# The Future of Work

John Howard
National Institute for Occupational Safety and Health
Washington, D.C.

14 June 2018

2018 WCIRB Annual Conference
Julia Morgan Ballroom
San Francisco, CA

# Industrial Revolutions

- **First Industrial Revolution**
  - Used water and steam power to mechanize production
- **Second Industrial Revolution**
  - Used electric power to create mass production
- **Third Industrial Revolution**
  - Used electronics & information technology to automate production
- **Fourth Industrial Revolution**
  - Using systems composed of physical entities controlled or monitored by digital algorithms, artificial intelligence

# Transformative Technologies

- The physical and digital worlds are converging in these industries as the **“digitization of everything”** pervades all of its fields, transforming nearly all enterprises with software, “big data,” and connectivity to the internet.

- The related **Internet of Things (IoT)—**the convergence of industrial machines, sensors, data, and the internet—is unleashing new ways to optimize the functionality, efficiency, and reliability of physical systems.

- **Advanced robotics, artificial intelligence, and machine learning** are making it possible to automate more and more worker tasks, opening the possibility of both productivity gains and labor market disruption.

- **Applied physics, materials science, and chemistry** are interacting to develop **advanced materials** with radically useful attributes, including incredible strength, conductivity or the ability to “remember” previous states.

- **Next-generation genomics** is bringing low-cost genetic analysis and “editing” to bear to improve medical diagnostics, accelerate drug discovery, and develop drought- and pest-resistant crops

# Drivers

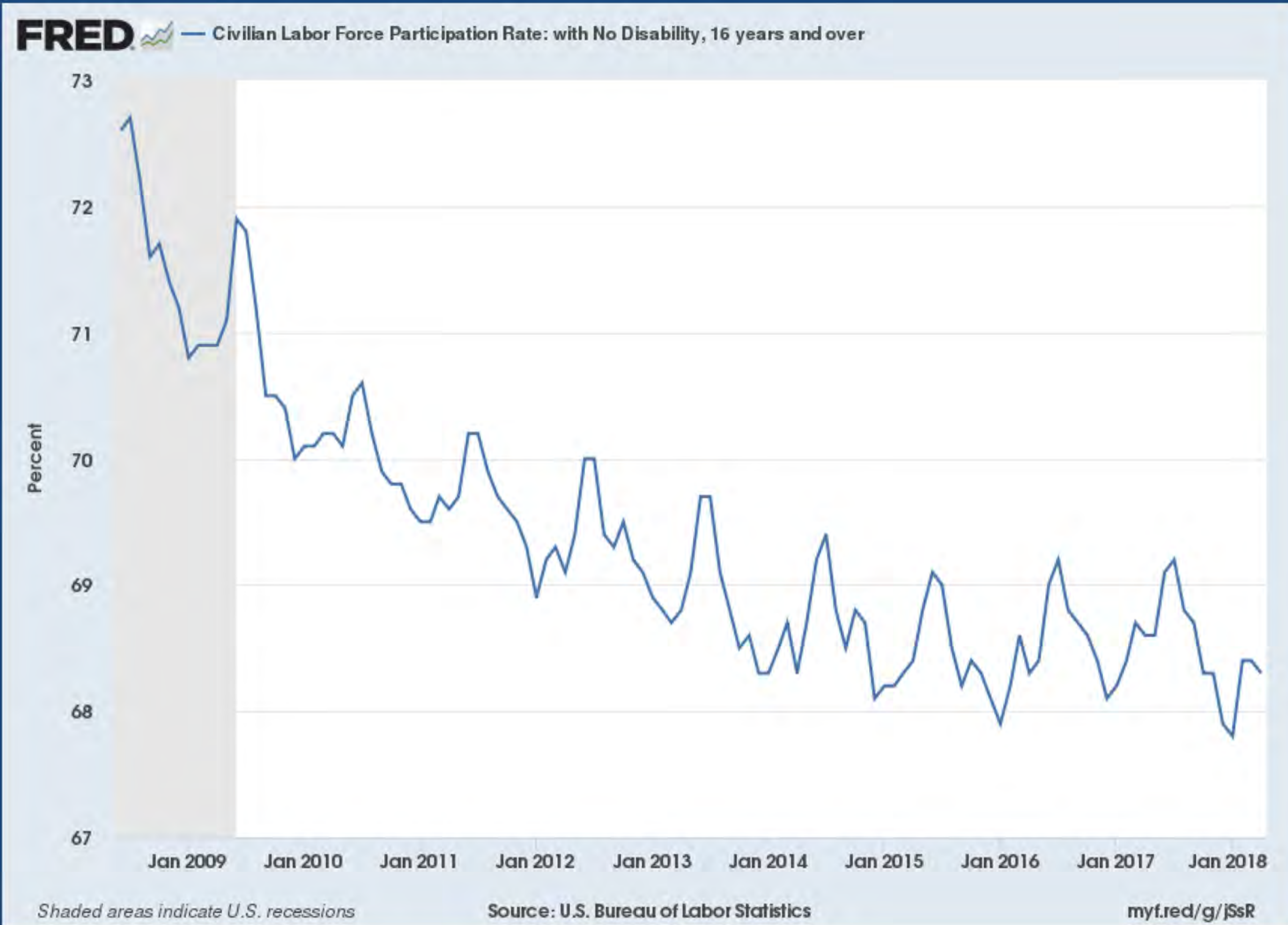
- Economic
  - Fewer Workers
  - Non-standard work arrangements
- Physical
  - Robotics
  - Automation
- Digital
  - Sensors
  - Artificial Intelligence

# Economic

**Labor Participation**

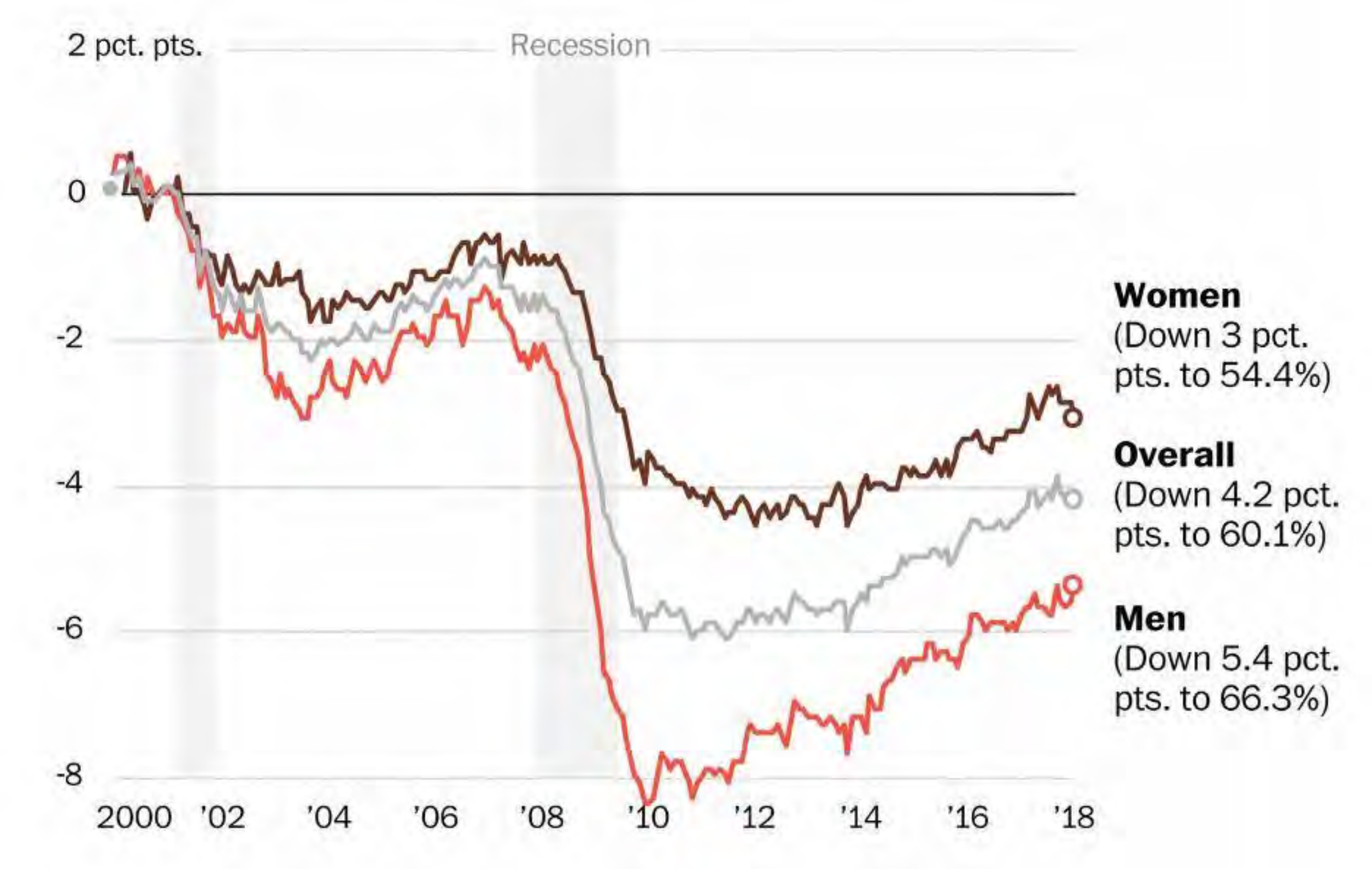
**Chronologically Gifted**

**New Economy Arrangements**

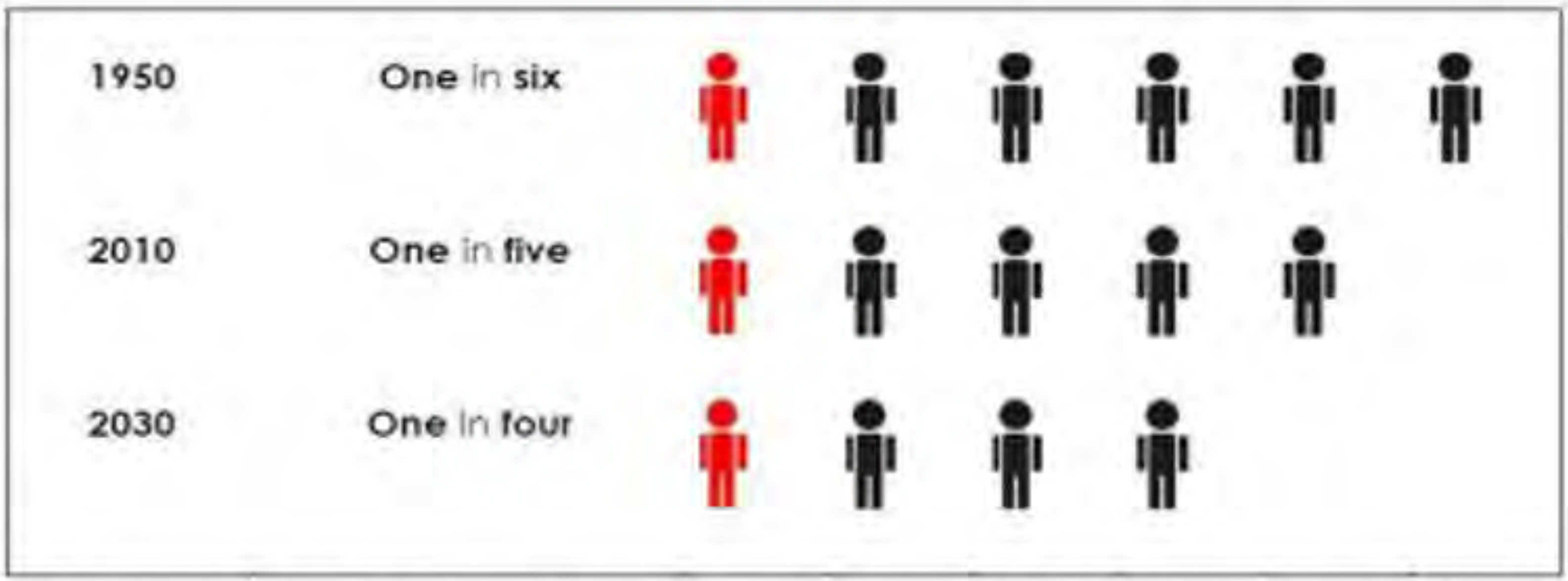

FRED
Civilian Labor Force Participation Rate: with No Disability, 16 years and over
Percent
73
72
71
70
69
68
67
Jan 2009
Jan 2010
Jan 2011
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018
Shaded areas indicate U.S. recessions
Source: U.S. Bureau of Labor Statistics
myf.red/g/jSsR

