lacking, can lead to fatigue, dizziness, and more.

Status: Evolving

Funding:

Product link:

Source: Performance-enhancing wearable hydration sensor provides immediate feedback
<http://www.rdmag.com/news/2015/05/performance-enhancing-wearable-hydration-sensor-provides-immediate-feedback>

2.1.19 WellBe

Technology name: WellBe stress bracelet

Description: WellBe monitors a user's heart rate and uses a patent-pending algorithm to alert a user when they are getting stressed. Compared to other heart-rate monitors, WellBe ties heart rate to stress levels to help a user recognize and avoid stressful situations, and it is also made from cork to be lightweight and comfortable.

Status: Evolving

Funding: Crowdfunding – surpassed \$100,000 target

Product link: <https://www.indiegogo.com/projects/the-wellbe#/story>

Source: Finally! A wearable that tells you when someone is too annoying to be around
<http://www.cnet.com/news/finally-a-wearable-that-tells-you-when-someone-is-too-annoying-to-be-around/>

2.1.20 Yu: HealthYu

Technology name: HealthYu

Description: HealthYu fits on a smartphone and gathers and transmits health-related data (heart rate, respiration rate, blood pressure, body temperatures, ECG).

Status: Soon to be released

Funding:

Product link: <http://www.yuplaygod.com/accessories/healthyu/>

Source: Yu has another wearable HealthYu which delivers all your vital health info on your smartphone <http://www.in.techradar.com/news/portable-devices/other-devices/Yu-has-another-wearable-HealthYu-which-delivers-all-yourvital-health-info-on-your-smartphone/articleshow/47249379.cms>



Photo source: <http://www.yuplaygod.com/accessories/healthyu/>

2.2 Other

2.2.1 Aroma Technology: NEXTToMe

Technology name: NEXTToMe

Description: NEXTToMe features sensors that detect carbon monoxide, temperature, blood alcohol content, UV rays, humidity, air pressure, altitude, and more. The information is transmitted to the NEXTToME app and shared with other users. The device is intended to create a network of data to provide users insight into their environmental conditions. The device offers a month-long battery life, is lightweight (26g), and small (1.8x0.35in). It can be mounted to a variety of surfaces.

Status: Evolving

Funding: Crowdfunding

Product link: <http://www.aroma-technology.com/>

Source: NEXTToMe Wearable Device Detects Multiple Environmental Factors to Keep You Healthy

<http://www.prnewswire.com/news-releases/nexttome-wearable-device-detects-multiple-environmental-factors-to-keep-you-healthy-300080588.html>



Photo source: <http://www.aroma-technology.com/#>

2.2.2 King Abdullah University of Science and Technology (KAUST)

Technology name: Nanoscale fin-shaped transistors

Description: Researchers are developing flexible, fin-shaped, metal-oxide-semiconductor transistors that can be placed on a variety of surfaces. The devices retain their electrical properties even when bending. The technology allows for implantable or embedded sensors, anticipated to be optimal for differently shaped devices and wearables in a range of materials and configurations.

Status: Evolving

Funding:

Product link:

Source: Wearable, implantable sensors possible with flexible transistors
<http://www.natureasia.com/en/nmiddleeast/article/10.1038/nmiddleeast.2015.92>

2.2.3 REFLX: Boogio Bionic Foot Sensor

Technology name: Boogio Bionic Foot Sensor

Description: This thin “smart shoe” sensor is placed in a shoe and tracks a user’s movement, gravitation force, inner balance, and more, and analyzes the data to help better understand a user’s movement. The sensors can indicate the user’s foot pressure, balance, and movement.

Status: Evolving

Funding:

Product link: <https://boogio.com/>

Source: Florida Hospital explores new Boogio technology
<http://www.orlandosentinel.com/news/os-florida-hospital-explores-new-boogio-technology-20150518-story.html>

2.2.4 Sungkyunkwan University

Technology name: Facial expression sensor

Description: This sensor, comprising a carbon nanotube film on electrically conductive elastomers, analyzes human expressions (smiling, frowning, brow-raising, etc.) and eye movement of persons wearing the sensor. Researchers suggest the device detects small strains on human skin, which are often the result of emotion.

Status: Evolving

Funding: Supported by the Basic Science Research Program (2013R1A2A1A01015232) through the National Research Foundation (NRF), funded by the Ministry of Science, ICT, & Future Planning.

Research link: <http://pubs.acs.org/doi/abs/10.1021/acsnano.5b01613>

Source: Robots can read your face now, but via wearable device
<http://www.microfinancemonitor.com/2015/05/01/sensors-robots-read-human-expressions-korean-researchers-interactive/>

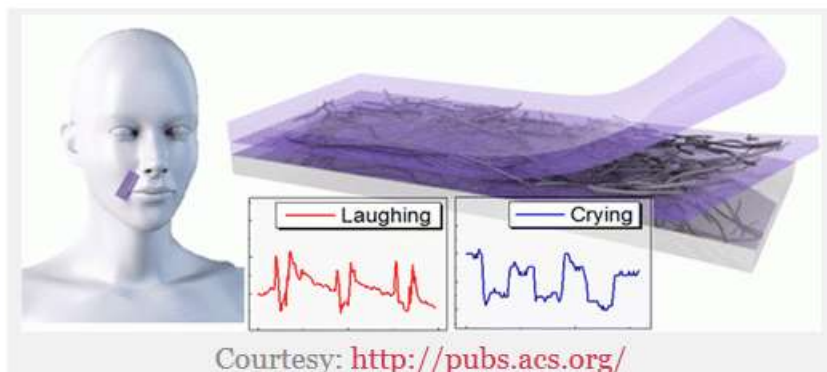


Photo source: <http://pubs.acs.org/doi/abs/10.1021/acsnano.5b01613>

2.2.5 X-labz

Technology name: UV badge

Description: The UV badge measures UV index, temperature, humidity, and air pressure every 2 seconds, collecting data over time to help users avoid sunburn, predict weather, and control or better understand their environment. The device comprises an ATtiny861A processor, LCD screen, sensors, and coin-cell battery with a month-long life.

Status: Available

Funding:

Product link: <https://hackaday.io/project/4706-uv-badge>

Source: Building a wearable UV index and weather sensor with tinyAVR
<http://blog.atmel.com/2015/05/27/building-a-wearable-uv-index-and-weather-sensor-with-tinyavr/>

Meanwhile, the electronics are all neatly housed inside a 3D-printed case. A plexi cover was laser-cut and attached to a simple, white adhesive plastic mask. In his next iteration, the case will be shrunk down a bit, while the touch button will be replaced by a mechanical tactile button to conserve energy.

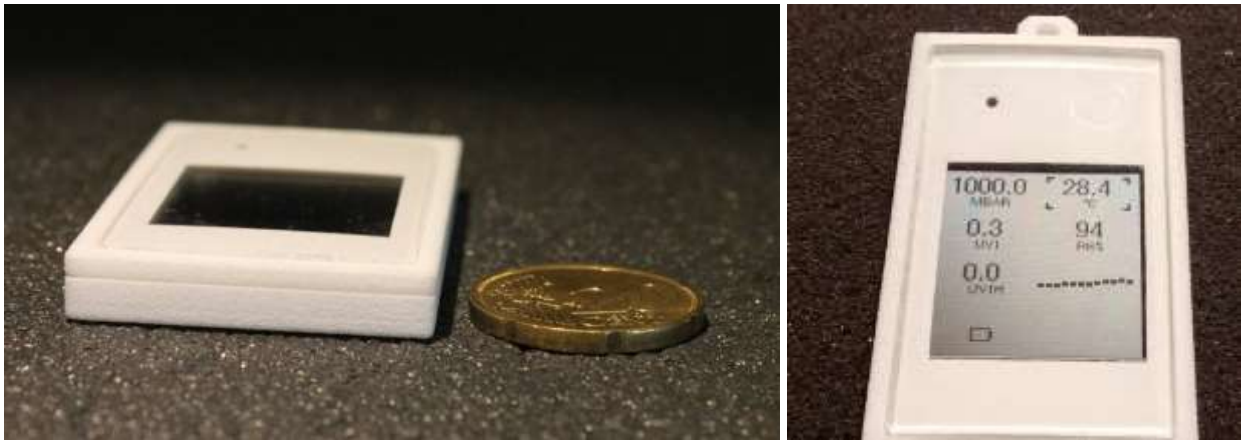


Photo source: <https://hackaday.io/project/4706-uv-badg>

3.0 Displays

3.1 Heads-up (on face or head)

3.1.1 Allwinner

Technology name: Smart glasses

Description: Competitor of Google Glass, Allwinner's smart glasses offer similar capabilities but for only \$199. The device features Allwinner's A33 system-on-chip, Bluetooth, wi-fi, and voice control, and pairs with a smartphone.

