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# Responder Technology Alert (October 2015)

**November 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



## CONTENTS

1.0	Sensors.....	1.1
1.1	Physiological.....	1.1
1.1.1	Andre Bertram, Frank Nguyen (individuals) .....	1.1
1.1.2	GraphWear .....	1.1
1.1.3	HTEC .....	1.2
1.1.4	Ecole Nationale Supérieure des Mines.....	1.2
1.1.5	Jawbone.....	1.3
1.1.6	Intelesens.....	1.3
1.1.7	MC10.....	1.3
1.1.8	Toyobo .....	1.4
1.1.9	University of Illinois Urbana-Champaign .....	1.4
1.1.10	University of Illinois at Urbana-Champaign .....	1.5
2.0	Displays .....	2.1
2.1	Heads-up (on face or head) .....	2.1
2.1.1	3M .....	2.1
2.1.2	Bay Innovation, Method.....	2.1
2.1.3	Google .....	2.2
3.0	Power.....	3.1
3.1	Chargers .....	3.1
3.1.1	Ion Tech Wear .....	3.1
3.2	Power supplies .....	3.1
3.2.1	LG Chem.....	3.1
3.2.2	Padre Electronics.....	3.2
3.2.3	Samsung SDI Co. ....	3.2
3.3	Power management .....	3.3
3.3.1	Murata .....	3.3
4.0	Communications.....	4.1
4.1	Hands-free operation .....	4.1
4.1.1	Apotact Labs .....	4.1
4.1.2	Muv Interactive .....	4.1
4.2	Integrated voice/data/video .....	4.2
4.2.1	Mutualink .....	4.2
5.0	Cameras .....	5.1
5.1.1	EE.....	5.1
6.0	Exoskeletons.....	6.1
6.1.1	Aalborg University .....	6.1

6.1.2	Arizona State University .....	6.1
6.1.3	Arizona State University .....	6.2
6.1.4	Arizona State University .....	6.2
6.1.5	Arizona State University .....	6.3
6.1.6	North Carolina State University .....	6.3
7.0	Wearable computers .....	7.1
7.1.1	Apple .....	7.1
8.0	Other .....	8.1
8.1.1	16Lab.....	8.1
8.1.2	ANTELOPE.CLUB.....	8.1
8.1.3	ARC Centre of Excellence for Electromaterials Science .....	8.1
8.1.4	Arizona State University .....	8.2
8.1.5	iMerciv .....	8.2
8.1.6	King Abdullah University of Science and Technology, University of Illinois at Urbana Champaign.....	8.2
8.1.7	Mobetrics.....	8.3
8.1.8	Parsons School of Design.....	8.3
8.1.9	Radiation Shield Technologies.....	8.4
8.1.10	UL .....	8.4
Appendix A Technology Summary .....		A.1

# 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

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#### 1.1.1 Andre Bertram, Frank Nguyen (individuals)

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**Technology name:** HeartWatch

**Description:** The HeartWatch tracks a user's vital signs (blood pressure, heart rate, blood oxygen levels), can obtain ECG readings to help predict a heart attack, and calls for help in the case of an emergency.

**Source:** Toronto teens invent wearable heart-monitoring device

<http://www.cbc.ca/news/canada/toronto/toronto-teens-invent-wearable-heart-monitoring-device-1.3289930>

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#### 1.1.2 GraphWear

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**Technology name:** SweatSmart™

**Description:** The SweatSmart sweat patch offers a noninvasive approach to monitor a user's hydration by measuring sweat for electrolytes. The patch is worn on the lower back and its graphene sensor transmits performance data to the user's smartphone via Bluetooth, which will provide performance feedback, including haptic notifications. Developers conducted proof-of-concept testing with the sensors to measure lactic acid and glucose levels, and are interested in using the device to also measure uric acid in a user's sweat.

**Source:** This wearable patch uses sweat to tell athletes their hydration needs

<http://medcitynews.com/2015/10/this-wearable-patch-uses-sweat-to-tell-athletes-their-hydration-needs/?rf=1>



Photo source: <http://medcitynews.com/2015/10/this-wearable-patch-uses-sweat-to-tell-athletes-their-hydration-needs/?rf=1>



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### 1.1.3 HTEC

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**Technology name:** ECG recorder

**Description:** HTEC's wearable 3-lead, dry-electrode ECG monitor provides continuous, remote cardiac monitoring. The device is powered by STMicroelectronics' STM32 microcontroller, which offers low-power, high-performance computing capabilities allowing for seven days of continuous recording without recharging. The microcontroller, in conjunction with HTEC's "signal-filtering algorithms," effectively translates the ECG data into medically useful information. The device is applied to a patient's chest where it monitors cardiac performance in real-time and sends the data via HTEC's cloud-based platform to a patient's physician. The device is currently being used in clinical trials.

**Source:** STMicroelectronics Chip Guards Hearts in Wearable Cardiac Recorder from HTEC

<http://www.marketwatch.com/story/stmicroelectronics-chip-guards-hearts-in-wearable-cardiac-recorder-from-htec-2015-10-19>

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### 1.1.4 Ecole Nationale Supérieure des Mines

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**Technology name:** Direct patterning of organic conductors

**Description:** Researchers developed a fabrication process to integrate organic conductive polymers onto fabric, enabling high-quality ECG monitoring and heartbeat recording. The proposed method deposits electrodes onto a polyester wristband, using a hydrophobic, rubbery polydimethylsiloxane for the stencil. The material took ECG and heart rate recordings comparable to and in some cases better than medical-grade electrodes, recorded data continuously for 72 hours without irritation, and could still be reused after a month in ambient air.