# Employment to Population Ratio

## Change from 1999 Average



# Chronologically Gifted




Sources: Bureau of Labor Statistics, "Labor Force Projections to 2018: Older Workers Staying More Active," *Monthly Labor Review*, November 2009; Bureau of Labor Statistics, "New Look at Long-term Labor Force Projections to 2050," *Monthly Labor Review*, November 2006.

# Total Chronic Condition Burden

Percentage of Adults age 55 and over (Total, Male & Female), with one or more, two or more, or three or more of a possible six chronic conditions: United States, 2008.

| | Total | | Male | | Female | |
|---|---|---|---|---|---|---|
| | % | SE | % | SE | % | SE |
| **Age 55 years and over** | (n=70,688,633) | | (n=32,130,140) | | (n=38,558,493) | |
| 1+ chronic conditions | 78.0 | 0.6 | 75.3 | 0.9 | 80.1 | 0.7 |
| 2+ chronic conditions | 47.0 | 0.7 | 41.8 | 1.0 | 51.3 | 0.9 |
| 3+ chronic conditions | 19.0 | 0.5 | 16.1 | 0.7 | 21.4 | 0.7 |
| **Age 55 to 64 years** | (n=33,502,260) | | (n=16,123,407) | | (n=17,378,853) | |
| 1+ chronic conditions | 69.5 | 1.0 | 67.7 | 1.4 | 71.1 | 1.2 |
| 2+ chronic conditions | 37.1 | 1.0 | 32.3 | 1.4 | 41.5 | 1.3 |
| 3+ chronic conditions | 14.4 | 0.7 | 11.1 | 0.9 | 17.4 | 1.0 |
| **Age 65 years and over** | (n=37,186,373) | | (n=16,006,733) | | (n=21,179,640) | |
| 1+ chronic conditions | 85.6 | 0.6 | 83.0 | 1.0 | 87.6 | 0.7 |
| 2+ chronic conditions | 56.0 | 0.9 | 51.4 | 1.4 | 59.4 | 1.1 |
| 3+ chronic conditions | 23.1 | 0.7 | 21.2 | 1.2 | 24.6 | 1.0 |

Source: CDC/National Center for Health Statistics: National Health Interview Survey.

## COLLABORATIVE ECONOMY

An economy built on distributed networks of connected individuals and communities versus centralized institutions, transforming how we can produce, consumer, finance and learn.

## COLLABORATIVE CONSUMPTION

An economic model based on sharing, swapping, trading or renting products and services enabling access over ownership. It is reinventing not just what we consume but how we consume.

## SHARING ECONOMY

An economic model based on sharing underutilized assets from spaces to skills to stuff for monetary or non-monetary benefits.

## PEER ECONOMY

Person-to-person marketplaces that facilitate the sharing and direct trade of products and services built on peer trust.

COLLABORATIVE LAB

# Types of Work Arrangements

- **Employment Work Arrangements**
  - Organization has directive control
    - **Standard employment relationship**
      - One employer—one employee
    - **Co-employment arrangement**
      - Two employers—one employee (agency and client)
      - Two employers are often confused about safety & health responsibilities

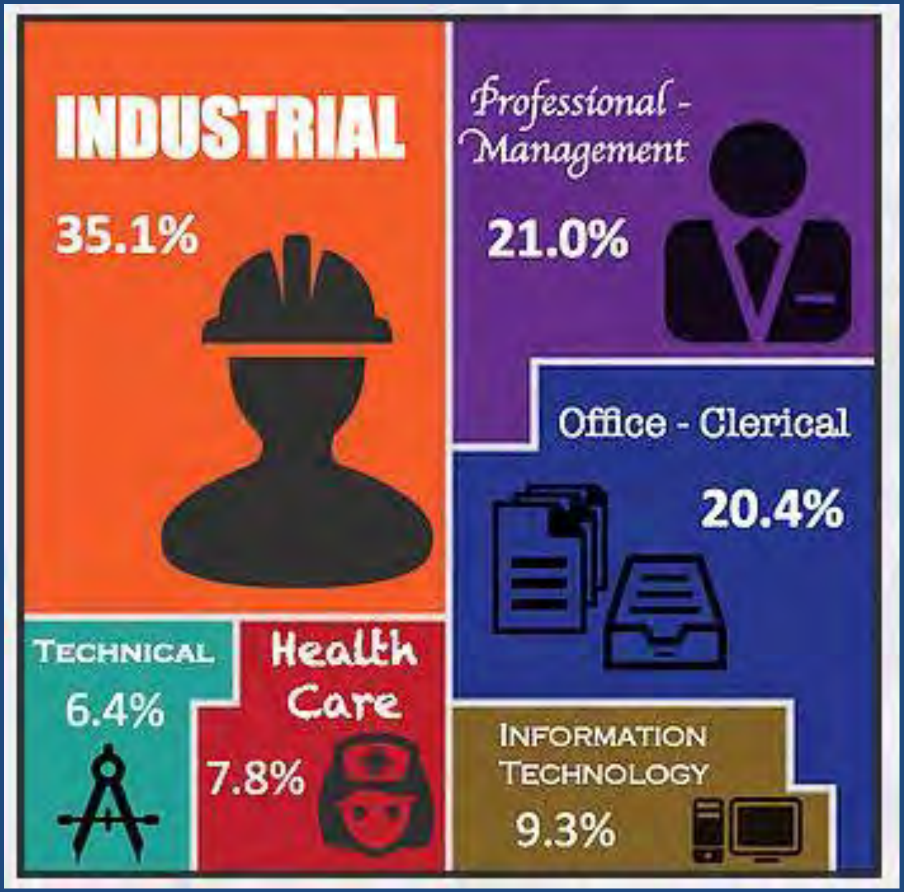
- **Traditional Contract Work Arrangements**
  - Organization lacks directive control
  - Business relationship exists (offer and acceptance)
    - Specifies the *what, the when, but not the how*
    - No employer and no employees

- **New "Gig" Work Arrangements**
  - Organization lacks directive control (or so they say)
  - No employer? No employees?
  - Digital platform connects customers with service providers—it "intermediates"

# Co-Employment

- Temporary staffing industry is perhaps best known for its earlier years when it placed female clerical workers and day laborers/farm workers.
  - Russell Kelly, 1946

- But the industry has expanded to include nearly every occupation in the US and globally.
  - 2015, Kelley Services placed 550,000 persons
  - Across all industries & occupations



# Differential Costs

- **Workers**
  - More hazardous work assigned to temporary workers.
  - Higher injuries rates in temporary workers depending on industry
  - Worker might quickly find herself out of a job and, depending on the severity of an injury, the prospects of new employment might be slim.

- **Society**
  - Employer-based health insurance is a rarity for NSWA workers, so the costs of treating injuries are sometimes shifted to the worker or the public at large (e.g., SSA disability insurance benefits)

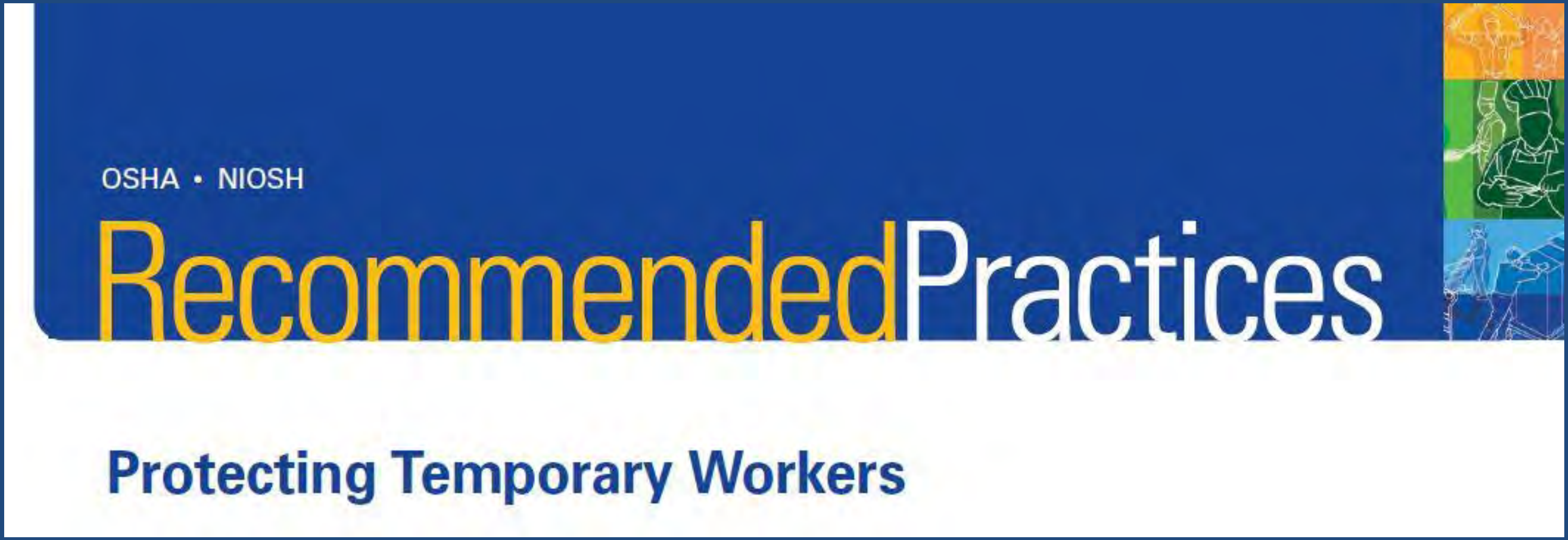
- **Employers**
  - Client—do not directly pay for workers' compensation and health insurance—they are insulated from premium adjustments based on the cost of workers' injuries.
  - Employers of NSWA workers escape the financial incentives that drive employer decisions to eliminate hazards for their workers.

