MÄLARDALEN UNIVERSITY
SWEDEN

JÖNKÖPING UNIVERSITY
School of Engineering

PREMIUM
Professional Education for Manufacturing Innovation

Industry 4.0 - Introduction

MÄLARDALEN UNIVERSITY
SWEDEN

A seminar about what we are doing and learning in this course

Course code: PPU213
ECTS: 5 (33% ~12-13 hours/week)
Level: First cycle

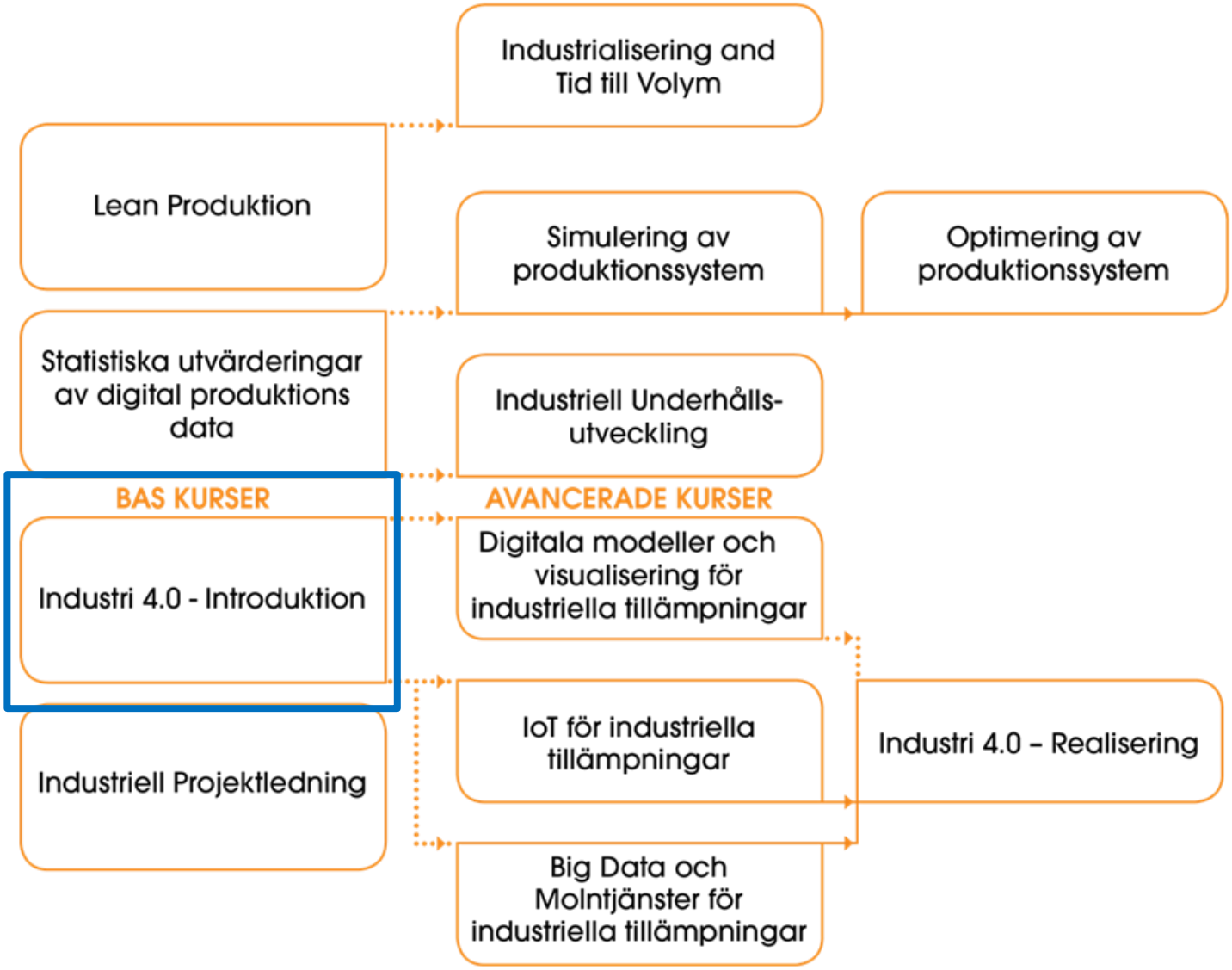
Mats Ahlskog, Researcher at MDH and course responsible

KK-stiftelsen

Outline

- **Background**
- **About the course**
- **Some examples from the different areas/lectures covered in the course**
- **Additional information**

Background


Industrialisering and Tid till Volym
Lean Produktion
Simulering av produktionssystem
Optimering av produktionssystem
Statistiska utvärderingar av digital produktions data
Industriell Underhålls-utveckling
BAS KURSER
AVANCERADE KURSER
Digitala modeller och visualisering för industriella tillämpningar
Industri 4.0 - Introduktion
IoT för industriella tillämpningar
Industri 4.0 – Realisering
Industriell Projektledning
Big Data och Molntjänster för industriella tillämpningar

Background: Industry 4.0 Introduction

- This course provides basic knowledge of industry 4.0. The course gives insight and understanding of the 4th Industrial revolution and how it will impact on the industry and humans. The aim is to give a conceptual understanding of how an industry 4.0 system can be built up and run, as well as an overall understanding of which technologies can be included.

- The course includes the following parts
  - Introduction to Industry 4.0
  - Introduction to the main technologies in Industry 4.0
  - The economic drivers for implementing Industry 4.0 technology
  - The production and development engineer's role in development of future production system
  - The impact of digitization on industry and human beings

The main target group is people in need of understanding the principles of Industry 4.0. The focus is production but anyone from another functions can take this course.

Background

- This a new course that is given for the first time
- This course was supposed to be held with a combination of meetings at MDH and online

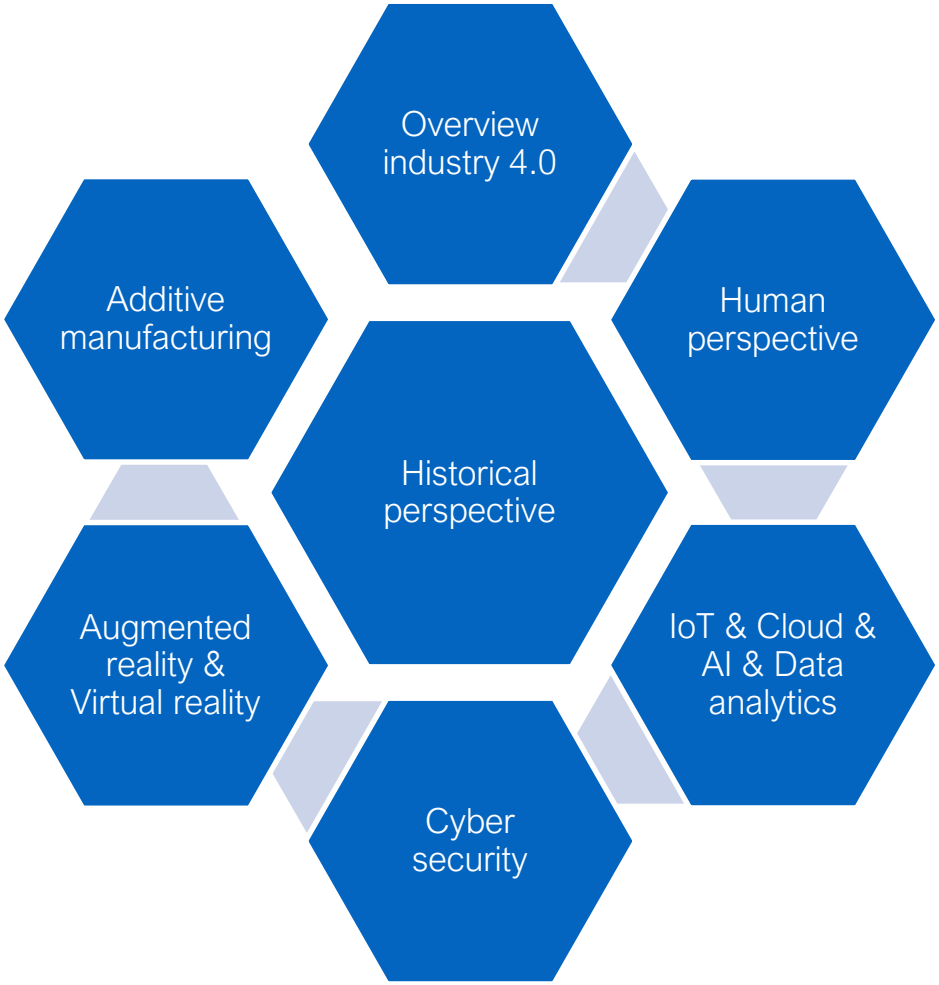
2020-04-15 Aktuellt

Snabb omställning till digital kurs för industrin

Efter ett intensivt omställningsarbete kunde fortbildningskursen Industri 4.0 – introduktion, starta helt digitalt 30 mars. Kursen var planerad att ges med både fysiska och digitala träffar samt laborationer, men Coronakrisen gjorde att den efter ett intensivt arbete konverterades till helt digital.