Status: Evolving

Funding:

Product link:

Source: Here Is The \$199 Wearable That Will Compete With Google Glass
<http://wccftech.com/199-wearable-compete-google-glass/>

3.1.2 Fujitsu: Ubiquitousware

Technology name: Ubiquitousware head-mounted display

Description: Fujitsu's new head-mounted display comprises a small display, camera, two microphones, and sensors. The camera can transmit the user's field of vision to a remote user. The rugged device features a 4-hour battery life and can withstand a 1.5m fall. The user can operate the device with an arm-mounted keyboard and voice controls.

Status: Available

Funding:

Product link: <http://www.fujitsu.com/global/about/businesspolicy/business/ubiquitous/>

Source: Fujitsu's new wearables might not be sexy, but they could save your life
<https://www.techinasia.com/fujitsu-enterprise-wearable-tech/>



Photo source: <https://www.techinasia.com/fujitsu-enterprise-wearable-tech/>

3.1.3 Google

Technology name: Curved display

Description: Google's recent patents suggest the next generation of Google Glass may feature a curved display that will help users perceive depth. The device would also be controlled using a touch interface. The display is suggested to have benefits for users determining the depth of field for whatever they are viewing.

Status: Evolving

Funding:

Product link: [Patent link](#)

Source: A new Google patent hints at a curved display for the next generation of Glass
<http://qz.com/398329/a-new-google-patent-hints-at-a-curved-display-for-the-next-generation-of-glass/>

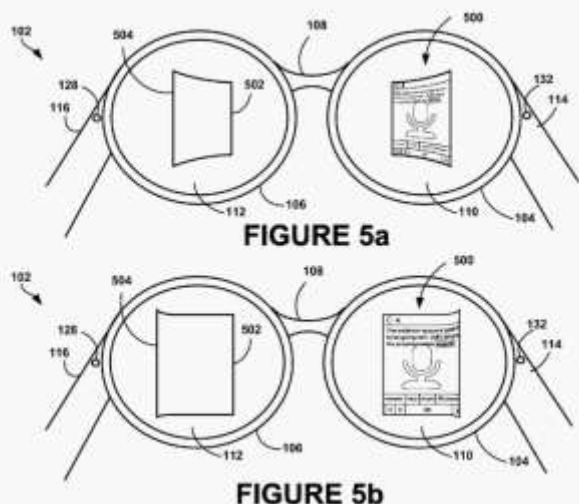


Photo source: <http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&u=%2Fnetacgi%2FPTO%2Fsearch-adv.htm&r=51&f=G&l=50&d=PTXT&s1=google.ASNM.&p=2&OS=AN/google&RS=AN/google>

3.1.4 Trimble Partners, Microsoft

Technology name: Microsoft HoloLens and Trimble Connect, SketchUp, and V10 Imaging Rover

Description: Trimble Partners and Microsoft are integrating HoloLens head-mounted holographic display with Windows 10 with Trimble's platforms to benefit architecture, engineering, and construction. The device will allow users to interact with 3D models and offers new opportunities for collaboration and sharing of information in a visual environment. In a recent demonstration at Microsoft's Build Developer Conference, architects were able to interact with and manipulate their digital building sketches and share designs with remote collaborators. The partners' work is using Trimble's Connect (collaborative environment), SketchUp (3D modeling platform) and Imaging Rover (integrated camera system).

Status: Evolving

Funding:

Product link:

Source: Trimble Partners with Microsoft to bring Microsoft HoloLens wearable holographic technology to the AEC industry

<http://www.healthcarefacilities.today.com/posts/Trimble-Partners-with-Microsoft-to-bring-Microsoft-HoloLens-wearable-holographic-technology-to-the-AEC-industry-Press-Releases--9086>

3.1.5 Vision Technologies

Technology name: Smart glasses

Description: Vision Technologies is developing software and created GiveVision.net to power smart glasses for visually impaired users. The software works on any wearable device.

Status: Evolving

Funding: Seeking investors

Product link: <http://www.givevision.net/>

Source: Funding to drive growth at wearable tech firm
<http://www.insidermedia.com/insider/midlands/139982-funding-drive-growth-wearable-tech-firm/>

3.2 Body worn (wrist, arm, or chest)

3.2.1 FlexEnable: Demonstrator

Technology name: Demonstrator flexible screen technology

Description: FlexEnable, specialized in flexible electronics, announced plans to create a Wearable Technology Lab. FlexEnable also recently demonstrated its transistor screen technology that offers an electroluminescent display fit for the sleeve of an outdoor jacket.

Status: Evolving

Funding:

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

Source: FlexEnable launches wearable technology lab
<https://www.plusplasticelectronics.com/wearables/flexenable-launches-wearable-technology-lab>



*A FlexEnable wearable screen demonstrator has been designed for the outdoor apparel market –
Source: FlexEnable*

3.2.2 Lenovo

Technology name: Magic View, Smart Cast, Smart Shoes

Description: Lenovo recently announced a range of wearables and displays including:

- The Magic View smartwatch offers two screens – a conventional and an interactive display—to simulate a screen “20 times the size of the main watch frame.” The approach is alleged to provide a better experience for map and video viewing.
- Smart Cast combines a laser projector and infrared motion detector in a smartphone. Developers expect it to allow for virtual keyboards and gesture-based interaction with projected displays.
- Smart Shoes, which uses Lenovo’s cloud-based internet-of-things ecosystem open software development kit in conjunction with footwear that tracks fitness data, provides GPS guidance, and reports on a user’s mood.

Status: Evolving

Funding:

Product link:

Source: Lenovo's Wearables Vision Includes a Dual-Screen Smartwatch

<http://www.datamation.com/feature/lenovos-wearables-vision-includes-a-dual-screen-smartwatch.html>

4.0 Power

4.1 Self-powering (Harvesters)

4.1.1 Chinese Academy of Sciences

Technology name: Perovskite solar cell

Description: Researchers are exploring ultra-thin, bendable perovskite solar cells with the ability to convert greater percentages of solar energy into electricity, and at a size “400 times thinner than conventional silicon cells.” Researchers are exploring applications such as weaving the cells into clothing, which could be ideal for chargers and wearable devices. According to researchers, in fiber the cells demonstrate a power conversion efficiency of 3% and maintain 89% efficiency after 96 hours in ambient conditions. They are working to address challenges such as the impact of air and moisture, which reduces productivity.

Status: Evolving

Funding:

- National Natural Science Foundation of China. Grant Numbers: 21273269, 11302241
- National Basic Research Program by Ministry of Science and Technology. Grant Number: 2010CB934700
- Knowledge Innovation Program by Chinese Academy of Sciences. Grant Number: KJCX2.YW.M12
- International Science and Technology Cooperation Project of Jiangsu Province. Grant Number: BZ2011049

Research link: <http://doi.org/f272zw>

Source: Solar-cell thread heralds promise of wearable chargers
<http://www.biospace.com/News/solar-cell-thread-heralds-promise-of-wearable/379102>

4.1.2 Commonwealth Scientific and Industrial Research Organization: Flexible Integrated Energy Device

Technology name: Flexible Integrated Energy Device (FIED)

Description: The FIED is designed to be a wireless, wearable power source. The system features an energy-harvesting system that harnesses via the pack’s straps energy from the user’s body movements; a flexible battery; and washable fabric with conductive fibers that also connect to electronic devices. The FIED offers several outlets and pockets into which users can plug in their electronics, LED lights, and retractable USB cables.