**Source:** Accurate textile-based wearable sensor inspired by Japanese kimono dyeing method

<http://www.materials360online.com/newsDetails/59257;jsessionid=81F6233E6D5220224709C49CF1750A20>

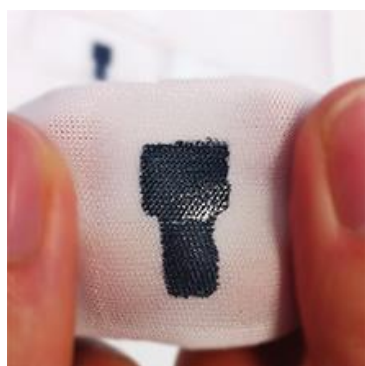


Photo source: <http://www.materials360online.com/newsDetails/59257;jsessionid=81F6233E6D5220224709C49CF1750A20>



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### 1.1.5 Jawbone

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**Technology name:** Ingestible sensors

**Description:** Jawbone is exploring ingestible sensors that, once swallowed, collect and analyze data in the bloodstream and can be safely passed through the system. Developers are considering both short- and longer-term ingestibles.

**Source:** Jawbones Ingestibles May Be The New Wearables

<http://www.itechpost.com/articles/16368/20151015/ingestibles-may-be-the-new-wearables.htm>

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### 1.1.6 Intelesens

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**Technology name:** Zensor

**Description:** The Zensor wearable measures a user's vital signs (respiration rate, heart rate, motion) and ECG data after they leave the hospital. The device received FDA 501(k) clearance. The battery-powered device clips to an adhesive, electrode-equipped patch that can be worn for up to seven days and transmits data to the cloud via Wi-Fi where it is accessible via a smart device. It can also be downloaded directly from the device via a USB cord.

**Source:** FDA clears Intelesens's zensor, a wearable vitals monitor

<http://mobihealthnews.com/47424/fda-clears-intelesenss-zensor-a-wearable-vitals-monitor/>

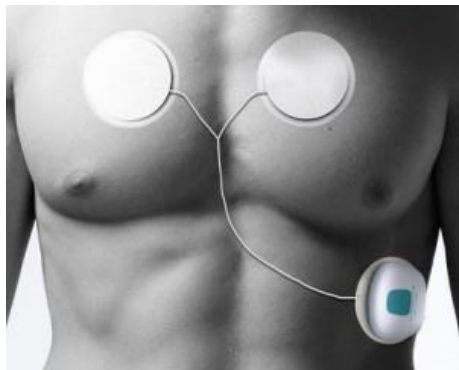


Photo source: <http://www.intelesens.com/inhomemonitoring/zensor.html>

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### 1.1.7 MC10

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**Technology name:** BioStampRC Wearable Sensing Platform

**Description:** The Air Force Research Laboratory conducted proof-of-concept testing of the BioStampRC Wearable Sensing Platform to track biomedical data. The platform comprises a non-intrusive, flexible patch that monitors performance, electrocardiography, and temperature, among other parameters and the results are sent via Bluetooth to a handheld platform. The device is proposed to have applications in monitoring wounded victims in the field and for wellness management of forces in the field. Proposed future developments include incorporating sweat and lactic acid measuring capabilities to monitor fatigue.



**Source:** Air Force successfully tests wearable biometric sensors

<https://gcn.com/articles/2015/10/06/biostampc.aspx>

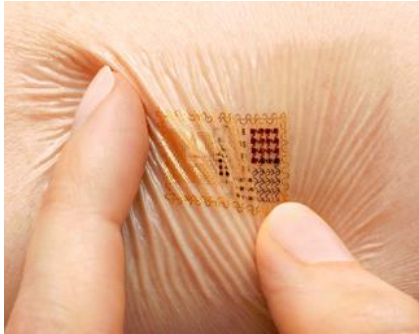


Photo source: <https://gcn.com/articles/2015/10/06/biostampc.aspx>

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## 1.1.8 Toyobo

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**Technology name:** Cocomi

**Description:** Cocomi is a thin (0.3 millimeter), stretchy, tape-like material that is applied to clothing to measure biometric information (myocardial electrical signals, sweat, respiration, etc.) that is then sent to a smart device. The material features electrodes and sensors that attach to clothing by thermo-compression bonding. The product provides indicators of heart and lung health.

**Source:** Tape-like material sticks to clothes and analyses your insides

<http://www.cnet.com/news/japanese-company-developing-tape-like/>

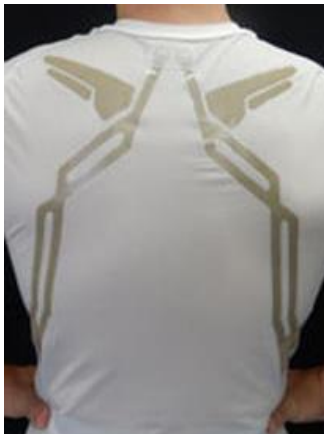


Photo source:

[http://www.toyobo.co.jp/news/2015/release\\_5866.html](http://www.toyobo.co.jp/news/2015/release_5866.html)[http://www.toyobo.co.jp/news/2015/release\\_5866.html](http://www.toyobo.co.jp/news/2015/release_5866.html)[http://www.toyobo.co.jp/news/2015/release\\_5866.html](http://www.toyobo.co.jp/news/2015/release_5866.html)

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## 1.1.9 University of Illinois Urbana-Champaign

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**Technology name:** Anansi

**Description:** Anansi is a wrist-worn device with integrated sensors that measure individual physiological parameters and that vibrate to notify a user when they surpass specific thresholds. Users push a button to indicate a non-emergency; otherwise the device sends alerts and the user's GPS location to emergency



services. Developers aim to enable the technology to monitor personalized parameters for a flight or fight response.