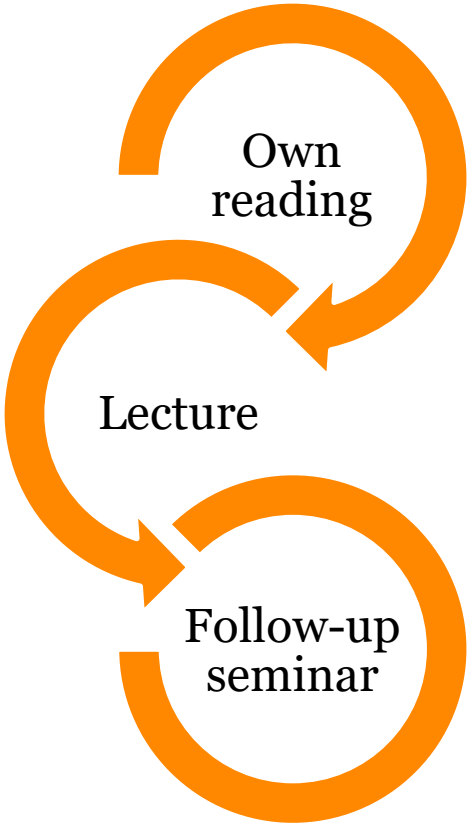
- https://www.mdh.se/samverkan/fortbildning-och-kompetensutveckling-for-yrkesverksamma/kompetensutveckling-med-premium

Areas covered



Course design

A combination of broad and narrow focus is needed



Broad focus	Technology focus	Technology focus
Module 1	**Module 2**	**Module 3**
Book chapter + reports	Book chapter + reports	Book chapter + reports
• Historical perspective • Overview industry 4.0 • Human perspective	• IoT & Cloud • AI & Data analytics • Cyber security	• Augmented reality • Virtual reality • Additive manufacturing
Discussion on the module topics **INL1a**	Discussion on the module topics **INL1b**	Discussion on the module topics **INL1c**

All material in the course is digital

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Course assignments

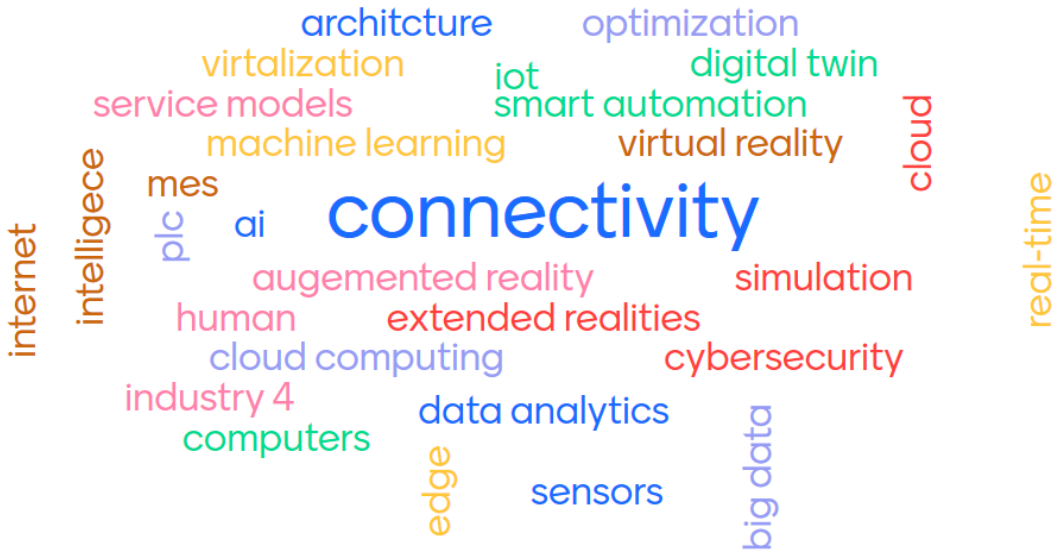
Assignments	What	When	How	Why
INL1	Three written assigments based on the moduels in this cours	After each modul	Individual	Check knowledge and way of thinking
Canceled due to Covid-19 LAB	FESTO equipment at MITC AR & VR	One day	Individual	Increase knowledge about digital technologies and relationships
Replacement for the LAB INL2	Identification of challenges and possibilities - from a report	During the course – final seminar in the end of the course	Individual or group	Increase knowledge about challenges and possibilities
PRO1	Assessment of your companies maturity level – predefined frameworks	During the course – final presentation in the end of the course	Individual or group	Reflection Bring something back to the company

Teachers

Namn	Roll	E-post	Area
Mats Ahlskog	Examiner, Teacher	mats.ahlskog@mdh.se	Historical perspective
Filip Flankegård	Assistant Teacher	filip.flankegard@mdh.se,	
Alessio Bucaioni	Teacher	alessio.bucaioni@mdh.se	Introduction to Ind 4.0
Rachel Tripny Berglund	Teacher	rachael.tripney.berglund@mdh.se	Human perspective
Moris Benham	Teacher	moris.behnam@mdh.se	IoT & Cloud
Markus Bohlin	Teacher	markus.bohlin@mdh.se	AI & Data analytics
Francesco Flammini	Teacher	francesco.flammini@mdh.se	Cybersecurity
Christopher Gustafsson	Teacher	christopher.gustafsson@mdh.se	Additive Manufacturing
Barrett Sauter	Teacher	barrett.sauter@mdh.se	AR & VR

I wanted to include as many as possible different knowledge domains and perspectives in this course

Introduction to the main technologies and terminology



Module 1 – Broad focus

- Historical perspective - Mats Ahlskog
- mats.ahlskog@mdh.se

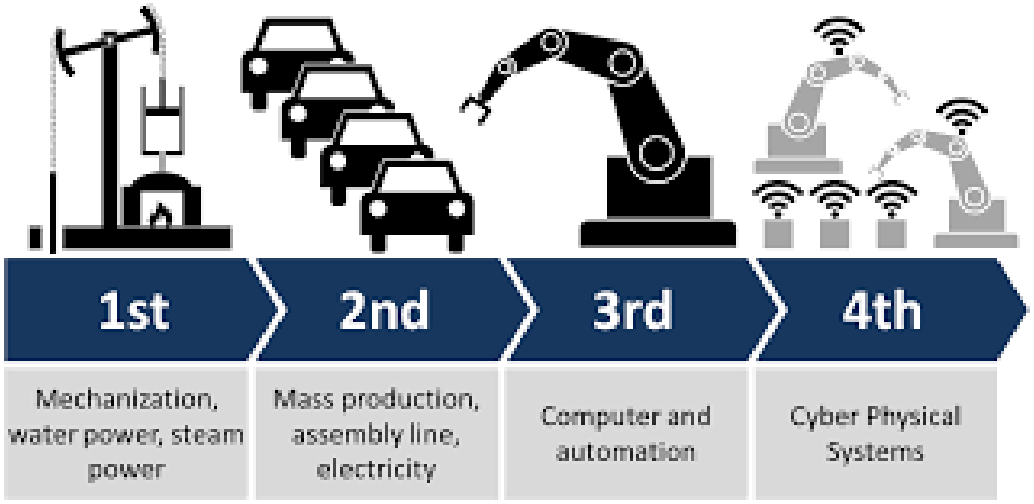
- Overview industry 4.0 - Alessio Bucaioni
- alessio.bucaioni@mdh.se

- Human perspective - Rachel Tripny Berglund
- rachael.tripney.berglund@mdh.se

- I have borrowed some slides from their lecturers

Module 1 – Broad focus

- What is Industry 4.0?
- That is something we discuss during the course
- Industry 4.0, was first declared by German government during Hannover Fair in 2011 as the beginning of the 4th industrial revolution.

