NIOSH'S RESPONSE TO INCREASED USE AND COMPLEXITY OF ROBOTS

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69th Meeting, NIOSH Board of Scientific Counselors
September 26, 2017

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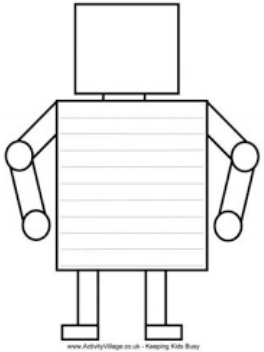
PRESENTATION OUTLINE



- Issue
- Virtual center
- What we have done and are planning
- Questions for the BSC

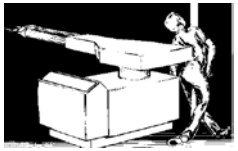
ISSUE: INCREASED USE AND COMPLEXITY OF ROBOTS

TRADITIONAL ROBOTS

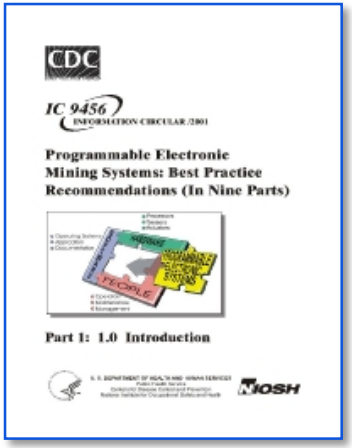
- Decades of experience
- Established safety measures that keep human workers separate from robots

LONGSTANDING GUIDANCE ON WORKING SAFELY WITH ROBOTS

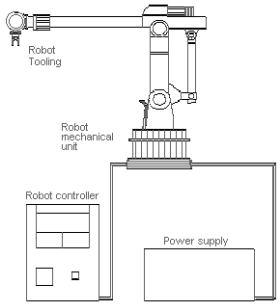
Preventing the Injury of Workers by Robots, NIOSH Pub. No. 85-103



