Wearable Robotics/Exoskeleton/Augmentation Definitions and Taxonomy

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Integrated Capability Enhancement Branch

Human Research and Engineering Directorate

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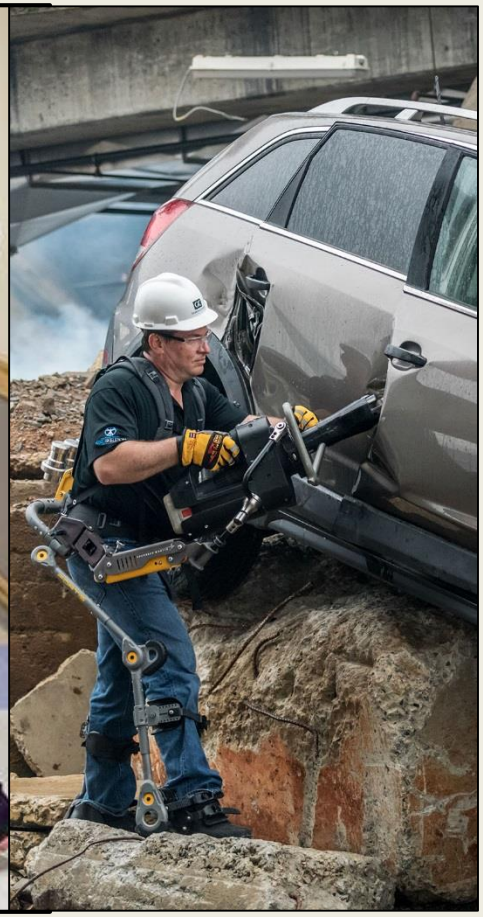
Varied Applications

Military | Industry | Medical | First Responders



Survey Questions

1. I would categorize myself as being interested in Standards and Testing for wearable robotics from the (circle one)

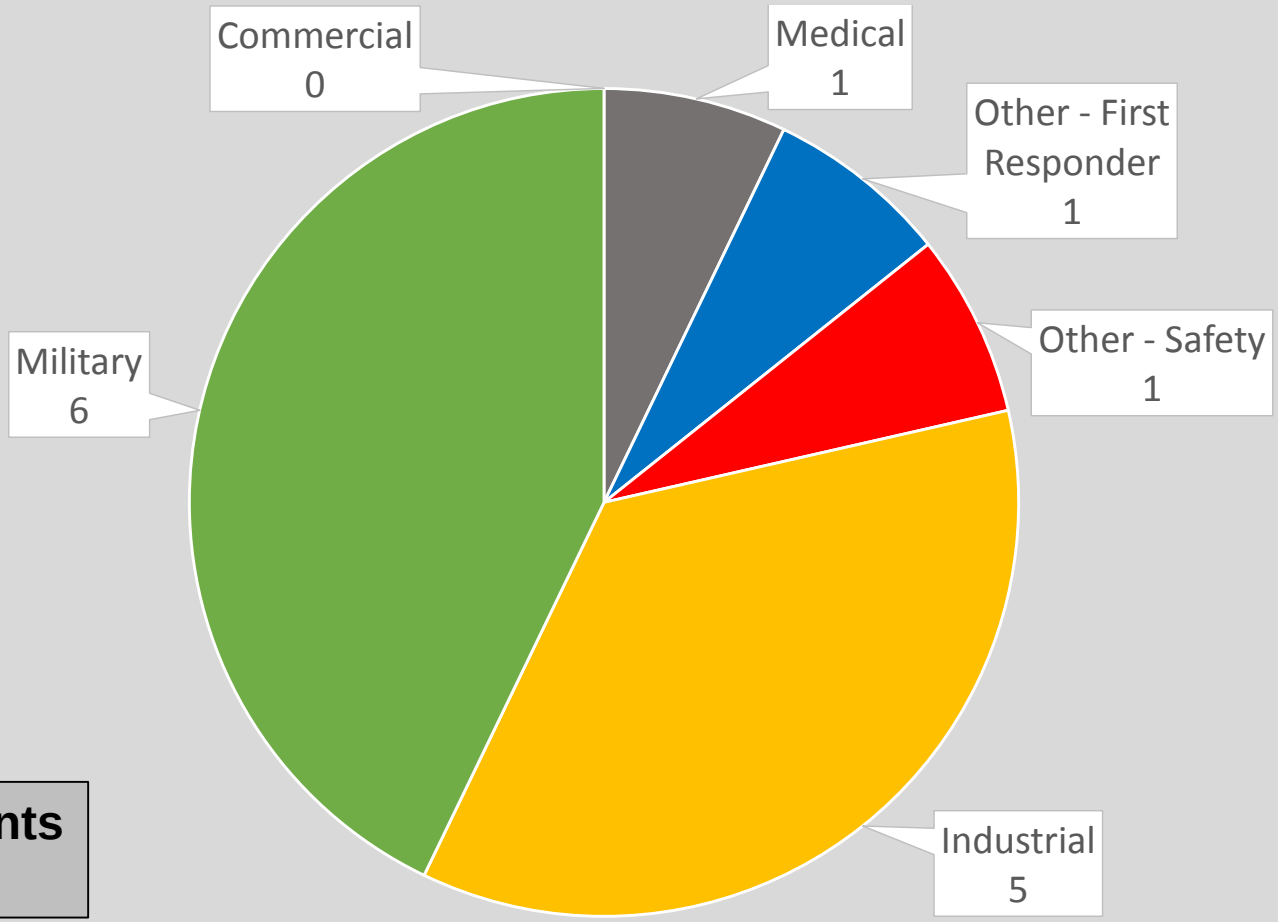
   medical / military / industrial / commercial point of view.

