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

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
Driver 1: Job Creation & Losses During Industrial Revolutions in UK (where I.0 began)

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.

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

During the peak of Industry 2.0:

- Catastrophic losses in manufacturing jobs
- Monumental leap in manufacturing productivity
Driver 2: Convergence for Competitiveness

- Industrial
- Digitization and 3-D printing

- Information
- Autonomous systems and intelligent robotics

- Micro/nano
- 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
With history as witness, is the 4th Industrial Revolution is good for humanity?

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

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

**Human Strengths**
- Perception
- Speech clarity
- Near vision
- Fine manual dexterity
- Selective attention
- Problem sensitivity
- Oral & written expression
- 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

**Machine Strengths**
- 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

“A new division of labor.”

Humans can work on, with, or for digital agents

<table>
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<th>CRAFT</th>
<th>INDUSTRIAL</th>
<th>POSTINDUSTRIAL</th>
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<td>WORK ON DIGITAL AGENTS</td>
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<tr>
<td>CREATE TOOL/TECHNOLOGY</td>
<td>USE TOOL/TECHNIQUE</td>
<td>WORK WITH DIGITAL AGENTS</td>
</tr>
<tr>
<td>WORK FOR DIGITAL AGENTS</td>
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Pre-Industry | Industry 1-4 | H.0

Source: Deloitte analysis.

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” primarily 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...

**Tesla CEO: New “tent” assembly line is “way better” than conventional factory**

“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 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

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.

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

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 a road trucking operation, which consists of 36 trucks, by 2017.

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.

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

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

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

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.”

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.”
Human Insertion

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

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.