Safe Maintenance Guidelines for Robotic Workstations, NIOSH Pub. No. 88-108



OSHA Instructional Manual, Chapter 4: Industrial Robots and Robot System Safety

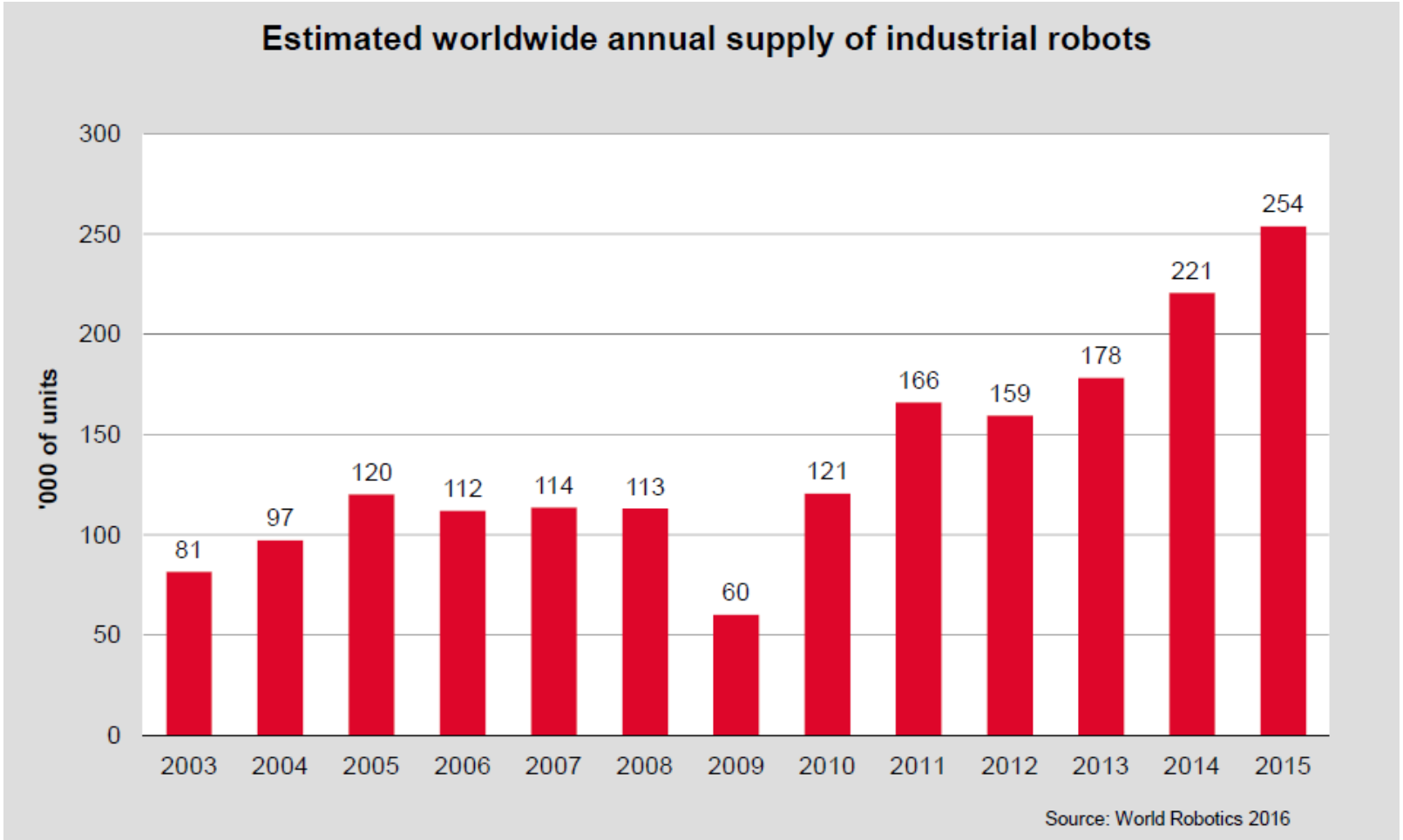


1740. Robots and Robotic Equipment

ROBOT RELATED DEATHS AND SERIOUS INJURIES

- Keyword searches to identify cases
- 61 robot-related deaths, 1992-2015, CFOI*
- OSHA and NIOSH investigations suggest injuries result from failure to follow established safety measures

*Unpublished analyses by NIOSH. Through a MOU with BLS, NIOSH receives Census of Fatal Occupational Injury (CFOI) research files with restricted access requirements. Views expressed herein to not necessarily reflect the views of BLS.



Source: International Federation of Robotics, World Robotics 2016 Industrial Robots
http://www.ifr.org/industrial-robots/statistics/

ROBOT GROWTH PROJECTIONS, 2016-2019

- 12% annual growth
- Breakthrough in human robot collaboration
- Compact and easy to use collaborative robots will drive market
- Increased use by small and medium companies
- Expansion in non-manufacturing industries
- Robots will do tedious, dirty and dangerous work

Source: International Federation of Robotics, World Robotics 2016 Industrial Robots
http://www.ifr.org/industrial-robots/statistics/

NEW TYPE OF ROBOT: COLLABORATIVE

- Designed to work alongside and in conjunction with human workers

NEW TYPE OF ROBOT: WEARABLES/EXOSKELETONS

- Reduce mechanical stress
- Amplify or transform worker movements
- Industrial market projected to grow 229% per year between 2016 and 2021*

Photo courtesy of Suit X,US Bionics Inc. Use of photo is not an endorsement

*WinterGreen Research, Inc. (2015). Wearable Robots, Exoskeletons: Market Shares, Market Strategies, and Market Forecasts, 2015 to 2021. Report #SH26511914, Lexington, MA.

