FACTORY H.0

Establishing Human-Centric Manufacturing to Maximize Quality of Life and Productivity in the 21st Century
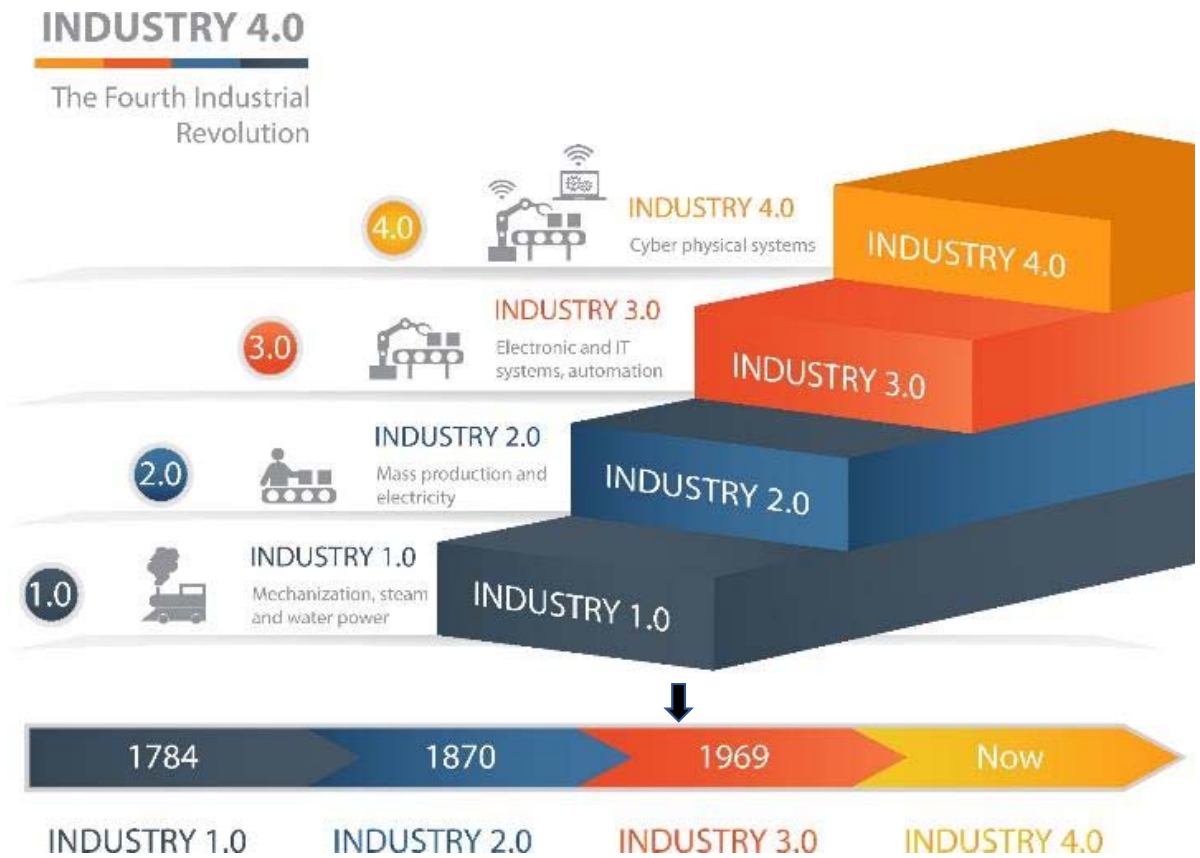
Ajay & Harsha Malshe, June 2019

"It's not human versus machine, it's humans and machines."

Anonymous

Industrial Revolutions and their Objectives

- ❖ Scalability
- ❖ Productivity
- ❖ Precision
- ❖ Efficiency
- ❖ Reliability
- ❖ Reproducibility
- ❖ Resilience
- ❖ Profitability

INDUSTRY 4.0

The Fourth Industrial Revolution

INDUSTRY 4.0 — Cyber physical systems

INDUSTRY 3.0 — Electronic and IT systems, automation

INDUSTRY 2.0 — Mass production and electricity

INDUSTRY 1.0 — Mechanization, steam and water power

1784	1870	1969	Now
INDUSTRY 1.0	INDUSTRY 2.0	INDUSTRY 3.0	INDUSTRY 4.0

Race for

automation...