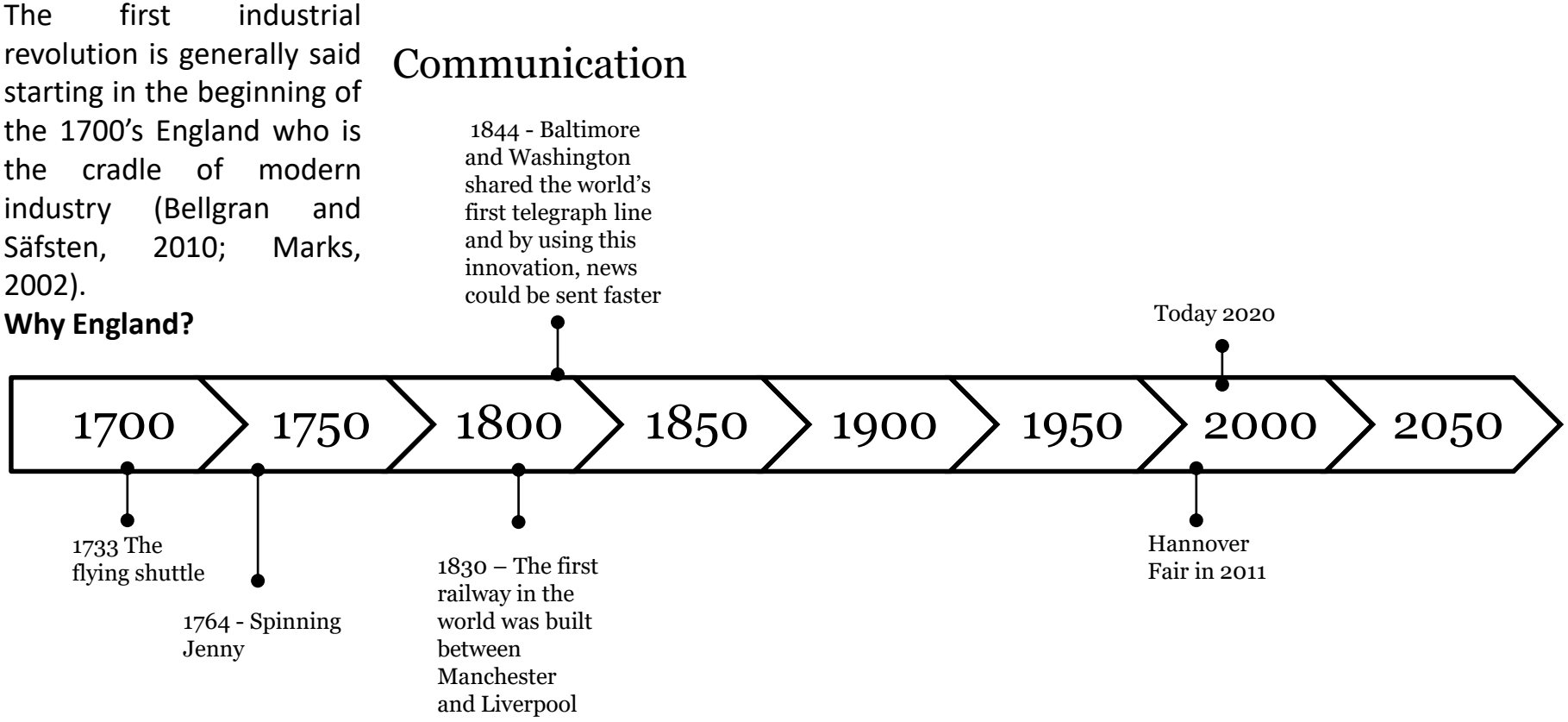


Module 1 – Timeline 1st Ind. revolution

Where started the first industrial revolution?

The first industrial revolution is generally said starting in the beginning of the 1700's England who is the cradle of modern industry (Bellgran and Säfsten, 2010; Marks, 2002).

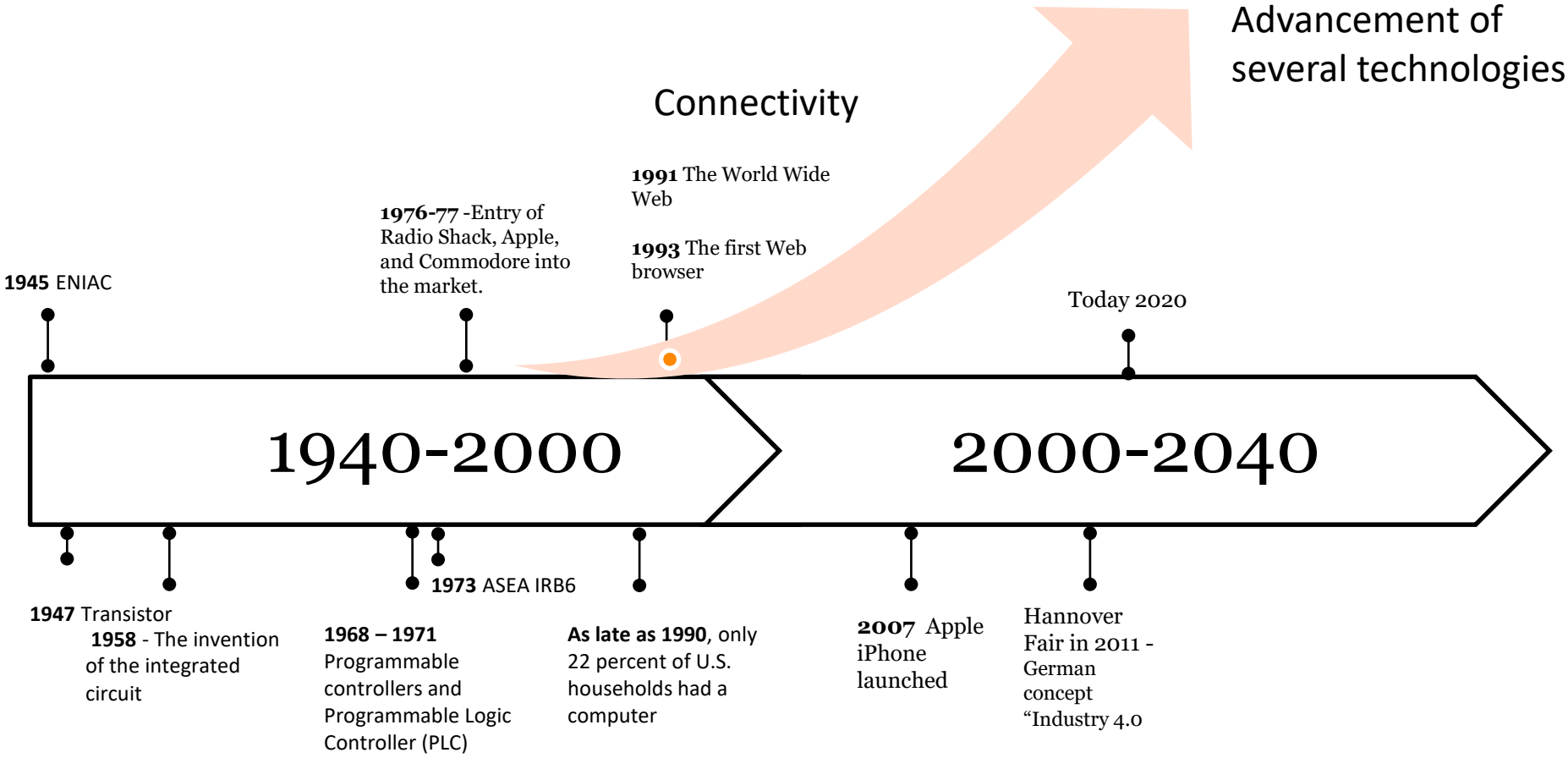
Why England?



Module 1 – Timeline 3rd Ind. revolution

3rd Industrial revolution

4th Industrial revolution



Computerization and automation

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Module 1

- Based on the past – what will happen?
- How will this digital transformation affect us as humans?