2. I am primarily involved in the (circle one) development / assessment / consumer aspect of wearable robotics.
3. I would define 'Wearable Robotics' as….
4. I would define 'Augmentation System' as….
5. What is not included in Wearable Robotics?
6. What is not included in an Augmentation System?

Survey completed at 23 August 2016

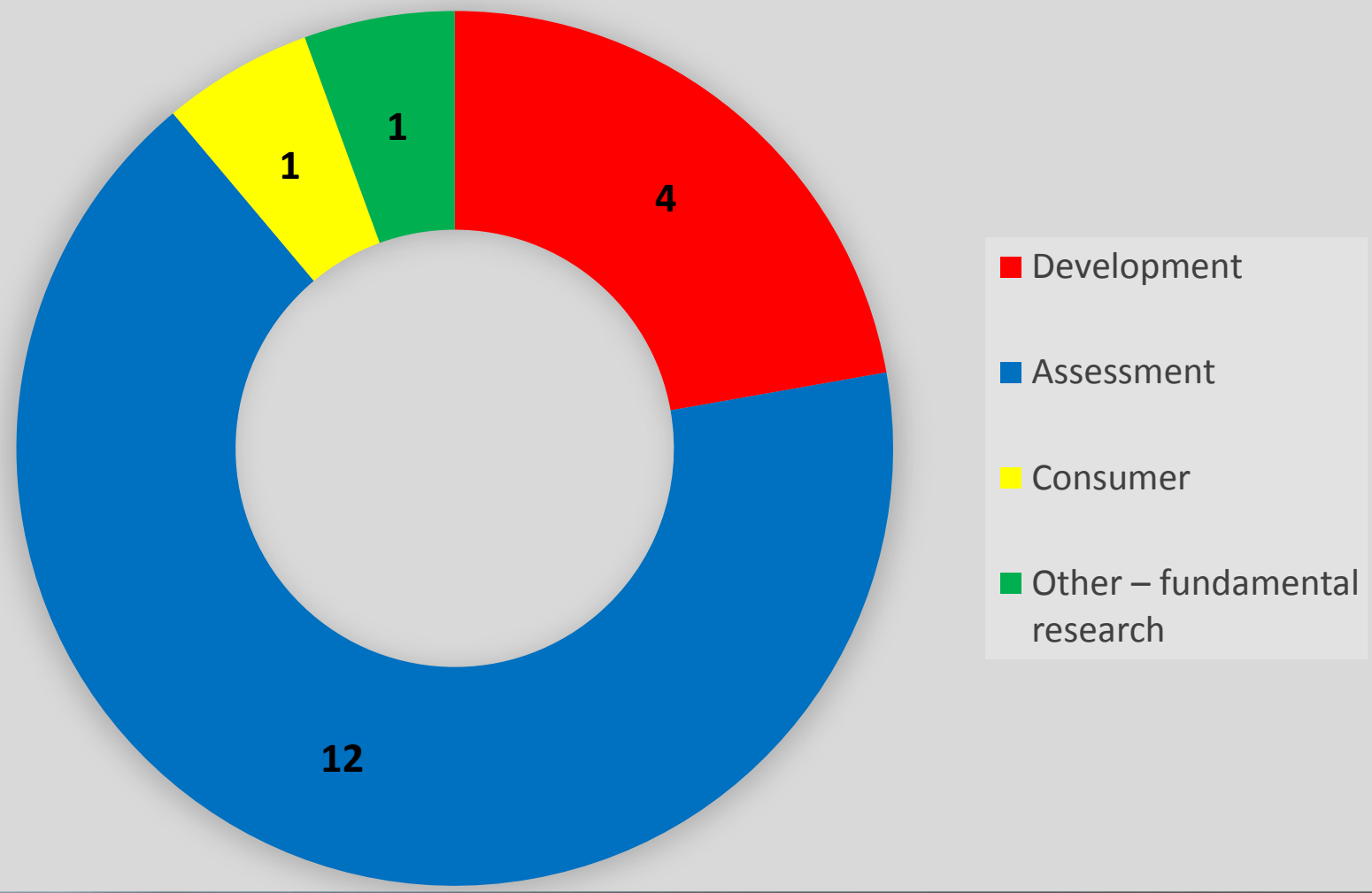
Human Worn Robotics / Wearable Performance Augmentation Standards and Test Methods Meeting

1. I would categorize myself as being interested in Standards and Testing for wearable robotics from the (circle one) <u>medical / military / industrial / commercial / other</u> point of view.