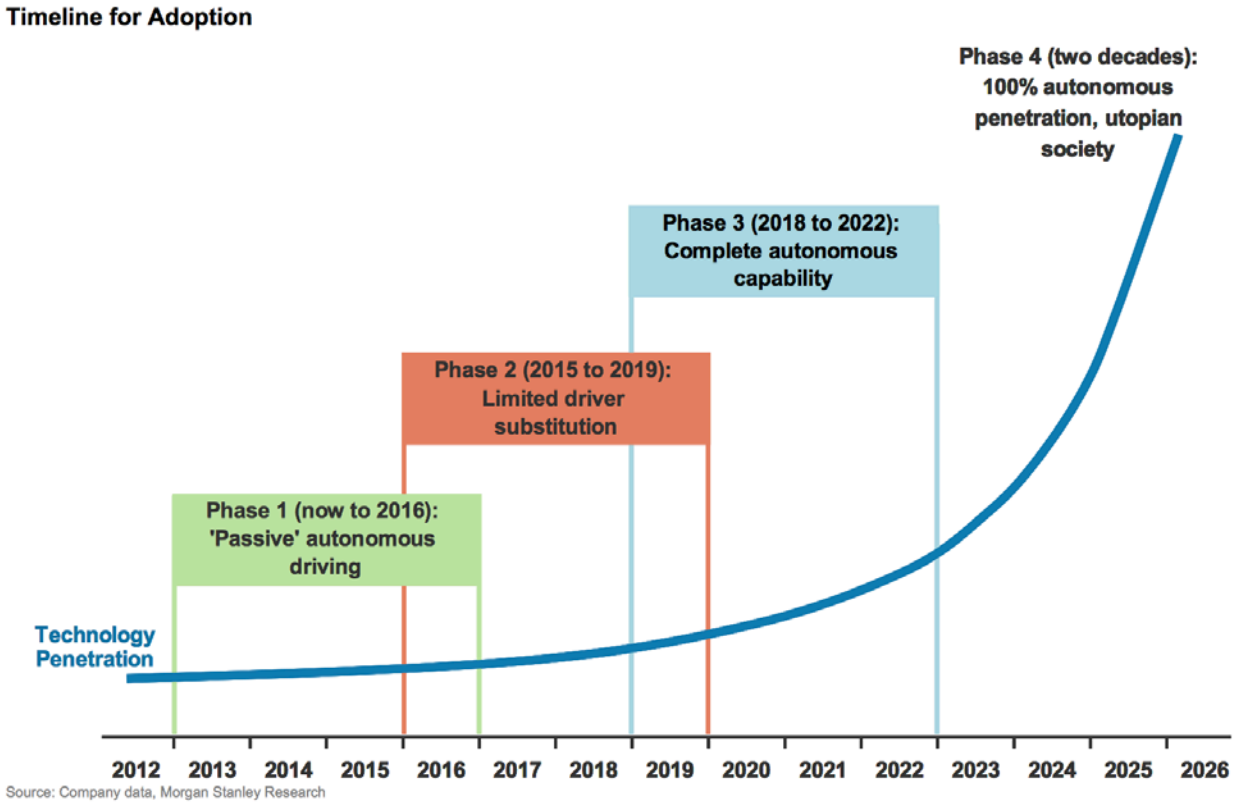
NEW TYPE OF ROBOT: MOBILE/CO-EXISTING

- Moves alongside and in shared space with workers

NEW TYPE OF ROBOT: AUTOMATED GROUND VEHICLES

- Operate in less controlled environments
  - may include human workers and manned vehicles

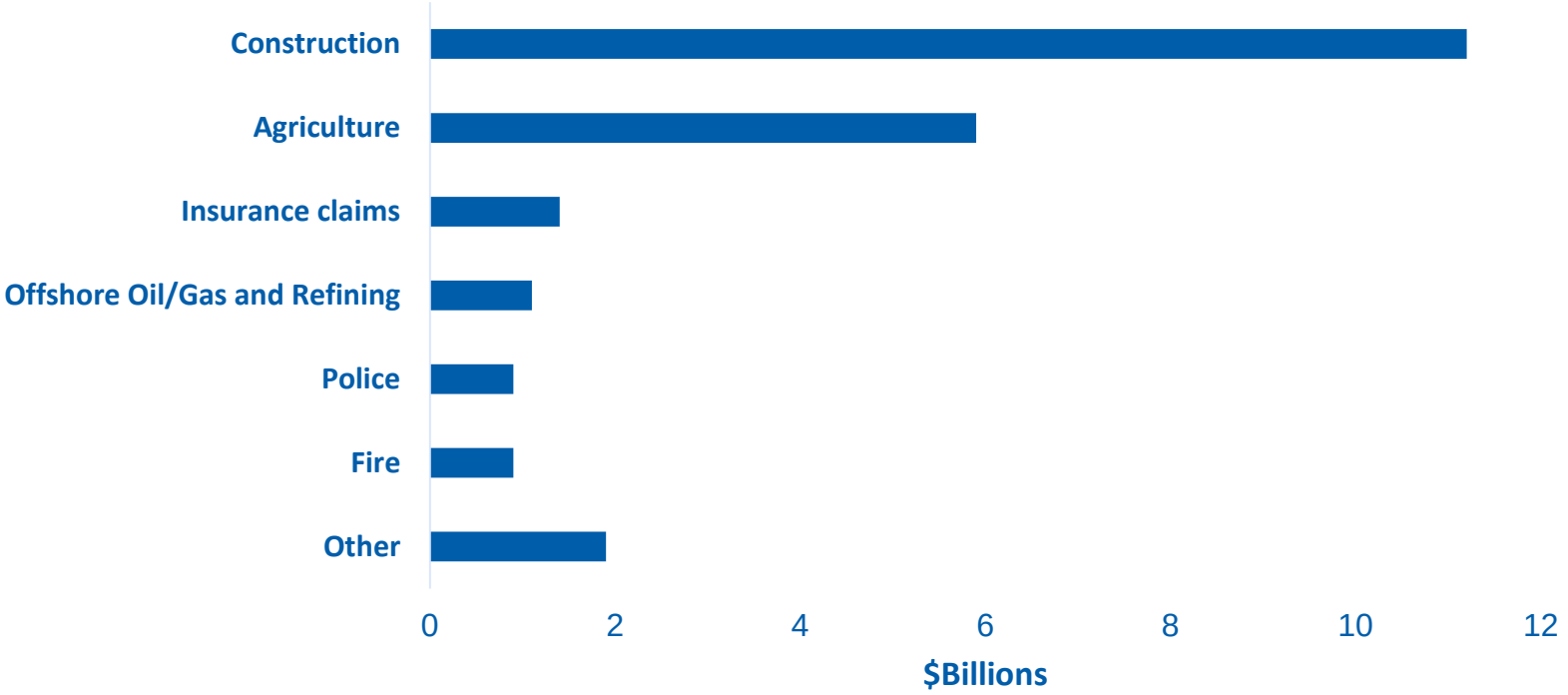
PROJECTIONS: AUTOMATED VEHICLE TECHNOLOGIES



Source: https://robotonomics.files.wordpress.com/2014/04/morgan-stanley-dcars.png

