Robotics and Automation in the Construction Industry

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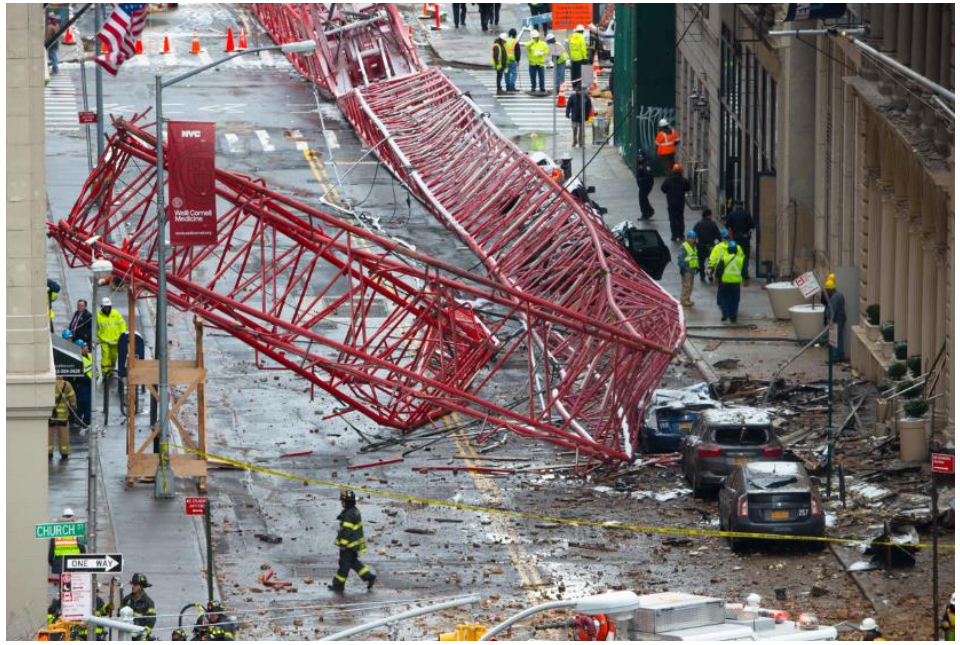
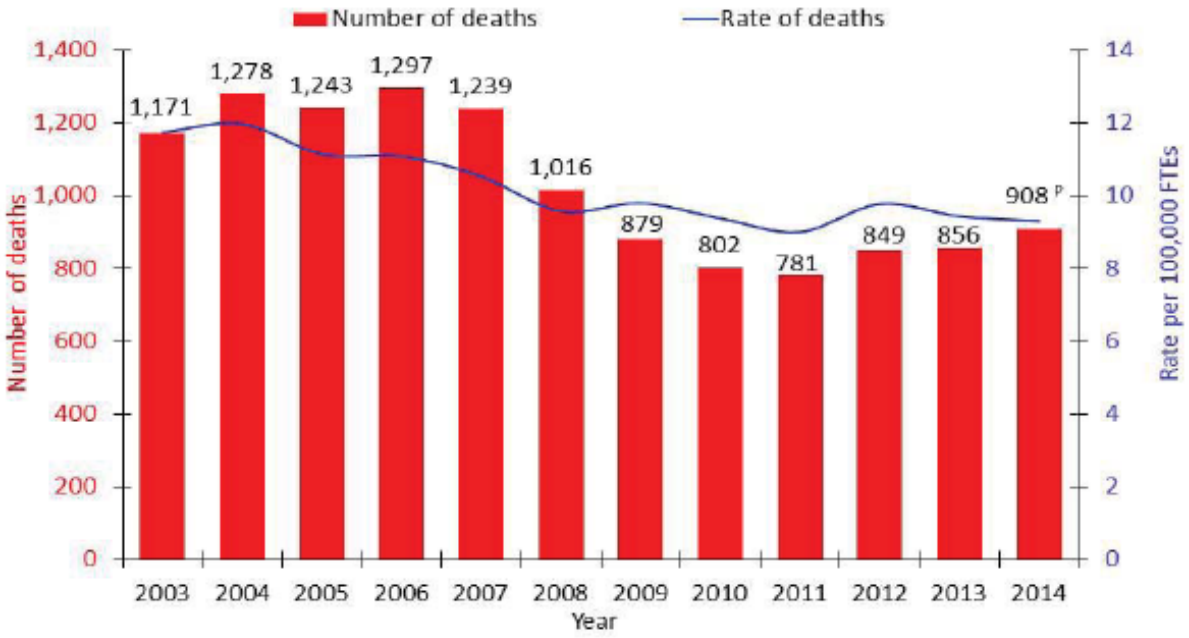
NIOSH Construction Program Mission

To eliminate construction fatalities, injuries, and illnesses through a focused program of research and prevention