Modern Times (1936)

Side effects of automation…

Traditional Components of Industry 4.0

- ✓ Big Data
- ✓ Machine learning
- ✓ IOT
- ❖ Scalability
- ❖ Productivity
- ❖ Precision
- ❖ Efficiency
- ❖ Reliability
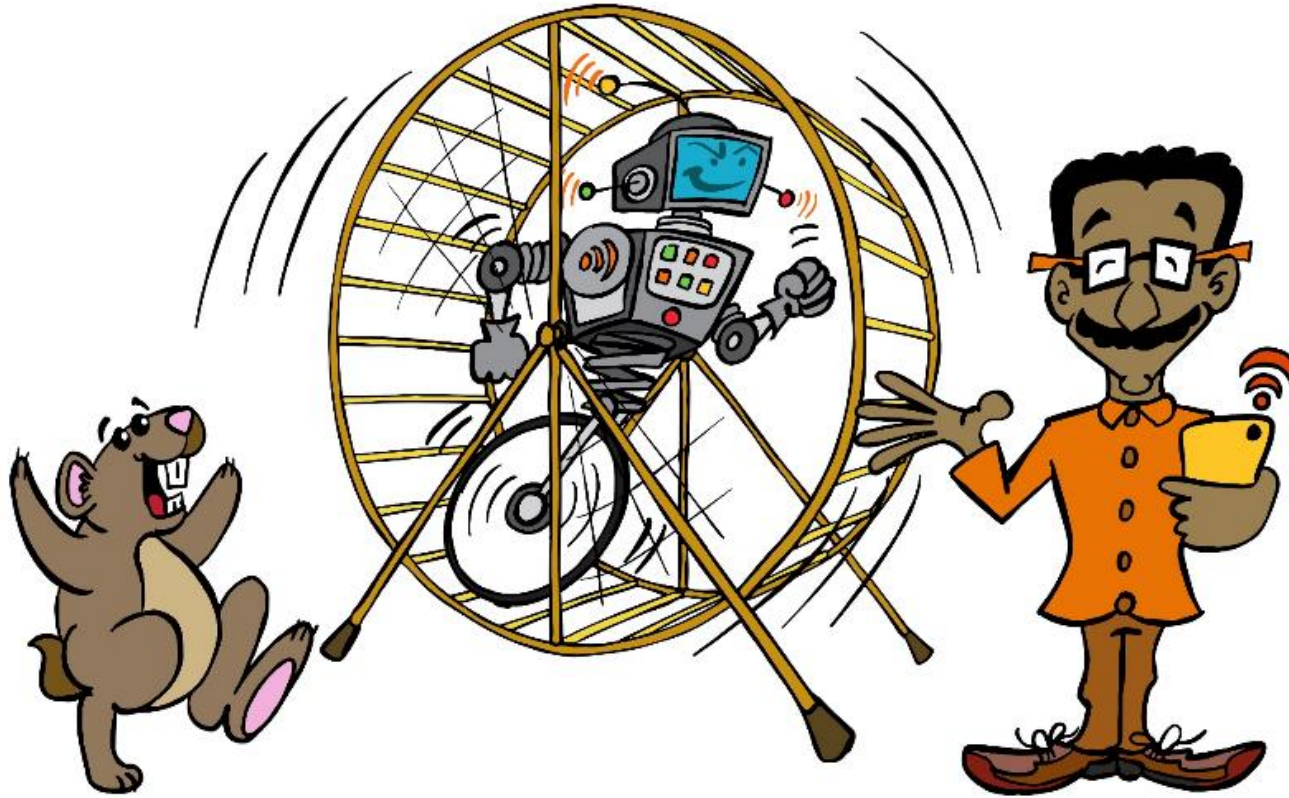- ❖ Reproducibility
- ❖ Resilience
- ❖ Profitability...

Accelerating automation...

"Quo Vadis: where are you going?"

The Hamster Wheel of Automation

HYPERAUTOMATION & The Law of Diminishing Returns

Drivers for Urgency

Human **Survival**

Individual **Competitiveness**

Societal **Democratization**

UK manufacturing industry lost 600,000 jobs in a decade:

A study by the GMB union found that *every region in the UK has suffered a decline in manufacturing employment over 10 years, with London, Scotland and the north-west the worst affected*.

Jude Brimble, GMB national officer, said: *"We are at a critical crossroads in UK manufacturing*