Status: Evolving

Funding:

Product link: http://csironewsblog.com/2015/04/29/a-much-smarter-watch-how-our-flexible-batteries-and-electrified-fabrics-can-improve-wearables/?blogsub=confirming#blog_subscription-3

Source: Backpack Is a Wireless, Wearable Charging System

http://www.designnews.com/author.asp?section_id=1386&doc_id=277496&dfpPParams=ind_184,industry_alt,industry_consumer,kw_46,aid_277496&dfpLayout=blog



The Flexible Integrated Energy Device (FIED) is a backpack that combines wearable technology and wireless power sources to create a complete power system for your personal electronics.

(Source: Commonwealth Scientific and Industrial Research Organization)

Photo source: http://csironewsblog.com/2015/04/29/a-much-smarter-watch-how-our-flexible-batteries-and-electrified-fabrics-can-improve-wearables/?blogsub=confirming#blog_subscription-3

5.0 Communications

5.1 Hands-free operation

5.1.1 Aria Wearable

Technology name: Aria Wearable gesture controller

Description: The clip-on gesture controller clips to a smartwatch and allows a user to navigate the device using gestures. Gestures can be customized using the Aria app. The device has a built-in battery and uses Bluetooth Low Energy. Aria offers two versions, one for Pebble Time and one for Andorid Wear. It can also be used to control an iPhone or iPad, but not Apple Watch at this time. Users can use typical smartphone-type movements such as miming of tapping, swyping, etc. to control the device.

Status: Evolving

Funding: Crowdfunding

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

Source: Aria: An Accessory that Let Users Control a Smartwatch Using Gestures
<http://au.idigitaltimes.com/aria-accessory-let-users-control-smartwatch-using-gestures-100358>

5.1.2 Google: ATAP Project Soli

Technology name: ATAP Project Soli

Description: ATAP Project Soli will allow users to interact with smaller screens and control smaller devices using gestures and “hand motion vocabulary.” The device uses radar to bring accuracy and precision to detecting fine hand and finger movements, allowing users to manipulate devices even through materials. The device features haptic feedback and is fit for small devices.

Status: Evolving – targeted for availability later this year.

Funding:

Product link:

Source: ATAP’s ‘Soli’ Radar-Based Gesture Control Could Be The Perfect Wearable Interface
<http://techcrunch.com/2015/05/29/ataps-soli-radar-based-gesture-control-could-be-the-perfect-wearable-interface/>



Photo source: <http://techerunch.com/2015/05/29/ataps-soli-radar-based-gesture-control-could-be-the-perfect-wearable-interface/>

5.1.3 Playtabase: Reemo

Technology name: Reemo gesture controller

Description: Reemo is a wrist-worn gesture controller that allows users to control home devices through pointing and six selected gestures. Users must be within 10 meters of a smart device. The device features a 48-hour battery life and is water resistant for up to 30 minutes and 3 meters deep.

Status: Soon to be released – expected October 2015

Funding: Playtabase recently gained an additional \$100,000 in funding, plus an existing \$400,000 from angels/partners and a previous accelerator.

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

Source: Minneapolis Wearable Startup Playtabase Lands Spot In Nashville Accelerator
<http://tech.mn/news/2015/05/14/playtabase-reemo-nashville-accelerator-jumpstart-foundry/>



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

6.0 Cameras

6.1.1 GoPro

Technology name: Virtual reality device, quadcopter drone

Description: GoPro is developing a virtual reality device that uses six GoPro Hero cameras to create a spherical shot. The footage will be synced to the cloud, eliminating the need for memory cards. GoPro is also developing quadcopter drone that will take aerial footage.

Status: Evolving

Funding:

Product link:

Source: GoPro News: Wearable Camera Company Working on a Virtual Reality Device and Drone
<http://www.latinpost.com/articles/56095/20150528/gopro-wearable-camera-company-working-on-a-virtual-reality-device-and-drone.htm>

6.1.2 Inobrand: iSECAM-HD

Technology name: iSECAM-HD wearable security camera

Description: iSECAMHD is a clip-on wearable camera that offers 8 hours of recording with its rechargeable battery, 32GB memory, 4G/3G/wifi/GPS connectivity, 1921x180 HD resolution, encryption, night vision, and a weatherproof structure (water proof, impact resistant, withstands -3C-55C). It is small (120mm x 80mm x 40 mm) and weighs 168 grams.

Status: Available

Funding:

Product link: <http://www.inobrand.com/wearable-security-body-camera>

Source: Inobrand Wearable Security Camera – iSECAM-HD
<http://www.inobrand.com/wearable-security-body-camera>



Photo source: <http://www.inobrand.com/wearable-security-body-camera/>

6.1.3 Mobius

Technology name: Mobius wearable camera package

Description: The wearable camera package features the standard Mobius Camera with a proprietary magnet mount and clip to mount it on a visor, dashboard, or even a bow, as well as almost any surface. The small camera (1.38 x 2.40 x .72 inches) provides 1080P HD video and audio and its 820mah battery offers 120 minutes of recording time.

Status: Available

Funding:

Product link: <https://www.mobius-actioncam.com/store/products/mobius-wearable-camera-package/>

Source: New Wearable Camera Package for the Standard Mobius
<https://www.mobius-actioncam.com/new-wearable-camera-package-for-the-standard-mobius/>



Photo source: <https://www.mobius-actioncam.com/store/products/mobius-wearable-camera-package/>

6.1.4 Sony: FDR-X1000V 4K Action Cam

Technology name: FDR-X1000V 4K Action Cam

Description: Sony's Action Cam allows a user to monitor the device (up to 5 cameras) live via wifi on a wrist-mounted remote. The device features HD and 4k resolution, has a built-in stabilizer, and is waterproof to 3 meters. It offers a slender shape, fit for mounting aside helmets or other objects. It also has a dog mount, which may be of benefit to law enforcement.

Status: Available

Funding:

Product link: <http://www.sony.net/Products/actioncam/en-us/products/cameras/FDR-X1000V/>

Source: Sony's Action Cam takes on GoPro

<http://www.afr.com/technology/review-sonys-action-cam-takes-on-gopro-20150511-ggwcam>



If you want to capture every perspective of a special road trip, you can set up five Action Cams and monitor them live via Wi-Fi on a wrist mounted remote.

Photo source: <http://www.afr.com/technology/review-sonys-action-cam-takes-on-gopro-20150511-ggwcam>

7.0 Exoskeletons

7.1.1 Alex Czech (individual)

Technology name: 3D-printed hand exoskeleton

Description: Developer Alex Czech is creating a 3D-printed hand exoskeleton, with a goal to advance to a full-body exoskeleton. The hand feature 13 printed parts, weighing 173 grams. The device costs an estimated \$8.16 to create, including plastic, nuts, and bolts. Future versions could include elongated fingers for delicate handling of harmful materials.

Status: Available

Funding:

Product link: <https://selfy.com/p/BXw2/>

Source: 3D-Printed Exoskeleton Hands Could Augment Human Bodies
<http://www.psfk.com/2015/05/3d-printed-hands-alex-czech.html>



Photo source: <http://3dprintit.com.au/index.html>

7.1.2 Berkeley: Berkeley Lower Extremity Exoskeleton (BLEEX)

Technology name: Berkeley Lower Extremity Exoskeleton (BLEEX)

Description: Created to assist first responders, BLEEX was designed to be a “self-powered exoskeleton for strength and endurance enhancement of humans that is ergonomic, highly maneuverable, mechanically robust, lightweight and durable.” The exoskeleton allows for versatile transport and reduces load to the user. The prototype featured powered anthropomorphic legs, a power unit, and a backpack-style frame for mounting loads. It allows for mobility in all directions while carrying a load. Should the device lose power, the legs can be removed and the entire device becomes a standard backpack. The device utilizes a control algorithm that “ensures that the exoskeleton moves in concert with the pilot with minimal interaction force between the two. The control scheme needs no direct measurements from the human or from the human-machine interface (e.g., sensors between them). The controller,

based on measurements from the exoskeleton only, estimates (i.e., computes very quickly) how to move so that the wearer feels very few forces.”