**Source: A Wearable That Can Sense When You're In An Emergency And Dial 911**

<http://chicagoinno.streetwise.co/2015/10/23/safety-device-wearable-anansi-will-call-911-based-on-fight-or-flight/>

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### 1.1.10 University of Illinois at Urbana-Champaign

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**Technology name:** Epidermal electronic sensor system

**Description:** The flexible skin-worn patch uses small, inexpensive heat sensors to noninvasively map blood flow beneath the skin's surface. Understanding the fluid dynamics of blood flow can help monitor skin health parameters. To monitor how the wearer's blood carries heat, the device heats the skin and temperature sensors around the heating element record the direction and amount of heat. The sensor monitors the flow of blood vessels in both large and small vessels beneath the skin, up to 2 millimeters deep. The adhesive patch is less sensitive to motion than typical blood-flow monitoring devices. The device is currently ready for use in a clinical setting. Developers hope to reconfigure the sensors and heating element to sense at greater depths.

**Source: New Wearable Device Can Measure Your Blood Flow**

<http://www.technologyreview.com/news/542931/new-wearable-device-can-measure-your-blood-flow/>

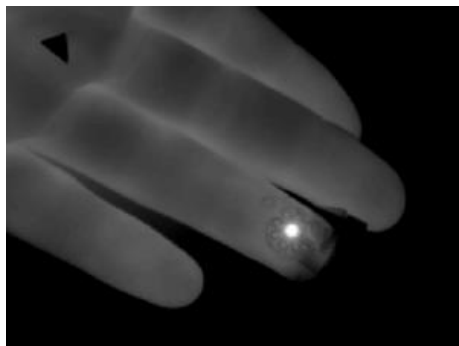


Photo source: <http://advances.sciencemag.org/content/1/9/e1500701>





## 2.0 DISPLAYS

### 2.1 Heads-up (on face or head)

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#### 2.1.1 3M

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**Technology name:** Speedglas Auto-Darkening Filter Kit 9100XXi

**Description:** The 9100XXi Auto-Darkening Filter Kit provides welders improved visibility in dark and light environments with optics that provide detail, contrast, and natural color as well as a crisper view of the welder's work. The device can be paired with a faceplate that features two pre-set welding modes selected via an external button on the helmet (the user does not have to remove their safety gloves or helmet) and the ability to automatically return to the most recently used settings.

**Source:** Auto-Darkening Filter promotes visibility for welders.

<http://news.thomasnet.com/fullstory/auto-darkening-filter-promotes-visibility-for-welders-20049910>



Photo source: <http://news.thomasnet.com/fullstory/auto-darkening-filter-promotes-visibility-for-welders-20049910>

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#### 2.1.2 Bay Innovation, Method

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**Technology name:** Vivi

**Description:** Vivi clips onto a headband, positions over one eye, and offers a minimalist approach to users by alerting them to only the most critical information, such as when there is a change in a patient's vital signs during surgery. It features a small, monochrome, 8-bit-style display that is configurable via a smartphone app to display specific information (breathing, heart rate, etc.). It can connect via Bluetooth to medical equipment. Users can swivel the Vivi out of their field of view without removing it.

**Source:** This HUD For Doctors Proves Less Is More For Future Wearables

<http://www.fastcodesign.com/3052529/innovation-by-design/this-hud-for-doctors-proves-less-is-more-for-future-wearables>



Photo source: <http://method.com/work/vivi>

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## 2.1.3 Google

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**Technology name:** Lightguide with multiple in-coupling holograms for head wearable display

**Description:** Google was approved for a patent for a wearable that can display holograms, superimposing images onto the user's actual worldview.

**Source:** Google Just Got a Patent for Adding Holograms to a Google-Glass-Type Headset  
<http://www.entrepreneur.com/article/251325>





## 3.0 POWER

### 3.1 Chargers

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#### 3.1.1 Ion Tech Wear

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**Technology name:** Ion Belt

**Description:** The Ion Belt has a lithium ion battery capable of holding enough power—3000 mAH—for approximately 1.5 charges of a mobile phone. It features Encapsulpak™ technology. The user can plug their device directly a discreet built-in USB port into the leather. Users can plug the buckle into a wall adapter or laptop to charge.

**Source:** Shark Tank's Most Successful Inventor Crowdfunding New Wearable That'll Ensure You Never Get Caught With Your Pants Down Again <http://www.prnewswire.com/news-releases/shark-tanks-most-successful-inventor-crowdfunding-new-wearable-thatll-ensure-you-never-get-caught-with-your-pants-down-again-538794851.html>

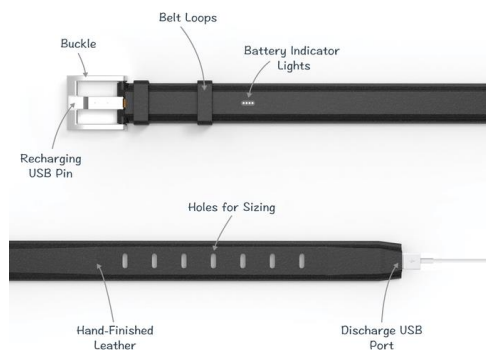


Photo source: <https://www.kickstarter.com/projects/iontechwear/the-ion-belt-sleek-safe-and-stylish-portable-charge>

### 3.2 Power supplies

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#### 3.2.1 LG Chem

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**Technology name:** Flexible batteries

**Description:** LG Chem developed a wristband-style, wire-type battery that can be folded in half as well as a hexagonal-shaped battery. The batteries reportedly offer double the typical smartwatch battery capacity.