MANUFACTURING EMPLOYMENT

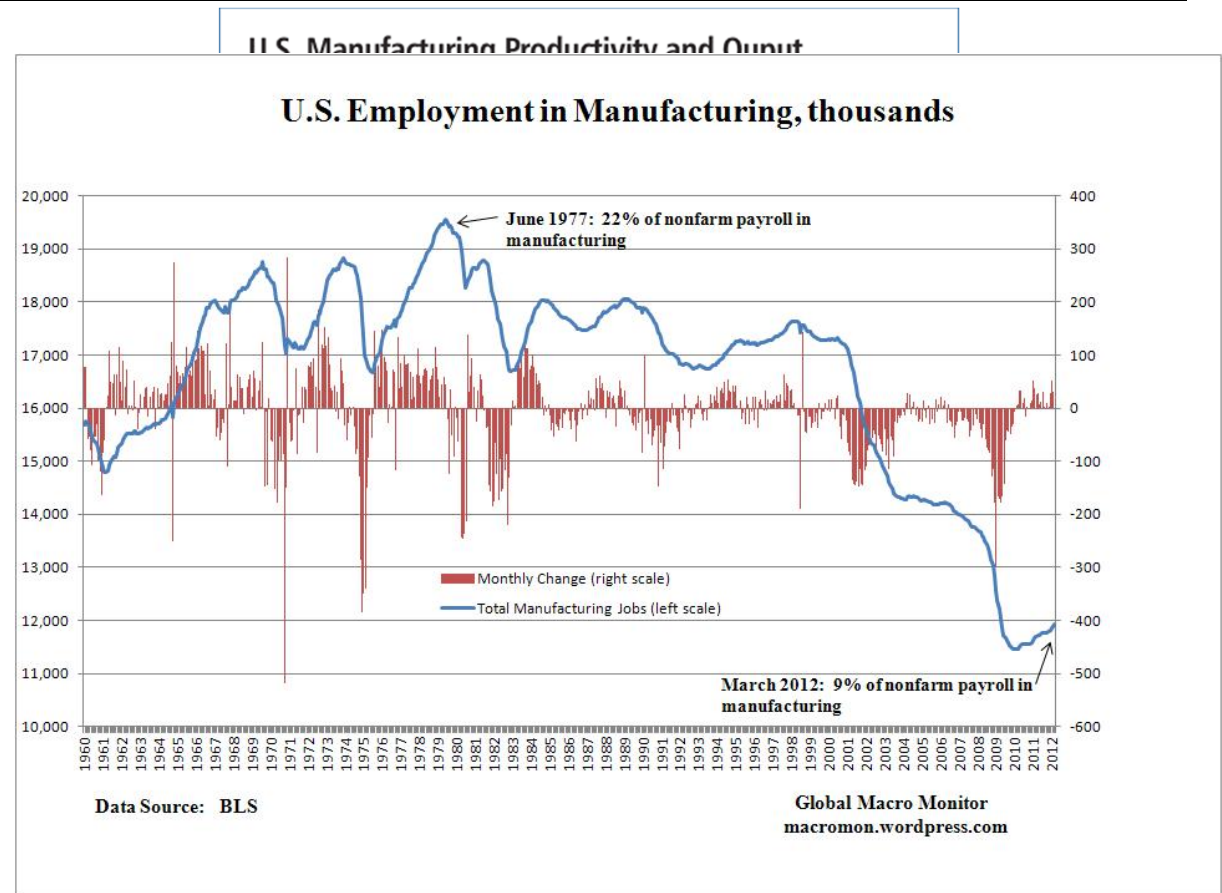| (Thousands)	1995	1996	1997	1998	1999	2000
South East	461	485	487	512	499	493
Eastern	378	385	382	383	373	367
G London	312	309	310	311	300	290
South West	332	341	350	349	337	335
West Midlands	583	583	581	585	551	542
East Midlands	429	442	437	447	427	418
Yorks & Humbs	431	436	439	437	422	416
North West	480	486	485	479	460	449
North East	193	209	197	201	188	184
Merseyside	75	68	70	70	67	66
Wales	220	228	225	232	218	215
Scotland	339	328	335	329	311	306
N Ireland	111	107	113	114	112	111
United Kingdom	**4345**	**4408**	**4412**	**4449**	**4266**	**4191**

https://www.theguardian.com/business/2018/jun/04/uk-manufacturing-has-lost-600000-jobs-in-a-decade-says-union; https://www.tutor2u.net/economics/content/diagrams/manufacturing10.gif

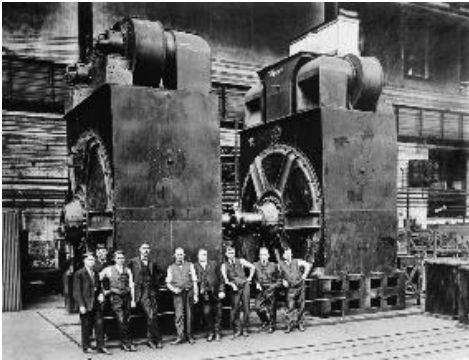# Driver 1 (America): Job Creation & Losses During Industrial Revolutions in US

During the peak of Industry 2.0:

❑ Catastrophic <u>losses</u> in manufacturing **jobs**

❑ Monumental <u>leap</u> in manufacturing **productivity**

U.S. Manufacturing Productivity and Ouput

U.S. Employment in Manufacturing, thousands

June 1977: 22% of nonfarm payroll in manufacturing

Monthly Change (right scale)
Total Manufacturing Jobs (left scale)