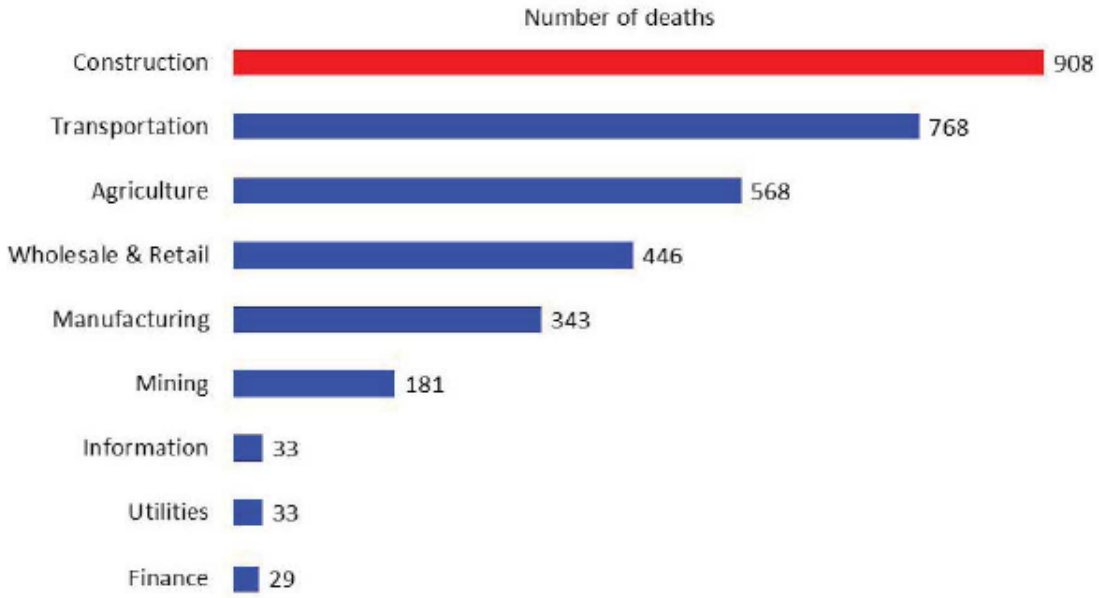


Work-related Fatalities

2. Number and rate of work-related fatalities in construction, 2003-2014 (All employment)



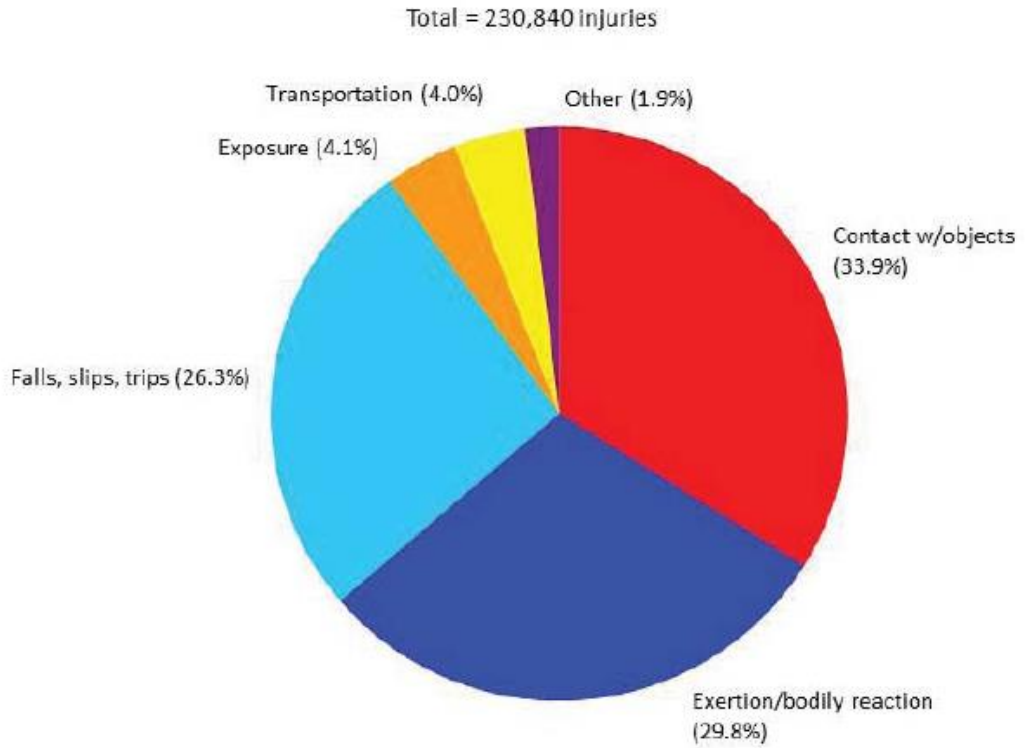
3. Number of work-related fatalities, by major industry, 2014[P] (All employment)



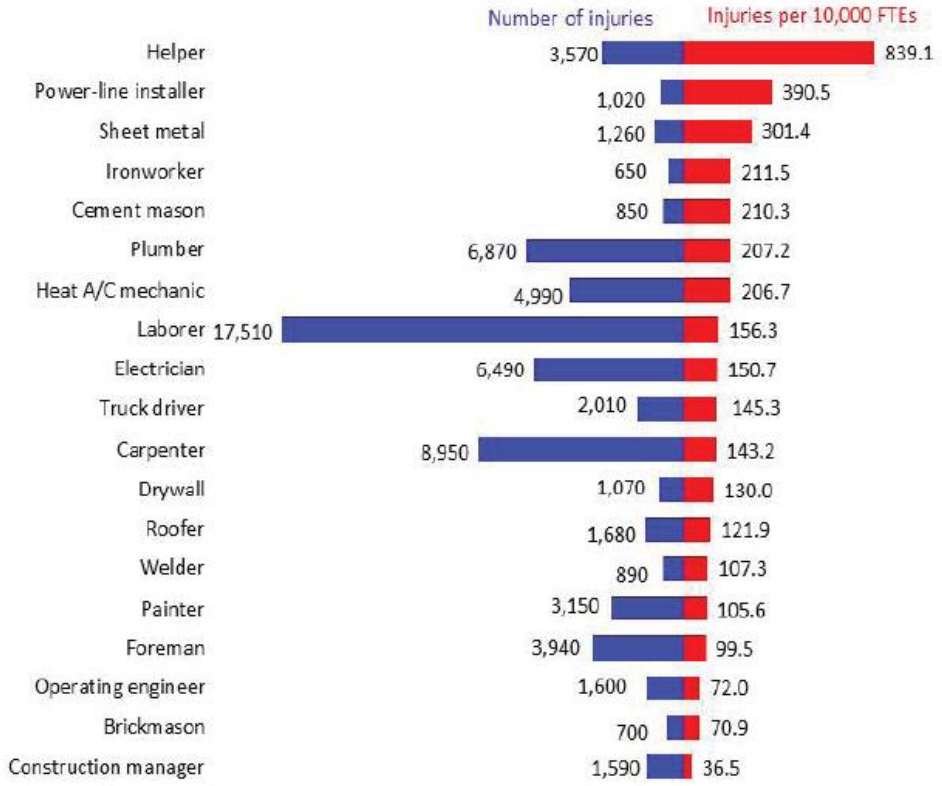
Source: CPWR Quarterly Data Report: Fatal and Nonfatal Injuries among Construction Trades, 2015

Nonfatal Injuries in Construction

21. Distribution of nonfatal injuries resulting in days away from work in construction, by event, 2011-2013 total
(Private wage-and-salary workers)



22. Number and rate of nonfatal injuries involving days away from work, selected occupations, 2013
(Private wage-and-salary workers)



Source: CPWR Quarterly Data Report: Fatal and Nonfatal Injuries among Construction Trades, 2015

Early Construction…

Workers having lunch atop RCA Building. Possibly Charles C. Ebbets.