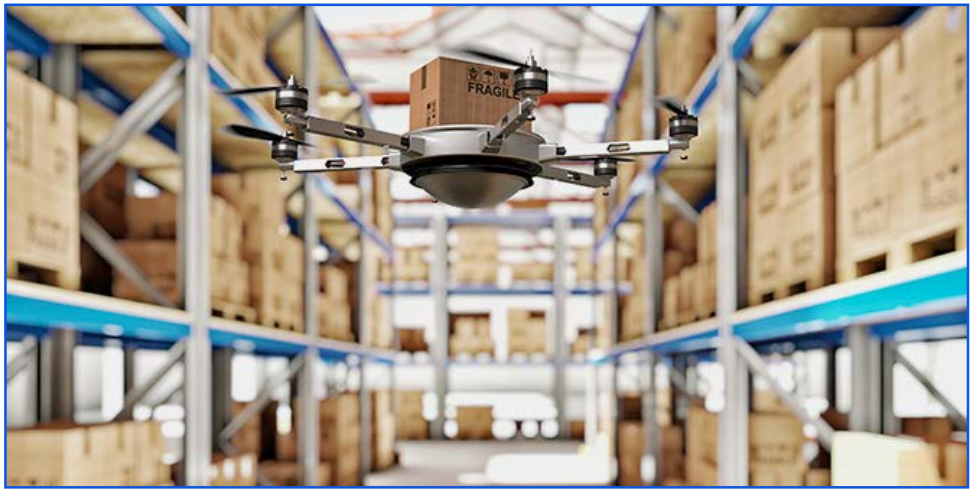
PILOTS OF AUTONOMOUS COMMERCIAL VEHICLES

PROJECTED DRONE MARKET BY INDUSTRY/FUNCTION, 2016-2020



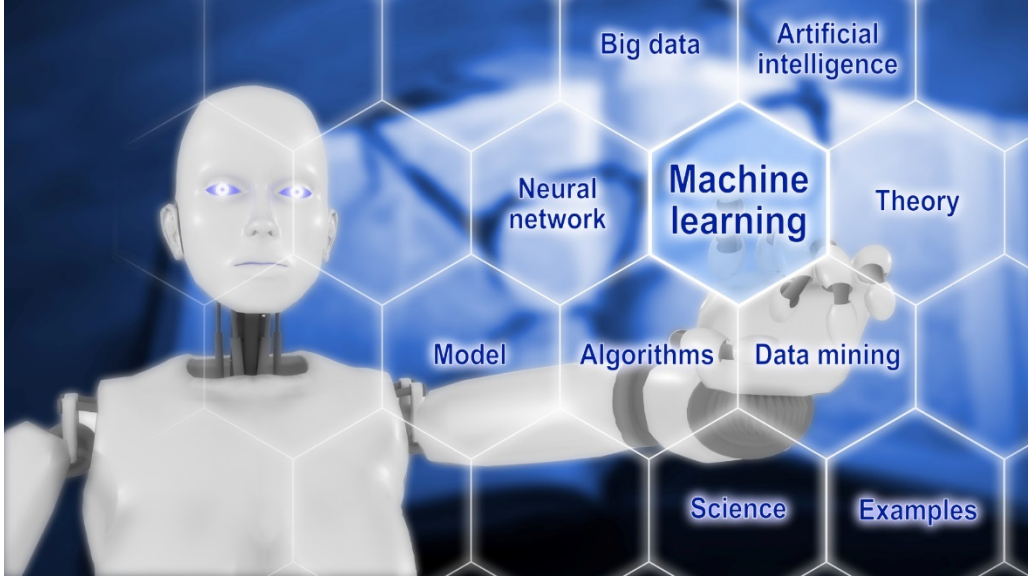
Source: Goldman Sachs [2016]. Drones reporting for work. www.goldmansachs.com/our-thinking/technology-driving-innovation/drones.