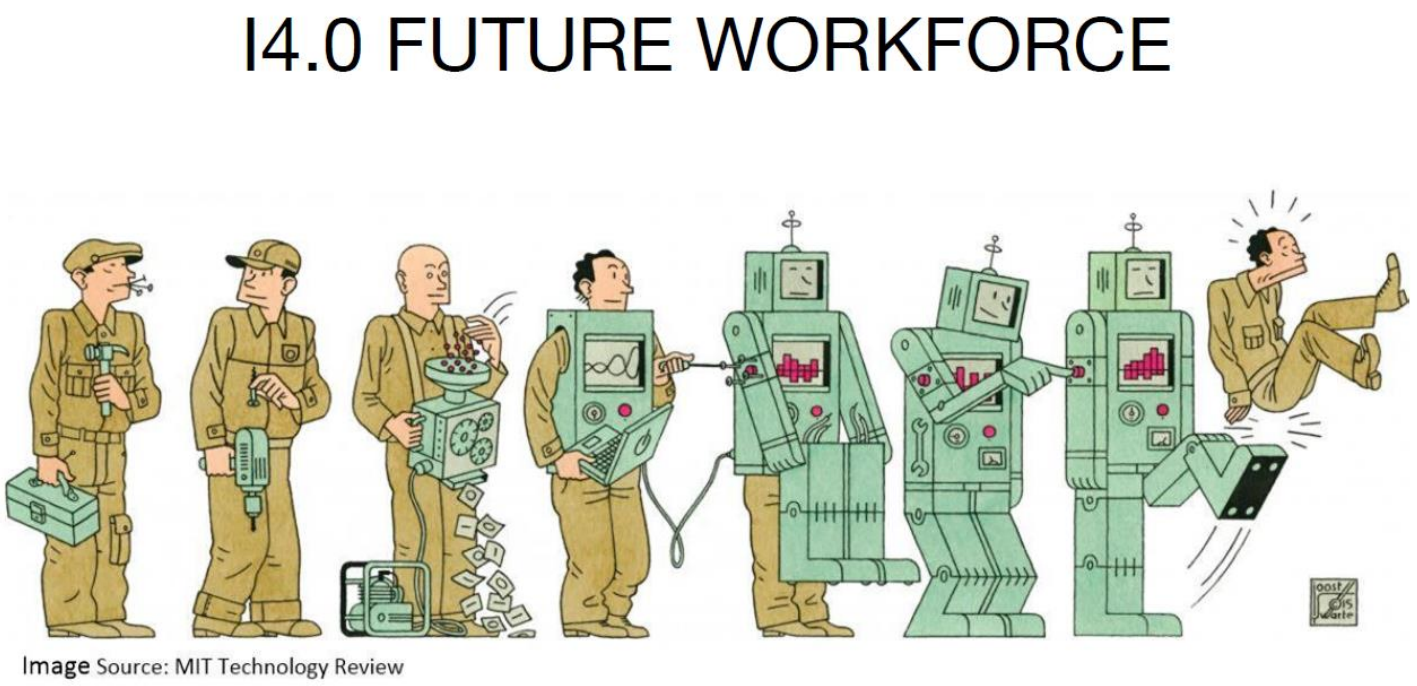


Image Source: MIT Technology Review

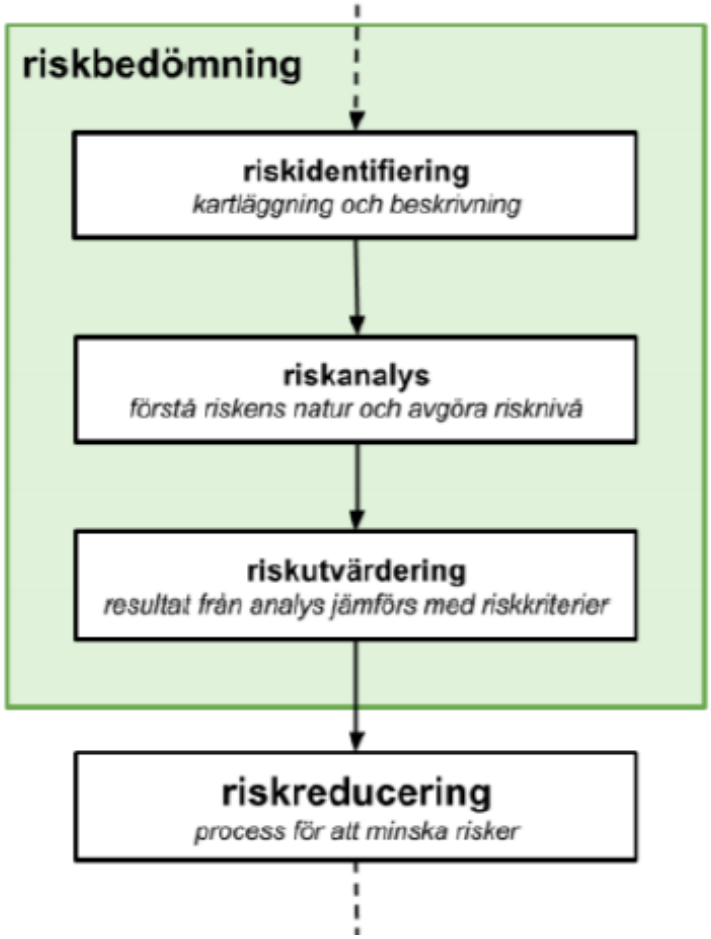
Module 1

- Change management (digitalization) from a human perspective
- Work environment

Module 1

Do no harm

Orsak	Antalet dödsfall om året
Stress	772
Skiftarbete	728
Motoravgaser	545
Damm, Kol	421
Asbes	267
Passivrökning	195
Kvarts damm	125
Svetsrök	71
Olyckor	37



Module 1 – Some examples from follow-up seminar

- People will lose their jobs in some areas
- Lifelong learning
- Laws & Regulations
- More work from home
  - Less social interaction
  - Difficult to separate work and private life
- Less distinction between white and blue collars
- Bigger gap between specialists and generalists/workers prevalence and domination of AI and robotics in offices and workspace

Module 2 – Technology focus

1. IoT & Cloud – Professor Moris Benham
   moris.behnam@mdh.se

2. AI & Data analytics – Professor Markus Bohlin
   markus.bohlin@mdh.se

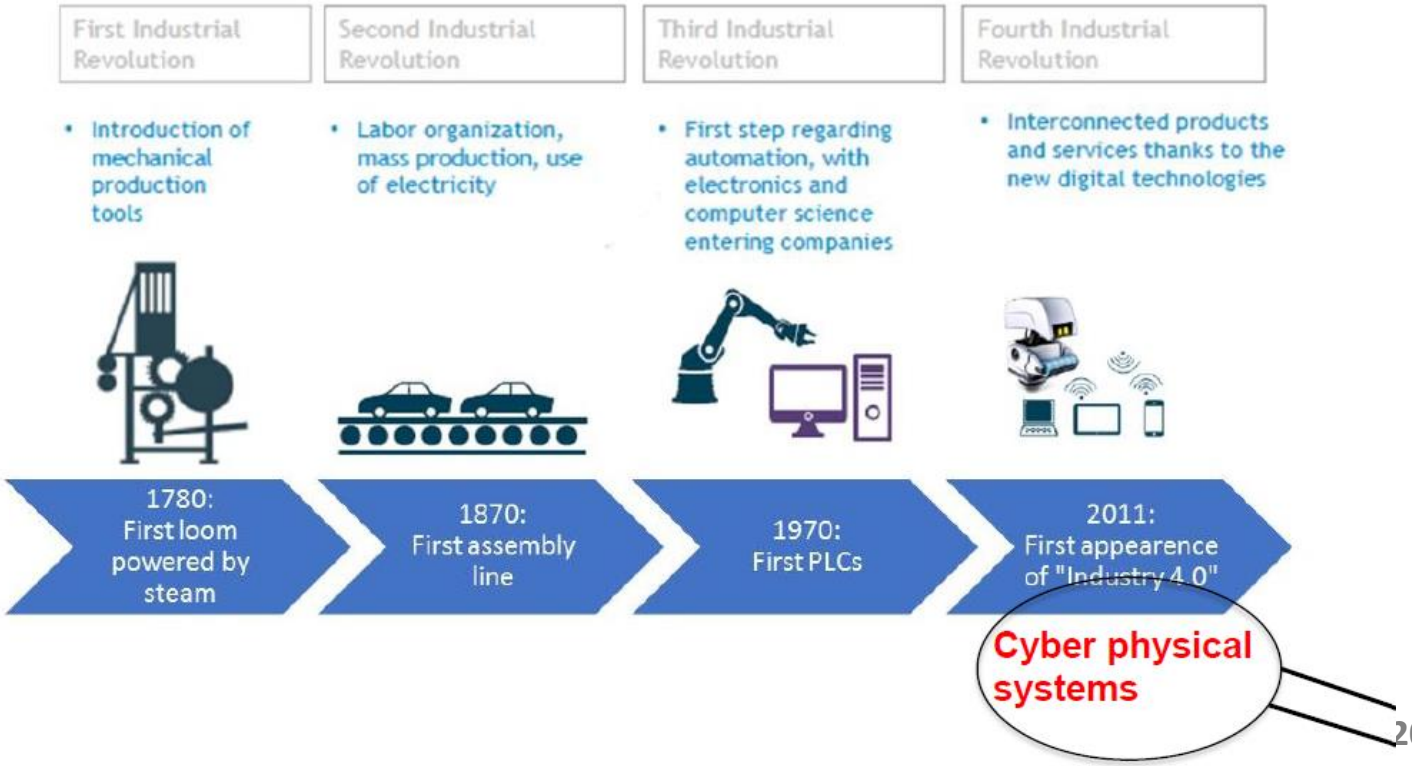
3. Cybersecurity – Professor Francesco Flammini
   francesco.flammini@mdh.se