# Differential Risks

- Temporary jobs can be more hazardous than standard worker jobs
  - Less experience & familiarity with operations due to short tenure at a worksite
  - Fewer hours of safety training relevant for the specific job assignment
  - More distant relationships with longer-term workers who could help navigate worksite hazards
- Limited availability & use of personal protective equipment
- Less likely to report unsafe conditions because of risks associated with precarious employment
- Confusion (real or perceived) about who is responsible for worker safety:
  - Who is the responsible employer? How do you tell?
    - Common law test, economic realities test, IRS test, various court cases

# OSHA/NIOSH Recommended Practices

- 8 recommendations for staffing agencies and host employers.
- https://www.osha.gov/Publications/OSHA3735.pdf
- http://www.cdc.gov/niosh/docs/2014-139/pdfs/2014-139.pdf



# Gig Economics: On the Bright Side

- Faster matching customer demand and worker supply
  - Digital platform "intermediates" between customers and workers
  - Relies on proprietary algorithms and a sophisticated rating system
  - Reduces costly "search frictions" (Pissarides, 2010)

- Platform removes transaction hassles
  - Theory of the firm (Coase, 1937)
  - Control over workforce and production is cheaper than cost on the open market and haggling for each individual transaction
  - Intermediation drastically lowers transaction costs

- Replaces workforce with an external "crowd"
  - Lowers costs of a permanent workforce
    - As long as the court believes you have no employees!
    - *Dynamex Operations West v. Lee* (CA Supreme Court No.S222732) (CA wage orders)
      - Burden is on the business to demonstrate that every worker is **<u>not</u>** an employee by proving <u>all three</u> of these elements: (1) worker is free from the control and direction of the hirer in connection with the performance of the work, both under the contract for the performance of such work and in fact; (2) worker performs work that is outside the usual course of the hiring entity's business; and (3) worker is customarily engaged in an independently established trade, occupation, or business of the same nature as the work performed for the hiring entity.

- Creates surplus value in the economy

# Gig Economics: On the Dark Side

- Post-industrial corporation
  - Maximize profit but not through productive enterprise
  - Create value through asset manipulation, speculation, and regulatory arbitrage

- Regulatory entrepreneurship
  - Tax opportunism
    - Taking advantage of an existing gap in the law available due to inherent features of the new sharing model
  - Arbitrage
    - Deliberate manipulation of the structure of a deal to take advantage of a gap between the economic substance of the transaction and its regulatory treatment.
      - Fire all workers, rehire them as independent contractors

- Core of gig business model
  - Evasion of employment law?
  - Classifying workers as contractors allows platforms to offer services without have to pay for the cost of workers

- Leads to negative externalities and devolution of responsibilities to micro-entrepreneurs

# Devolution of Responsibilities

- In U.S., social benefits are not attached to citizenship, but to employment or the individual.
  - Most states exempt independent contractors from benefits
  - Many benefits are administered by a particular employer and do not transfer
- Portability of the safety net for the 1099 economy
  - Many proposals for a safety net in a multiemployer world populated by crowdsourced workforce
- A contractor by any other name is still a contractor for OSHA purposes

# Physical

Robotics

Automation

# Occupational Robotics

- New field of practice for safety and health practitioners

- Robots & Exoskeletons

- Risky interactions between human and robot workers?

# Robot Census

- **South Korea**
  – 478 robot workers per 10,000 workers
- **Japan**
  – 315 robots/10,000 workers
- **Germany**
  – 292 robots/10,000 workers
- **United States**
  – 164 robots/10,000 human workers
- **China**
  – 36 robots/10,000 workers

# Organizational Profile

- **Superior Performance**
  - Robot workers are simply better than people at some tasks
    - Mundane, repetitive, and precise jobs as clear candidates.
    - Robot workers already taken over as the primary worker in many industrial factories.
  - With perfect memories, internet connectivity, and high-powered processors for data analysis, robots can also provide informational support beyond any human capability.
    - Keep perfect record of project progress
    - Provide real-time scheduling and decision support
    - Have perfect recall
- **Managerial Promise?**
  - Robots be placed in management positions where they can remind a team of deadlines, procedures, and progress
- **Operational Cost Reduction Derivative from Automation**
  - Permanent employees cost a lot of money—30 to 40% more than salary
  - Costs barely $8 an hour to use a robot for spot welding in the auto industry, compared to $25 for a worker—and the gap is only going to widen.

# 5 Types of Robots

- **Industrial robots**
  - Fixed in location
  - Humans and robots are separated
- **Collaborative robots**
  - Designed to work together with humans
- **Exoskeletons**
  - Wearable robotics
- **Service robots**
  - Autonomous ground vehicles (Driverless cars)
  - Unmanned aerial vehicles (Drones)
  - Household service robots
- **Companion robots**
  - Express human emotion

# 1. Industrial Robots

# Traditional Industrial Robots

- Decades of experience
- Used since the 1970s in auto manufacturing
- Established safety measures that keep human workers ***separated*** from robots

# 2. Collaborative Robots (Cobots)


# 2. Collaborative Robots

- Designed to work alongside human workers
- Controlled by human workers, by an algorithm, or by both
- Equipped with sensors designed to stop robot when contact with human worker occurs

# Newer Collaborative Robots

- Move alongside, and in shared space, with human workers


# Extreme Collaborative Robots

MATT SIMON SCIENCE 12.06.17 05:00 PM

## SAN FRANCISCO JUST PUT THE BRAKES ON DELIVERY ROBOTS


WIRED

# 3. Exoskeleton Robotics

- Mobile with the human
- Reduce mechanical stress
- Amplify or transform worker or soldier movements
- Industrial market projected to grow 229% per year between 2016 and 2021
    - Suit X, U.S. Bionics
    - Winter Green Research, Inc. (2015). Wearable Robots, Exoskeletons: Market Shares, Market Strategies, and Market Forecasts, 2015 to 2021. https://www.marketresearchreports.biz/reports/716060/wearable-robots-industrial-exoskeletons-shares-market-research-reports.pdf

# 4. Service Robots

- Automated Ground Robots
  - Currently operate in less controlled environments
    - May include human workers and manned vehicles
    - Agriculture, mining and manufacturing
    - Public roads and highways


# 4. Service Robots
## Large Vehicles

- Service robots used by Rio Tinto in Pilbara, Western Australia
  - No coffee breaks, fatigue and driver changeovers.
  - Stops only once a day for refueling.
- Engineers at Rio’s operations center in Perth (2 hours flight away) remotely control trucks
- Workforce at the mine is already about one-third lower as a result of automation.
- Autonomy enables drilling to run for almost a third longer on average than with manned rigs, and to churn through 10% more meters/hr. .

# 4. Service Robots:

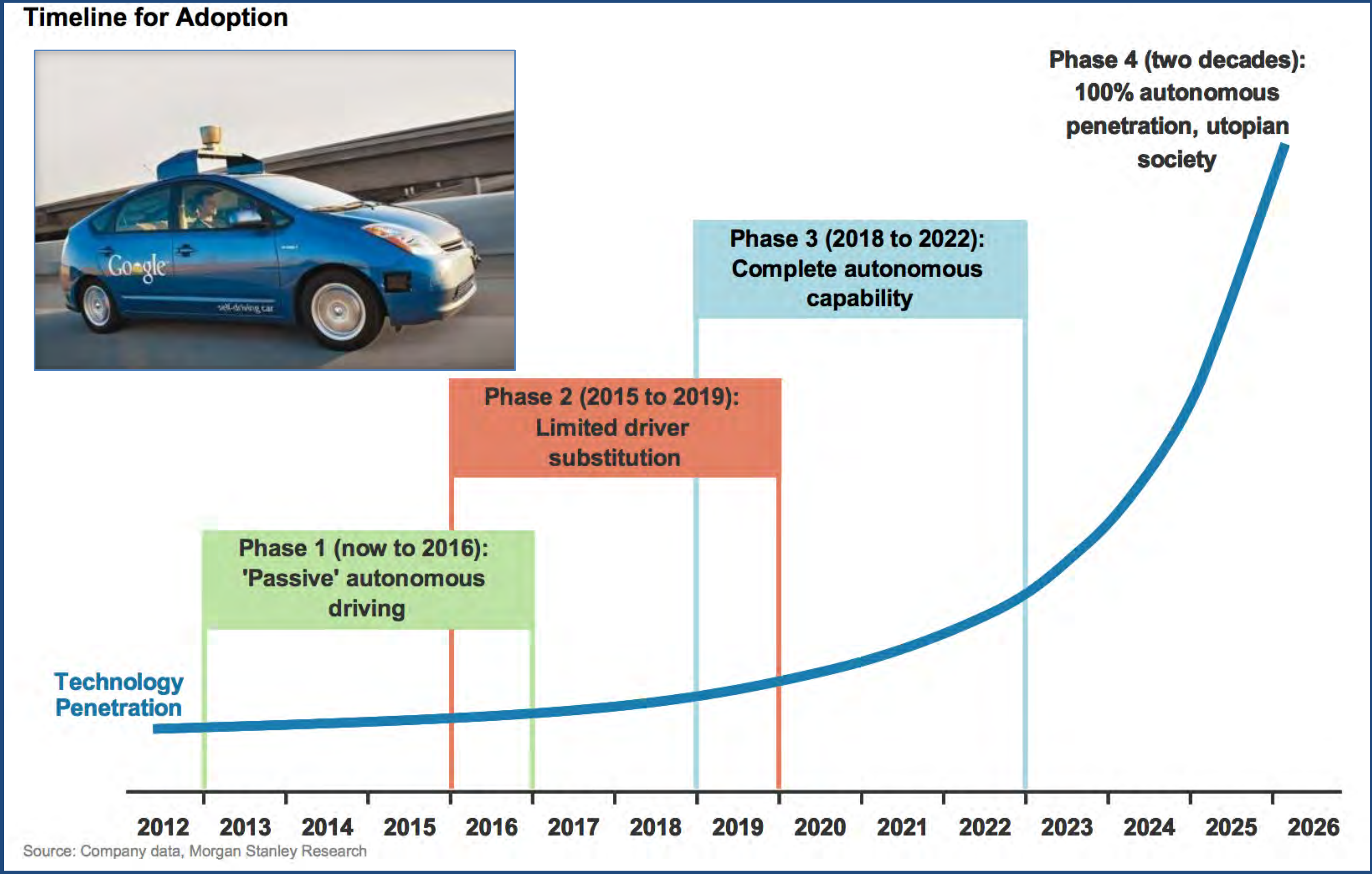
## Truck Platooning

- **Safety**
  - With the following trucks braking immediately, with zero reaction time, platooning can improve traffic **safety**.


- **Cost**
  - Platooning is also a **cost-saver** as the trucks drive close together at a constant speed. This means lower fuel consumption and less CO2 emissions.
- **Efficiency**
  - Platooning **efficiently** boosts traffic flows thereby reducing tail-backs. Meanwhile the short distance between vehicles means less space taken up on the road.