March 2012: 9% of nonfarm payroll in manufacturing

Data Source: BLS

Global Macro Monitor
macromon.wordpress.com

Driver 2: Convergence for Competitiveness

- Industrial

- Information

- Micro/nano

- Digitization and 3-D printing

- Autonomous systems and intelligent robotics

- General/widespread artificial Intelligence

Driver 3: Democratization and Harmony

Bell-Time,' wood engraving after
Winslow Homer drawing of 1868

2018 and near future

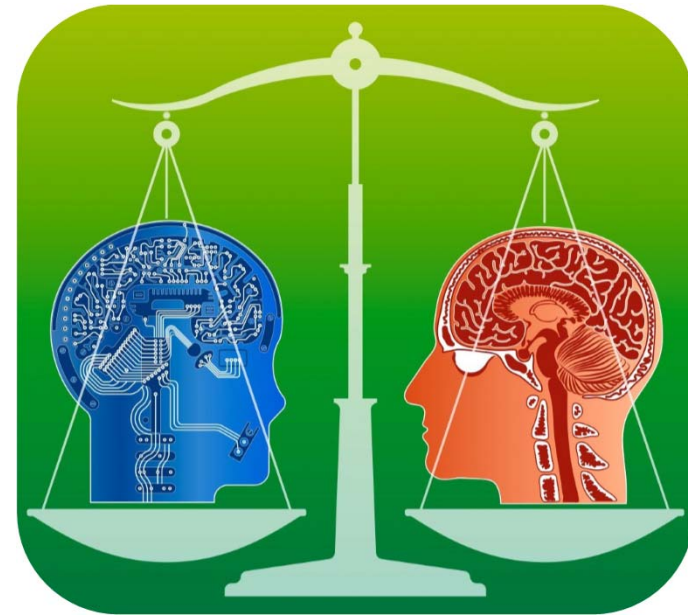*Loss of jobs, human connectivity and quality of life...*

"The pessimist sees difficulty in every opportunity. The optimist sees opportunity in every difficulty."

Winston Churchill

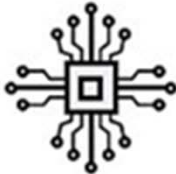How do we realize the much needed and **human-centric** industrial revolution (industry or work **H.0**)?

Look Within

"Our deepest fear is not that we are inadequate. Our deepest fear is that we are powerful beyond measure. It is our light, not our darkness that most frightens us."
Marianne Williamson

Human and Machines Differential Specs

	Weight	Space	Processor Speed	Energy Efficiency
	3 pounds (1.4 kg)	1/6 basketball (80 cubic inches or 1,300 cm³)	Up to 1,000,000 trillion operations per second	20 watts
	150 tons	Basketball court (cabinets over 4,350 square feet, or 400 m²)	93,000 trillion operations per second	10 million watts

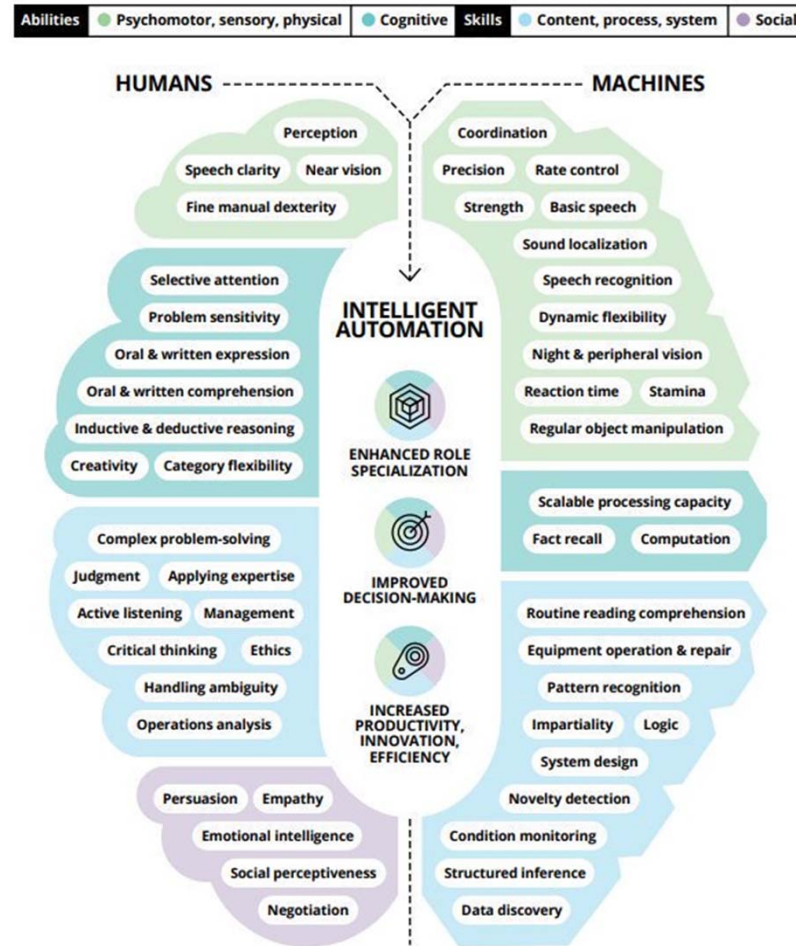https://www.educba.com/artificial-intelligence-vs-human-intelligence/

