

# Wearable Robotics Landscape and Opportunities

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## *Defense Trends & Outlook*

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[www.wearablerobotics.com](http://www.wearablerobotics.com)

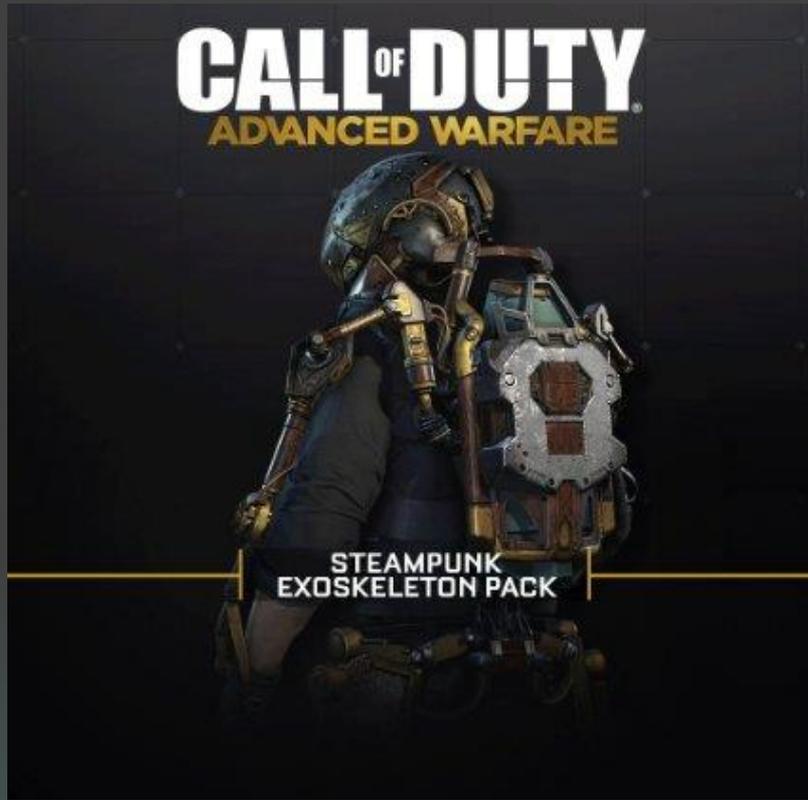
*Help shape a global future leveraging technology in a purposeful and synergetic fashion to **improve quality of life** and accelerate the advent of **transformative human capabilities**.*

# Fueling the Growth

- Desire to retain advantage over other militaries and reduce long-term costs of injury
- Changing demographics globally with long-lived populations
- Foundational technology enablers are available.
- Increasing activity and funding especially in Europe and Asia.
- Public curiosity and comfort with wearable technology