# 4. Service Robots

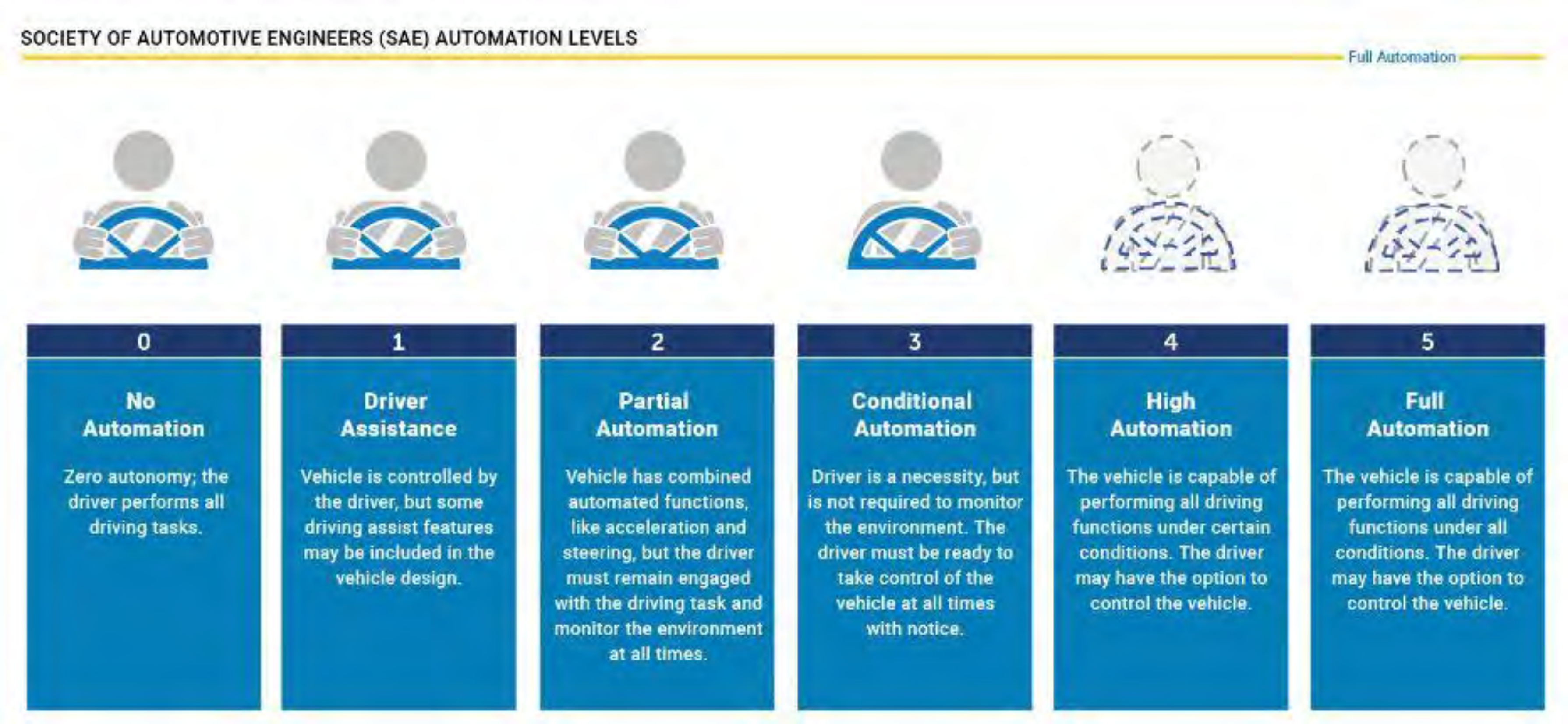
## Driverless Cars and Fleet Management



# 4. Service Robots

## Driverless Cars

- Self-driving vehicles ultimately will integrate onto U.S. roadways by progressing through several levels of driver assistance technology advancements in the coming years.



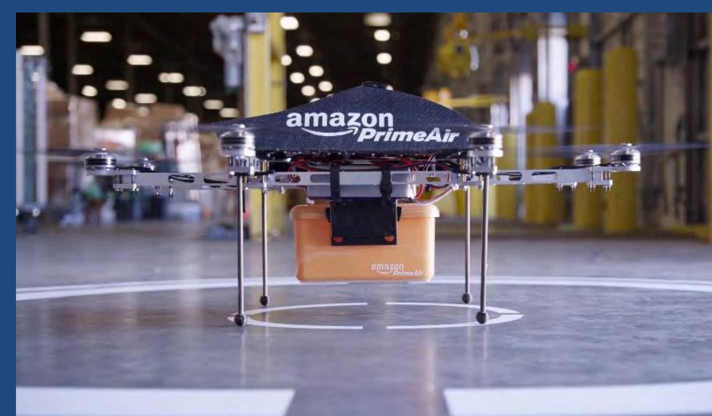
# 4. Service Robots

## Unmanned Aerial Vehicles

Military

Recreational

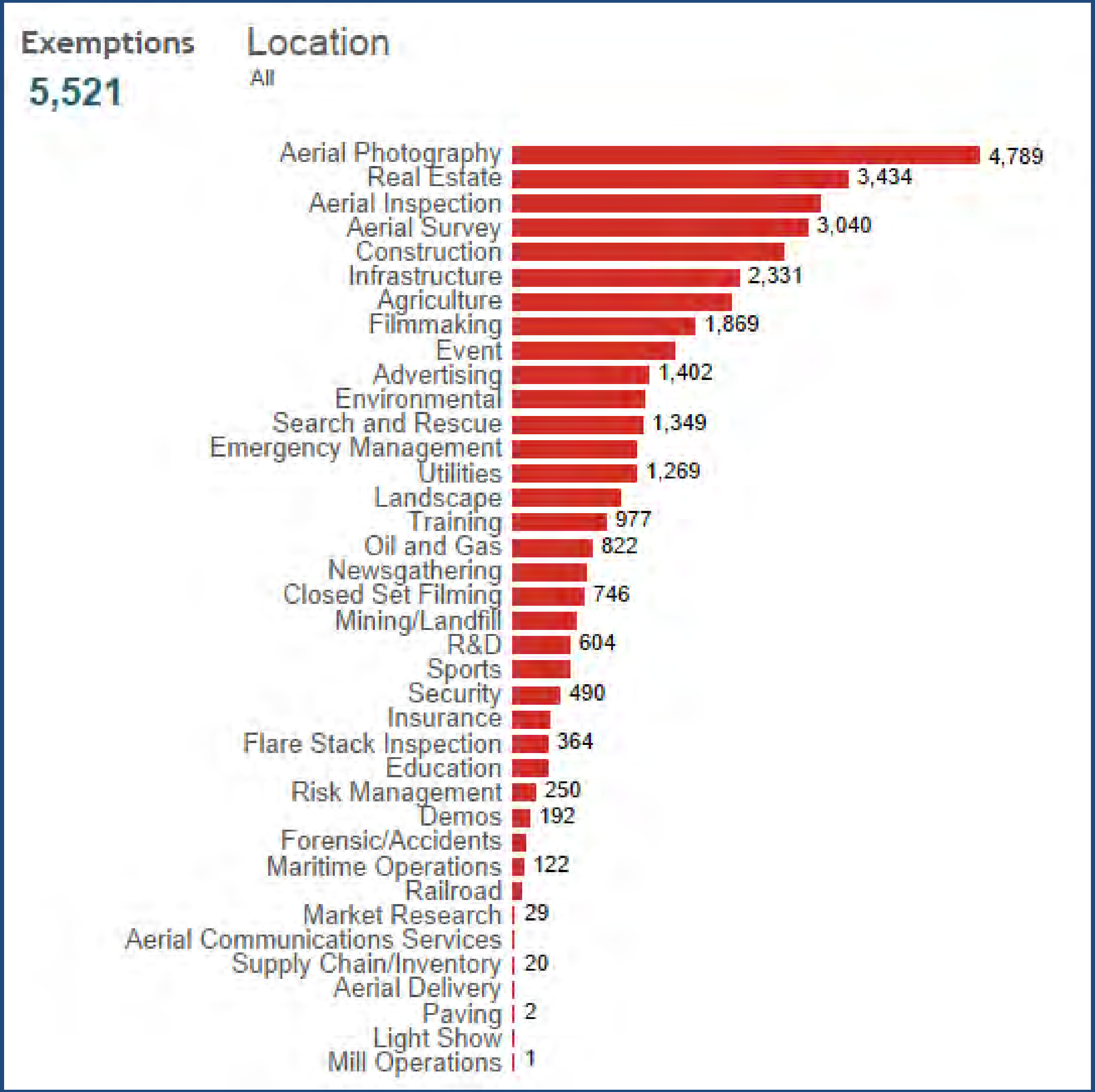

Public




Commercial

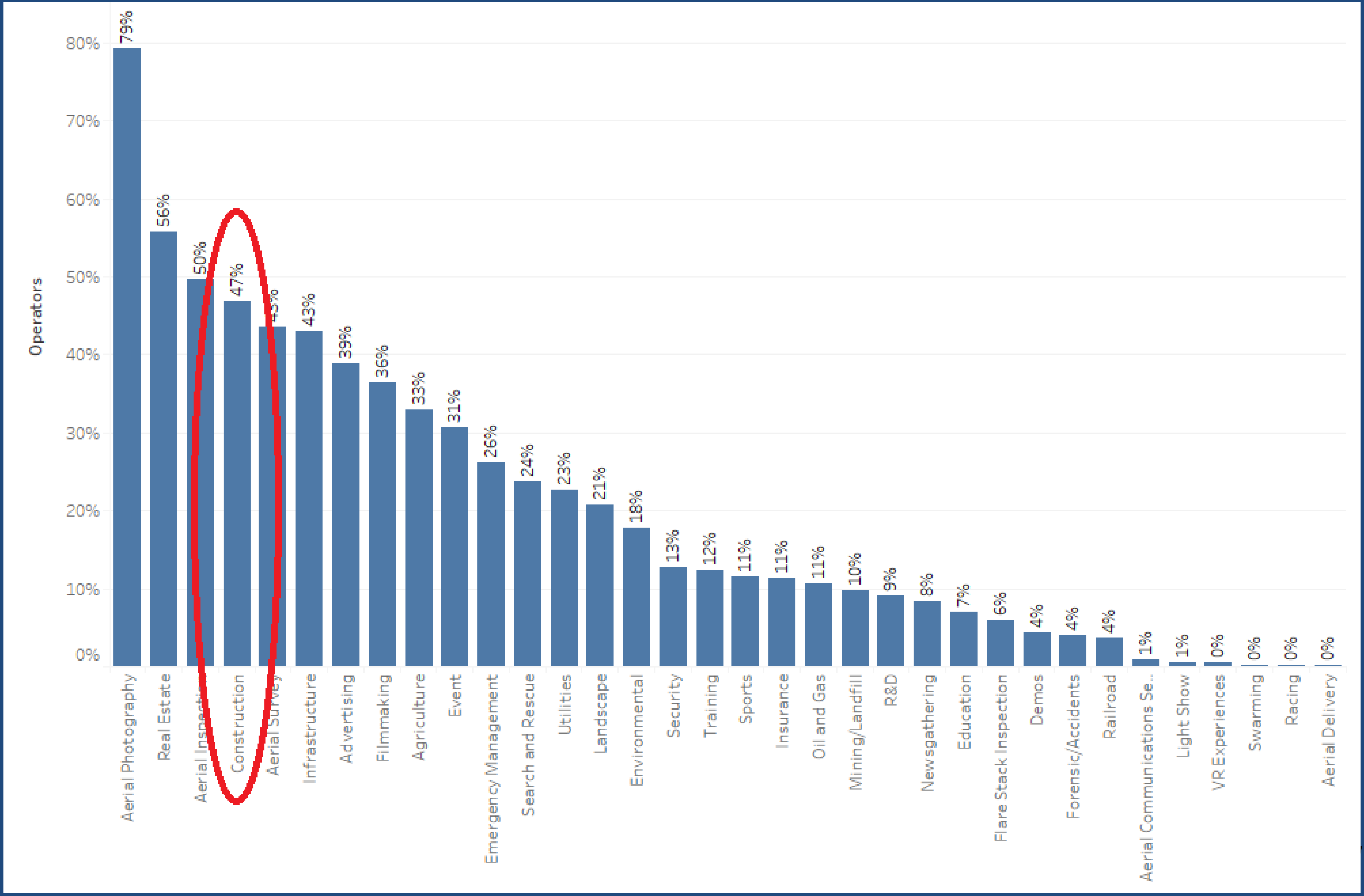
# Drone Application Areas

(by Section 333 exemptions as of August 2016, before 14 CFR Part 107)