Human Strengths

Machine Strengths

Figure 1. A new mind-set for the no-collar workforce

Humans and machines can develop a symbiotic relationship, each with specialized skills and abilities, in a unified workforce that delivers multifaceted benefits to the business.
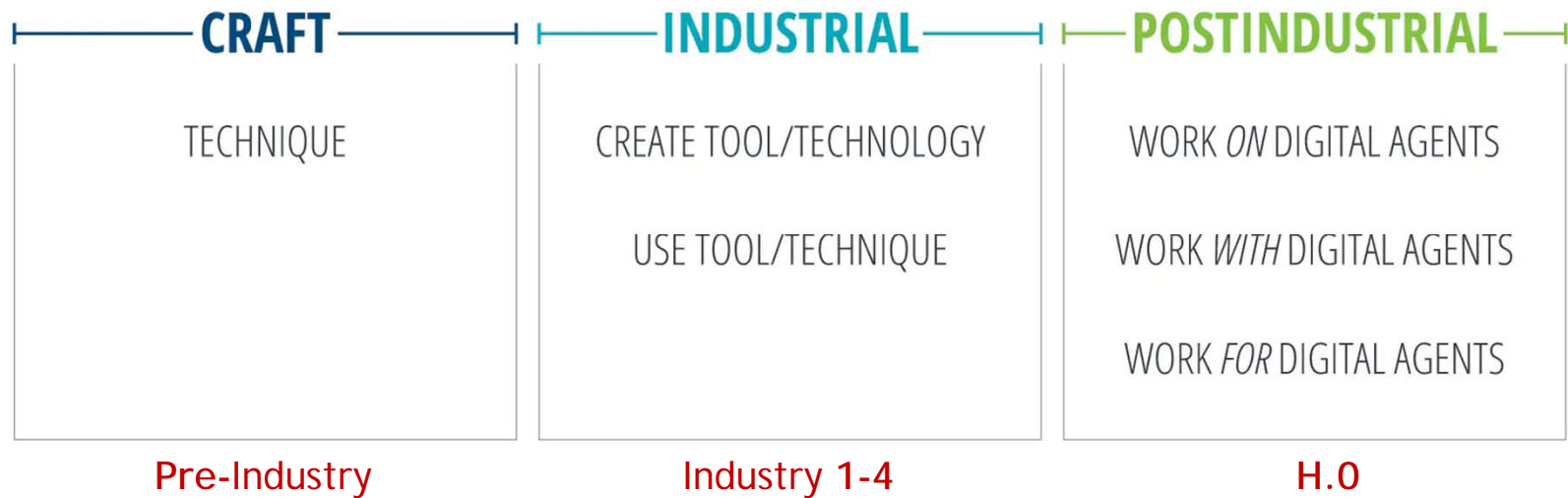
| Abilities | ● Psychomotor, sensory, physical | ● Cognitive | Skills | ● Content, process, system | ● Social |

HUMANS - **MACHINES**

HUMANS
- Perception
- Speech clarity
- Near vision
- Fine manual dexterity

- Selective attention
- Problem sensitivity
- Oral & written expression
- Oral & written comprehension
- Inductive & deductive reasoning
- Creativity
- Category flexibility

- Complex problem-solving
- Judgment
- Applying expertise
- Active listening
- Management
- Critical thinking
- Ethics
- Handling ambiguity
- Operations analysis

- Persuasion
- Empathy
- Emotional intelligence
- Social perceptiveness
- Negotiation

INTELLIGENT AUTOMATION

ENHANCED ROLE SPECIALIZATION

IMPROVED DECISION-MAKING

INCREASED PRODUCTIVITY, INNOVATION, EFFICIENCY

MACHINES
- Coordination
- Precision
- Rate control
- Strength
- Basic speech
- Sound localization
- Speech recognition
- Dynamic flexibility
- Night & peripheral vision
- Reaction time
- Stamina
- Regular object manipulation