- I have borrowed some slides from their lecturers

Module 2 – IoT & Cloud

Industry 4.0

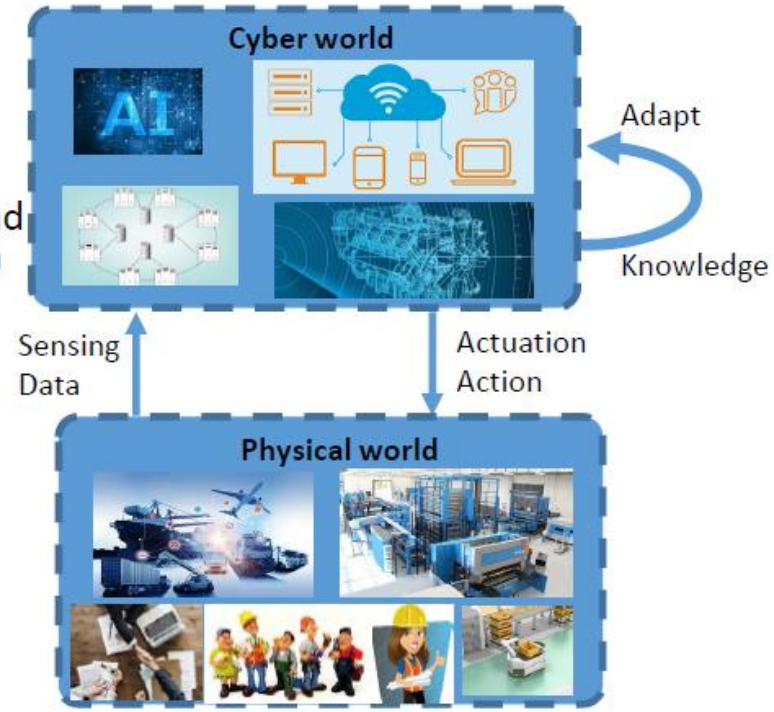
The Fourth Industrial Revolution



Module 2 – IoT & Cloud

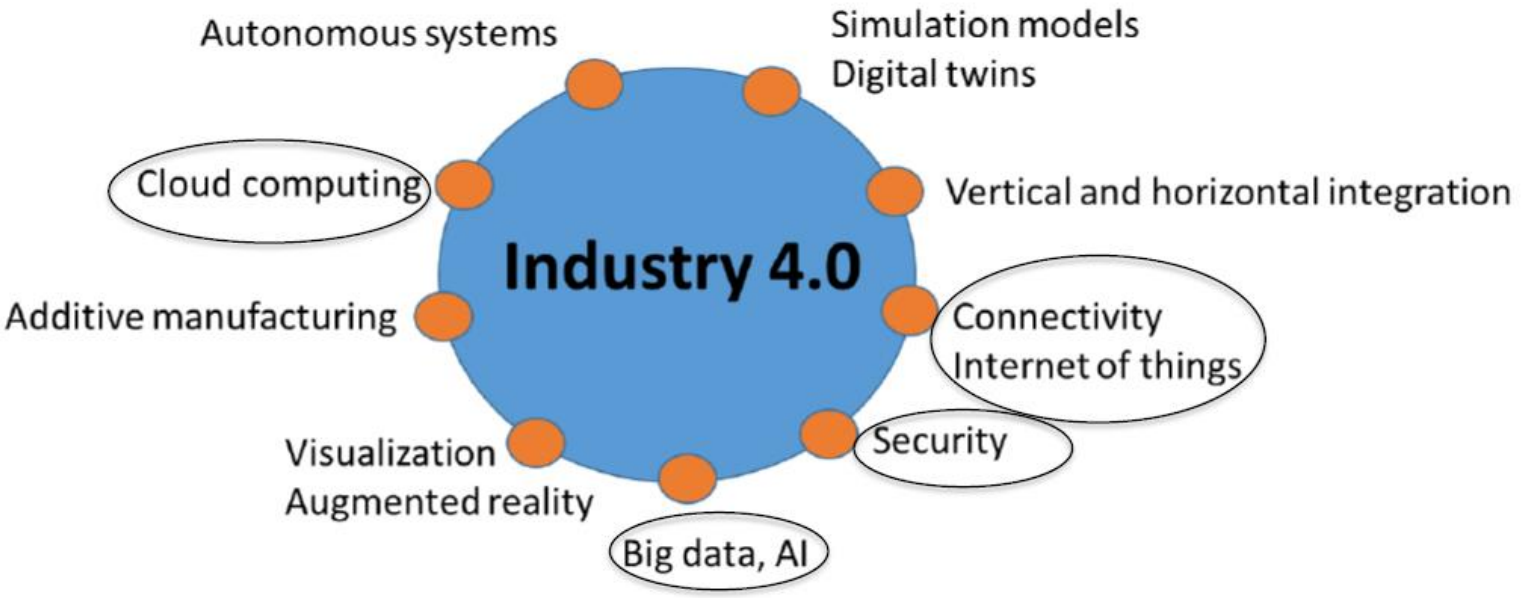
Cyber-physical systems CPS

- CPS: It is the integration of Cyber world, computation & network, and physical processes.
- Its purpose is to **control** a physical process and **adapt itself in real-time to new conditions** in order to **optimize** the performance.
- It allows creation of **autonomous and cooperative** elements and sub-systems, with the purpose of optimization production processes.
- CPSs can be considered as Digital Twins DT
- CPS academia, DT industry



Module 2 – IoT & Cloud

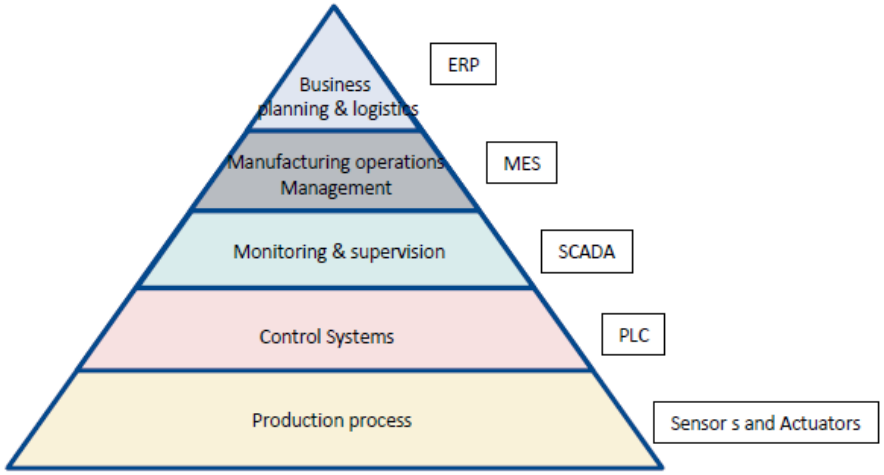
Industry 4.0 technologies



Module 2 – IoT & Cloud

Traditional automation in manufacturing

- **The automation pyramid** provides a hierarchical structure that allows the various technologies and systems used for planning, managing, and assessing the value creation process to be assigned to various levels of the company.

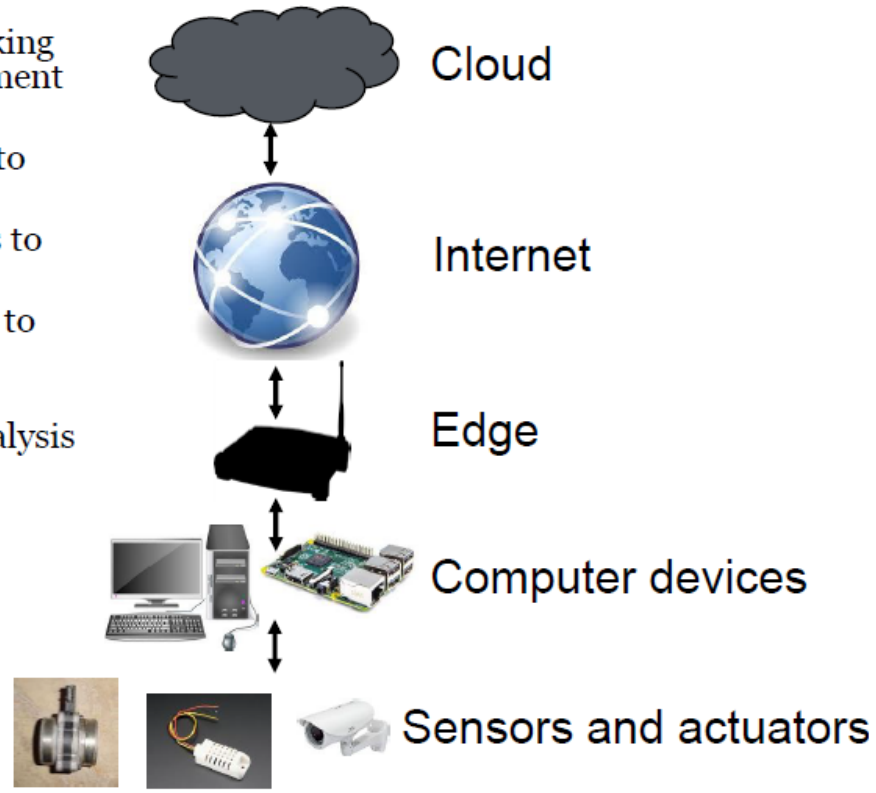


In practice, the lines between the levels are often blurred, and the individual levels can rarely be clearly identified.

Module 2 – IoT & Cloud

IoT Architecture

- Sensors: used to measure the environment, actuators are taking actions to change the environment
- Computers: Read the sensor measurements and transfer it to the internet
- Edges: connect the computers to the internet
- Internet: transferring the data to the Cloud
- Cloud: provides storage and computation power for the analysis and decision making
- Different data communication technologies are used between levels



Module 2 – IoT & Cloud

What's in the cloud?