AUVSI

# Part 107 Waivers as of July 31, 2017: Application Areas

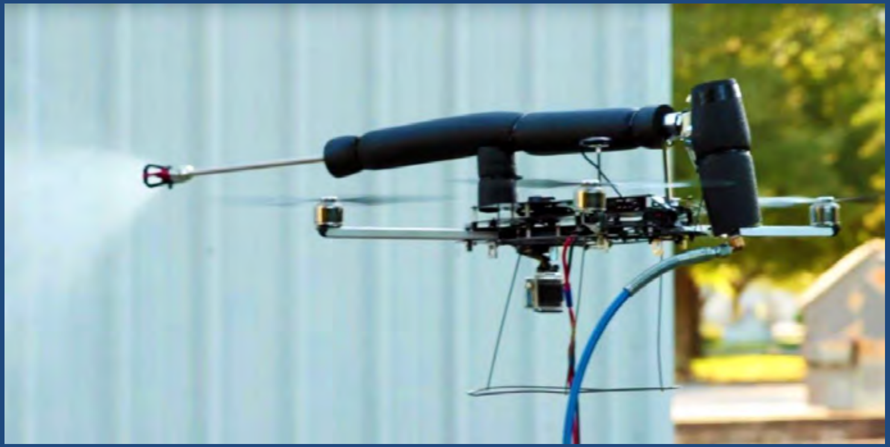


# UAVs Uses in Construction

Monitoring

Inspection

Maintenance



Hazardous Applications

# Sources of Risk from UAVs

- **Engineering**
  - Errors in the drone’s mechanics (e.g., loose connections across parts, faulty electronics and sensors).
- **Human**
  - Errors in programming, interfacing peripheral equipment, and connecting input/output sensors resulting in unpredicted movement or action by the drone;
  - Errors in judgment resulting from “over-attributing” to autonomous robots more human-like qualities and capabilities;
  - Errors in remote operating.
- **Environmental**
  - Unstable flying conditions, extreme temperature, poor sensing in difficult weather or lightning conditions leading to incorrect response

# 5. Companion Robots

- ***Pepper*** is a humanoid robot by Aldebaran Robotics and *SoftBank* Mobile designed with the ability to read emotions. An emotional robot.
  - Introduced on 5th June 2014 to enhance human well-being.
  - Available on February 2015 at a base price of JPY 198,000 ($1,931) at Softbank Mobile stores.
- Pepper's emotion comes from the ability to analyze expressions and voice tones.

# Robotics & Safety

**Potential**

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

**Concerns**

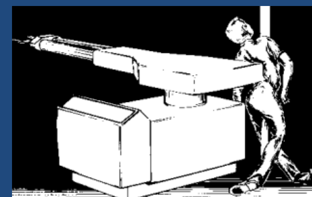
- Likely increase in robot-related human injuries
- New types of robots will require refined and new protection strategies
  - Robot with dynamic machine learning capabilities challenge static safety procedures
- Rapid advances in technology may outpace guidance/standards setting
- Stress associated with changing workplace and potential for human worker displacement

# Injuries to Humans by Robots

- **U.S. Census of Fatal Injuries (CFOI)**
  - 53 Robot-related deaths, 1992-2013
- **OSHA**
  - 38 Robot-related fatalities, 1983-2013
- **U.S. Bureau of Labor Statistics**
  - 61 robot-related deaths, 1992-2015 (CFOI)
- **Germany, July 2015**
  - 22-year-old worker died from injuries he sustained when he was trapped by a robotic arm and crushed against a metal plate

# Guidance on Working Safely with Robots

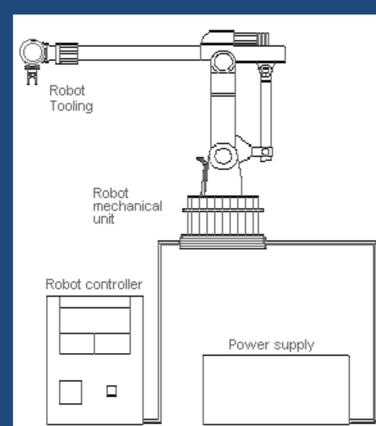
**Preventing the Injury of Workers by Robots, NIOSH Pub. No. 85-103**



**1740. Robots and Robotic Equipment**

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


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




# ANSI/RIA Robotic Safety Standards

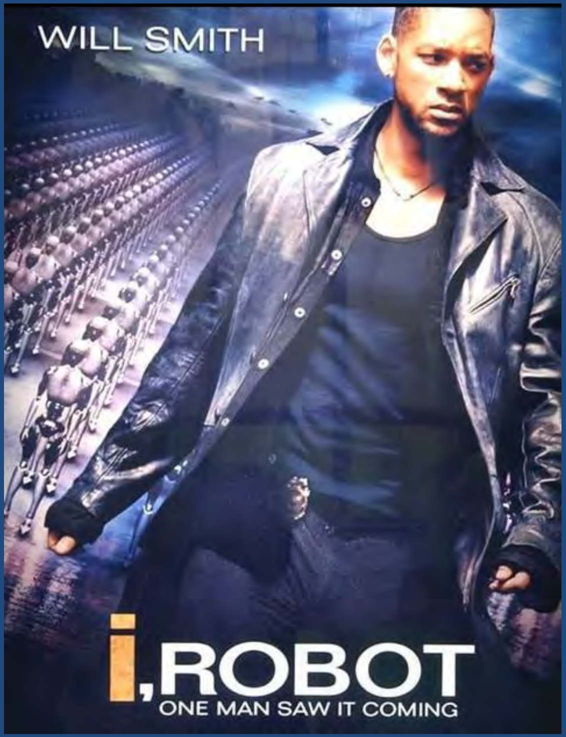
- **ANSI/RIA R15.06-2012**
  - American National Standard for Industrial Robots and Robot Systems- Safety Requirements
    - Approved March 28, 2013
    - Revision of ANSI R15.06-1999
  - Provides guidelines for the manufacture and integration of industrial robots and robot systems
    - Emphasis on their safe use, the importance of risk assessment and establishing personnel safety.
    - Key feature in the standard is "collaborative operation,"
      - Introduction of a worker to the loop of active interaction during automatic robot operation.

# Robot Ethics

- **Two cars sinking in the water**
  - Detective Del Spooner (Will Smith)
  - Young girl, Sarah

- **Robot could save only one of them, Spooner yells "*Save the girl!*"**
  - Probability of survival for Spooner was 45%
  - Probability of survival for Sarah was 11%

- **Robot saved Spooner; girl drowned.**




- Fleetwood, J. Public Health, Ethics, and Autonomous Vehicles. *Am J Pub Health*. 2017; 107(4): 532-537

MORAL MACHINE

Home | Judge | Classic | Design | Browse | About | Feedback | En


Welcome to the Moral Machine! A platform for gathering a human perspective on moral decisions made by machine intelligence, such as self-driving cars.

We show you moral dilemmas, where a driverless car must choose the lesser of two evils, such as killing two passengers or five pedestrians. As an outside observer, you **judge** which outcome you think is more acceptable. You can then see how your responses compare with those of other people.

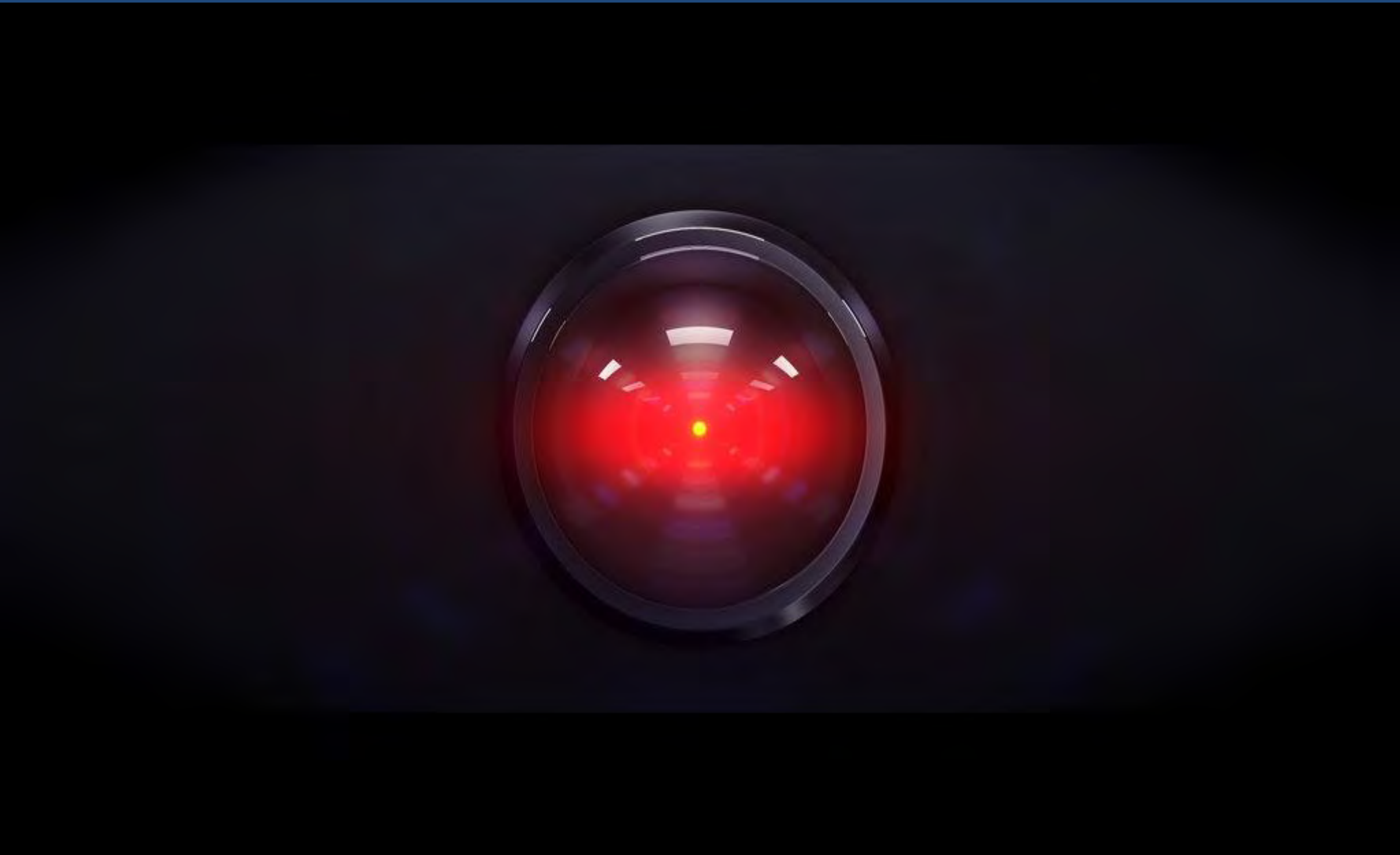
If you're feeling creative, you can also **design** your own scenarios, for you and other users to **browse**, share, and discuss.