Atop the Woolworth Building. By Leslie Jones via Boston Public Library

Key Issues in Construction today

KPMG

Smart construction

How offsite manufacturing can transform our industry

Skills shortage – The industry is struggling to provide the skilled workforce needed to meet the demand for current and planned projects – 82% of respondents to a CIOB survey believed a skills shortage exists across the construction sector[12]

Data transparency – A lack of timely and accurate project and investment performance data adversely impacts client decision making.

Productivity – The construction industry continues to suffer from low labour productivity rates, and has failed to realise any substantial growth in productivity in the last 20 years[10]

Certainty in delivery – Despite some high profile success stories including the Olympics and Crossrail, the sector has a reputation for unreliable project delivery times and costs – in 2015 only 69% of projects were completed on budget and only 40% on time[11]

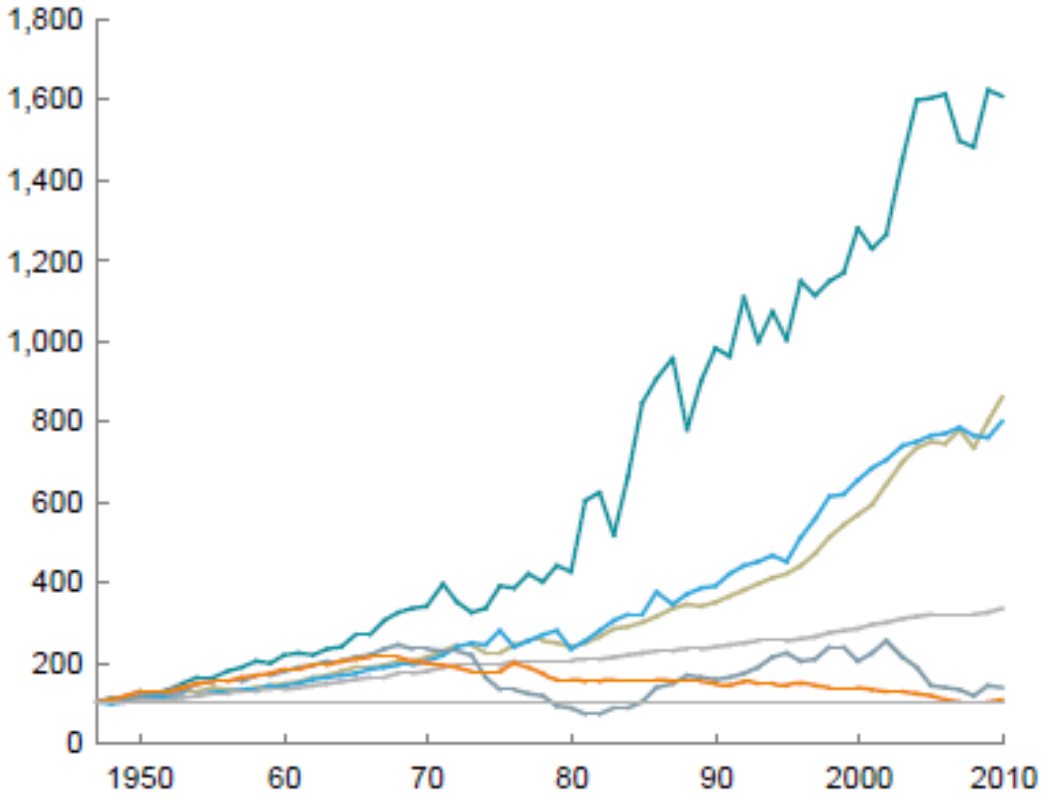
While the industry is currently buoyed by predicted growth and expansion, it continues to underperform in four key areas:

Productivity by Industry Sector

Many sectors have transformed and achieved quantum leaps in productivity; construction has changed little, limiting productivity gains
Key advances, 1947–2010

Agriculture	Manufacturing	Retail	Construction
Leveraged scale through land assembly and automation; deployed advanced bioengineering to increase yields	Implemented entirely new concepts of flow, modularized and standardized designs, and aggressively automated to increase production	Utilized scale advantages and cutting-edge logistics to provide affordable goods to the masses	Limited improvements in technological capabilities, production methods, and scale

Gross value added per hour worked, constant prices
Index: 100 = 1947



	Compound annual growth rate, 1947–2010 %	Total change
Agriculture	4.5	16.1x
Manufacturing	3.5	8.6x
Wholesale and retail	3.4	8.0x
Overall economy	1.9	3.3x
Mining	0.5	1.4x
Construction	0.1	1.1x

What does the Future look like?....

Researchers & theorists in the field of robotics say… ***automated machines are about to migrate from factories and manufacturing facilities to building and construction sites as a result of rapid technological advances*** which enable them to perform increasingly complex tasks.