**Source:** Samsung, LG tap battery biz for wearables <https://www.koreaobserver.com/samsung-lg-tap-battery-biz-for-wearables-54228/>



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### 3.2.2 Padre Electronics

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**Technology name:** PD250835 ultra-narrow lithium polymer battery

**Description:** Padre Electronic's launched an ultra-narrow (8-millimeter-wide) lithium polymer (lipo) rechargeable battery with a capacity of over 40 mAh. The narrowness is proposed to be beneficial for wearable devices, particularly wristbands. The battery is going into mass production. While this ultra-narrow battery is a step forward in design, developers are still exploring how to address the thickness added by the protection circuit module.

**Source:** NEW 8MM ULTRA NARROW LIPO BATTERY RELEASED BY PADRE TO WORK WITH WEARABLE DEVICES

<http://www.pressreleaserocket.net/new-8mm-ultra-narrow-lipo-battery-released-by-padre-to-work-with-wearable-devices/343782/>

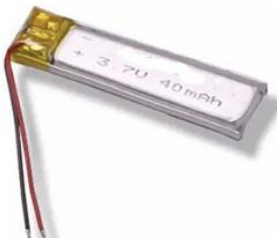


Photo source: <http://www.pdbattery.com/lithium-polymer-battery>

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### 3.2.3 Samsung SDI Co.

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**Technology name:** Flexible batteries

**Description:** Samsung created a stripe- and a band-style flexible battery for use in wearables. The stripe battery is 0.3 millimeters thin and made with fiber that allows for enhanced flexibility. The band battery is designed for use in smart watches, with a reported 50% increased capacity and the ability to withstand more than 50,000 bendings.

**Source:** Samsung, LG tap battery biz for wearables <https://www.koreaobserver.com/samsung-lg-tap-battery-biz-for-wearables-54228/>



Photo source: <http://www.engadget.com/2015/10/25/samsung-stripe-and-band-batteries/>



## 3.3 Power management

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### 3.3.1 Murata

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**Technology name:** UMAC

**Description:** UMAC is a high—energy-storage-capacity, cylinder-style, miniature device designed for wearables, digital pens, and power sensor nodes in wireless sensor networks. The technology offers high-energy storage, low internal resistance, flat voltage characteristics, extended cycle life, and fast charge/discharge rates, and it can withstand load fluctuations. It can serve as a secondary battery similar to a capacitor. Safety wise, its construction does not allow for thermal runaway, eliminating the threat of smoke/fire from a short circuit.

**Source:** Murata – New small energy device for wearables storage applications

<http://www.electropages.com/2015/10/murata-small-energy-device-wearables-storage-applications/>





## 4.0 COMMUNICATIONS

### 4.1 Hands-free operation

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#### 4.1.1 Apotact Labs

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**Technology name:** Gest

**Description:** Gest measures a user's movements, enabling them to type in the air or any surface. Gest is a hand-worn device that clips to a user's fingers, sans the thumb (it can infer the thumb's movement based on movement from the user's palm). The fingers' motions are measured by accelerometer, gyroscopes, and magnetometers in the main control unit in the strap. Its open Software Development Kit allows users to use gestures for a range of activities similar to a mouse, such as controlling desktop items. Users can also personalize gestures to control various functions. Developers anticipate applications in conjunction with smartphones and virtual reality goggles.

**Source:** Gest Is A Wearable, Keyboard-less Keyboard You Wear Like A Glove

<http://www.techtimes.com/articles/101121/20151029/gest-wearable-keyboard-less-wear-glove.htm>



Photo source: <https://www.kickstarter.com/projects/asdffilms/gest-work-with-your-hands>

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#### 4.1.2 Muv Interactive

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**Technology name:** Bird

**Description:** The Bird is a finger-worn device equipped with 10 sensors that allows users to interact with multiple surfaces and displays. It connects to a smart-device and offers remote touch, gesture control, and voice commands. It operates like a mouse with surfaces up to 100 feet away. It also offers multi-user capabilities such that up to 10 people can interact at the same time.

**Source:** This Wearable Wants To Deliver Your Powerpoint Presentations From Anywhere

<http://www.forbes.com/sites/jenniferelias/2015/10/12/this-wearable-wants-to-deliver-your-powerpoint-presentations-from-anywhere/>



Photo source: <http://www.forbes.com/sites/jenniferelias/2015/10/12/this-wearable-wants-to-deliver-your-powerpoint-presentations-from-anywhere/>

## 4.2 Integrated voice/data/video

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### 4.2.1 Mutualink

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**Technology name:** Wearable Smart Gateway™

**Description:** The Wearable Smart Gateway is a palm-sized communications and information sharing platform designed to bridge first responder's devices (wearable cameras, heart rate monitors, locator beacons, etc.) and securely transmit with command posts. The gateway is powered by the small, ultra-low power Intel® Edison™ module, which reduces response times. The Wearable Smart Gateway reduces constraints and increases efficiency of responders by connecting their devices and enabling real-time sharing of information over a secured wide-area networks. Data is transmitted to Mutualink's secured multimedia network, the Interoperable Response and Preparedness Platform, which allows sharing of information between hundreds of state and local responder agencies and organizations. The device is part of the Internet of Public Safety Things™ that Mutualink is leading to support interconnected technologies for first responders. The device is FirstNet-ready and has been used in New Jersey's FirstNet network.