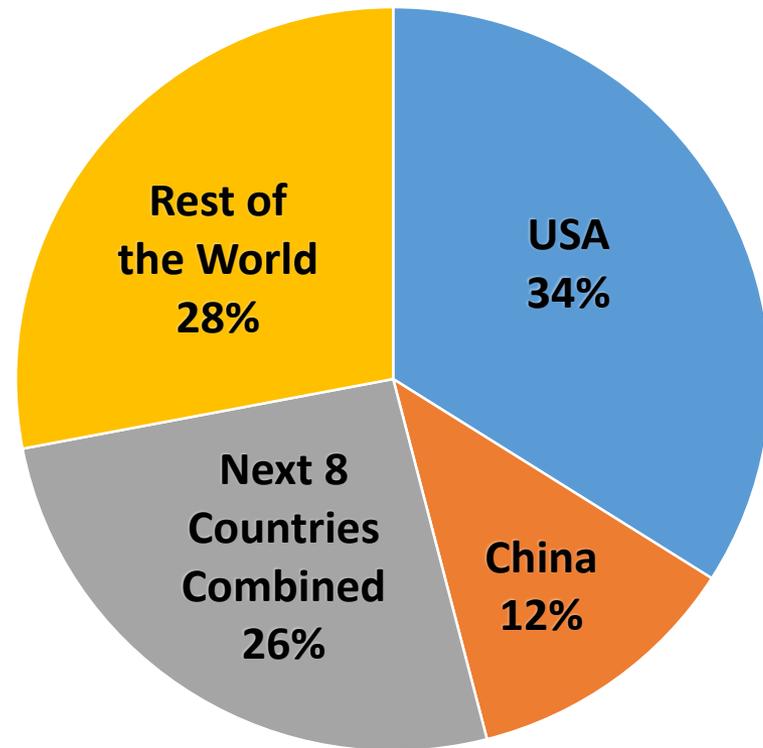


# Fueling the Growth



# Global Share of Defense Spending in 2014

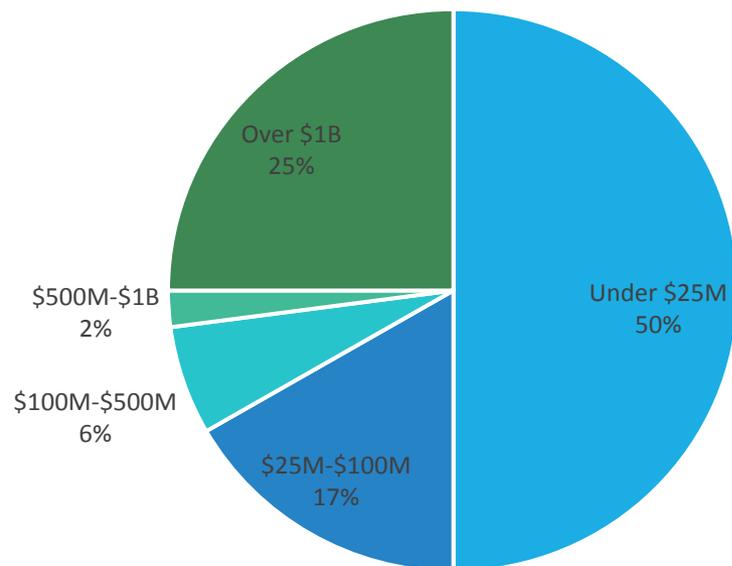
World Ranking 2014	Country	% of World Defense Outlays
1	USA	33.9%
2	China	12.0%
3	Russia	4.7%
4	Saudi Arabia	4.5%
5	France	3.5%
6	UK	3.4%
7	India	2.8%
8	Germany	2.6%
9	Japan	2.5%
10	Korea	2.0%



# Snap Shot of 48 Companies

- Half are still in the start-up mode with valuations that are less than \$25M.
- One-quarter are large global companies such as Daewoo and Lockheed-Martin, who have made their names in other business lines and are interested in getting into the exo-skeleton market.
- Many of the remaining quarter started as small firms spun out of research or university organizations that were bought-up by larger companies.

Exo-Companies by Size

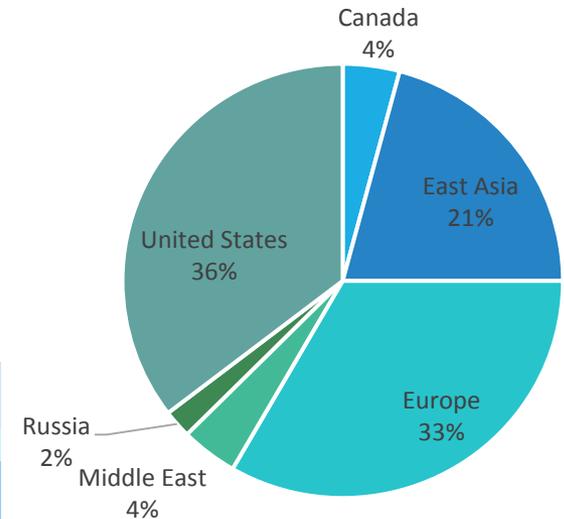


# Snap Shot of 48 Companies

<b>Cyberdyne</b>	Japan	East Asia
<b>DSME Daewoo</b>	South Korea	East Asia
<b>Panasonic</b>		
<b>Activelink</b>	Japan	East Asia
<b>Samsung</b>	South Korea	East Asia
<b>Kawasaki</b>	Japan	East Asia
<b>Toyota</b>	Japan	East Asia
<b>Yaskawa Electric</b>	Japan	East Asia
<b>Honda</b>	Japan	East Asia
<b>Innophys</b>	Japan	East Asia
<b>Hexar Systems</b>	South Korea	East Asia
<b>Rex Bionics</b>	New Zealand	East Asia
<b>Ossur</b>	Iceland	Europe
<b>Endolite</b>	England	Europe
<b>Hocoma</b>	Switzerland	Europe
<b>otto Bock</b>	Austria	Europe
<b>Festo</b>	Germany	Europe
<b>BAE Systems</b>	England	Europe
<b>RB3D</b>	France	Europe
<b>Againer</b>	Latvia	Europe
<b>AxoSuit</b>	Romania	Europe
<b>Kinetek - Wearable Robotics</b>	Italy	Europe
<b>Kinetic</b>		
<b>Innovations Ltd</b>	United Kingdom	Europe
<b>Marsi Bionics</b>	Spain	Europe
<b>Noonee</b>	Switzerland	Europe
<b>Technaid S.L.</b>	Spain	Europe
<b>Armon Products</b>	Netherlands	Europe
<b>Mawashi</b>	Montreal	Canada
<b>B-temia</b>	Quebec	Canada