Module 2 – IoT & Cloud

Service models

1- Cloud Software as a Service (SaaS)

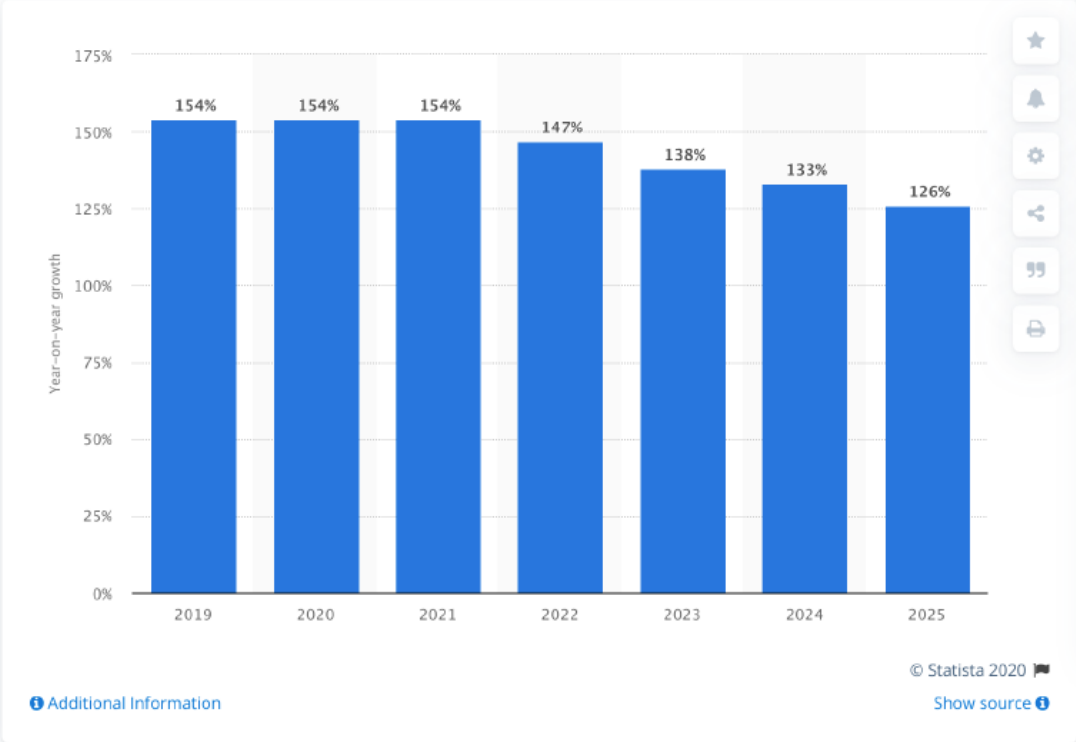
2- Cloud Platform as a Service (PaaS)

3- Cloud Infrastructure as a Service (IaaS)

Module 2 – AI & Data analytics

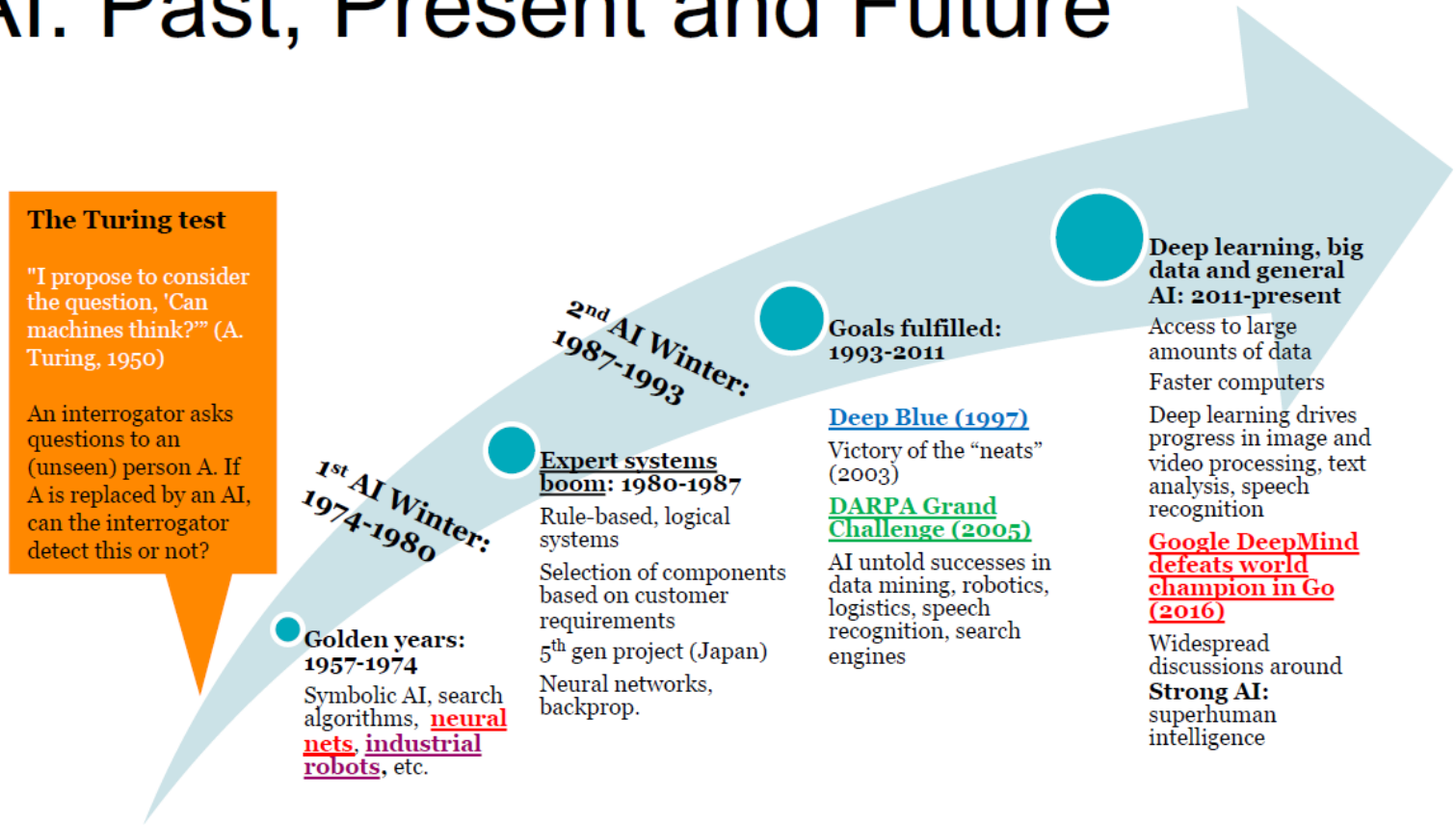
What is A.I.?

"Our intelligence is what makes us human, and AI is an extension of that quality." – Yann LeCun Professor, New York University



Module 2 – AI & Data analytics

AI: Past, Present and Future



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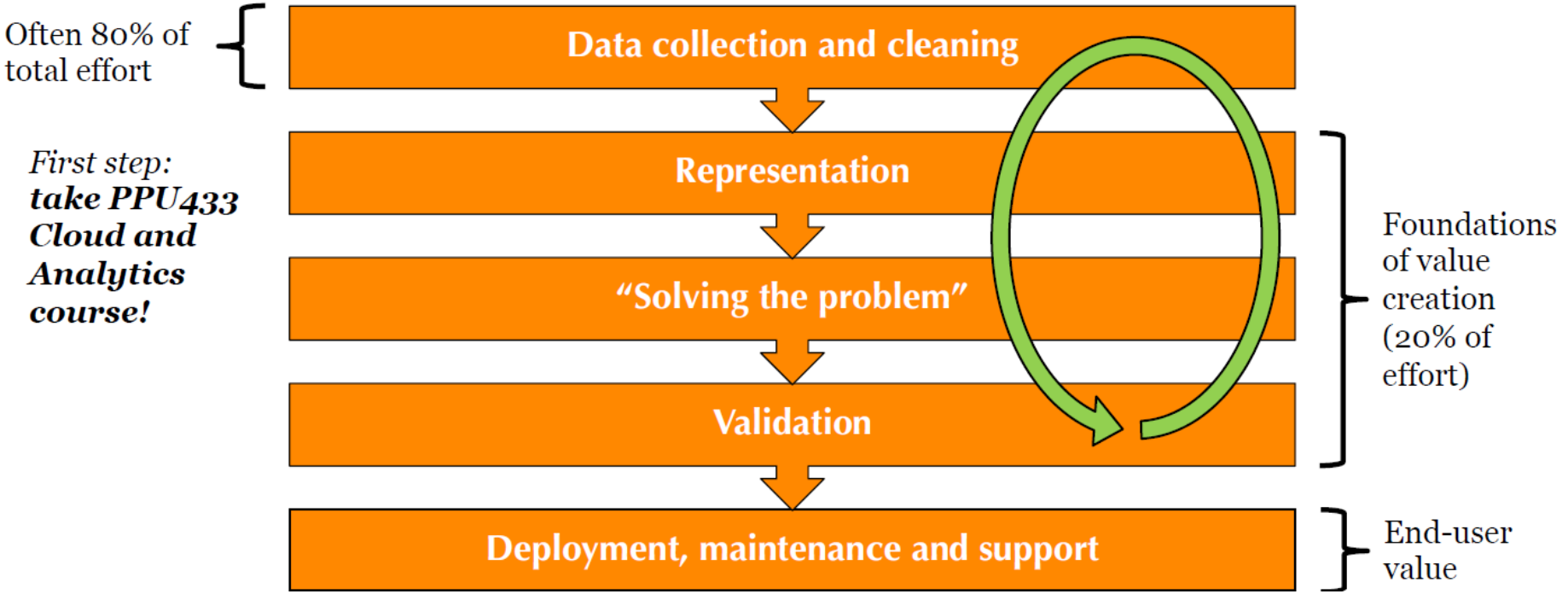
Module 2 – AI & Data analytics