**Source:** Mutualink Unveils World's First Wearable Gateway for First Responders Using Intel® Technology <http://www.businesswire.com/news/home/20151021005872/en/Mutualink-Unveils-World%E2%80%99s-Wearable-Gateway-Responders-Intel%C2%AE>



Photo source: <http://www.businesswire.com/news/home/20151021005872/en/Mutualink-Unveils-World%20%99s-Wearable-Gateway-Responders-Intel%C2%AE>







## 5.0 CAMERAS

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### 5.1.1 EE

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**Technology name:** 4GEE Capture Cam

**Description:** The 4GEE Capture Cam offers wearable 4G streaming camera capabilities and an 8 megapixel camera. The device features a 4G SIM card and can live stream 720p video via the Skeegle private sharing service. When equipped with 4GB storage, the device can record in 1080p high definition.

**Source:** EE launches world's first wearable 4G streaming camera

<http://www.irisht Examiner.com/technow/tech/ee-launches-worlds-first-wearable-4g-streaming-camera-361791.html>



Photo source: <http://www.irisht Examiner.com/technow/tech/ee-launches-worlds-first-wearable-4g-streaming-camera-361791.html>



# Exoskeletons



## 6.0 EXOSKELETONS

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### 6.1.1 Aalborg University

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**Technology name:** AXO Suit

**Description:** Researchers are developing an exoskeleton equipped with sensors that detect movement and trigger robotic support for the user. Electric motors provide 30-50% of the energy required to carry an activity in combination with a user's own muscle movement.

**Source: Portable exoskeleton to help keep elderly active**

<http://eandt.theiet.org/news/2015/oct/exoskeleton-for-elderly.cfm>



Photo source: [http:// www.gizmag.com/axo-suit-exoskeleton-seniors/39852/](http://www.gizmag.com/axo-suit-exoskeleton-seniors/39852/)

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### 6.1.2 Arizona State University

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**Technology name:** Jet Pack

**Description:** Jet Pack features two small air jets that strap to the user's back. It consumes 24 volts and 100 amps, giving the runner a push, up to a 30% augmentation but for only 4-6 minutes. It is one of the lab's two devices offering "metabolic augmentation" to overcome weight gain and improve performance.

**Source: Tinkerer's paradise: Tom Sugar's ASU lab is where exoskeletons come to life**

<https://asunow.asu.edu/20151002-tom-sugar-exoskeletons-lab>

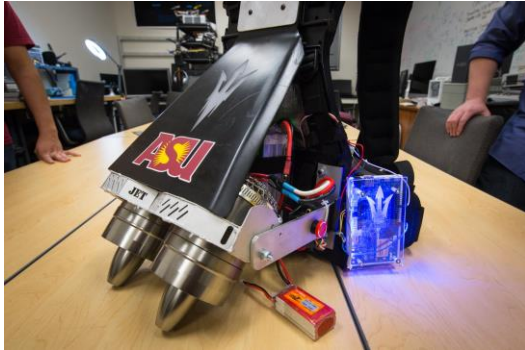


Photo source: <https://asunow.asu.edu/20151002-tom-sugar-exoskeletons-lab>

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## 6.1.3 Arizona State University

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**Technology name:** Air Legs

**Description:** Air Legs help carry the load for a user. The technology is powered by a high-pressure air tank that is charged externally and mounted to the system. The system pushes and pulls the user's upper legs, using a phase-controller to calculate timing to trigger the air tank. The technology demonstrated 10% metabolic augmentation.

**Source:** Tinkerer's paradise: Tom Sugar's ASU lab is where exoskeletons come to life  
<https://asunow.asu.edu/20151002-tom-sugar-exoskeletons-lab>

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## 6.1.4 Arizona State University

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**Technology Name:** Odyssey

**Description:** Odyssey is a spring-loaded, ankle-worn device designed to provide lower-leg amputees with an increased range of mobility and improved comfort compared to traditional prosthetics.

**Source:** Tinkerer's paradise: Tom Sugar's ASU lab is where exoskeletons come to life  
<https://asunow.asu.edu/20151002-tom-sugar-exoskeletons-lab>



Photo source: <https://asunow.asu.edu/20151002-tom-sugar-exoskeletons-lab>



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## 6.1.5 Arizona State University

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**Technology name:** Pogo Suit

**Description:** The Pogo Suit assists a user by oscillating the load, moving it in rhythm with the user's movement as opposed to the load moving as a response to the user's movement, thus saving the user energy.

**Source: Tinkerer's paradise: Tom Sugar's ASU lab is where exoskeletons come to life**  
<https://asunow.asu.edu/20151002-tom-sugar-exoskeletons-lab>

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## 6.1.6 North Carolina State University

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**Technology name:** Exoskeleton Simulator

**Description:** Researchers are developing a carbon-fiber exoskeleton simulator that can reduce the load to the user's muscles by up to 30%. The device weighs approximately one pound, can be used with any typical running shoe, and does not require a motor. It provides a small amount of support with each step, reducing the energy required by the user and helping them run or walk longer.

**Source: NC State projects adds bounce to your walk or run** <http://wncn.com/2015/10/06/nc-state-projects-adds-bounce-to-your-walk/>



Photo source: <https://www.youtube.com/watch?v=ePvxBq9gj-Q>



# Wearable computers



## 7.0 WEARABLE COMPUTERS

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### 7.1.1 Apple

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**Technology name:** Devices and methods for a ring computing device

**Description:** Apple has applied for a patent for a finger-worn device that uses voice, gesture, and touch controls to interact with larger computing devices such as an iPhone. The device will reportedly feature an onboard processor, microphone, multiple input/output components (touchpads, touch screens, etc.), and the ability to charge inductively. It is described as including a built-in accelerometer and gyroscope precise enough to accurately capture handwriting. It provides audio cues to a user as well as tactile response via its Taptic Engine. The device communicates with a paired device via Wi-Fi, cellular, Bluetooth, near-field communications, etc.