<b>ReWalk</b>	Israel	Middle East
<b>Bama Teknoloji</b>	Turkey	Middle East
<b>ExoAtlet</b>	Moscow	Russia
<b>VQ Orthocare</b>	California	United States
<b>AlterG</b>	California	United States
<b>Sarcos</b>	Utah	United States
<b>IHMC</b>	Florida	United States
<b>CyberGlove Systems</b>	California	United States
<b>Equipois</b>	New Hampshire	United States
<b>Revision Military</b>	Vermont	United States
<b>Parker Hannefin</b>	Ohio	United States
<b>Lockheed Martin</b>	Maryland	United States
<b>Ekso Bionics</b>	California	United States
<b>Interactive Motion Technologies</b>	Massachusetts	United States
<b>Biom</b>	Massachusetts	United States
<b>Myomo</b>	Massachusetts	United States
<b>StrongArm Tech</b>	New York	United States
<b>Us Bionics</b>	California	United States
<b>OtherLabs</b>	California	United States
<b>SpringActive</b>	Arizona	United States

Exo-Companies by Region





- United States: emerging from research centers aligned with universities and from engineers in the industry deciding to step-out on their own.
- Europe: similar trend.
- East Asia: illustrates a very different trend with the majority of the action occurring in old-line, well-capitalized industry giants.
- China: ?

# Functional Landscape

## ➤ Return function

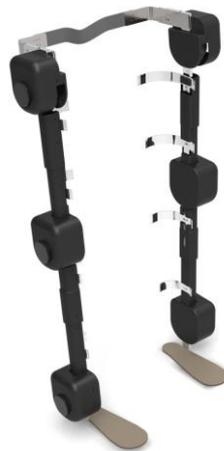
- Spinal cord injury
- Rehabilitation
- Elderly

## ➤ Enhance function

- Manufacturing
- Construction
- Defense and Emergency Responders

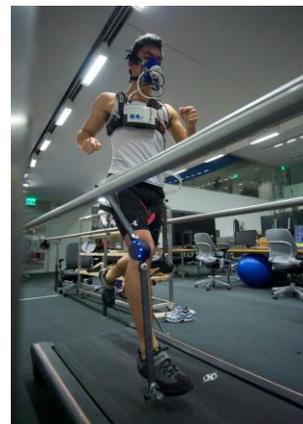
## ➤ Enhance Quality of Life

- Recreation



EXO-H2  
Technaid  
Spain

POWER LOADER  
Light  
Panasonic  
Activelink  
Japan



Clutch-Spring  
Knee for Running  
MIT, USA

# Defense



SARCOS, XOS-2, USA



Human Universal Load Carrier, USA



Google, USA



AirLegs Exoskeleton, USA



Harvard/Wyss, USA



Powered Exos, China

## Component Classification

### User Input

Touch: touchscreen, pressure sensor, rocker-switch  
Sound: voice recognition, sub-threshold  
Gestures: accelerometer, optical tracking  
Brain Activity: EEG

### User Output

Haptics: vibration, device-based, surface coverage  
Sound: speaker, earpiece  
Display: OLED, LED, e-paper, prism, projection, see-through, quantum dots



### Computing

Hardware: processor, data storage  
Software: apps, artificial intelligence, local vs remote (cloud)

### Sensing

Environment: Video imaging, geolocation, bio-chemical detection, velocity, elevation, temperature, wind, electrical field  
Soldier: Heart rate, blood O<sub>2</sub>/CO<sub>2</sub>, ECG, galvanic sweat response, respiration, EEG, temperature  
Interactive sensors: sound, motion, force