INDUSTRIAL DRONES: OUTDOORS AND INDOORS



FUTURE ROBOTS

- Advanced use of artificial intelligence
- Expand to white collar and managerial jobs
- Expanded concerns about worker displacement
  - Industry reports that new jobs will be created



Emerging Robotics and Worker Safety and Health

Potential

- Expand dangerous work done by robots
- Robotic systems augment workers' abilities

Concerns

- Likely increase in injuries
- New types of robots will require refined and new protection strategies
- Rapid advances in technology may outpace standards setting
- Stress associated with changing workplace and potential for displacement

Trends in robot deaths and injuries

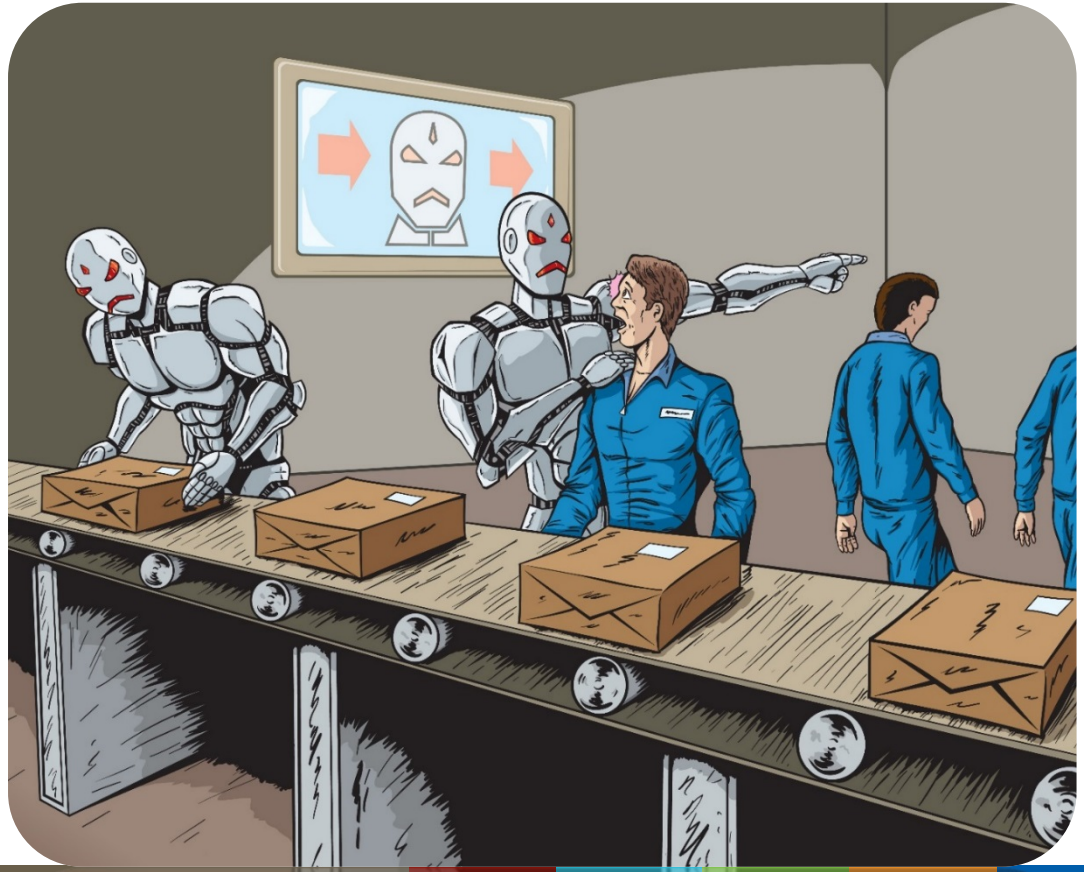
- Cases likely to increase as prevalence of robots increases
- Since new types of robots are just entering the market, there will be a lag before cases appear in national data

Standards/Guidance

- Need for guidance that addresses new technologies
- Standards are being revised to address technology advances
- Standards/guidance under development for wearables and vehicles
- Prevention through design is critical