**Source:** Apple invents ring-style wearable device with voice control, haptics, cameras and more  
<http://appleinsider.com/articles/15/10/01/apple-invents-ring-style-wearable-device-with-voice-control-haptics-cameras-and-more>





## 8.0 OTHER

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### 8.1.1 16Lab

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**Technology name:** Ozon

**Description:** Ozon is a finger-worn, Bluetooth, gesture control device. Compared to previous models, it is 30% thinner and offers wireless charging. It features a small touchpad and allows a user to control devices using typical gestures (up down, swipe, etc.). The ring can be used as an electronic key, can pair with a smartphone to send alerts to the user, and can serve as an electronic wallet. In a demonstration, users manipulated objects on screen and controlled a virtual-reality view in a series of prototype apps.

**Source:** 16Lab shrinks its sensor-laden wearable computing ring, preps dev kit release

<http://www.pcworld.com/article/2989579/wearables/16lab-shrinks-wearable-computing-ring-will-sell-dev-kit-soon.html>

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### 8.1.2 ANTELOPE.CLUB

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**Technology name:** Antelope Series

**Description:** The Antelope Series is a training and performance tracking system using smart fabric with wiring and electrodes, a Bluetooth-controlled booster, and the Antelope steering app, which allows users to personalize training. The system utilizes Electrical Muscle Stimulation to activate muscle fibers and enhance a user's performance. Antelope offers five garments including the full-body Suit, Tank Top, Calf Guards, Wing (arm enhancements), and pelvic floor pants (Women's Dream).

**Source:** ANTELOPE.CLUB Brings Wearable Fitness Technology to the U.S.

<http://www.digitaljournal.com/pr/2722664#ixzz3qMFluILc>

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### 8.1.3 ARC Centre of Excellence for Electromaterials Science

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**Technology name:** Knitted polymeric composite fiber

**Description:** Researchers developed polymeric composite fibers to monitor movement and store energy. Researchers knitted together stretchable and conductive fibers that, when coupled with an electronic device, can transmit information about the user's movement. This is anticipated to have applications diagnostics, sports training, and rehabilitation. Researchers also braided the fibers, which gives the material energy storage capabilities.

**Source:** Knit it, braid it, turn it on and use it! (w/video) <http://www.nanowerk.com/nanotechnology-news/newsid=41575.php>

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### 8.1.4 Arizona State University

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**Technology name:** Cool Suit

**Description:** Cool Suit assists users in hot environments. The technology comprises a small refrigeration unit carried on the back of the user, where it circulates cool liquid across the upper body.

**Source: Tinkerer's paradise: Tom Sugar's ASU lab is where exoskeletons come to life**  
<https://asunow.asu.edu/20151002-tom-sugar-exoskeletons-lab>

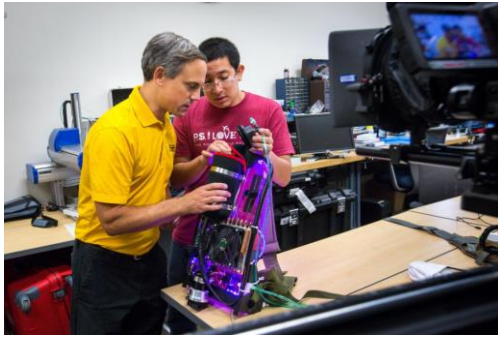


Photo source: <https://asunow.asu.edu/20151002-tom-sugar-exoskeletons-lab>

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### 8.1.5 iMerciv

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**Technology name:** BuzzClip

**Description:** BuzzClip is a discreet wearable designed to assist visually impaired users with haptic feedback. The clip-on device easily attaches to a user's clothing, where it detects and vibrates to alert users to obstacles in their surroundings (upper body and head level area). The device operates by sending and receiving sound waves then relaying that information to a user via "intuitive vibrations"—the frequency and intensity increases as obstacles come closer. It offers two detection ranges, 1 meter and 2 meters. It includes a 10-hour battery life and charges via a micro-USB cable.

**Source: Canadian Start-Up creates a 'Buzz' for the Blind with new Wearable Tech**  
<http://www.prnewswire.com/news-releases/canadian-start-up-creates-a-buzz-for-the-blind-with-new-wearable-tech-532638991.html>

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### 8.1.6 King Abdullah University of Science and Technology, University of Illinois at Urbana Champaign

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**Technology name:** Stretchable, far-field communication antenna

**Description:** Researchers are developing a thin-film, far-field communication antenna that can withstand flexing/stretching while maintaining its essential properties and operations (frequency, bandwidth, etc.). The device uses a metal-polymer bilayer that allows it to be worn on stretchable fabric and communicate up to 80 meters despite stretching, bending, and strain—reportedly up to 30% strain and through 2,000 stretching cycles. A polymer backing allows it to return to its original shape after manipulation. The

## Other

device can still operate on a single Wifi frequency while being stretched or bent. Researchers plan to integrate the stretchable antenna into a flexible and stretchable wearable sensor array.

**Source: A stretchable far-field communication antenna for wearable electronics**

<http://www.nanowerk.com/spotlight/spotid=41569.php>

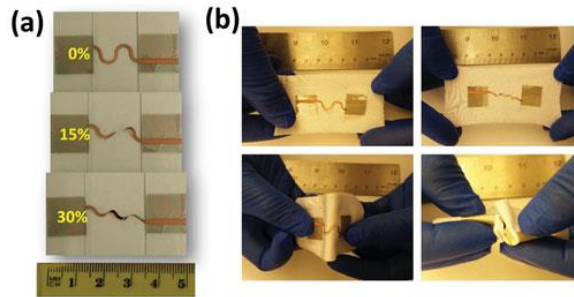


Photo source: <http://dx.doi.org/doi:10.1002/adfm.201503277>

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### 8.1.7 Mobetrics

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**Technology name:** Second Sight

**Description:** The Second Sight system uses Android and Google Glass with existing technology to give nuclear workers real-time measurements of their heart rate, ambient suit temperatures, and radiation dose. The device offers visual messaging, barcode scanning, and live image streaming to Google Glass. The device is intended to help workers make informed decisions about performance in what are often high-stress, radioactive environments.