- Basic introduction to:
- Different challenges within A.I.
- The Industrial A.I. stack
- Data cleaning and preparation
- Optimization in artificial intelligence
- Some problems in Machine Learning
  - Overtraining

Module 2 – AI & Data analytics

The Industrial A.I. stack in reality

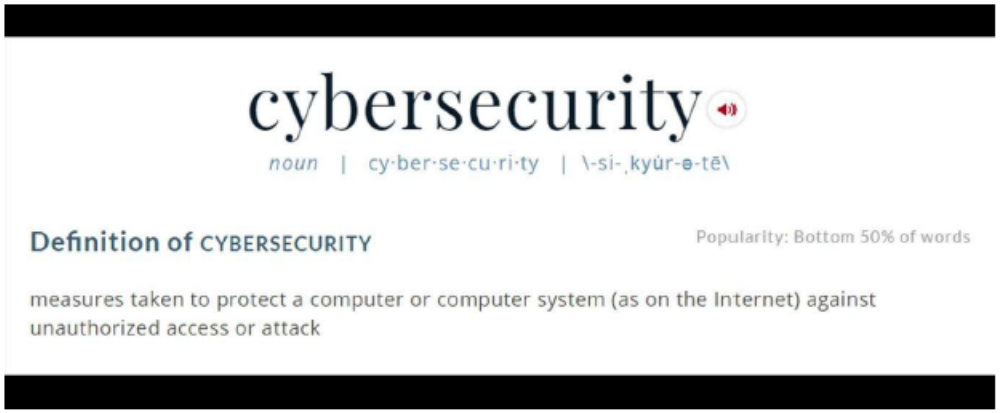


First step: ***take PPU433 Cloud and Analytics course!***

Module 2 – Cybersecurity

Definition of cybersecurity

Complex concept, no single definition!



cybersecurity

noun | cy·ber·se·cu·ri·ty | \-si-ˌkyůr-ə-tē\

Definition of CYBERSECURITY

Popularity: Bottom 50% of words

measures taken to protect a computer or computer system (as on the Internet) against unauthorized access or attack

Cybersecurity is the art of protecting networks, devices, and data from unauthorized access or criminal use and the practice of ensuring confidentiality, integrity, and availability of information. (https://www.us-cert.gov/ncas/tips/ST04-001)

Module 2 – Cybersecurity

Holistic vision of cybersecurity

- Focus on:
  - People – education, awareness, etc.
  - Process – procedures, regulations, etc.
  - Technology – intrusion detection systems, antivirus, etc.

Module 2 – Cybersecurity

- Importance of cybersecurity
- Cybersecurity in Industry 4.0
- Cyber-physical systems (CPS) security
- Security threats to intelligent systems
- Vulnerability Assessment
- Examples of some classic cyberattacks (STUXNET, Denial of Service (DoS) attacks
- Etc.

Module 3

- Augmented reality & Virtual reality - Barrett Sauter
- barrett.sauter@mdh.se

- **Additional lectures - Not covered in this presentation**
- FESTO-Overview Leo Hatvani
- leo.hatvani@mdh.se

- Special lecture – From theory to practice – how to implement Ind 4.0 – Mats Ahlskog

- **Not covered in this presentation – lecture next week**
- Additive manufacturing - Christopher Gustafsson
- christopher.gustafsson@mdh.se

- I have borrowed some slides from their lecturers

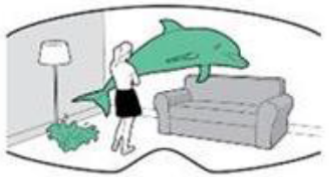
Module 3 - Augmented reality

Agenda

- What are eXtended Realites?
- Augmented Reality (AR)
  - AR examples
  - Industrial AR applications
  - Case studies
  - Industrial AR challenges
- Virtual Reality (VR)
  - VR examples
  - Industrial VR applications
  - Case studies
  - Industrial VR challenges

Module 3 - Augmented reality

eXtended Reality: a range of technologies. Includes virtual & augmented reality environments



Virtual reality (VR)

- User sees full digital world through headset
- Creator has much control, can show viewer exactly what they want
- Relatively high resources needed to produce

Augmented reality (AR)

- User sees digital information overlayed on the real world
- Content needs to be integrated with real world objects
- Relatively lower resources needed to produce

Module 3 - Augmented reality

eXtended Realites

Virtual Reality
(VR)

Augmented Reality
(AR)

Module 3 - Augmented reality

Case Studies

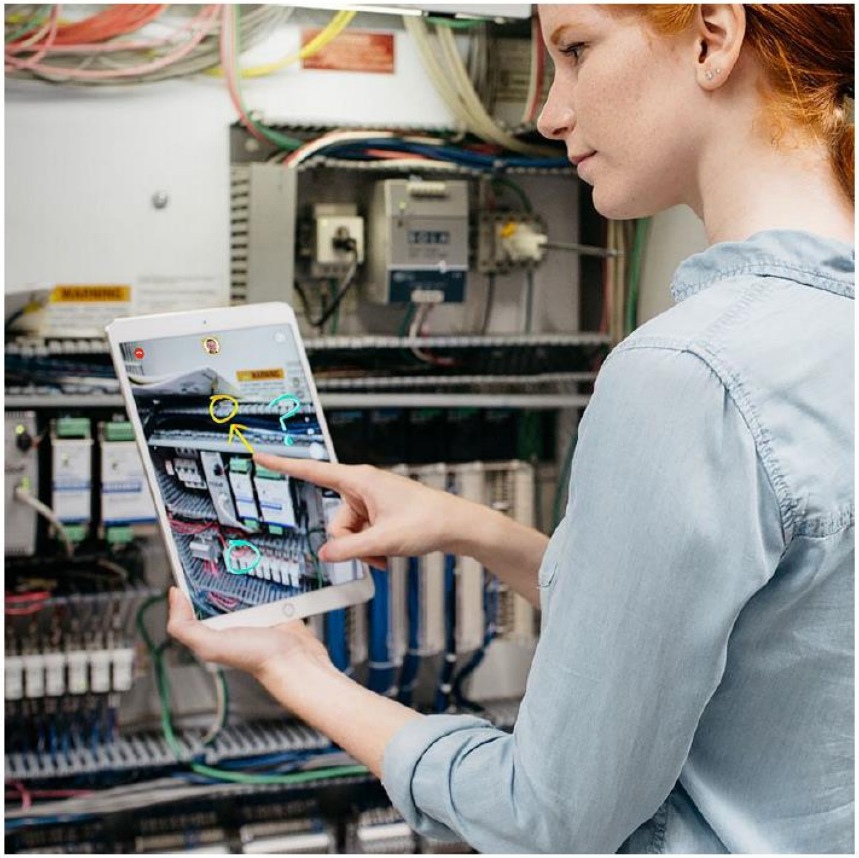
- Remote maintenance

Ex: Toyota

What: remote assistance and communication while adhering to strict privacy regulations

Use: Chalk is used to connect experts with workers both inside and outside of their organization via mobile or tablet. Chalk combines live video, audio and ability for both participants to draw digital annotations on the live shared view.

Results: Subcontractors are able to tackle complex or unfamiliar challenges with the help of an expert when and where they need it. Company has adopted Chalk because of its security control functions.