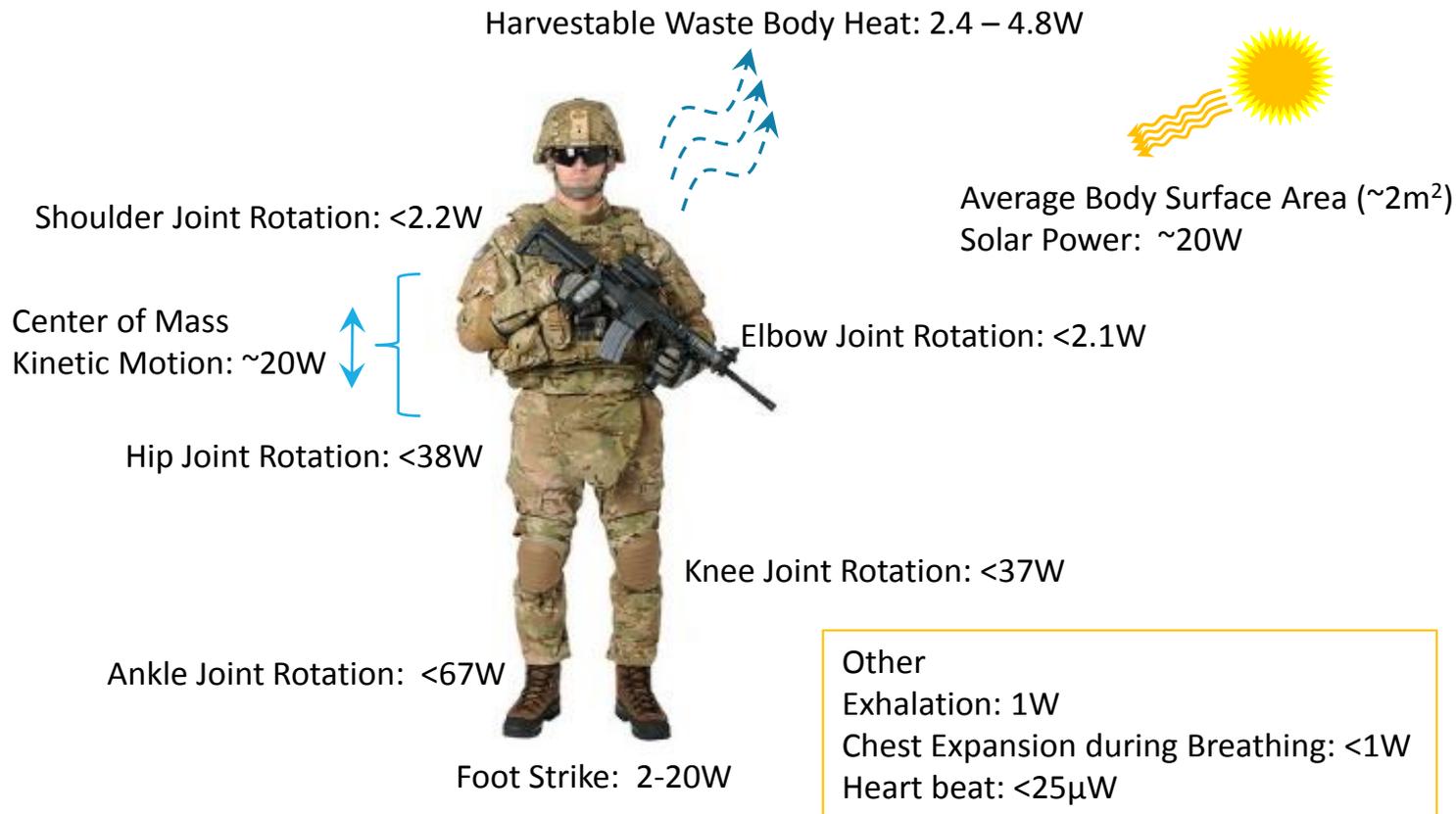
### Communications

Standards: WiFi, 3G/4GLTE, Near-Field Communications (NFC), Bluetooth, Hard-wired  
Infrastructure: Internet, intranet, device-to-device, vehicle

### Power

Storage: Batteries, super-capacitance, fuel cells  
Harvesting: thermal, solar, piezo-electric, radio frequencies  
Charging: wired or wireless

# Energy Harvesting Sources Max Theoretical Limits



# Opportunities

## Regional diversity creates opportunities for overseas collaboration

- Asia – large corporation sponsored research and development
  - Productivity focused
- Europe – start-ups emerging from academic research
  - Government-Academia-Industry collaboration
  - Productivity and Growth focused
- USA – starts-ups emerging from academic research
  - Strong angel/venture/growth capitol
  - Growth focused in manufacturing and health industries
  - Strong R&D support by Dept of Defense for defense-related uses

## Functional diversity leads to excellent Dual-Use opportunities

- Spinal cord injury – leaders emerging, convergence
- **Defense – Supporting R&D, awaiting commercial off the shelf**
- Assistive/Elderly – need is increasing, opportunities exist
- Industrial – most promising near term opportunities
- Recreational – divergence, hyper-growth potential

- Challenges: High SWaP-C for full load-path-to-ground systems.
  
- The need for wearable robotic technology is growing.
  
- Much of the current innovation is happening with unknown inventors and small businesses across the globe.
  
- There is both regional and functional diversity in the market.
  
- WearRA can assist inventors and small businesses explore new opportunities and support their success. We are also connecting gov't need with industry leaders.
  
- Visit [www.wearablerobotics.com](http://www.wearablerobotics.com) and join us at WearRAcon16, Feb 2016, Phoenix, Arizona.
  - Leaders of industry will attend
  - US Dept of Commerce NIST sponsored “Standards and Test Methods” workshop

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