Status: Evolving

Funding: Defense Advanced Research Project Agency (DARPA)

Product link: <http://bleex.me.berkeley.edu/wp-content/uploads/hel-media/images/CV/BLEEX-Summary.pdf>

Source: BLEEX
<http://bleex.me.berkeley.edu/research/exoskeleton/bleex/>



Photo source: <http://bleex.me.berkeley.edu/research/exoskeleton/bleex/>

7.1.3 Buckhead Shepherd Center: Indego

Technology name: Indego

Description: Indego is a powered, lightweight (26 pounds) exoskeleton that mimics the movement of human legs, providing power at the hip and knees, essentially walking for the user.

Status: Evolving—Available for research purposes in clinical settings; commercial availability expected in 2015.

Funding:

Product link: <http://www.indego.com/indego/en/home>

Source: Buckhead's Shepherd Center Helps Paralyzed Teen Walk for Graduation
<http://patch.com/georgia/buckhead/buckheads-shepherd-center-helps-paralyzed-teen-walk-graduation-0>

7.1.4 Cyberdyne Inc.: Hyber Assistive Limb (HAL)®

Technology name: HAL

Description: Sumitomo Mitsui Banking Corp. is using Cyberdyne Inc. robotic suits to assist in cash delivery by reducing the load workers carry. The technology can reduce the burden by 40%. According to the Cyberdyne web site, “HAL® preforms assistance for the wearer’s motions by a combination of Cybernic Voluntary Control [CVC] system, with which Robot Suit® moves as the wearer intends by detecting [bio-electric signals], and Cybernic Autonomous Control [CAC] system, with which Robot Suit® replicates human motions based on fundamental motion patterns in the absence of BES.”

Status: Evolving – available in some countries

Funding:

Product link: <http://www.cyberdyne.jp/english/products/HAL/>

Source: Robot Suits To Help Bank Employees Deliver Heavy Cash Stacks
<http://blogs.wsj.com/japanrealtime/2015/05/08/robot-suits-to-help-bank-employees-deliver-heavy-cash-stacks/>



Photo source: Sumitomo Mitsui Banking Corp.

7.1.5 Esko Bionics: Industrial Exoskeleton

Technology name: Industrial Exoskeleton

Description: Esko Works Industrial Exoskeleton is a lightweight (16 lbs) and powerless, using counterweights and a standard, sprung arm like those used on image-stabilizing Steadicams. The device's carbon fiber harness and metal-tube frame running down a user's legs and translates the weight of the user's load through the suit and into the ground.

Status: Evolving

Funding:

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

Source: Exoskeleton for Construction Workers
<http://www.constructioncitizen.com/blog/exoskeleton-construction-workers/1505071>

7.1.6 Jiazhen 'Ken' Chen (individual): Advanced Firefighting Apparatus

Technology name: Advanced Firefighting Apparatus

Description: Industrial designer Jiazhen 'Ken' Chen is developing the Advanced Firefighting Apparatus powered exoskeleton to increase firefighter's performance (walking, running, carrying). The suit reduces the load of a firefighter, being able to load 91kg. It is customizable, can operate for two hours, and will be equipped with an impulse water gun system and movable joystick for operation.

Status: Evolving

Funding:

Product link: <https://www.behance.net/gallery/12324165/AFA-Powered-Exoskeleton-Suit-for-Firefighter>

Source: Super firemen: These fire fighting exoskeleton suits give superhuman abilities
<http://www.techly.com.au/2015/05/22/super-firemen-these-fire-fighting-exoskeleton-suits-give-superhuman-abilities/>



Photo source: <https://www.behance.net/gallery/12324165/AFA-Powered-Exoskeleton-Suit-for-Firefighter>

7.1.7 NYU Polytechnic School of Engineering

Technology name: Exoskeleton research

Description: Doctoral student Henry Clever is pursuing mathematical models of energetic performance and stability control for use in the design of lower-extremity robotic exoskeletons to accelerate the development of better-performing, lower-cost assistive devices. The exoskeleton aims to help users with lower limb impairments.

Status: Evolving

Funding: National Science Foundation

Research link: <http://engineering.nyu.edu/press-release/2015/05/26/nyu-engineering-student-earns-prestigious-nsf-fellowship-wearable-robot-res>

Source: NYU Engineering Student Earns Prestigious NSF Fellowship for Wearable-Robot Research
<http://www.virtualpressoffice.com/publicsiteContentFileAccess?fileContentId=2015341&fromOtherPageToDisableHistory=Y&menuName=News&sId=&sInfo=>

7.1.8 Revision Military

Technology name: Kinetic Operations Suit

Description: At the 2015 Special Operations Forces Industry Conference, Revision Military demonstrated its Kinetic Operations Suit, which offers a hard body-armor protection that covers 60% of the wearer and can stop rifling rounds. It is also load-bearing, reducing the weight to the users, and offers motorized actuators on each leg.

Status: Evolving – prototype expected in August 2018

Funding: SOCOM intends to funnel \$80 million into research and development over the first four years.

Product link:

Source: Firms Pitch Exoskeletons and Body Armor for SOCOM's Iron Man Suit

<http://www.military.com/daily-news/2015/05/21/firms-pitch-exoskeletons-and-body-armor-for-socom-iron-man-suit.html>

7.1.9 Samsung Elect Ltd

Technology name: Exoskeleton

Description: Samsung Elect Ltd plans to pursue exoskeletons to enhance the speed and strength of soldiers. Recent patents published related to a robot that attaches to the body and can be controlled by the wearer. The device detects the user's movement and generates auxiliary torque to provide extra strength. According to patent illustrations, the device will feature electromyogram sensors on each leg to communicate with the controller and move the device (and the wearer) forward. The device features a gyrometer and accelerometer that also registers the wearer's movement and guides the exoskeleton.

Status: Evolving

Funding:

Product link: [Patent information](#)

Source: Samsung Brings "Call Of Duty" Exo Skeleton To Life

<http://www.bidnesstc.com/43292-samsung-brings-call-of-duty-exo-skeleton-to-life/>

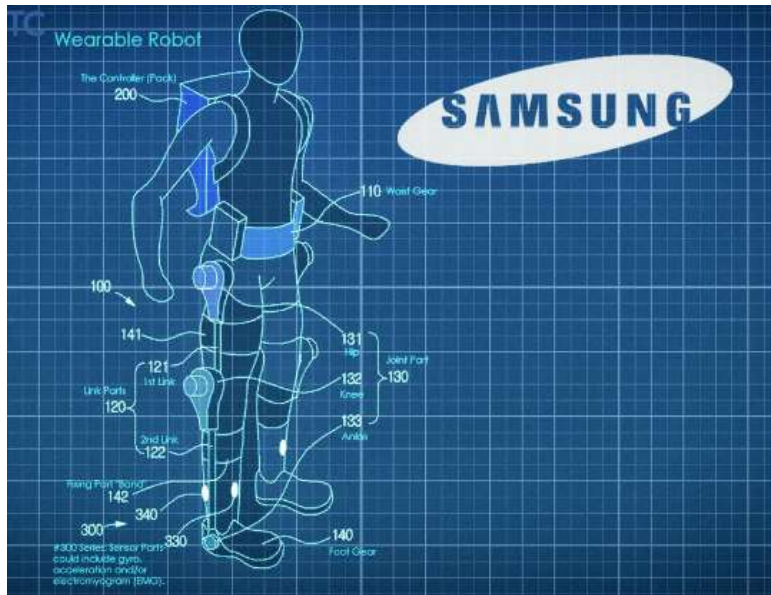


Photo source: <http://www.bidnesstc.com/43292-samsung-brings-call-of-duty-exo-skeleton-to-life/>

7.1.10 United Instrument Manufacturing Corporation

Technology name: Mind-controlled dual-use exoskeleton

Description: Russia's United Instrument Manufacturing Corporation is developing military-grade automated control and dual-use robotic systems for defense R&D tasks. The exoskeleton will help soldiers carry loads up to 300 kg. The system's neuro interface will allow the user to control the suit through images; thinking of certain images will coordinate a response in the system.

