

01001100 01000101 01000111 01000001 01000011 01011001 00100000 01000011 01001100 01000101 01000001 01001110 01010101 01010000

$$R(t) = R_0 e^{-\lambda t}$$

$$A_t = A_0 e^{-\lambda t}$$

$$N_t = N_0 e^{-\lambda t}$$

$$I_x = I_0 e^{-\lambda x}$$

$$A = \lambda N$$

$$D = \Gamma A / d^2$$

$$t_{(1/2)} = \tau \ln(2)$$

$6.022 \times 10^{23}$

3.14159

0.66274

2.71828

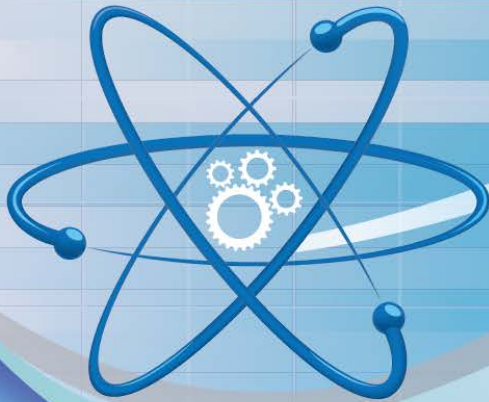
1.41421

0.57721

1.61803

0.66016

U.S. Department of Energy  
Office of Environmental Management



**Office of  
Technology Development**

innovation  technology

# Worker-Wearable, Worker-Attachable Industrial Robotic Devices

## Exoskeleton Technical Interchange Meeting

### Breakout Session Overview

Crystal Gateway Marriott, 1700 Jefferson Davis Hwy, Arlington, VA 22202

June 28 and 29, 2017

# Purpose of Breakout Sessions

- ❖ Breakouts will allow us to dive deeper into specific areas and engage the broader group of meeting attendees
- ❖ Facilitators will lead discussions on these two questions related to the assigned topic:
  - What needs to happen to allow exoskeletons/wearable robotics to be fully integrated into industrial settings?
  - What next steps can we take to help address the needs identified in the first question?
- ❖ Each breakout will assign someone to give a brief report to the full group tomorrow morning

- ❖ Facilitators: Bill Billotte and Roger Bostelman, National Institute of Standards and Technology (NIST)
- ❖ Breakout description:
  - Exoskeleton developers have struggled to design and execute specific experiments to determine the efficacy of their devices in realistic environments. For example, if a wearable system reduces the load on joints but increases the metabolic cost of the user, how do we know if that is a net win for the workers? There is a need to identify and standardize test methods and metrics that are relevant to the end application. Consistent and realistic control conditions also need to be generated. This session will discuss these challenges.

- ❖ Facilitators: Brian Lowe and Tom McDowell, National Institute for Occupational Safety and Health (NIOSH)
- ❖ Breakout description:
  - For an industrial exoskeleton system to be useful, it must reduce the forces acting on the body such that the risks of injuries are reduced, and be practical and safe to use. While these systems provide specific benefits to the user, they may also create other challenges. For instance, increasing the user's time on task may increase exposures to other physical agents (respiratory, noise, hand-transmitted vibration, and transference of load to other muscle groups). This session will discuss ergonomic considerations of exoskeletons as a control technology to prevent workplace fatigue and injury and the ergonomic effects of exoskeletons on users.

- ❖ Facilitators: Jason Wheeler and Philip Heermann, Sandia National Laboratories (SNL)
- ❖ Breakout Description:
  - Workers come in all shapes and sizes. Exoskeletons must be designed to comfortably accommodate this variability. The interfaces to the person are critical for comfort and function of the device. As industrial exoskeletons enter the marketplace, how can design and manufacturing efforts ensure the devices fit a high percentage of the workforce comfortably? What are the tradeoffs between adjustability and multiple sizes? Are the conventional size charts for clothing/apparel useful for exoskeletons? What issues exist for exoskeletons that are worn outside of clothes or PPE compared to those worn underneath clothes/PPE. What are the donning and doffing issues, particularly donning for first responders and doffing for emergency evacuations or personal medical emergencies?

- ❖ Facilitators: Richard Minichan and Eric Krikku, Savannah River National Laboratory (SRNL)
- ❖ Breakout Description:
  - As exoskeletons begin to permeate industrial environments, care and thought must be given to risks, liabilities and regulations around their use. It is not yet clear what role the government, insurance companies, unions, and employers play in this process. How is fitness-for-service assessed? What are the requirements for basic knowledge, proficiency, and refresher training established? Should the use of exoskeletons be a personal choice? Today's wearable technologies are now equipped with activity/fitness trackers for monitoring (tracking) physiological parameters such as heartbeat, calorie consumption, heartbeat, core body temperature, and muscle motion. Is it fair or reasonable to compare such metrics of a worker that is 25 years old with that of a worker that is 50 years old wearing? This session will discuss the risks and regulatory challenges of exoskeletons and potential roles of the various stakeholders.