STRESS ASSOCIATED WITH DISRUPTED WORKPLACE

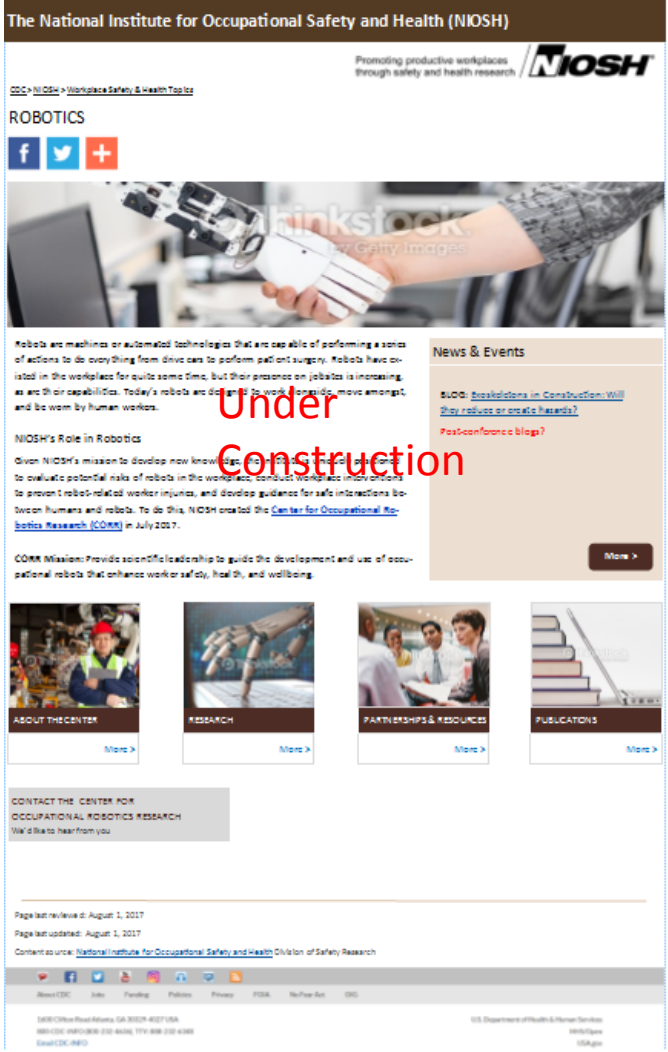
- Worker fears are real whether this scenario proves to be true or overblown



CENTER FOR OCCUPATIONAL ROBOTICS RESEARCH

VIRTUAL CENTER

- Just getting established
- Transition from previous interdivisional workgroup



MISSION

Provide scientific leadership to guide the development and use of occupational robots that enhance worker safety, health, and well-being.

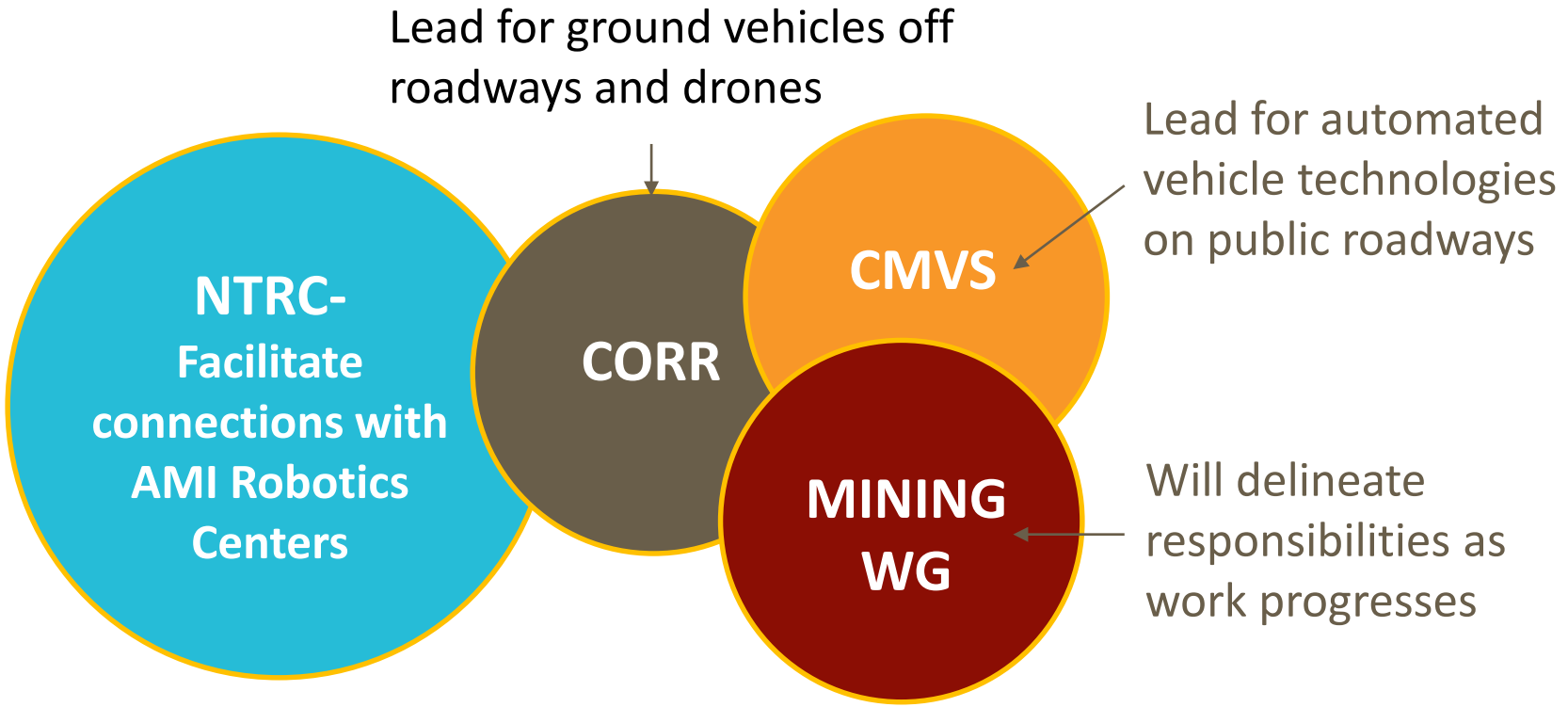
CENTER SCOPE

- Traditional industrial robots
- Emerging robotics technologies
  - Collaborative robots
  - Mobile/Co-existing robots
  - Wearable robotics/Powered exoskeletons
  - Remotely controlled and autonomous vehicles and drones
  - Future robots using advanced artificial intelligence