Status: Evolving

Funding:

Product link:

Source: Will Russia Field Robo-Soldiers in 5 Years?

<http://thediplomat.com/2015/05/will-russia-field-robo-soldiers-in-5-years/>

7.1.11 University of Texas, Dallas

Technology name: Artificial muscles

Description: Researchers are exploring the use of high-strength polymer fishing line and sewing thread to create artificial muscles for exoskeletons, under the principle that "Coiled polymer fiber react to changes in temperature, contracting when heated and then loosening when cooled" similar to human muscles. These materials, in addition to being lightweight and affordable, contract even further than human muscles (30% more), giving added strength.

Status: Evolving

Funding:

Research link: http://www.utdallas.edu/news/2014/2/21-28701_Researchers-Create-Powerful-Muscles-From-Fishing-L_story-wide.html

Source: This Is What A Realistic Gundam Suit Will Be Like Artificial muscles will get even stronger
<http://www.gizmodo.com.au/2015/05/this-is-what-a-realistic-gundam-suit-will-be-like/>

7.1.12 Wyss Institute

Technology name: Soft exosuit

Description: Wyss's is developing an exosuit that uses specially designed fabrics, which are lighter weight and allow for greater movement. Potential applications include reducing the physical burden of firefighters, paramedics, and other load-bearing occupations.

Status: Evolving

Funding:

Product link:

Source: Soft Exosuit
<http://wyss.harvard.edu/viewpage/456>



The soft exosuit uses a combination of sensors, including a hyperelastic strain sensor (1) and sensors around the wearer's hip, calf and ankle (2)-(5), all secured by straps. Flexible membranes cover sensors and straps (6).

Photo source: <http://wyss.harvard.edu/viewpage/456>

8.0 Wearable Computers

8.1.1 TypeTime: iType

Technology name: iType smartwach

Description: The iType smartwatch is a wrist-worn smartphone with an improved typing feature. It features two navigation buttons on the watch's side (a back button and a sleep/wake button), a camera, and a SIM card. The device is SIM-unlocked. The device is water resistant and has a battery life comparable to typical smartphones. It features a 240x240 display, MediaTek dual-core A7 CPU, 1GB of RAM, 8GB of storage, 5-megapixel camera with 720p video. It also offers wifi, Bluetooth, GPS, and G-Sensor connectivity (but not LTE).

Status: Available

Funding: Crowdfunding

Product link: <http://www.typtime.net/>

Source: The iType smartwatch from TypeTime brings practical ability to type in feature packed wearable running full Android

http://www.phonearena.com/news/The-iType-smartwatch-from-TypeTime-brings-practical-ability-to-type-in-feature-packed-wearable-running-full-Android_id69303



Photo source: <http://www.typtime.net/>

9.0 Other

9.1.1 Bridgecrest Medical

Technology name: Fatigue management

Description: Bridgecrest Medical's design uses predictive analytics to measure fatigue and provide real-time medical alerts. A patient is screened for major risk factors impacting sleep; the results are synchronized with Bridgecrest Medical's secure data analytics platform. The patient wears a smart watch that measures various biometrics (heart rate, quality/quantity of sleep), which is transmitted to a computer that then categorizes and analyzes the data into risk categories. The information is made available to the patient's medical or safety team who can then make determinations about treatment or response, and it can also be compared to other users.

Status: Evolving

Funding:

Product link: <http://www.bridgecrestmed.com/fatigue-management/>

Source: Fatigue management combining wearable technology and real-time alerts
<http://im-mining.com/2015/05/27/fatigue-management-combining-wearable-technology-and-real-time-alerts/>

9.1.2 Digital FOV: Digital Crosshairs I-Targeting Monocular

Technology name: Digital Crosshairs I-Targeting Monocular wireless targeting monocular

Description: The Digital Crosshairs monocular is a wireless targeting accessory for the Digital Crosshairs rifle scope night vision clip that "transmits live video of the scope's targeting field of view to a small wearable micro monitor that attaches to shooting glasses." The device gives the user visibility of their surroundings with one eye, while the other can still see the crosshairs. The device automatically switches to infrared vision at night.

Status: Soon to be released – anticipated June 2015

Funding:

Product link: www.digitalcrosshairs.net

Source: New Wearable Night Vision Rifle Targeting Glasses Released
<http://www.pr.com/press-release/620837>

9.1.3 Fujitsu: Ubiquitousware

Technology name: Ubiquitousware location badge

Description: The Ubiquitousware badge offers pedestrian-dead-reckoning technology using an accelerometer and standard GPS. The location data can detect a user in a building and even one who has fallen down, as was demonstrated at a recent press conference using a mannequin. The technology can detect when a user is on an unstable surface or moving too fast and provide real-time monitoring.

Status: Available

Funding:

Product link: <http://www.fujitsu.com/global/about/businesspolicy/business/ubiquitous/>

Source: Fujitsu's new wearables might not be sexy, but they could save your life
<https://www.techinasia.com/fujitsu-enterprise-wearable-tech/>



Photo source: <https://www.techinasia.com/fujitsu-enterprise-wearable-tech/>

9.1.4 Google: Project Jacquard

Technology name: Project Jacquard

Description: Project Jacquard is weaving technology into clothing, integrating touch and gesture interactivity into any textile using industrial looms, turning a garment into a touchpad. The technology is a platform essentially turning any cloth into an interactive surface. The touch panel will reside in just a portion of the garment and requires a chip and battery which are the size of button and sewn onto the garment. The technology features Bluetooth and wifi connectivity and utilizes sealed electronics allowing for machine washing.

Status: Evolving

Funding:

Product link: <https://www.google.com/atap/project-jacquard/>

Source: Project Jacquard: Google reinvents the wearable as stuff you actually wear
<http://mashable.com/2015/05/30/project-jacquard-analysis-google/>



Photo source: <http://mashable.com/2015/05/30/project-jacquard-analysis-google/>

9.1.5 Kinetic

Technology name: Smartbelt and alert system

Description: Kinetic's two-part device detects when a user is lifting and which muscles are being used, indicating to users when they may be at risk for injury. The device features a wristband and back-brace with interacting sensors that calculate the risk of injury and use LED lights and/or vibration to warn a user.

Status: Evolving

Funding:

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

Source: Corporate Wellness: How a Wearable Belt, Smartband May Save Your Employees' Backs
<http://www.personaltechmd.com/blogs/team-ptmd/2015/05/corporate-wellness-how-a-wearable-belt-smartband-may-save-your-employees-backs.aspx>



Photo source: <http://wearkinetic.com/>

9.1.6 Massachusetts Technology Institute (MIT)

Technology name: Personal-cooling technology

Description: Researchers are developing personal-cooling technology “using an infrared-transparent visible-opaque fabric (ITVOF), which provides passive cooling via the transmission of thermal radiation emitted by the human body directly to the environment.” According to researchers, “By providing personal cooling in a form amenable to everyday use, ITVOF-based clothing offers a simple, low-cost solution to reduce energy consumption in HVAC systems.”

Status: Evolving

Funding:

Research link: <http://pubs.acs.org/doi/pdf/10.1021/acsphotonics.5b00140>

Source: Infrared-Transparent Visible-Opaque Fabrics for Wearable Personal Thermal Management
<http://pubs.acs.org/doi/pdf/10.1021/acsphotonics.5b00140>

9.1.7 Mentor®: Embedded Nucleus®

Technology name: Embedded Nucleus® real-time operating system

Description: Embedded Nucleus® is a comprehensive operating system and protocol support for Internet-of-Things devices and cloud connectivity, equipped with built-in power management support, memory space partitioning, and system-on-chip architecture. The technology offers wi-fi, Bluetooth, and 6LoWPAN connectivity and extended battery life through effective power management. The device’s Qt® framework optimizes graphics capabilities while maintaining a small footprint fit for wearables.