Construction Areas of Interest

Emerging Issues

Nanotechnology

Opioid addiction

Terrorist threats

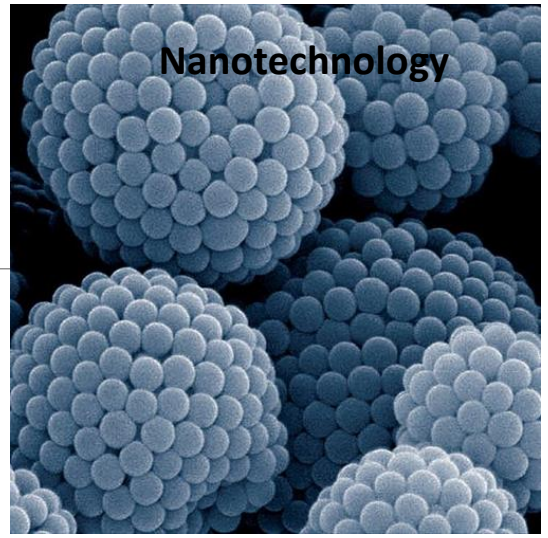
Radiofrequency

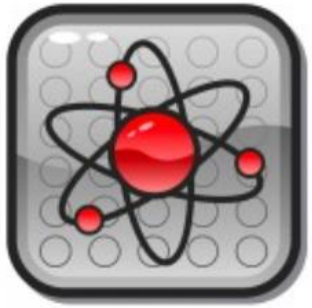
Wearable safety devices

Smart construction

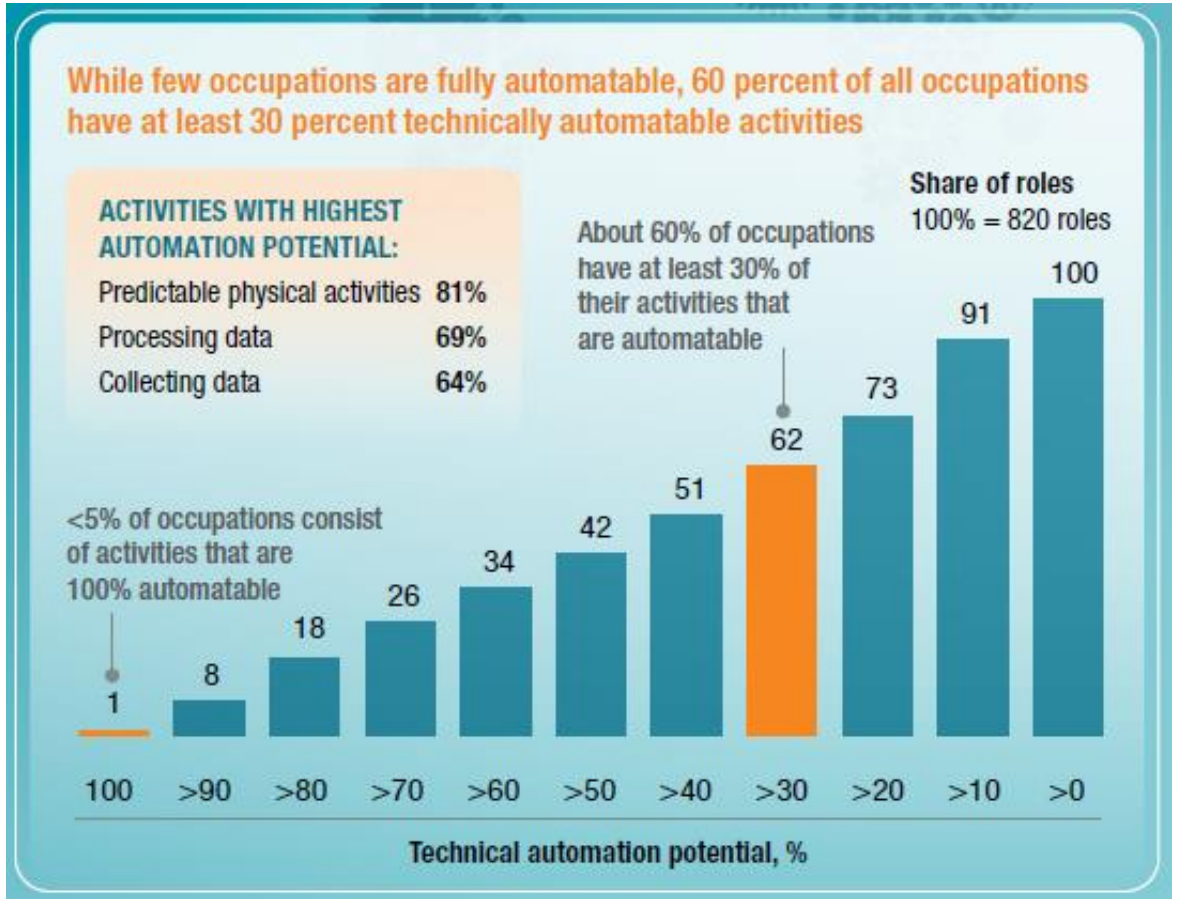
Robotics and automation

Building Information Modeling (BIM)





Adoption of Automation and Robotics



Five factors affecting pace and extent of adoption

1. **TECHNICAL FEASIBILITY** Technology has to be invented, integrated, and adapted into solutions for specific case use
2. **COST OF DEVELOPING AND DEPLOYING SOLUTIONS** Hardware and software costs
3. **LABOR MARKET DYNAMICS** The supply, demand, and costs of human labor affect which activities will be automated
4. **ECONOMIC BENEFITS** Include higher throughput and increased quality, alongside labor cost savings
5. **REGULATORY AND SOCIAL ACCEPTANCE** Even when automation makes business sense, adoption can take time

Challenges In Construction

The work environment is highly unstructured and involves handling heavy objects,

Work at height, adverse weather, large heavy equipment,

Low levels of standardization, medium levels of industrialization and pre-fabrication, many small businesses,

Productivity, skill shortages, coordination between architects, builders, suppliers, etc.