CENTER NICHE

- Closely coordinate with federal agencies addressing worker safety
  - Defense: exoskeletons and vehicles
  - Energy: exoskeletons and work in hostile environments
  - Transportation: guidance/regulations for autonomous vehicles
- Prioritize research in areas where worker safety is not addressed by others
  - Construction, agriculture, mining
  - Indoor use of drones
  - Autonomous vehicle technologies in specialized work vehicles (e.g. fire trucks)

COORDINATION WITHIN NIOSH



PARTNERS

- Academic researchers
- Trade associations
- Robotics manufacturers
- Employers using robotics technologies
- Labor organizations
- Other federal agencies

ACTIVITIES

- Monitor trends in injuries
- Evaluate robotics technologies as sources of, and as interventions for, workplace injuries and illnesses
- Establish risk profiles of robotic workplaces
- Identify research needs and conduct research
- Support the development and adoption of consensus standards
- Develop and communicate best practices, guidance and training for safe interactions between human workers and robotics technology

WHAT WE HAVE DONE AND ARE PLANNING

PARTNERSHIPS-
WHAT WE HAVE DONE

- Participate on NSF-led interagency group
- Participate in exoskeleton meetings led by NIST and DOD
- Reciprocal meetings with OSHA workgroup
- Participate in meetings for DOE/OEM technology roadmap
- Robotics Industry Association on NORA Traumatic Injury Prevention Council

PARTNERSHIPS-
WHAT WE ARE PLANNING

- OSHA/NIOSH/Robotics Industry Association Alliance
  - Training and education
  - Outreach and communication
  - Identification of research needs and opportunities for field-based research
- Follow-up from discussion with ERC Directors
- One MOU/yr with academic centers

SURVEILLANCE-
WHAT WE HAVE DONE

- Preliminary analyses of CFOI
- Identification of FACE and OSHA investigations

SURVEILLANCE-
WHAT WE ARE PLANNING

- Comments to BLS on OIICS coding structure and ability to identify robot-related injuries
- Publish injury data summaries using existing data
- Conduct FACE investigations for events involving emerging technologies

STANDARDS COMMITTEES- PARTICIPATION

- ANSI/RIA R15.06/08, Robot Safety/Industrial Mobile Robot Safety
- ANSI B11, Machine Safety
- ANSI A10, Construction Safety
- ANSI/ASSE Z15- Technical Report on Autonomous Vehicles
- ASTM/NIST/DOD/Other- Meetings to pursue exoskeleton standards

RESEARCH NEEDS- WHAT WE HAVE DONE/PLANNING

Done

- Encompassed in some NORA Agendas
- Encompassed in draft NIOSH strategic plan, FY 2019-23
  - Multiple industries

Planning

- Request for information

RAISE AWARENESS- WHAT WE HAVE DONE

JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL HYGIENE
2016, VOL. 13, NO. 3, D61–D71
http://dx.doi.org/10.1080/15459624.2015.1116700

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COMMENTARY

Working safely with robot workers: Recommendations for the new workplace

Vladimir Murashov, Frank Hearl, and John Howard

National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Washington, DC

ABSTRACT

The increasing use of robots in performing tasks alongside or together with human co-workers raises novel occupational safety and health issues. The new 21st century workplace will be one in which occupational robotics plays an increasing role. This article describes the increasing complexity of robots and proposes a number of recommendations for the practice of safe occupational robotics.

KEYWORDS

Collaborative robots; industrial robots; occupational safety; risk assessment; risk mitigation; service robots; workers; workplace

2016

A Robot May Not Injure a Worker: Working safely with robots

Categories: Manufacturing, Technology

November 20th, 2015 9:27 am ET - **Vladimir Murashov, PhD; Frank Hearl, PE; and John Howard, M.D.**

Robots are used in increasing numbers in the workplace and in society in general. As their numbers and capabilities increase, observers have urged that scientists, engineers, and policymakers explore the implications of robotics for society, to ensure that the rise of robots will not spell "doom for humanity" as some critics have warned [1]. To avoid this scenario, in 1942 Isaac Asimov set out three laws of robotics in his short story "Runaround". The first law of robotics centered on the safety of people states: "A robot may not injure a human being or, through inaction, allow a human being to come to harm." How well has this law been applied to worker safety as robots take on more tasks in the 21st century workplace and become robot

Wearable Exoskeletons to Reduce Physical Load at Work

Posted on March 4, 2016 by Brian D. Lowe, PhD, CPE; Robert B. Dick, PhD, Captain USPHS (Ret.); Stephen Hudock, PhD, CSP; and Thomas Bobick, PhD, CSP, CPE

Photo courtesy of SuitX, US Bionics, Inc.