- Scalable processing capacity
- Fact recall
- Computation

- Routine reading comprehension
- Equipment operation & repair
- Pattern recognition
- Impartiality
- Logic
- System design
- Novelty detection
- Condition monitoring
- Structured inference
- Data discovery

Sources: Deloitte LLP, *Talent for Survival: Essential skills for humans working in the machine age*, 2016; Deloitte LLP, *From brawn to brains: The impact of technology on jobs in the UK*, 2015; Jim Guszcza, Harvey Lewis, and Peter Evans-Greenwood, *Cognitive collaboration: Why humans and computers think better together*, Deloitte University Press, January 23, 2017; Carl Benedikt Frey and Michael A. Osborne, *The Future of Employment: How Susceptible are Jobs to Computerisation?*, University of Oxford, September 17, 2013; O*NET, US Department of Labor.

Deloitte Insights | Deloitte.com/insights

Data Science Association - https://www.datascienceassn.org/content/humans-vs-machines-skills-abilities

"A new division of labor."

Humans can work *on*, *with*, or *for* digital agents

CRAFT	INDUSTRIAL	POSTINDUSTRIAL
TECHNIQUE	CREATE TOOL/TECHNOLOGY USE TOOL/TECHNIQUE	WORK *ON* DIGITAL AGENTS WORK *WITH* DIGITAL AGENTS WORK *FOR* DIGITAL AGENTS
Pre-Industry	**Industry 1-4**	**H.0**

Source: Deloitte analysis.

Deloitte Insights | deloitte.com/insights

https://www2.deloitte.com/insights/us/en/focus/technology-and-the-future-of-work/the-new-division-of-labor.html

Disruptions (new innovations) ensure continuous returns and increase perceived value...
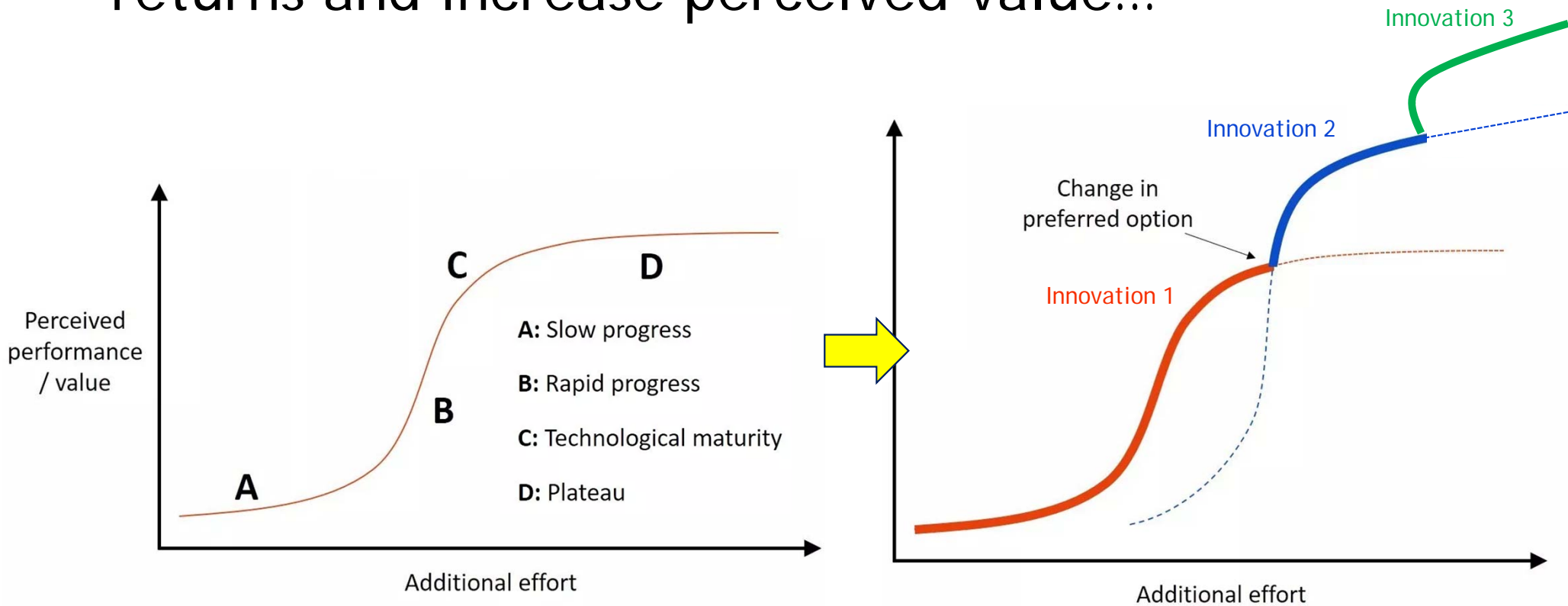
"Sometimes, a deeper order—a better fit to a purpose—is achieved through simplification rather than further increases in complexity."