Increasing use of advanced technologies

Advantages/Disadvantages of Construction Robotics

Robot mobility may be limited

Weight and size of robots

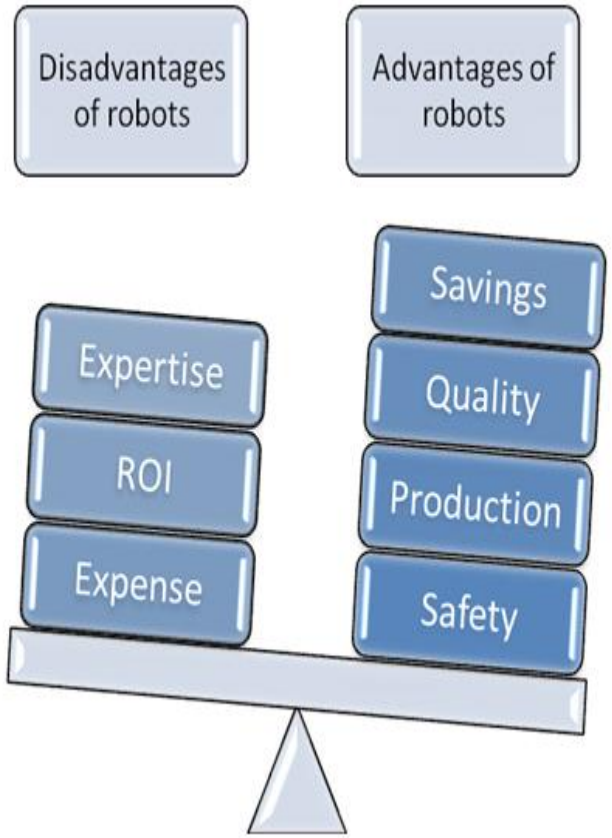
Robot accuracy for limited duties

Robot operation and maintenance

Stress, unemployment, worker displacement

High initial costs

Use may outpace standards



Improved work quality

Consistency and accuracy

Reduced labor costs

Savings accrued on safety and health improvements

Time savings

Improved productivity

Human safety- reduced MSDs

Use in dangerous environments

Trends in Construction

Increasing trends toward green construction

Greater use of off-site construction methods

Growing adoption of Building Information Modelling (BIM) and advanced technologies

Use of Virtual & Augmented Reality (VR/AR)

Prefabricated or modular building gains traction

Greater use of robotics and automation

Expanding application of additive manufacturing (3D printing)

Applications In Construction Automation

Repetitive works like fabrication of large panels, stacking, and their installation etc.

Construction of modular houses

Fabrication of components and construction of pre-engineered buildings

Welding and fabrication of steel structures

Repair and maintenance of skyscrapers, particularly outer facade

Dismantling of old buildings

Removal of debris after disasters and sensing live human bodies

Fire protection and extinguishing in skyscrapers

Earthmoving and piling, tunneling

Concrete floor finishing and spray painting

(synergypositioning.co.nz)

Desilting and inspection of drains, water supply lines, sewer lines and other service lines

Automated Rebar Tying

WORKPLACE SOLUTIONS

From the National Institute for Occupational Safety and Health

Reducing Work-Related Musculoskeletal Disorders among Rodbusters

Summary

NIOSH evaluated reinforcing ironworkers' (rodbusters) exposures to risk factors for developing low-back and hand disorders when tying together reinforcing steel bars (rebar) on a freeway bridge. Rodbusters used three techniques to tie rebar together—a pliers and a tie wire wheel, a battery operated power tier (PT), and a PT with an extension handle (PTE). NIOSH found that using the PT and PTE reduced the rodbusters' exposures to risk factors for work-related low-back and hand-wrist disorders. In addition, power tying was twice as fast as than pliers tying.

Description of Exposure

Reinforcing ironworkers have reported high prevalence rates for work-related musculoskeletal disorders (WMSD) symptoms affecting the low-back (80.2%) and wrists/hands (48.4%) [Cook et al 1996]. Boston-area rodbusters reported high prevalence rates for self-reported symptoms of the low-back (52.2%) and hands/wrists/fingers (47.8%) and high prevalence rates of doctor-diagnosed WMSDs, including ruptured spinal discs (14%) and carpal tunnel syndrome (16%) [Forde et al. 2005].

Traditionally, *pliers and a tie wire wheel* have been used to pull, wrap, twist, and cut the 'tie' wire around two or more concrete reinforcing bars. This requires using both hands and making rapid and repetitive hand, wrist, and forearm movements while gripping the pliers. In recent years, *power tiers* have become available. The PT is a battery-powered and trigger-operated wire tier that automatically wraps, cuts, and ties the wire around the rebar. Tying rebar at ground level using either the pliers or the PT requires working in a stooped posture. A height-adjustable extension handle (PTE) is commercially available for one type of hand-held PT enabling the worker to tie the rebar while standing.

Evaluation

A concrete reinforcing contractor requested that NIOSH evaluate workers' exposures to WMSD risk factors during rebar tying on a freeway bridge deck construction project that required making more than 2 million "ties." The contractor's workers used both pliers and PTs to tie rebar. NIOSH introduced the PTE as a third technique to be investigated in the study. Although rodbusters perform other job activities that require "maximum muscle force to lift, push, pull, or carry objects" [ONET 2008], NIOSH analyzed only rebar tying during this study because of the nature of the request and time constraints.

The three rebar tying methods were studied with relation to (1) hand, wrist, and forearm position and movements and (2) trunk (or back) position.

Results

Hand/Wrist

- *Pliers* tying involved the most hand, wrist, and forearm motions and the highest risk for developing a WMSD of the hand-wrist (see Figure 1).
- *PT* and *PTE* tying involved fewer hand, wrist, and forearm motions and less risk for developing a WMSD of the hand-wrist.

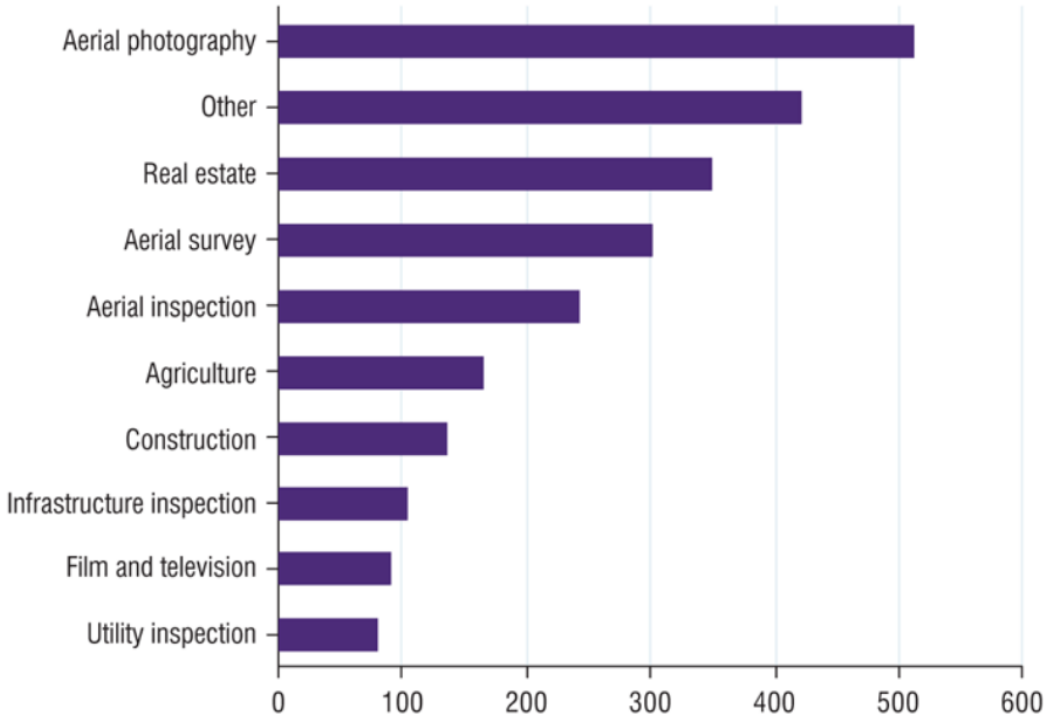
DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH

Prefabrication and Additive Manufacturing

Construction of conventional buildings using CC
source: http://3dprint.com

Drones- aerial mapping, inspections, and surveying construction sites



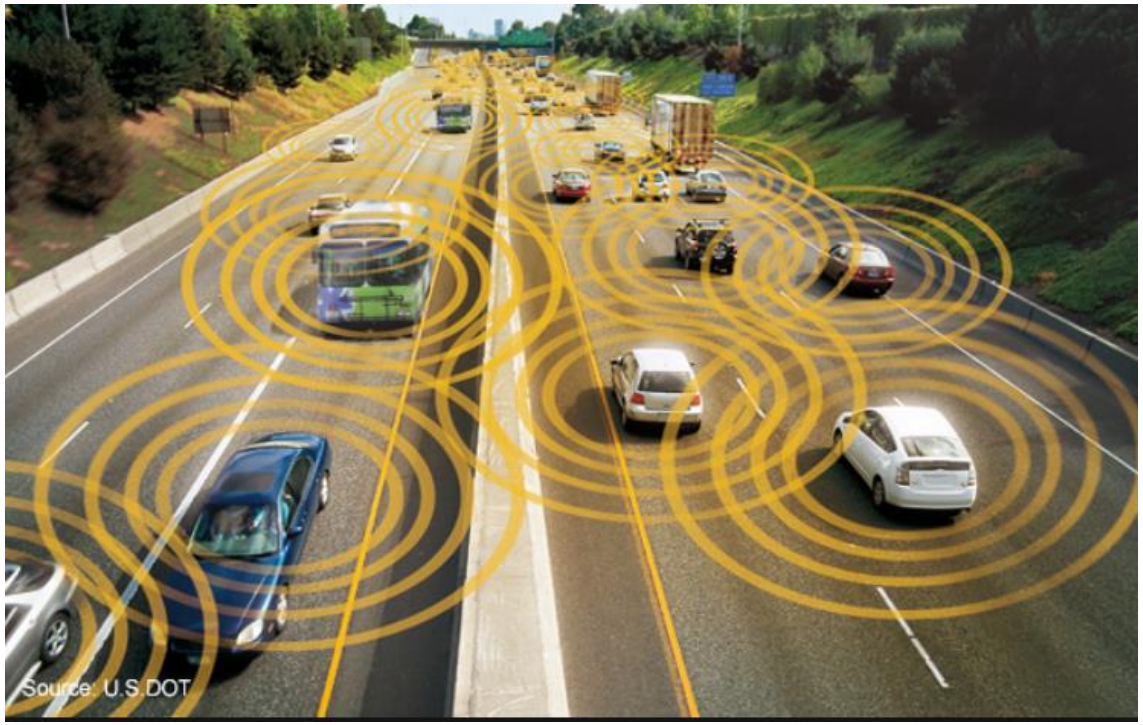
Photography Tops List of Commercial Drone Uses

First 1,000 federal exemptions for unmanned aerial systems, by type of industry/operation

Identified Technologies SKYCATCH senseFly

Source: "The First 1,000 Commercial UAS Exemptions," Association for Unmanned Vehicle Systems International, September 2015, p. 4, http://tinyurl.com/jtbyo89

Automated Trucks & Vehicles



Ground-breaking solution for future autonomous and electric freight transport

Workzone Safety and Automation

Royal TRUCK & EQUIPMENT, INC.