Robotic-like suits which provide powered assist and increase human strength may conjure thoughts of sci-fi and superhero film genres. But these wearable exoskeleton devices are now a reality and the market for their applications in the workplace is projected to increase significantly in the next five years. As with any technologic innovation some of the pros and cons and barriers to adoption are not completely understood. In this blog our objectives are to: (1) describe wearable exoskeletons in the context of workplace safety and health control strategies; (2) highlight current and projected trends related to industrial applications of these technologies; and (3) invite input from our stakeholders on workplace health and safety experiences, positive or negative, with these devices.

The **wearable exoskeleton** was defined by de Looze et al. (2015) as *"...a wearable, external mechanical structure that enhances the power of a person. Exoskeletons can be classified as 'active' or 'passive'. An active exoskeleton comprises one or more actuators that augments the human's power and helps in actuating the human joints. ...A strictly passive system does not use any type of actuator, but rather uses materials, springs or dampers with the ability to store energy harvested by human motion and to use this as required to support a posture or a motion."* Passive systems require no external power and use springs, elastic cords, or other resilient elements to provide either a restoring moment that unloads the low back muscles, or additional vertical lift force to augment arm and shoulder muscles when supporting tools or materials. More complex active exoskeleton systems use electric servo-motors and powered actuators on an external frame with joints matched

Exoskeletons in Construction: Will they reduce or create hazards?

Posted on June 15, 2017 by Alissa Zingman, MD; G. Scott Earnest, PhD, PE, CSP; Brian D. Lowe, PhD, CPE; Christine M. Branche, Ph.D., FACE;

Wearable exoskeleton devices can reduce some of the mechanical stress of manual labor (1). These wearable machines can be powered by electricity or by human motion, and they can be as large as a space suit or as small as a glove. (1; 2) They are used to amplify or transform worker movements, improve biomechanics and efficiency, and are increasingly prevalent in the public and private sectors. NIOSH published its first blog on this topic in 2016 (3). As these devices are deployed more widely in the workplace, sound research is required to assess potential dangers and benefits of this new technology.

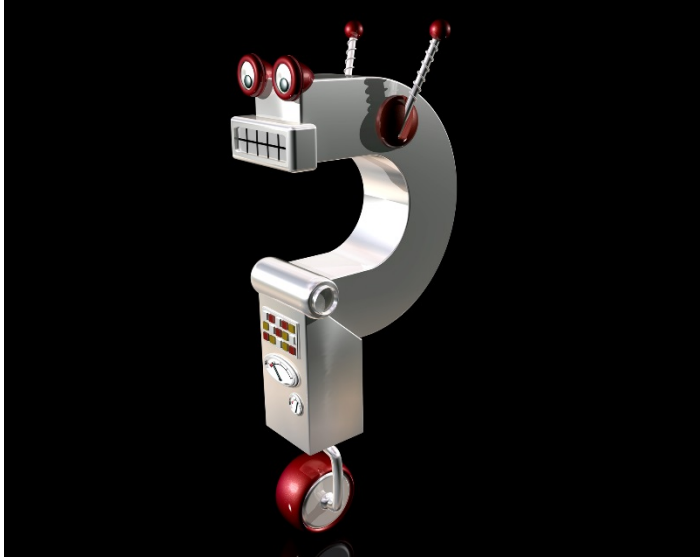
Construction is a physically demanding, labor-intensive industry with heavy manual material handling and awkward work postures. Musculoskeletal disorders (MSDs) are a leading cause of injury among construction workers (4; 5), with overexertion in lifting causing over one-third of these injuries. (6) The rate of work-related musculoskeletal disorders in construction is 16% higher than in all industries combined(5). Since back injuries are the most prevalent work-related musculoskeletal disorders in construction, (5) and shoulder and other joint injuries are also major causes of injury, exoskeletons present an attractive possibility.

RAISE AWARENESS- WHAT WE ARE PLANNING

- Presentation at Oct. National Robot Safety Conference
- Presentation at Oct. Tri-State Occupational Medical Association conference
- Article on drones in construction (Howard)
- Topic for 2018 National Occupational Injury Research Symposium

QUESTIONS FOR THE BSC

- Thoughts on refining NIOSH niche?
- Suggestions for key partnerships to pursue?
- Suggestions for raising awareness/engaging the occupational safety and health community?
- Thoughts on priority research questions?



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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.