Status: Available

Funding:

Product link: <http://www.mentor.com/embedded-software/nucleus/>

Source: Mentor Graphics Announces Nucleus RTOS for Wearable Devices
<http://www.newswiretoday.com/news/152469/>

9.1.8 North Carolina State Textile Protection and Comfort Center

Technology name: First responder garments

Description: Researchers are developing clothing for emergency workers, with added protection against a range of hazards including fire, water, chemicals, jagged debris, etc. The team at North Carolina State Textile Protection and Comfort Center is partnered with Protect the Force Inc. to manufacture 150 of the prototypes for field testing with first responders.

Status: Evolving

Funding: \$718,000 grant from the Department of Homeland Security

Product link:

Source: Outfitting First Responders
<https://news.ncsu.edu/2015/05/outfitting-first-responders/>

9.1.9 QuickLogic Corporation: SenseMe™

Technology name: SenseMe algorithm library

Description: The SenseMe is comprehensive sensor fusion algorithm library, including fusion, activity, transport, gesture, and device location algorithms. The algorithms are acclaimed to shorten developer time, ensure cross-platform portability, reduce memory footprint, minimize power consumption, and support data from a range of sensor classes (i.e., inertial, magnetic, biological, proximity and light). The algorithms work with Android Operating System including KitKat 4.4, Lollipop 5.0 and real-time operating systems.

Status: Available

Funding:

Product link: www.quicklogic.com/senseme

Source: QuickLogic Announces SenseMe Software Library Licensing for Smartphone, Wearable, and IoT Applications
<http://www.stockhouse.com/news/press-releases/2015/05/27/quicklogic-announces-senseme-software-library-licensing-for-smartphone-wearable>

9.1.10 ReVault

Technology name: ReVault wearable cloud

Description: ReVault is a portable, wearable hard drive that syncs a user's data from multiple devices. The device uses wi-fi and Bluetooth and comes in 32GB and 128GB capacity.

Status: Evolving

Funding: Crowdfunding

Product link: <http://revault.io/>

Source: ReVault Happens To Be A Wearable Cloud
<http://www.ubergizmo.com/2015/05/revault-happens-to-be-a-wearable-cloud/>

9.1.11 Samsung: Artik

Technology name: Artik system-on-chip

Description: Samsung is developing a system-on-chip series “as powerful as full-fledge computers” to power smart devices and appliances. Artik 1 will offer Wi-Fi, BLE, Zigbee, RFID and Bluetooth connectivity, memory, and a 9-axis sensor path in a 11.5 mm x 12.5 mm chip. The Artik 6 SoC will be a computer on a chip, reportedly the size of an SD card, 1.8 MHz processor, 16GB RAM, and typical range of sensors and radiofrequency function.

Status: Available

Funding:

Product link: <https://www.artik.io/>

Source: Samsung Set To Unveil New Chips To Power Internet Of Things
<http://www.forbes.com/sites/parmyolson/2015/05/12/samsung-artik-system-on-a-chip-internet-of-things/>

9.1.12 University of Exeter

Technology name: Electronic textiles with embedded, flexible graphene electrodes

Description: Researchers are exploring techniques to embed transparent, flexible graphene electrodes into fibers, creating electronic textiles. Proposed applications include clothing containing computers, phones, and MP3 players, as well as in textile GPS systems, biomedical monitoring, and personal security. The researchers are using monolayer graphene with exceptional electrical, mechanical, and optical properties.

Status: Evolving

Funding:

Product link:

Source: Graphene holds key to unlocking creation of wearable electronic devices
http://www.eurekalert.org/pub_releases/2015-05/uoe-ghk051115.php

9.1.13 University of Manchester

Technology name: Printable graphene for wearables

Description: Researchers are developing a binder-free process for printing graphene ink with high electrical conductivity and have successfully used the material to print a flexible radiofrequency antenna. The typical binding process requires additional heating not often fit for substrates for wearables. Using this bind-free process, the ink can dry at 100°C and be compressed, which reportedly “improved the adhesion of the graphene to the substrate, and it increased the conductivity of the applied graphene 50-fold.” Researchers proposed suggested applications such as RFID tags for wearable electronics.

Status: Evolving

Funding:

Research link: <http://dx.doi.org/10.1063/1.4919935>

Source: Toward Printable Graphene for Wearable Electronics
http://www.osa-opn.org/home/newsroom/2015/may/toward_printable_graphene_for_wearable_electronics/

9.1.14 Utility Associates: Evidence EcoSystem

Technology name: Evidence EcoSystem evidence-capturing device

Description: The Evidence Ecosystem is a comprehensive evidence-capturing device connecting Internet-of-Things devices with real-time connectivity, data analysis, and data storage. The device features audio and video, Generation 2 BodyWorn video cameras, core-in-car video recording, fixed location video cameras, gunshot audio analysis and location reporting systems, automated license plate reader, 911 and computer-aided dispatch, video integration centers gathering multiple feeds, connectivity to the National Crime Center and other federal/state databases, crime zone prediction algorithms, and metadata evidence storage and distribution systems with the ability to share with involved parties. According to developers, “This integration provides reliable capture of the facts and can all be pulled together in AVaiL Web, which enhances officer safety and protecting citizen privacy rights.” AVaiL Web is described as a “secure command and control application that provides an automatic real-time, map-based view of the location and status of mobile operations, including personnel, vehicles and tools.” The device also integrates with DataSync, which updates every 15 seconds with a fleet’s location, diagnostics and RFID tag data.

Status: Available

Funding:

Product link:

Source: The Mobile IoT Engine is the Future
<http://www.utility.com/products/>

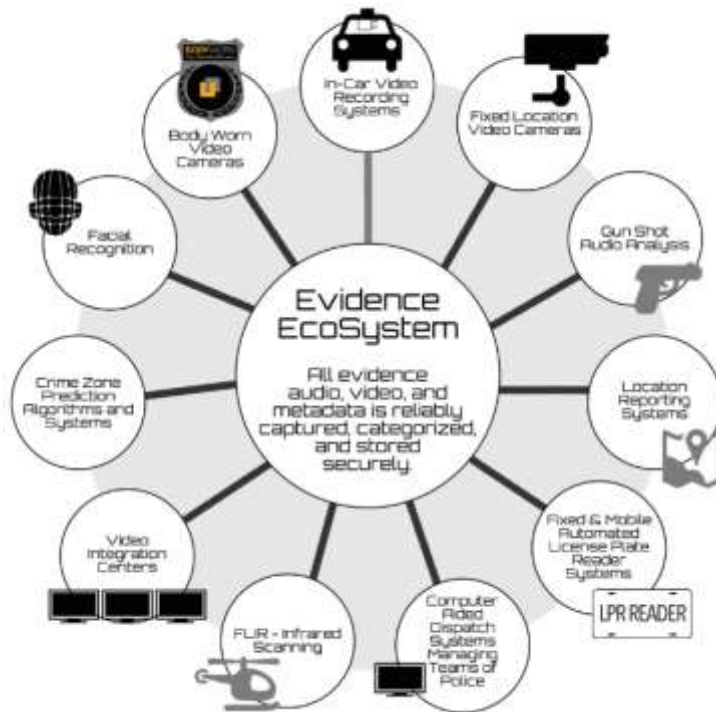


Photo source: <http://www.utility.com/products/>

9.1.15 Wild Acre Metals, Nuheara

Technology name: Hearing and speech technology

Description: Wild Acre Metals is entering the wearables market after acquiring Nuheara, which created wireless earbuds that allow users to augment their hearing and connect (cable free) to voice-enabled smart devices. The partners will create “hearing technology platform that combines unique speech augmentation software with spatial directionality and placement, Bluetooth connectivity and app software components.”