Automated Road Construction & Paving

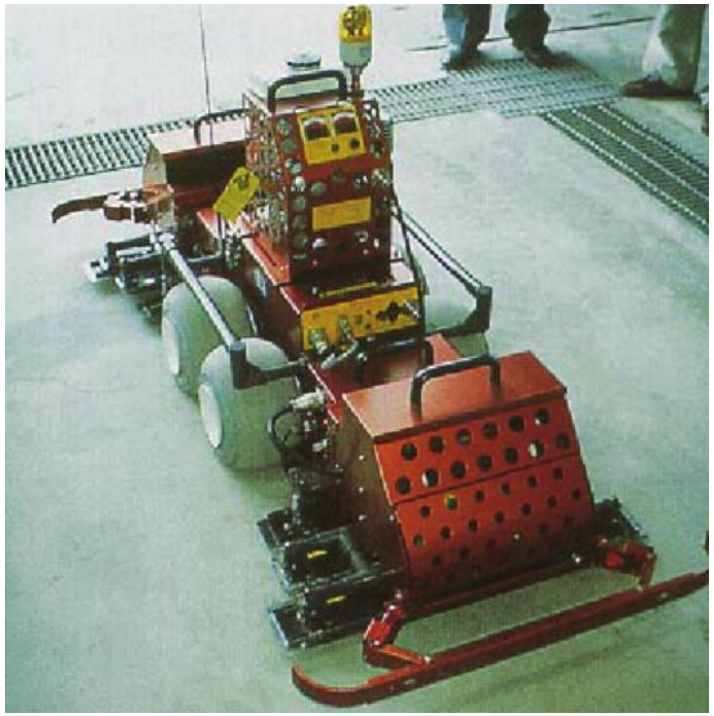
Automated Demolition

BROKK

Husqvarna

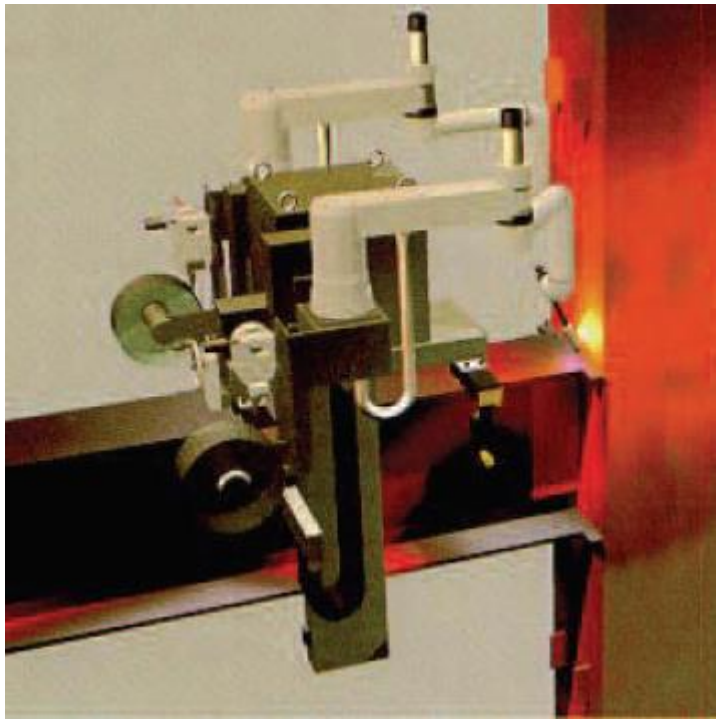
ERO
CONCRETE RECYCLING ROBOT

Automated Building Construction



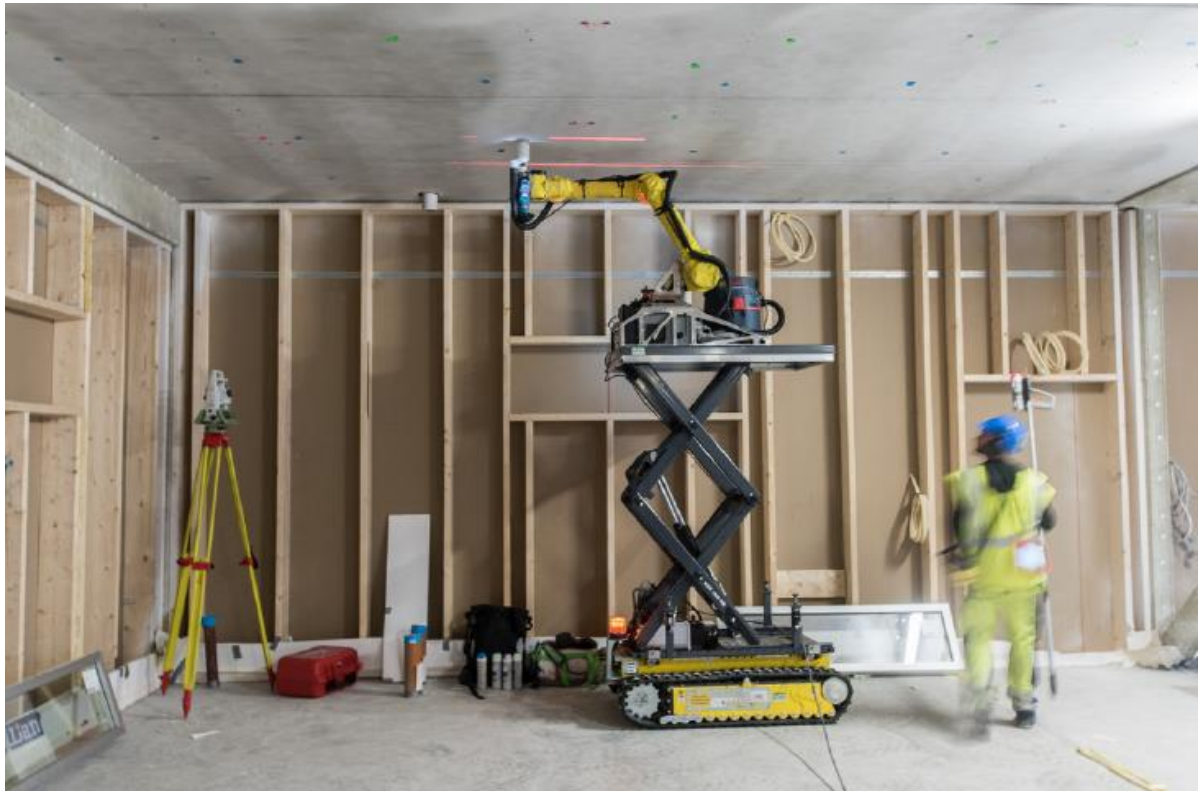
Concrete finishing robot

Brick Laying robot



Welding robot

Automated Welding and Drilling



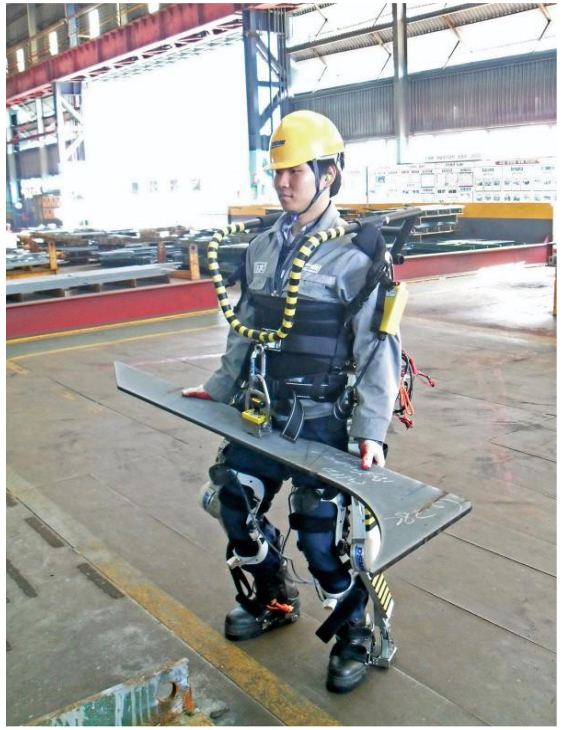
KRANENDONK
Smart robotics

KIBERYS
ROBOTIC SYSTEMS

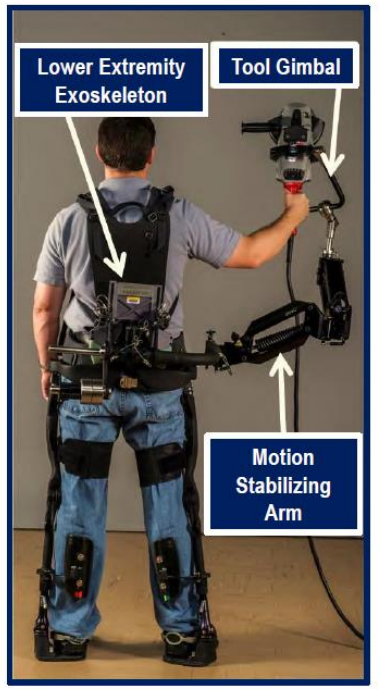
nLink

Powered (active) and Non-powered (passive) Exoskeleton Systems

Human Universal Load Carrier (HULC) from Lockheed Martin. $250,000 battery powered and hydraulically actuated exoskeleton



Multi-Attachment Non-Tethered Industrial System (MANTIS) variation - $15,000-$20,000



CYBERDYNE ActiveLink ekso BIONICS DAEWOO

Conclusions

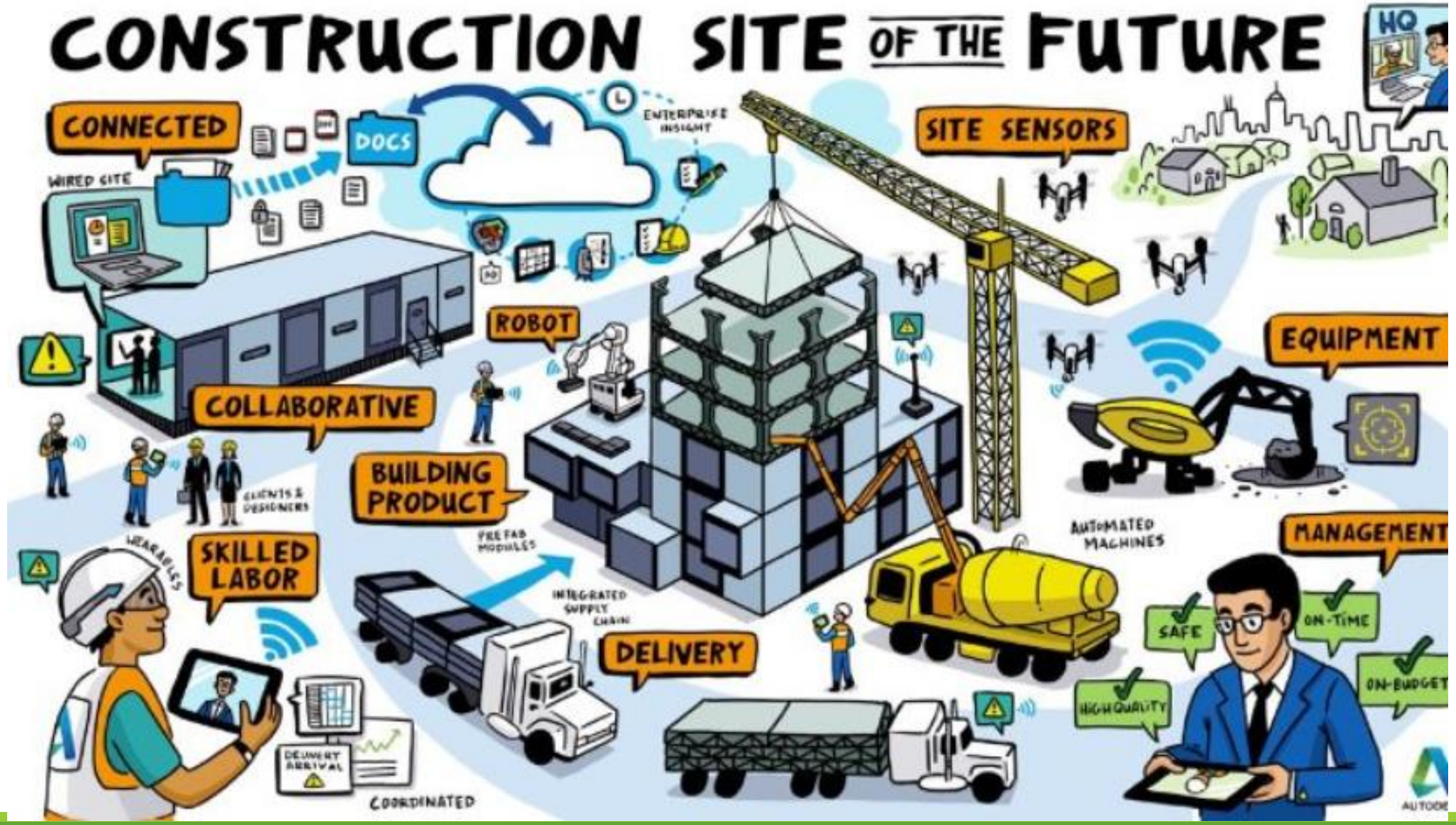
Construction sites are complex systems involving many disciplines; automating construction processes and integrating them into the overall process requires high skills and advanced technologies.

Construction is going through rapid changes involving prefabrication, green building, automation, robotics, & smart technologies.

The application of robotics in construction has not caught up with other industries such as automobile manufacturing.

Increased use of automation and robotics is one approach for construction companies who are seeking ways to improve productivity, quality, and safety.

More research is needed to ensure that these rapidly expanding technologies are implemented safely.



Source: Autodesk's 2016 One Team Conference

Thank you!

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CSH The Office of Construction Safety and Health
At the National Institute for Occupational Safety and Health—NIOSH

NIOSH Directory of Construction Resources
www.cdc.gov/niosh/construction/
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NIOSH Robotic Research Areas

Research Needs:

Area 1: Robot-related incident surveillance and hazard analysis

Area 2: Robot incident risk factors

Area 3: Research design and evaluation of safety interventions

Area 4: Robot safety implementation

Area 5: Dissemination of robot-safety information