**Source: Cumbrian firm developing unique wearable technology** <http://www.in-cumbria.com/Cumbrian-firm-developing-unique-wearable-technology--fd4d4869-c023-44c6-b456-a48638c264d0-ds>

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### 8.1.8 Parsons School of Design

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**Technology name:** KeyBod

**Description:** KeyBod is a semi-transparent sheath equipped with programmable keys on the arms, chest, and back of the shoulders. Pressing the different keys performs different functions. It can also recognize bad posture or ergonomics and alert the user by sending a message to the computer.

**Source: This Wearable Keyboard Makes You Move If You Want To Write An Email**

<http://www.fastcoexist.com/3051717/this-wearable-keyboard-makes-you-move-if-you-want-to-write-an-email>



Photo source: <http://nitchafa.me/keybod.html>

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### 8.1.9 Radiation Shield Technologies

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**Technology name:** Demron ICE

**Description:** The Demron ICE full-body suit offers chemical, biological, radiological, nuclear, and explosive threat protection. The technology's self-cooling fabric keeps harmful substances out while allowing internal heat to escape.

**Source:** Radiation Shield Technologies launches new protective suit

<http://bioprepwatch.com/stories/510645307-radiation-shield-technologies-launches-new-protective-suit>



Photo source: <http://www.radshield.com/Demron-RST.php>

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### 8.1.10 UL

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**Technology name:** Wearable compliance and security

**Description:** UL is exploring standardization of wearable compliance services, such as user privacy and how personal data is acquired and secured, particularly as majority of it is transmitted over wireless networks. UL proposes a certification approach such that products will be certified, marked, and publicly listed.

**Source:** UL creating standard for wearable privacy and security

<http://www.computerworld.com/article/2991331/security/ul-creating-standard-for-wearable-privacy-and-security.html>

# **Appendix A**

## **Technology Summary**

# Technology summary

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

Company	Technology	Description
<b>Sensor</b>		
<b>Physiological</b>		
Andre Bertram, Frank Nguyen (individuals)	<a href="#">HeartWatch</a>	Tracks a user's vital signs (blood pressure, heart rate, blood oxygen levels), can obtain ECG readings to help predict a heart attack, and calls for help in the case of an emergency.
Ecole Nationale Supérieure des Mines	<a href="#">Direct patterning of organic conductors</a>	Fabrication process to integrate organic conductive polymers onto fabric, enabling high-quality ECG monitoring and heartbeat recording.
GraphWear	<a href="#">SweatSmart</a>	Sweat patch offering a noninvasive approach to measure a user's sweat for lactic acid and glucose levels, and potentially uric acid, in sweat to help monitor performance and hydration.
HTEC	<a href="#">ECG recorder</a>	Wearable 3-lead, dry-electrode ECG monitor that provides continuous, remote cardiac monitoring.
Intelesens	<a href="#">Zensor</a>	Measures a user's vital signs (respiration rate, heart rate, motion) after they leave the hospital. Clips to an adhesive, electrode-equipped patch that can be worn for up to seven days and transmits data to the cloud via Wi-Fi where it is accessible via a smart device. It can also be downloaded directly from the device via a USB cord.
Jawbone	<a href="#">Ingestible sensors</a>	Ingestible sensors that, once swallowed, collect and analyze data in the bloodstream and can be safely passed through the system
MC10	<a href="#">BioStampRC Wearable Sensing Platform</a>	Comprises a non-intrusive, flexible patch that monitors performance, electrocardiography, and temperature, among other parameters and the results are sent via Bluetooth to a handheld platform.
Toyobo	<a href="#">Cocomi</a>	Thin, stretchy, tape-like material that is applied to clothing to measure biometric information (myocardial electrical signals, sweat, respiration, etc.) that is then sent to a smart device.
University of Illinois at Urbana-Champaign	<a href="#">Epidermal electronic sensor system</a>	Flexible, skin-worn patch that uses small, inexpensive heat sensors to noninvasively map blood flow beneath the skin's surface.
University of Illinois Urbana-Champaign	<a href="#">Anansi</a>	Wrist-worn device with integrated sensors that measure physiological parameters and that vibrates to notify a user when they surpass specific thresholds
<b>Displays</b>		
<b>Heads-Up</b>		
3M	<a href="#">Speedglas Auto-Darkening Filter Kit 9100XXi</a>	Provides welders improved visibility in dark and light environments with optics that provide detail, contrast, and natural color as well as a crisper view of the welder's work.
Bay Innovation, Method	<a href="#">Vivi</a>	Clips onto a headband, positions over one eye, and offers a minimalist approach to users by alerting them to provide only the most critical information. It features a small, monochrome, 8-bit-style display that is configurable via a smartphone app to display specific information (breathing, heart rate, etc.). It connects via Bluetooth to medical equipment.
Google	<a href="#">Lightguide with multiple in-coupling holograms for head wearable display</a>	Displays holograms, superimposing images onto the user's surroundings