~15 respondents total

2. I am primarily involved in the (circle one) development / assessment / consumer aspect of wearable robotics.



3. I would define 'Wearable Robotics' as….

Example responses:

- "A body worn device that is powered and provides support and power/torque to a body part (arm, leg, lower extremities) to assist movement or aid in the user's ability to perform a given task."
- "Any system that augments the human capability."
- "Any human worn technology that is powered and/or transfers loads/forces to the ground. May be powered with electrical, pneumatic, hydraulic, spring, stored energy source, and with or without feedback control."
- "Mechanical systems worn on the body for the purpose of improving/maintaining the individual's ability to perform required task (thought: does 'robotic' imply an active system requiring some sort of computation/power?)"
- "Technology worn on the body that restores or enhances the biomechanical aspects of the person."

3. I would define 'Wearable Robotics' as….

Frequency of Use

8	7	6	5	4	3	2	
human	**powered**	**perform**	**wearable**	**robotic**	capabilities	situational	control
	system	**tasks**	**user**		augmentation	assistance	provide
	worn	**robot**	**ISO**		considered	mechanical	devices
		body			mechanical	physically	assist
					definition	electrical	robots
					physical	assistant	animal
					provides	cognitive	one
					robotics	awareness	arm
					without	required	may
					ability	autonomy	normal
					device	movement	
					person	intended	
					task	consider	
						systems	
						programmable	

4. I would define 'Augmentation System' as….

- "Assistance or enhancement in the performance or a given task. Ability to perform a task better, longer, or complete a task you could previously not do but can now do."
- "Helps the user exceed 'normal' capabilities"
- "Taking a current capability and adding technology that gives the individual an increase to that capability"
- "Any system that enhances (augments) human performance (Physical strength, endurance, sensory, cognitive)"
- "Supplementing or improving functionality or capability."
- "Powered and unpowered devices that can assist in performance of normal activities"
- "The addition of technology or devices to the human body with the goal of biomechanical improvement"
- "Enhancement of someone's inherent capability or return them to normal performance from a degraded state."

4. I would define 'Augmentation' as….

Frequency of Use			
5	4	3	2
performance	technology	normal	supplementing
capability	human		capabilities
task			augmentation
			enhancement
			previously
			devices
			system
			making

5. What is not included in Wearable Robotics?

- Completely autonomous systems
- Purely passive devices, no power required and no ‘smart’ features
- Basically nothing
- Artificial intelligence, learning systems that take feedback
- UAVs, UGVs, robots or robotics independent of the body (non-attached), technology to enhance solely vision and hearing
- Implantables
- Devices only worn on body for transportation and/or do not interact with the host. e.g. man-portable UAVs are NOT "wearable robotics".
- Passive system without programmable, controlled, powered assistance input to the musculoskeletal system, would not be wearable “robotics”.
- Anything worn by a person, not powered to enhance performance
- Mech systems that are more akin to a human in a robot vs. a wearable system
- Collaborative robots (e.g., robots working with humans but not fixture to humans)
- Systems that rely primarily on wheels for transport
- Technology that enhances performance but doesn’t intimately interact with person

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Common Ideas

- Unpowered
- Unattached to a person
- Transportation

6. What is not included in an Augmentation System?

- Pharmaceuticals (augmentation systems are externally applied mechanical/electrical assist devices)
- Anything that does not improve some aspect of a person's, system's, or component's performance
- Something that does not improve capabilities.
- Nothing
- External systems/devices that perform functions not under direct human control
- Soft vs hard robotics technology. Pneumatic system
- Handheld tools
- Pharmaceuticals
- Devices which do not provide additional capability to an existing feature set.
- Def of augmentation system should exclude technologies that are not self-contained with respect to the user. "Wearable" may be synonymous with "self-contained"

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Common Ideas

- Pharmaceuticals
- Should improve a capability/performance

Other Terms

Based on the survey responses, several more terms emerged that likely need to be defined:

- Passive
- Active
- Pseudo passive
- Pseudo active
- Exoskeleton
- Robot
- Wearable robot
- Medical exoskeleton
- Augmentation
- Performance
- Resiliency
- Performance enhancement
- Collaborative robots

Others?

Variety of Systems


SARCOS, XOS-2, USA


Human Universal Load Carrier, USA


Google, USA


20 Knots Plus, USA


Powered Exos, China


AirLegs Exoskeleton, USA


Mawashi, Canada


Harvard/Wyss, USA


Revision, Canada


Otherlabs, USA

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