Ray Kurzweil

First Principles Thinking

Origin:

From Medieval Latin *manufactura "a making by hand", from Latin manu, ablative of manus "hand" + factura "a working," from past-participle stem of facere "to perform." *(Ref: https://www.etymonline.com/word/manufacture)*

Let's bring "HUMAN HANDS" back to manufacturing...

Vision

Manufacturing science and engineering **research** to enable the development of "human-centric" manufacturing factories for simultaneously maximizing quality of life **and** productivity across the world.

Human-Centric Manufacturing Factory

A long-term vision of success for building "Factories Engineered, Operated and Advanced" <u>primarily</u> by Human in Harmony with Machines:

- *What type of products and services should be manufactured?*

- *What type of factories will be required to produce such products?*

- *What kind human : machine interfaces need to be developed?*

- *What type of processes will be require to produce harmony between human and robots?*

- *What fundamental advancements in our understanding of manufacturing science and engineering are required to apply these processes economically?*

- *What autonomous systems need to be developed that can assemble components in these human-centric factories?*

Factory Operations for Human-centric Interfaces

- Fabrication
- Assembly
- Repair and service
- Storage
- Distribution
- Reclamation
- Maintenance and more...

Recent major example of human-centric automation disruption, increasing productivity...

HOW TESLA IS BUILDING CARS IN ITS PARKING LOT

Tesla's new Model 3 assembly line inside a 'tent' is 'way better' and cheaper than other line, says Elon Musk

Tesla CEO: New "tent" assembly line is "way better" than conventional factory

Cyrus Farivar • 06/19/2018 8:54 am • Cars
View non-AMP version at arstechnica.com

Instead of the floor-mounted, arm-like robots working in most plants, the tent is filled with gantries. Think of these like a series of gates, through which the car-carrying conveyor belt runs. They're not robots, but lift assists—devices that make it easy for human workers to move big hunks of metal. They're mostly used for "cross car" installations, putting together things that run the width of the vehicle, since that's work more easily done from above than from the side.

Inside the tent, that series of gantries installs various bits: The IP gantry puts in the instrument panels. The glazing gantry does the windshields and rear glass. You can guess what the "door on gantry" and "seat gantry" do. Something called the "marriage gantry" joins the underbody of the car (where you'll find the battery, suspension, and motors) to the top bit.

"I think it's kind of clever and ingenious that they've come up with a structure they can put up very very quickly," says Vadhavkar. And if this is the move that finally puts Tesla across that near-mythical 5,000-car-per-week mark, maybe Musk should consider setting up Sprung 4 —and using it for a whopping big party.

-says Abhay Vadhavkar, who spent the first few decades of his career in manufacturing at Ford and GM, and is now the director of manufacturing, engineering, and technology at the Center for Automotive Research

Ref: https://www.google.com/amp/s/www.wired.com/story/tesla-fremont-factory-model-3-production-tent-parking-lot-structure/amp; https://www.bizjournals.com/sanjose/news/2018/07/31/tesla-model-3-production-factory-tsla.html

Recent major example of human-centric automation disruption, sustaining quality of life...

Starsky Robotics sees truckers as essential to future of driverless trucking (with video)

Clarissa Hawes · 13 hours ago

Starsky Robotics launched "the future of driverless trucking is not driverless" campaign on June 11. Photo: Starsky Robotics

As some autonomous trucking startups seek to eventually eliminate drivers' jobs completely, Starsky Robotics is taking a different approach.

The three-year startup, headquartered in San Francisco, is developing autonomous trucks with remote driving capabilities. It launched its new campaign titled "The future of driverless trucking is not driverless" on June 11.

Stefan Seltz-Axmacher, Starsky's chief executive and co-founder, said the company is different from other self-driving startups because it pairs a "unique combination of human decision-making and automation."

Seltz-Axmacher explained to FreightWaves, "While others are trying to build fully autonomous trucks, we are building a truck that drives with no person in it and is remote-controlled for the first and last mile and that's a completely different mindset. We are not eliminating drivers' jobs. Instead, we are moving them from a truck to a safe and comfortable office where they utilize years of their long-haul trucking experience, but remain close to their families and go home between shifts."

Starsky currently has three autonomous trucks, However, this goal cannot be achieved without road trucking operation, which consists of 36 tr 2017.