## Technology summary

Power		
Chargers		
Ion Tech Wear	<a href="#">Ion Belt</a>	Has a lithium ion battery that can hold enough power—3000 mAH—for approximately 1.5 charges of a mobile phone. The leather belt has a discreet USB port to power a device, and the buckle can plug directly into a wall adapter or laptop to charge.
Power Supplies		
LG Chem	<a href="#">Flexible batteries</a>	A band-style, wire-type battery that can be folded in half as well as a hexagonal-shaped battery. The batteries reportedly offer double the typical smartwatch battery capacity.
Padre Electronics	<a href="#">PD250835 ultra-narrow lithium polymer battery</a>	Ultra-narrow (8-millimeter-wide) lithium polymer (lipo) rechargeable battery with a capacity of over 40 mAh.
Samsung SDI Co.	<a href="#">Flexible batteries</a>	Stripe- and a band-style flexible battery for use in wearables. The stripe battery is 0.3 millimeters thin and made with fiber that allows for enhanced flexibility. The band battery is designed for use in smart watches, with a reported 50% increased capacity and the ability to withstand more than 50,000 bendings.
Power Management		
Murata	<a href="#">UMAC</a>	High-energy-storage-capacity, cylinder-style, miniature device. Offers high-energy storage, low internal resistance, flat load characteristics, extended cycle life, and high charge/discharge rates, and it can withstand load fluctuations.
Communications		
Hands-Free		
Apotact Labs	<a href="#">Gest</a>	Hand-worn device that measures a user's movements, enabling them to type in the air or any surface. Its open Software Development Kit allows users to use gestures for a range of activities similar to a mouse controlling desktop items.
Muv Interactive	<a href="#">Bird</a>	Finger-worn device equipped with 10 sensors that allows users to interact with multiple surfaces and displays. Connects to a smart-device and offers remote touch, gesture control, and voice commands
Integrated voice/data/video		
Mutualink	<a href="#">Wearable Smart Gateway™</a>	Palm-sized communications and information sharing platform designed to bridge first responder's devices and securely transmit with command posts.
Cameras		
EE	<a href="#">4GEE Capture Cam</a>	4G streaming capabilities with an 8 megapixel camera. Features a 4G SIM card and can live stream 720p video via the Skeegle private sharing service. When equipped with 4GB storage, the device can record in 1080p high definition.
Exoskeletons		
Aalborg University	<a href="#">AXO Suit</a>	Exoskeleton equipped with sensors that detect movement and trigger robotic support for the user. Electric motors provide 30-50% of the energy required to carry an activity in combination with a user's own muscle movement.
Arizona State University	<a href="#">Jet Pack</a>	Features two small air jets that strap to the user's back. Consumes 24 volts and 100 amps, giving the runner a push, up to a 30% augmentation but at only 4-6 minutes.
Arizona State University	<a href="#">Air Legs</a>	Powered by a high-pressure air tank charged externally and mounted to the system. The system pushes and pulls the user's upper legs using a phase-controller to calculate timing to trigger the air tank.
Arizona State University	<a href="#">Pogo Suit</a>	Assists a user by oscillating the load, moving it in rhythm with the user's movement as opposed to in response to the user's movements, thus saving the user energy.



## Technology summary

Arizona State University	<a href="#">Odyssey</a>	Spring-loaded, ankle-worn device designed to provide lower-leg amputees with an increased range of mobility and improved comfort.
North Carolina State University	<a href="#">Exoskeleton Simulator</a>	Carbon-fiber exoskeleton simulator that can reduce the load to the user's muscles by up to 30%. The device weighs approximately one pound, can be used with any typical running shoe, and does not require a motor
<b>Wearable Computers</b>		
Apple	<a href="#">ring computing device</a>	Finger-worn device that uses voice, gesture, and touch controls to interact with computing devices such as an iPhone.
<b>Other</b>		
16Lab	<a href="#">Ozon</a>	Finger-worn, Bluetooth, gesture control device that is 30% thinner and offers wireless charging compared to previous models.
Antelope.Club	<a href="#">Antelope Series</a>	Training and performance tracking system using smart fabric with wiring and electrodes, a Bluetooth-controlled booster, and the Antelope steering app, which allows users to personalize training.
ARC Centre of Excellence for Electromaterials Science	<a href="#">Knitted polymer composite fiber</a>	Stretchable, conductive fibers that, when woven together, have the capability to monitor movement and store energy.
Arizona State University	<a href="#">Cool Suit</a>	Assists users in hot environments. Comprises a small refrigeration unit carried on the back of the user, where it circulates cool liquid across the upper body.
iMerciv	<a href="#">BuzzClip</a>	discreet wearable designed to assist visually impaired users with haptic feedback. The clip-on device easily attaches to a user's clothing, where it detects and vibrates to alert users to obstacles in their surroundings.
King Abdullah University of Science and Technology, University of Illinois at Urbana Champaign	<a href="#">Stretchable, far-field communication antenna</a>	Thin-film, far-field communication antenna that can withstand flexing/stretching while maintaining its essential properties and operations.
Mobetrics	<a href="#">Second Sight</a>	Uses Android and Google Glass with existing technology to give nuclear workers real-time measurements of their heart rate, ambient suit temperatures, and radiation dose
Parsons School of Design	<a href="#">KeyBod</a>	Semi-transparent sheath equipped with programmable keys on the arms, chest, and back of the shoulders. Pressing the keys performs different functions.
Radiation Shield Technologies	<a href="#">Demron ICE</a>	Full-body suit offers chemical, biological, radiological, nuclear, and explosive threat protection. The technology's self-cooling fabric keeps harmful substances out while allowing internal heat to escape.
UL	<a href="#">Wearable compliance and security</a>	Standardization of wearable compliance services, such as user privacy, and how personal data is acquired and secured, particularly as majority of it is transmitted over wireless networks. UL proposes a certification approach such that products will be certified, marked, and publicly listed.







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