Status: Evolving

Funding:

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

Source: WA company aiming to revolutionise the audio wearables market
<http://www.ferret.com.au/articles/news/wa-company-aiming-to-revolutionise-the-audio-wearables-market-n2522747>



WILD ACRE Metals is entering the wearables market, with its acquisition of WA-founded Nuheara, a startup developing hardware and software for multi-functional audio technology.

Photo source: <http://www.ferret.com.au/articles/news/wa-company-aiming-to-revolutionise-the-audio-wearables-market-n2522747>

9.1.16 WISeKey SA: NFCTrusted©

Technology name: NFCTrusted

Description: WISeKey is developing trusted near-field communications (NFC) technology, integrating security authentication and identification with wearable devices. According to the press release, “NFCTrusted© authentication tags can incorporate a WISeKey cryptographically secure digital certificate to prove authenticity. NFCTrusted© tags can be embedded in virtually any product, piece of equipment or common household item, and users can verify authenticity with an NFC-enabled smart phone, watch, connected device or other mobile device.”

Status: Evolving

Funding:

Product link:

Source: WISeKey Deploying large Scale IoT Digital Identities for Wearables with WISeID
NFCTrusted(c) Technology

http://smartwatch.einnews.com/pr_news/266635867/wisekey-deploying-large-scale-iot-digital-identities-for-wearables-with-wiseid-nfctrusted-c-technology

Appendix A

Technology Summary

Appendix A

Technology Summary

The following spreadsheet 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	Status
Sensor			
Physiological			
Atlas Wearables	Atlas Wristband activity tracker	Uses machine learning and analytics to track more than 50 activities and relevant metrics and allows users to log workouts, analyze data, and suggest new routines.	Evolving
California State University	iRythm ECG monitor	Wearable ECG monitor patch that is small (5cm), waterproof, and comprising a system-on-chip, sensor, microprocessor, and Bluetooth connectivity	Evolving
Cambridge Cognition	Cognitive testing	Uses physiological health data from wearables to trigger cognitive tests for users to establish a record of and better understand a user's mental function.	Evolving
Chinese Academy of Sciences	E-skin physiological sensor	Flexible electronics and nanotechnology in a thin film of carbon nanotubes and graphide oxide that can be worn close to the skin. The sensors monitor and transmit a user's blood pressure, pulse, etc., to provide real-time diagnostics.	Evolving
Colorado University Boulder	Skin temperature sensor	Measures skin temperature and allows a user to indicate their comfort, with a goal that the device could eventually recognize a user's thermal state and adjust the heating/cooling	Evolving
Echo Labs	Blood-monitoring wristband	Health-monitoring wristband uses optical signals to measure oxygen, CO2, pH, hydration, blood pressure.	Evolving
Ecole Polytechnique Federale de Lausanne	Sweat nanosensor	This sensor in an adhesive electronic stamp, with microscopic transistors, attaches to the skin to analyze sweat (ions, protons, pH, proteins, calcium, sodium, potassium, etc.) and measure hydration, stress, or fatigue.	Evolving
Fujitsu	Feelythm	Feelythm comprises an ear-worn and neck-worn wearable pulse sensor and mountable receiver for inside the vehicle.	Evolving
Fujitsu	Ubiquitousware vital-sensing band	Collects a user's vital signs (pulse rate, temperature, location, humidity) and uses algorithms to interpret the data to monitor stress, fatigue, and even falls or accidents.	Evolving
MC10, University of Rochester	BioStamp	Utilizing MC10's BioStamp biometric sensing device, software, cloud storage, and computing platform to combine physiological sensing and pattern recognition algorithms with clinical expertise and big data analytics for possible healthcare applications	Evolving
McLaren Applied Technologies	Wearable to reduce jet lag	The proposed device would analyze vital signs over time then analyze that data to predict the best time for the user to travel.	Evolving
Osram Opto Semiconductors	SFH 7051 BioMon Sensor	Energy-efficiency, green LED optical sensors products measure heart rate by shining light on the skin and measuring the volume of blood passing through by amount the light absorbed by blood and the surrounding tissue	Available
Pursuit Enterprises	Sleep technology	Uses miniature sensors near the user's eye and delivers alerts to an earbud-type device in the ear. The device also sends alerts to other users, such as a command center.	Evolving
Snowcookie	Snowcookie skin sensor	Monitors a user's body position, fatigue, muscle reaction, and movement, then alerting the user to trends in performance and making recommendations for a break.	Evolving

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toSense	CovVa™ Monitoring System	Remote heart-monitoring device that tracks a user's heart rate, fluid buildup, respiration, stroke volume, cardiac output and other data and transmits the data to the cloud, where it will be available to doctors.	Evolving
University of British Columbia	Reveal	Embedded sensors that measure indicators of anxiety including sweat, heart rate, and skin temperature, and transmit the data to a smart phone, with a goal to identify meltdowns before they happen.	Evolving
University of California San Diego	Biomedical sensor	Thin, multi-model electronic sheets with readout circuitry on flexible substrates that affix to the skin and record, process, and transmit electrophysiological data.	Evolving
University of Strathclyde	Skin-worn hydration monitoring sensors	Transdermal sensor to analyze electrolytes in sweat and provide real-time analysis of fluid loss during exercise.	Evolving
WellBe	WellBe stress bracelet	Monitors a user's heart rate and uses a patent-pending algorithm to alert a user when they are getting stressed.	Evolving
Yu	HealthYu	Fits on a smartphone and gathers and transmits health-related data (heart rate, respiration rate, blood pressure, body temperatures, ECG).	Soon to be released
Other			
Aroma Technology	NEXTToMe	Features sensors that detect carbon monoxide, temperature, blood alcohol content, UV rays, humidity, air pressure, altitude, and more.	Evolving
King Abdullah University of Science and Technology	Nanoscale fin-shaped transistors	Flexible, fin-shaped, metal-oxide-semiconductor transistors that can be placed on a variety of surfaces. The devices retain their electrical properties even when bending.	Evolving
REFLX	Boogio Bionic Foot Sensor	"Smart shoe" sensor placed in a shoe and tracks a user's movement, gravitation force, inner balance, and more, and analyzes the data to help better understand a user's movement.	Evolving
Sungkyunkwan University	Facial expression sensor	Sensor, comprising a carbon nanotube film on electrically conductive elastomers, analyzes human expressions (smiling, frowning, brow-raising, etc.) and eye movement of persons wearing the sensor.	Evolving
X-labz	UV badge	Measures UV index, temperature, humidity, and air pressure every 2 seconds, collecting data over time to help users avoid sunburn, predict weather, and control or better understand their environment.	Available
Displays			
Heads-Up Display			
Allwinner	Smart glasses	Affordable smart glasses featuring A33 system-on-chip, Bluetooth, wi-fi, and voice control, and pairs with a smartphone.	Evolving
Fujitsu	Ubiquitousware head-mounted display	Head-mounted display comprises a small display, camera, two microphones, and sensors.	Available
Google	Curved display	Recent patents suggest the next generation of Google Glass may feature a curved display that will help users perceive depth.	Evolving
Trimble Partners, Microsoft	Microsoft HoloLens and Trimble Connect, SketchUp, and V10 Imaging Rover	Integrating HoloLens head-mounted holographic display with Windows 10 with Trimble's platforms to benefit the architecture, engineering and construction field.	Evolving
Vision Technologies	Smart glasses	Vision Technologies is developing software and created GiveVision.net to power smart glasses for visually impaired users.	Evolving
Body-Worn			
FlexEnable	Demonstrator flexible	Transistor screen technology that offers an electroluminescent	Evolving