Ref: https://www.freightwaves.com/news/starsky-robotics-sees-truckers-as-essential-to-future-of-driverless-trucking; https://www.bloomberg.com/news/features/2017-06-22/these-truckers-work-alongside-the-coders-trying-to-eliminate-their-jobs

Bionic Exoskeletons

Human-integrated production technology like,

- Full-body exoskeletons for "superpowered" shop-floor associates

- Mech-suits for assembly or repair in extreme environments

- Automated prosthetics for veterans or other persons with disabilities

https://newsroom.lowes.com/fresh-thinking/new-suit-empowering-employees/

Immersive Experiences

- Virtual reality (VR) based training
- VR based programming
- Teleoperation of an entire factory of robots, a production line, or stop-gap intervention during highly robust modes of operation.

Augmented Reality

- Augmented reality safety glasses that provide real-time updates on the floor or assembly work-instructions for higher throughput and increased quality.

- Augmented reality interfaces with holographic display and human

Cognitive Interfaces

- Human-machine neural interfaces and bio-implants that enable light-speed control over machines and digital resources, and rapid human-computer intelligence-based decision-making, reacting to problems at a speed so fast it looks like "magic."

Product-sized Factories

- Automation and manufacturing technologies capable of sustaining "urban factories" whose form (e.g. gravity-based vertical factories) and function (e.g. product-sized factories) enable customization at untapped economies of scale

Multi-skilled Workforce

- Development of new curriculum and training methodologies to quickly transition an able workforce to non-intensive jobs that still require a high-level of skill; e.g. robot programmers, data scientists, etc.

The Washington Post

Democracy Dies in Darkness

Want to fix the tech industry? Start with the humanities.

The humanities are central to our conceptions of technology and science.

Technologies would not exist without the humans who create them. (iStock)

By **Eric Schatzberg**

Eric Schatzberg is professor and chair of the school of history and sociology at the Georgia Institute of Technology in Atlanta, and author of "Technology: Critical History of a Concept."

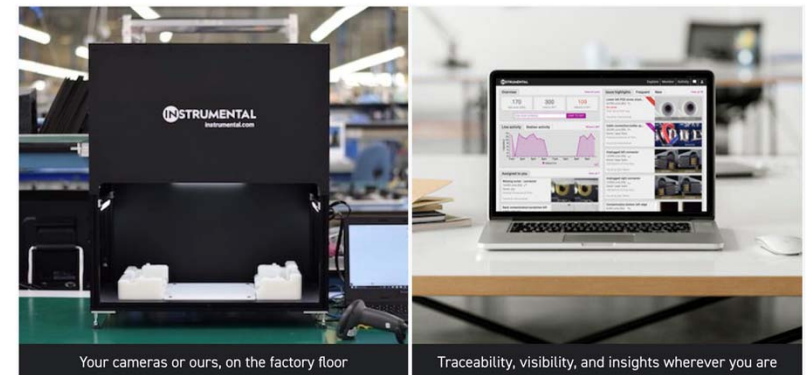*Technology cannot not exist without the human pursuit of life, liberty or happiness…*

"The engineering curriculum does require a modicum of credit hours in the humanities, ostensibly to make engineers well-rounded. But few courses examine technology itself as a human endeavor. Engineering programs tend to focus on technology strictly through a natural science lens, and calls for a greater focus on the human elements of technology."

Human Insertion

- Integration of human-in-the-loop data-based AI products, like deep learning algorithms for quality inspection that save time and money

Your cameras or ours, on the factory floor

Traceability, visibility, and insights wherever you are

Instrumental.AI - https://www.instrumental.com/

Common Concerns

- Safety & Well-being of humans

- Protection from extreme environments

- Security of hardware/software/data

- On-site, on-demand, and customized training, and back-up systems

- Hard and soft human-machine interfaces

- Political, economic and social issues

- Sustainable energy utilization and generation of waste products

Establishing a "Human-centric Manufacturing Factories" for Human-Machine-Data Convergent Systems R & D

Examples of platform projects:

(1) Human-integrated full-body exoskeletons; (2) Mech-suits for assembly and repair in extreme environments; (3) Virtual reality based training; (4) Augmented reality safety glasses that provide real-time factory updates; (4) Interfaces for lightspeed control over machines; (5) "urban factories" for flexible manufacturing; (6) new training methodologies for quick transition of able workforce; (7) Deep learning algorithms for assembly and quality inspection and more...

Industry Impact

- Energy
- Automotive
- Aerospace
- Mining
- Transportation
- Healthcare
- Housing
- Infrastructure
- Food and farming
- And more...

National & Global Impact:

- Mega-cities & small towns

- Giga-factories & small businesses

- On earth, under water, in air and through space

- The 1% and the 99%

"Everyone takes the limits of his own vision for the limits of the world."

Arthur Schopenhauer

Thanks for your attention.