Start Judging

Browse Scenarios

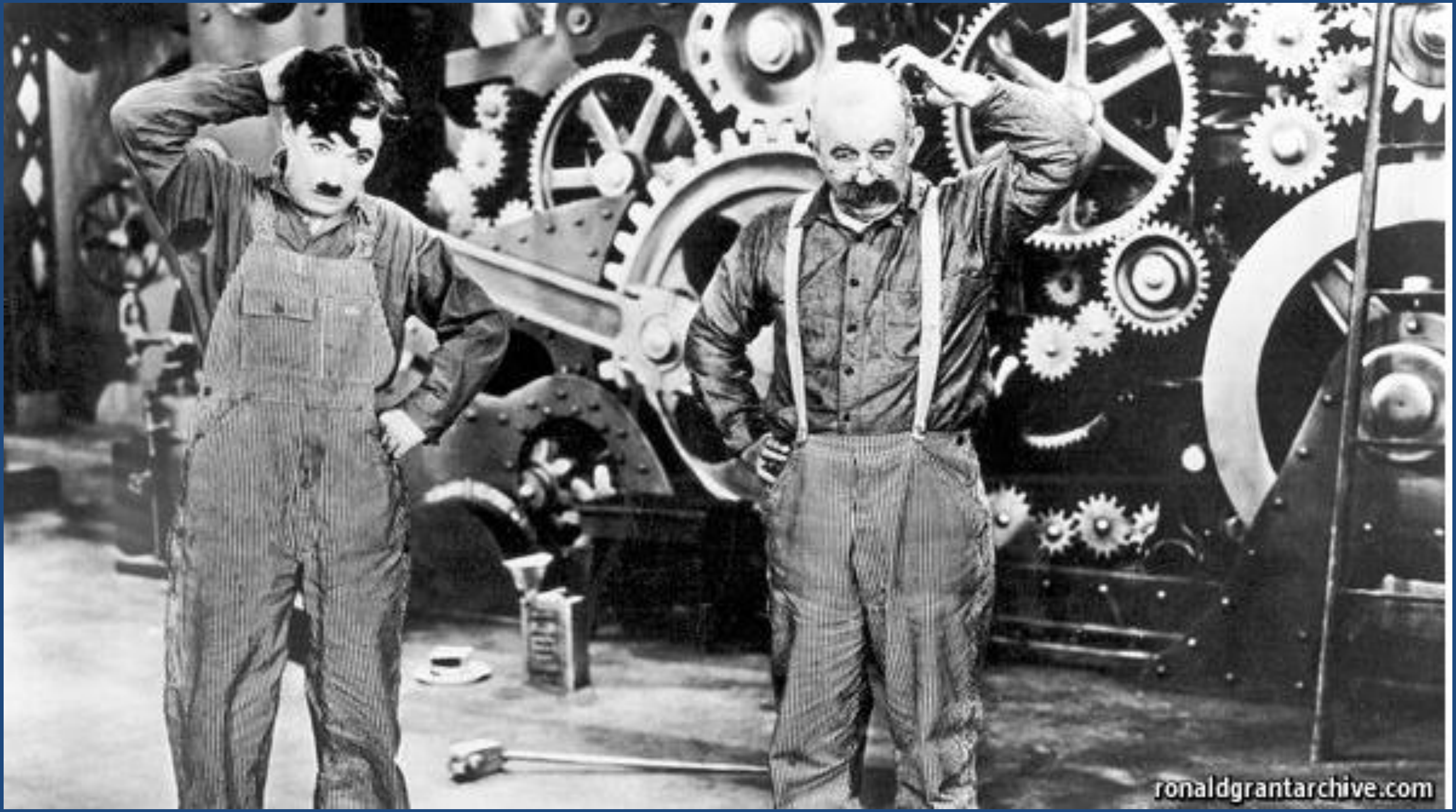
View Instructions

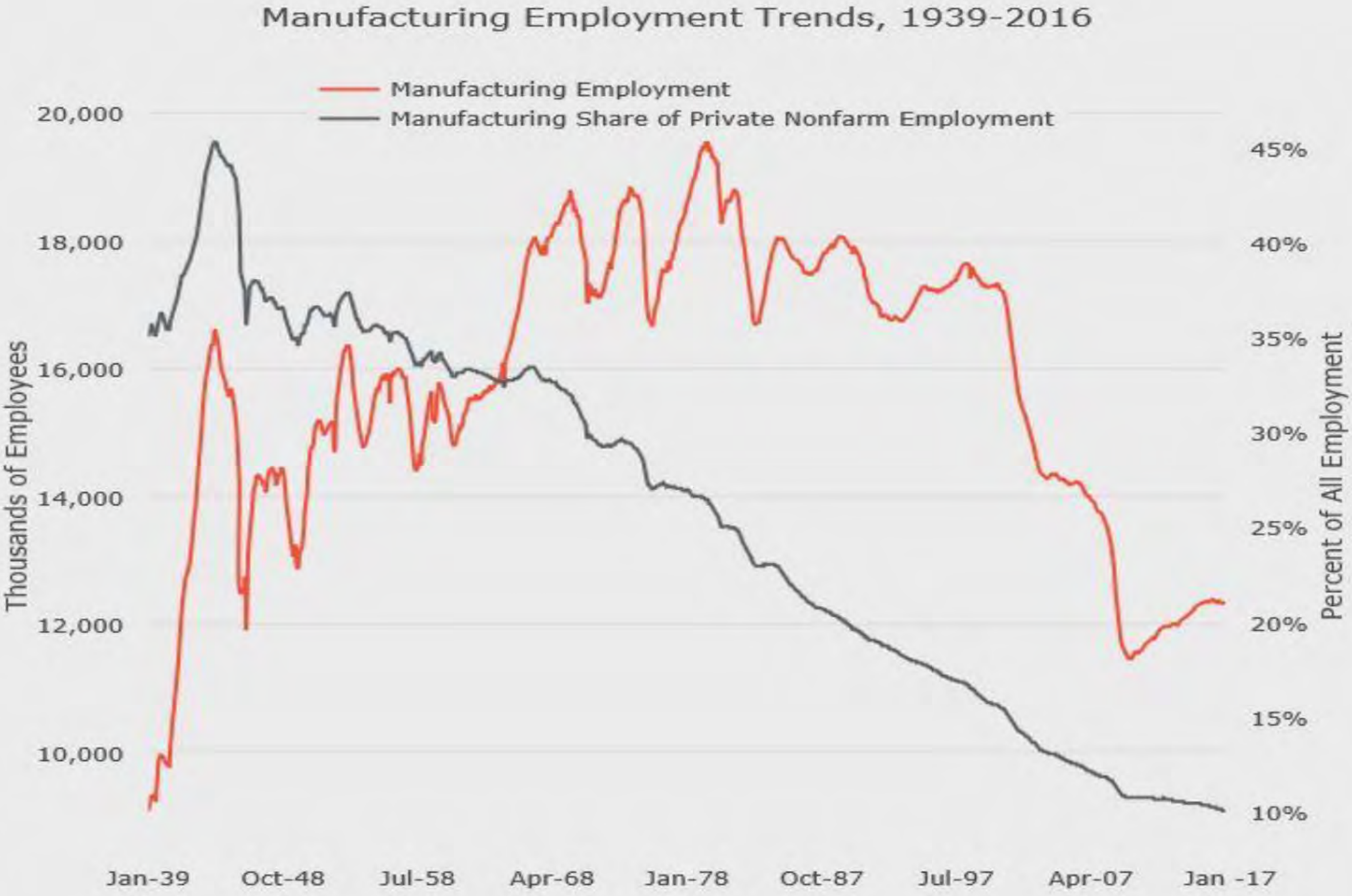
# "I'm sorry Dave, I'm afraid I can't do that"



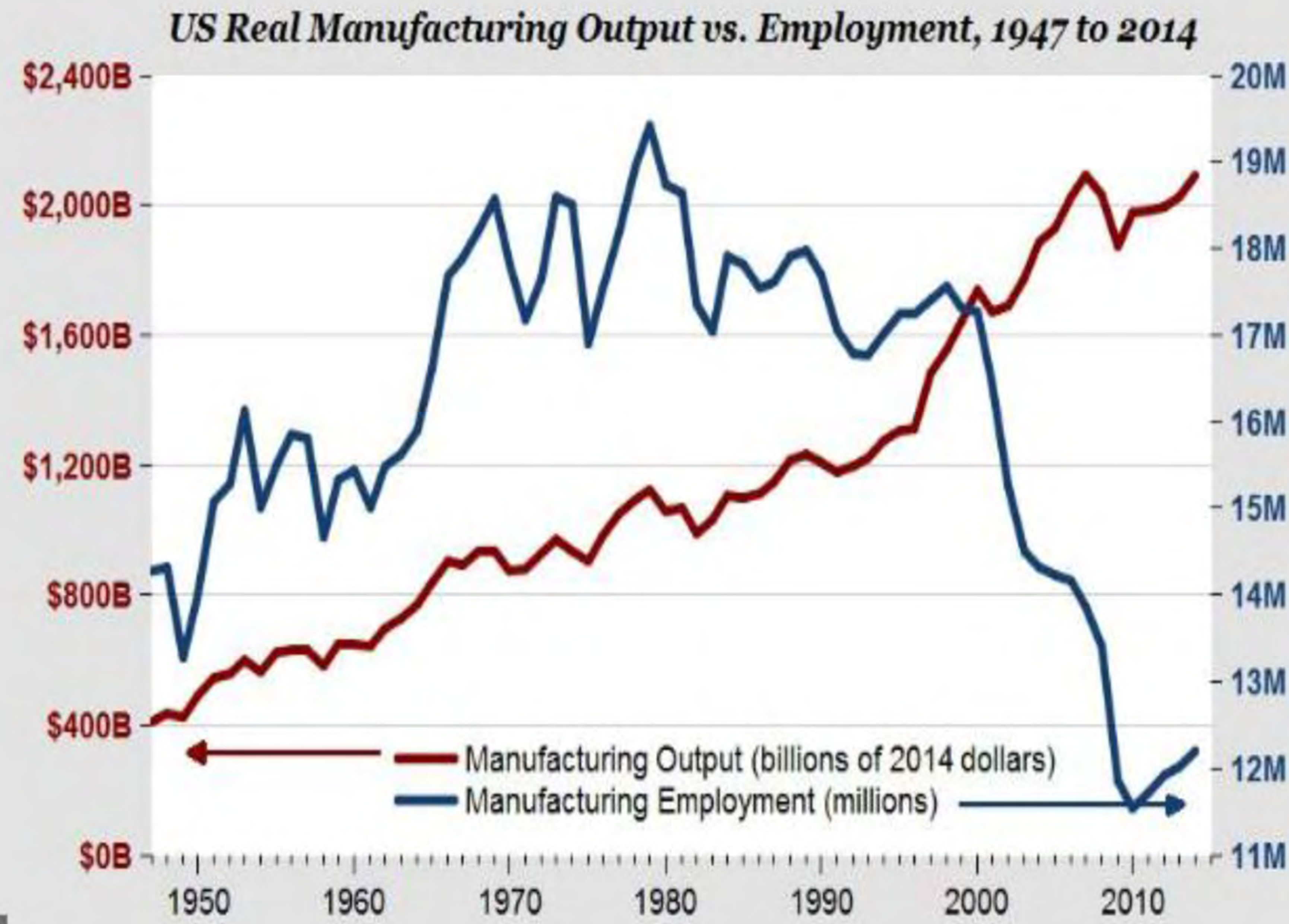
# Automation:
# The Case of Manufacturing

# Manufacturing—What Next?






Source: Current Employment Statistics.