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	screen technology	display fit for the sleeve of an outdoor jacket.	
Lenovo	Magic View, Smart Cast, Smart Shoes	Magic View offers two screens. Smart Cast combines laser projection and infrared motion detection. Smart Shoes uses Lenovo's cloud-backed internet-of-things ecosystem open software development kit in conjunction with footwear to track activity.	Evolving
Power			
Self-Powering (Harvesters)			
Chinese Academy of Sciences	Perovskite solar cell	Ultra-thin, bendable perovskite solar cells with the ability to convert greater percentages of solar energy into electricity	Evolving
Commonwealth Scientific and Industrial Research Organization	Flexible Integrated Energy Device	Wireless, wearable power source with energy-harvesting system that harnesses via the pack's straps energy from the user's body movements; a flexible battery; and washable fabric with conductive fibers that also connect to electronic devices.	Evolving
Communications			
Hands-Free			
Aria Wearable	Aria Wearable gesture controller	Clip-on gesture controller clips to a smartwatch and allows a user to navigate the device using gestures.	Evolving
Google	ATAP Project Soli	Harnesses fine hand movements to allow users to interact with smaller screens and control smaller devices using gestures	Evolving
Playtabase	Reemo gesture controller	Wrist-worn gesture controller that allows users to control home devices through pointing and six selected gestures.	Soon to be released
Cameras			
GoPro	Virtual reality device, quadcopter drone	A virtual reality device that uses six GoPro Hero cameras to create a spherical shot. The footage will be synced to the cloud, eliminating the need for memory cards. GoPro is also developing quadcopter drone that will take aerial footage.	Evolving
Inobrand	iSECAM-HD wearable security camera	Clip-on wearable camera that offers 8 hours of recording with its rechargeable battery, 32GB memory, 4G/3G/wifi/GPS connectivity, 1921x180 HD resolution, encryption, night vision, and a weatherproof structure (water proof, impact resistant, withstands -3C-55C).	Available
Mobius	Mobius wearable camera package	The standard Mobius Camera with a proprietary magnet mount and clip to mount it on a visor, dashboard, or even a bow, as well as almost any surface. The small camera (1.38 x 2.40 x .72 inches) provides 1080P HD video and audio and its 820mah battery offers 120 minutes of recording time.	Available
Sony	FDR-X1000V 4K Action Cam	Allows a user to monitor the device (up to 5 cameras) live via wifi on a wrist-mounted remote. The device features HD and 4k resolution, has a built-in stabilizer, and is waterproof to 3 meters.	Available
Exoskeletons			
Alex Czech (individual)	3D-printed hand exoskeleton	3D-printed hand exoskeleton, with 13 printed parts, weighing 173 grams. The device costs an estimated \$8.16 to create, including plastic, nuts, and bolts.	Available
Berkeley	Berkeley Lower Extremity Exoskeleton (BLEEX)	Self-powered exoskeleton featuring powered anthropomorphic legs, a power unit, and a backpack-style frame for mounting loads.	Evolving
Buckhead Shepherd Center	Indego	a powered, lightweight (26 pounds) exoskeleton that mimics the movement of human legs, providing power at the hip and knees, essentially walking for the user.	Evolving
Cyberdyne Inc.	Hyber Assistive Limb (HAL)®	Load-bearing robotic suit that reduces a burden to the user by 40%.	Evolving
Esko Bionics	Industrial Exoskeleton	Lightweight (16 lbs) and powerless exoskeleton that users counterweights and a standard, sprung arm.	Evolving

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Jiazhen 'Ken' Chen (individual)	Advanced Firefighting Apparatus	Powered exoskeleton to increase firefighter's performance. The device is customizable, equipped with an impulse water gun system and joystick, and can operate for two hours.	Evolving
NYU Polytechnic School of Engineering	Exoskeleton research	Mathematical models of energetic performance and stability control for use in the design of lower-extremity robotic exoskeletons to accelerate the development of better-performing, lower-cost assistive devices.	Evolving
Revision Military	Kinetic Operations Suit	Offers a hard body-armor protection that covers 60% of the wearer and can stop rifling rounds. The device is load-bearing, reducing the weight to the users, and offers motorized actuators on each leg.	Evolving
Samsung Elect Ltd	Exoskeleton	Exoskeleton that attaches to the body and can be controlled by the wearer. The device detects the user's movement and generates auxiliary torque to provide extra strength.	Evolving
United Instrument Manufacturing Corporation	Mind-controlled dual-use exoskeleton	military-grade automated control and dual-use robotic systems that allow the user to carry loads up to 300 kilograms and features a neuro interface that will allow the user to control the suit through images.	Evolving
University of Texas, Dallas	Artificial muscles	Exploring the use of high-strength polymer fishing line and sewing thread to create artificial muscles for exoskeletons.	Evolving
Wyss Institute	Soft exosuit	Uses specially designed fabrics, which are lighter weight and allow for greater movement.	Evolving
Wearable Computers			
TypeTime	iType smartwach	Wrist-worn smartphone with an improved typing feature, as well as two navigation buttons, camera, SIM card, 240x240 display, 1GB RAM, 8GB storage, wifi, Bluetooth, GPS, and G-sensor connectivity.	Available
Other			
Bridgecrest Medical	Fatigue management	Uses predictive analytics to measure fatigue and provide real-time medical alerts.	Evolving
Digital FOV	Digital Crosshairs I-Targeting Monocular	Wireless targeting accessory for the Digital Crosshairs rifle scope night vision clip that transmits live video of the scope's targeting field of view to a small wearable micro monitor attached to shooting glasses.	Soon to be released
Fujitsu	Ubiquitousware location badge	Offers pedestrian-dead-reckoning technology using an accelerometer and standard GPS.	Available
Google	Project Jacquard	Integrating touch and gesture interactivity into any textile using industrial looms, turning a garment into a touchpad.	Evolving
Kinetic	Smartbelt	Two-part device detects when a user is lifting and which muscles are being used, indicating to users when they may be at risk for injury. The device features a wristband and back-brace with interacting sensors that calculate the risk of injury and use LED lights and/or vibration to warn a user.	Evolving
Massachusetts Technology Institute	Personal-cooling technology	Personal-cooling technology that uses infrared-transparent visible-opaque fabric (ITVOF) to provide passive cooling via the transmission of thermal radiation emitted by the human body directly to the environment.	Evolving
Mentor	Embedded Nucleus® real-time operating system	Comprehensive operating system and protocol support for Internet-of-Things devices and cloud connectivity, equipped with built-in power management support, memory space partitioning, and system-on-chip architecture.	Available
North Carolina State Textile Protection and Comfort Center	First responder garments	Clothing for emergency workers, with added protection against a range of hazards including fire, water, chemicals, jagged debris, etc.	Evolving
QuickLogic Corporation	SenseMe algorithm library	Comprehensive sensor fusion algorithm library, including fusion, activity, transport, gesture, and device location algorithms.	Available

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ReVault	ReVault wearable cloud	Portable, wearable hard drive that syncs a user's data from multiple devices. The device uses wi-fi and Bluetooth and comes in 32GB and 128GB capacity.	Evolving
Samsung	Artik system-on-chip	Artik 1 will offer Wi-Fi, BLE, Zigbee, RFID and Bluetooth connectivity, memory, and a 9-axis sensor path in a 11.5 mm x 12.5 mm chip. The Artik 6 SoC will be a computer on a chip, reportedly the size of an SD card, 1.8 MHz processor, 16GB RAM, and typical range of sensors and radiofrequency function.	Available
University of Exeter	Electronic textiles with embedded, flexible graphene electrodes	Embedding transparent, flexible graphene electrodes into fibers, creating electronic textiles.	Evolving
University of Manchester	Printable graphene for wearables	Binder-free process for printing graphene ink with high electrical conductivity.	Evolving
Utility Associates:	Evidence EcoSystem evidence-capturing device	Comprehensive evidence-capturing device connecting Internet-of-Things devices with real-time connectivity, data analysis, and data storage.	Available
Wild Acre Metals, Nuheara	Hearing and speech technology	A hearing technology platform that combines speech augmentation software with spatial directionality and placement, Bluetooth connectivity, and app software components.	Evolving
WISeKey SA	NFCTrusted	Trusted near-field communications (NFC) technology, integrating security authentication and identification with wearable devices	Evolving



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