US Real Manufacturing Output vs. Employment, 1947 to 2014
$2,400B
$2,000B
$1,600B
$1,200B
$800B
$400B
$0B
20M
19M
18M
17M
16M
15M
14M
13M
12M
11M
1950
1960
1970
1980
1990
2000
2010
Manufacturing Output (billions of 2014 dollars)
Manufacturing Employment (millions)

# Technology & Job Density

- In manufacturing, as in other industries, job density—the number of jobs per process—is declining.
- The reason—automation—and robotics—and advanced manufacturing techniques.
- More generally, the “job intensity” of America’s manufacturing industries—and especially its best-paying advanced ones—is only going to decline.
- In 1980 it took 25 jobs to generate $1 million in manufacturing output in the U.S..
- Today it takes five jobs.

# Decline in Jobs: Is it Technology or Trade?

- **It's Technology (Robots)**
  - Erik Brynjolfsson, MIT Sloan School of Management
    - *Race Against the Machine*
    - *Second Machine Age*
- **It's Trade (China)**
  - David Autor, MIT Department of Economics
    - *The China Syndrome: Local Labor Market Effects of Import Competition in the United States. American Economic Review 2013, 103(6): 2121–2168*

**KIVA**

A Kiva Systems robot can scurry about the floor of a large warehouse to find ordered products. It then fetches the correct rack or pallet and brings it to a worker who packages the goods.

# Advanced Manufacturing Today

# Additive Manufacturing

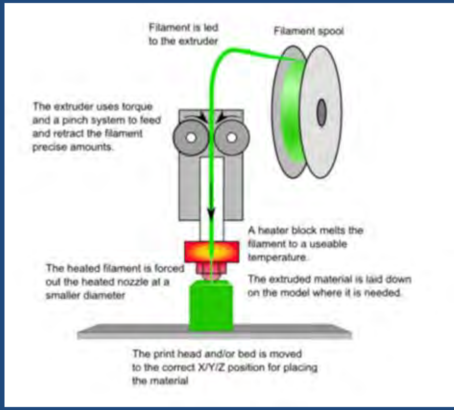
**Plastic, Metal or Living Tissue**

- **Techniques** (metal powder + laser)
  - Material extrusion
  - Material jetting
  - Binder jetting
  - Sheet lamination
  - Vat photopolymerization
  - Powder bed fusion
  - Directed energy deposition

- **Advantages**
  - Increases efficiency
  - Eliminates final assembly
  - Promotes customization over mass production
  - Democratizes manufacturing
  - Facilitates open design
  - Creates novel tort liabilities?

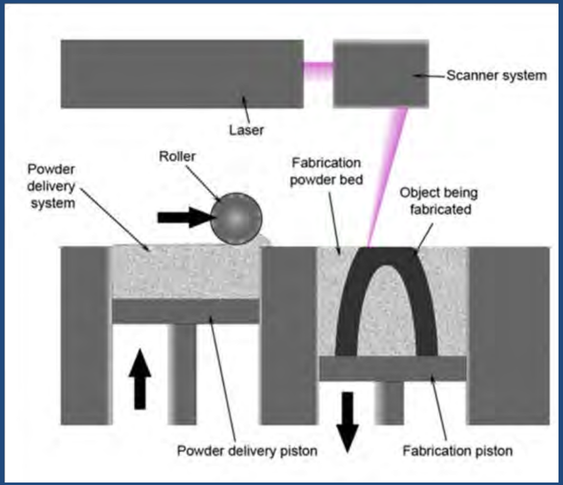
# Illustrating Basic Techniques

## Fused Filament Fabrication (FFF)

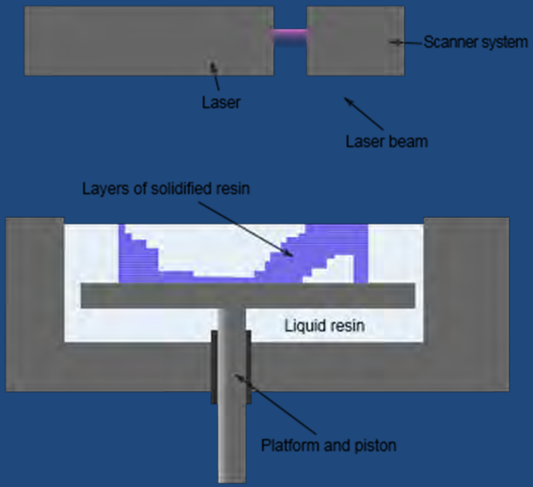



(3D Printing)

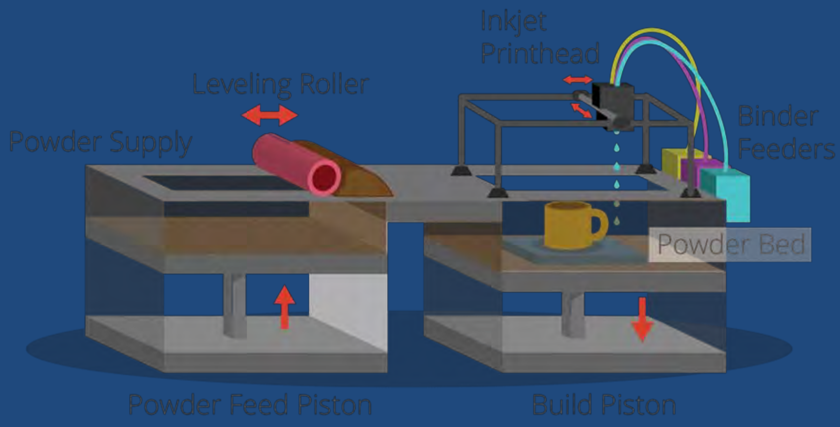
## Selective Laser Sintering (SLS)



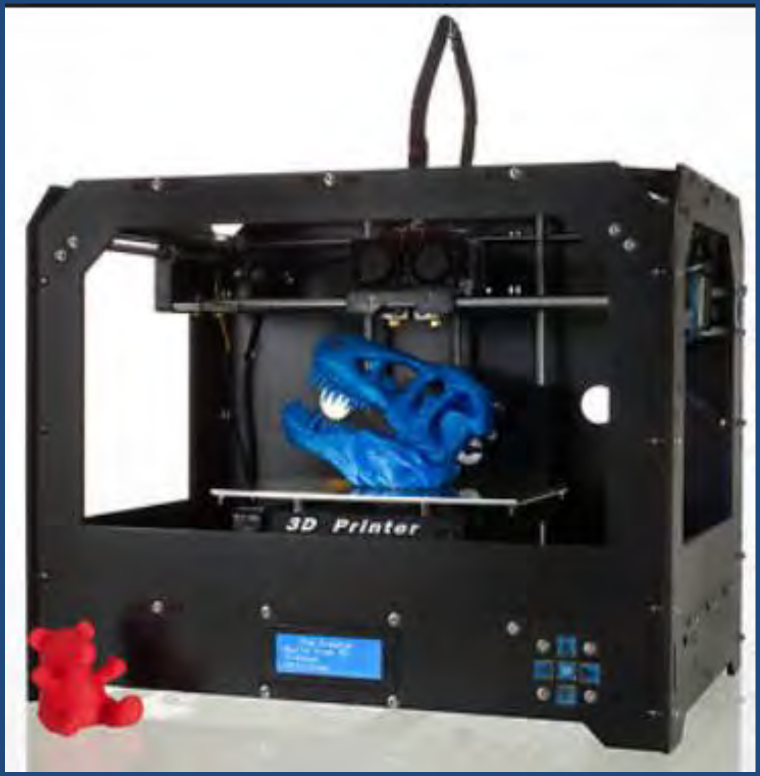

## Stereolithography




## Powder Bed Inkjet Binding



# Desktop 3D Printing




- Readily available
- Multiple polymer strands available
- Custom ‘at home’ strand compounding
- Prices dropping, units getting larger

NTRC NANOTECHNOLOGY RESEARCH CENTER

# This is also a 3D Printer

NTRC NANOTECHNOLOGY RESEARCH CENTER

# Additive Manufacturing


Rethink risk management?

- EHS, Security, Response Issues
- Uses pure (pyrophoric) Aluminum
- **Up to 400 lb per charge**
- Warehouse feedstock for 10 charges
- Emission, exposure, waste

NTRC NANOTECHNOLOGY RESEARCH CENTER

# Materials of Interest in Additive Manufacturing

## Polymers

- Acrylonitrile-butadiene-styrene
- Polylactic acid
- Propylene fumarate
- Poly(vinyl alcohol)
- Polycarbonate
- Polyethylene
- Polystyrene

## Solvents

- Dimethyl fumarate
- Isopropanol
- Acetone
- Methyl Ethyl Ketone
- 2-Butanone

## Metals

- Ti-6Al-4V
- IN 625 & IN 718 (Ni, Cr)
- 17-4 PH stainless steel
- Cobalt chromium

## Nanomaterials

- nFe (steel sintering)
- nAg (sintering, conductivity)
- nCB, CNT (conductivity, stiffness, tensile strength)
- $nSiO_x$ (polymer strength)

# Advanced Manufacturing Effects

**Tectonic Retooling?**

- Changes in the process of manufacturing
  - Customization
  - Reduction in parts
  - Reduction in time spent on production
- How designers go about their work
- What factory looks like
- Where production is located
- What production workers do
- Way business agreements are structured
- What work arrangements are used

# 3D Rocket Printing

- Fuel tank produced in days
- Traditional manufacture in one year
- Printed rocket engine and fuel tank tested 85 times at NASA facility in MS


# Digital

**Sensors**

**Artificial Intelligence**

# Sensor Technology Is Expanding

- **Enabling capabilities increasing exponentially**
  - Improvement of measurement science
  - Readily available geographic and spatial information
  - Miniaturization of instruments
  - Utilization of smart phone/tablet technologies

- **Types of Sensors**
  - Environmental sensors
    - Air, water environment
    - In-vehicle monitoring
  - Wearable sensors
    - Clothing
    - Hard hats
  - Embedded sensors
    - Internal biologic monitors

# Advanced Fabrics—Wearable Sensors


Marty Ellis, of Inman Mills in South Carolina, checks a machine manufacturing fabric developed through AFFOA.

# Functional Fabrics

- **DEFENSE**
  Functional fabrics will lighten soldiers' gear, enhance situational awareness on the battlefield, and decrease fratricide.
- **CONSUMER PRODUCTS**
  High value-added products based on advanced woven & nonwoven technologies.
- **VENTURE CAPITAL**
  Fund the coming surge of wearable products and startup ventures.
- **TRANSPORTATION**
  Join the wave of intelligent transportation systems with functional fabrics.
- **MANUFACTURING MACHINERY**
  Producing new fibers and textiles will require next-generation equipment and machinery.
- **ARCHITECTURAL & INTERIOR TEXTILES**
  'This old house' can now monitor, act, and re-act all by itself.
- **APPAREL**
  Smart clothes that can cool, change color, adjust size, last longer, mask or transmit odors, take photos, and so much more.
- **SOFTWARE & DATABASES**
  IT combined with functional fabrics enables highly insightful and useful information.
- **MEDICAL TEXTILES & SCANNERS**
  Clothing that can detect impending medical events and save lives.
- **RAW MATERIALS**
  Manufacturers of advanced functional materials for fibers and fabrics.
- **CONSUMER ELECTRONICS**
  Enabling the "internet of wearables" transforming apparel into consumer electronics.

# Internet of Things (IoT)

- Sensors are at the heart of the Industrial Internet
  - Deploying sensors, the entire workplace and everything and everyone in it can become a type of information system

- Sensors can become intelligent assets—devices equipped with sensors and connected to one another produce sensor-based analytics
  - Sensor maintenance = technician
  - Sensor placement, sensor data interpretation, control recommendations = ***Occupational Data Scientist***

# 21st Century Exposure Science:

- **Work environment**
  - Sampling & Analysis
  - Direct-reading instruments

- **Biologic environment**
  - Biomarkers of exposure
  - Biomarkers of effect

# Sensor-Enabled Exposure Assessment

- Was the worker overexposed?
  - Sensor measures concentration
- *Where* did the exposure occur?
  - Spatial positioning by satellite
- *When* did the exposure occur?
  - Timed exposure with atomic clock
- *Why* did the exposure occur?
  - Data stream makes it easier to analyze when correlated with simultaneous event video
- *Only issue left—controls*


# Sensors → Data → Intelligence

# Worker Protection Informatics

- The ***science and practice*** of determining ***which sensor information is relevant*** to protecting worker safety, health, well-being, and productivity, and then developing and implementing effective mechanisms
  - to *collect, validate, store, share, analyze, model, and apply the information, and then to confirm achievement of the intended outcome* from use of that information,
  - and then *conveying experience to the broader community, contributing to generalized knowledge, and updating standards and training*.

**Adapted from http://www.internano.org/nanoinformatics/ and Hoover et al. 2015**

# Artificial Intelligence

# Sensor Data Used by AI: Issues

- Do existing and proposed sensor methods **accurately measure** what they are supposed to be measuring?
- How can they be **adequately calibrated and validated**?
- When are they limited to use for screening and **when can they provide accurate characterizations** of specific hazards?
- Given the large to vast amounts of sensor data that may be collected, **how can those data be feasibly analyzed and interpreted by a occupational health data scientist**?





# Categories of AI

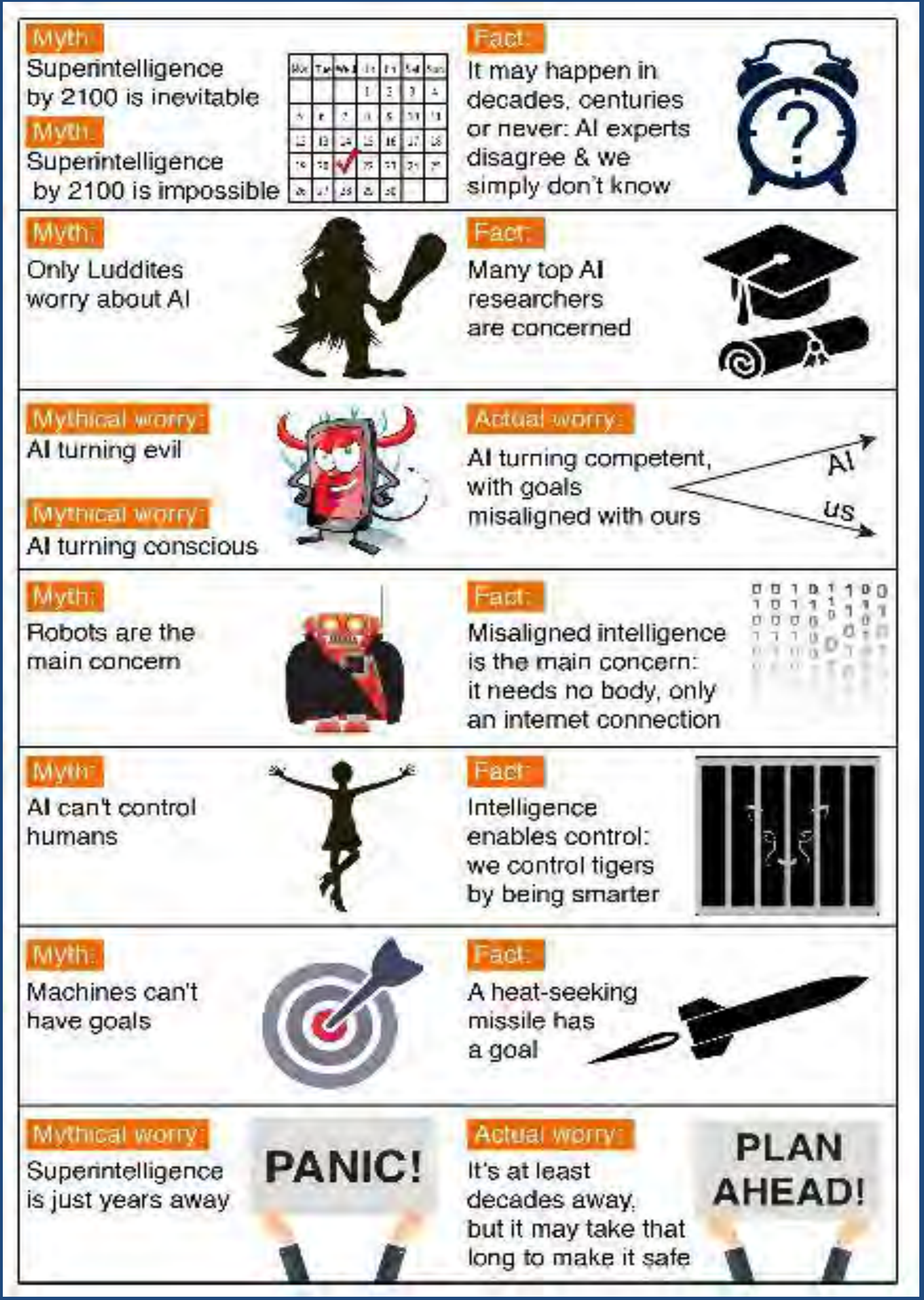
- **Artificial Narrow Intelligence (ANI):**
  - Referred to as *Weak AI*, Artificial Narrow Intelligence is AI that specializes in *one* area. There's AI that can beat the world chess champion in chess, but that's the only thing it does. Popular "chatbots" are other examples of *Weak AI*

- **Artificial General Intelligence (AGI):**
  - Referred to as *Strong AI*, or *Human-Level AI*, Artificial General Intelligence refers to a computer that is as smart as a human *across the board*—a machine that can perform any intellectual task that a human being can.

- **Artificial Superintelligence (ASI):**
  - Artificial Superintelligence ranges from a computer that's just a little smarter than a human to one that's trillions of times smarter—across the board.

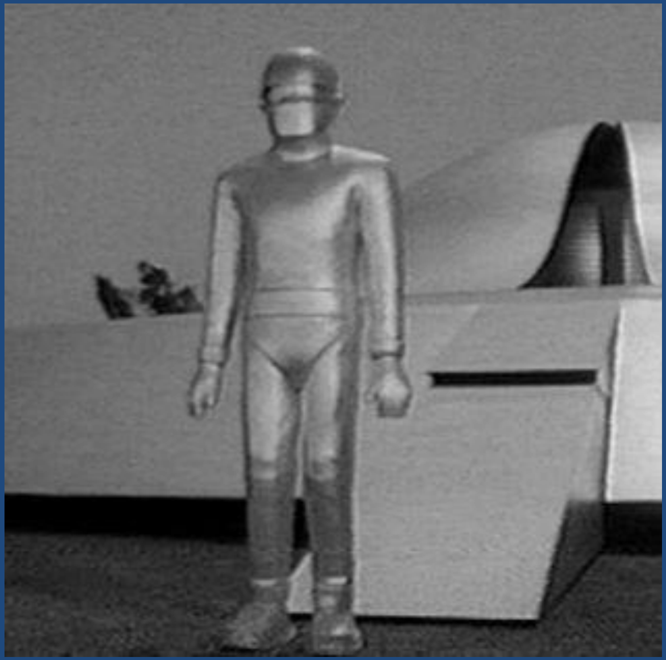
# AI Concerns

- Stephen Hawking, Elon Musk, Steve Wozniak, Bill Gates, and many other big names in science and technology have recently expressed concern about the risks posed by AI.
    - Future of Life Institute, https://futureoflife.org/background/benefits-risks-of-artificial-intelligence/



# AI and Safety Management

- Can AI recognize a near-miss?
- Can it assess data to present a risk assessment probability?
- Can it offer risk mitigation recommendations based on real-time sensor data and historical situations?
- Can it take control to prevent destructive human actions?



# Center for Workers' Compensation Studies

## at NIOSH

- Maximize the use of workers' compensation data and systems to improve workplace safety and health
  - Injury compensation data → injury prevention interventions
- Build partnerships between the public health, insurance, and social security disability compensation systems
  - To prevent injury, disability, and compensation costs

# CWCS Focus Areas

- Trend state-level **claims data** by industry and cause
  - State-based grants for WC surveillance
    - CA, MA, OH, TN, MI
  - Ohio Bureau of Workers' Compensation
    - Claims analyses
    - Cause of injury by industry
    - https://www.ncbi.nlm.nih.gov/pubmed/27667651
    - https://www.ncbi.nlm.nih.gov/pubmed/28953071

- Conduct **prevention effectiveness** studies
  - Ohio BWC Safety Grant
  - CA SCIF-focused risk control study

CWCS
CENTER FOR WORKERS' COMPENSATION STUDIES

CDC Workplace Safety and Health NIOSH

# CWCS Focus Areas

- Use insurer-collected **employer data** to understand exposures across industries
  - Insurer risk control interviews
  - Insurer industrial hygiene forms standardization

- Sponsor **worker care** studies
  - WC Stakeholder Perspectives Study (RAND)
  - Opioid addiction prevention—WCRI, OH, MA
  - Return-to-Work studies

- Promote **outreach** to insurers, public health community, and workers

CDC Workplace Safety and Health NIOSH

CWCS CENTER FOR WORKERS' COMPENSATION STUDIES

# Thank You!