19

PTC. (n.d.). *Toyota Selects Vuforia Chalk*. Retrieved from PTC: https://www.ptc.com/en/case-studies/toyota-selects-vuforia-chalk

Module 3 - Augmented reality & Virtual reality

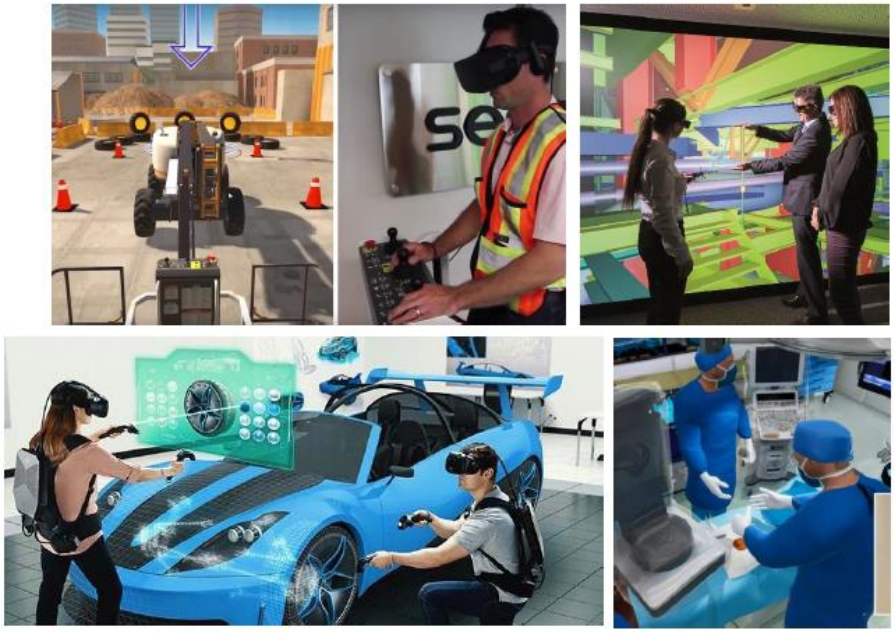
Why are these tools important?

The real world is 3D. Most data is trapped on 2D screen and pages.

XR speeds up our ability to understand the problem and act on it.

Module 3 - Virtual reality

General VR Uses

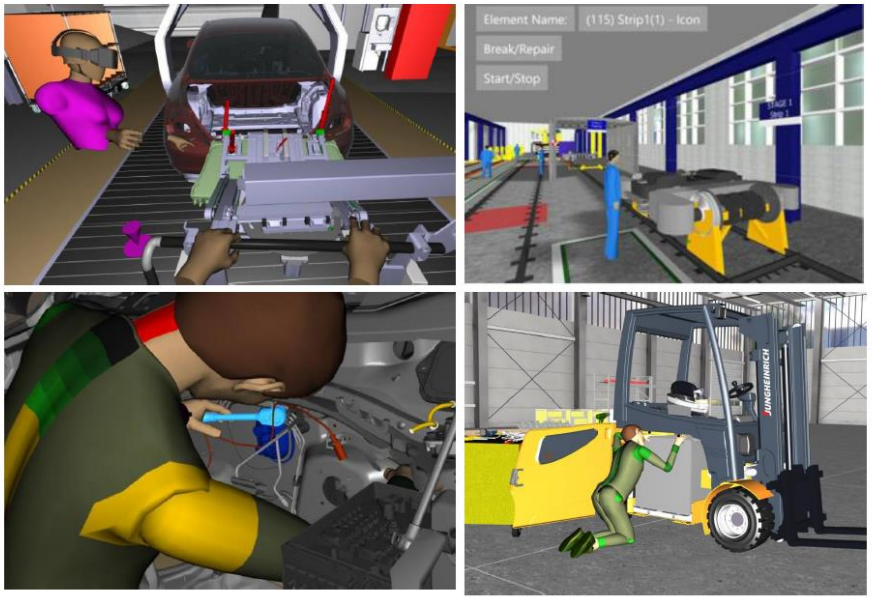


- Entire digital environments
- Training simulations
- Distance work collaboration
- Product development

Module 3 - Virtual reality

Industrial VR applications

- Product design & virtual prototyping
- Virtual factory
  - Planning, simulation & training
- Assembly & service
  - Training
  - Quality assurance
- Fault diagnosis



25

Damiani, L. e. (2018). Augmented and virtual reality applications in industrial systems: A qualitative review towards the industry 4.0 era. *IFAC PapersOnLine* (pp. 624-630). Elsevier.

Module 3 - Virtual reality

Case Study

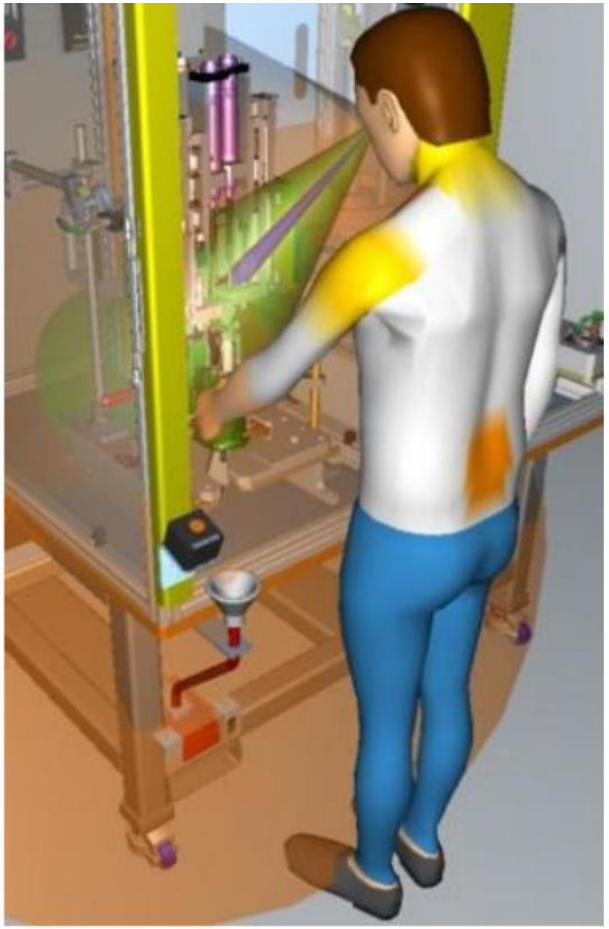
- Virtual factory

Ex: Automotive supplier

What: Virtually validated assembly

Use:virtual tool used for design and validation of elements such as space, human-factors and maintenance walidation. CAD drawings or mock-ups previously used.

Results: virtual build allowed for inspectors to walk around 1:1, inspect, interact, even operate the new sub-assembly long before first parts were made. Able to identify undesirable or dangerous conditions in time.



esi-group. (n.d.). *Automotive Supplier NEXTEER Virtually Validates Assembly Tools*. Retrieved from ESI: https://virtualreality.esi-group.com/resources/customer-successes/automotive-supplier-nexteer-automotive-virtually-validates-assembly

26

Module 3 - Virtual reality

Industrial VR advantages

- Visualization
  - VR makes it easier to view the effects of complex data and interactions in models
  - Additional views and navigation of a model not viewable with 2-D and in some cases difficult to see with screen-based 3-D prepresentations are possible with VR
- Understanding
  - Ability to capture and compare the virtual and physical state of objects
- Communication
  - Aids in communicating changes to both internal and external organizations

29

Turner, C. e. (2016). Discrete Event Simulation and Virtual Reality Use in Industry: New Opportunities and Future Trends. *IEEE Transactions on Human-Machine Systems, Vol. 46, No. 6*, 882-894.

Additional information

Lifelong Learning at Mälardalen University

- **Courses for professionals**
- **Developed in close cooperation with industry**

- **Gives university credits**
- **Free-of-charge for employees in Sweden and EU/EEA and Swiss citizens**

Production Engineering
- Industry 4.0
- Lean Production
- Simulation

Software Engineering
- Dependable Software
- Internet-of-Things
- Software Test

Applied AI
- Big Data
- Machine Learning
- Predictive Analytics

Environmental and Energy Engineering
- Circular Economy
- Climate Change
- Sustainable Development

Innovation Management
- Trendspotting and scenariodesign
- Innovation Management

mdh.se/en/malardalen-university/education/further-training

Seminar series Industry 4.0

Date	Title	Teacher
May 15	Industrial Internet of Things and the Opportunities in Manufacturing	Mohammad Ashjaei & Moris Behnam
May 29	Artificial Intelligence	Markus Bohlin
June 5	Simulation for evaluation and improvement of production systems	Ioanna Aslanidou
June 12	Introduction to industrial cybersecurity	Francesco Flammini
June 26	AR and VR for Industry 4.0: From Development to Maintenance	Leo Hatvani
August 14	Maintenance	Antti Salonen
August 21	Additive Manufacturing – The MDH way	Christopher Gustafsson
August 28	Cobot	Mikael Hedelind
September 4	Optimization of Production Systems	Konstantinos Kyprianidis & Yuanye Zhou & Stavros Vouros
September 11	Industrialization: a multiple perspectives	Koteshwar Chirumalla

Production engineering courses autumn 2020

(5 credits/course)

- **Lean production**

Study period 2020-08-31 - 2020-11-08

- **Internet of Things for the manufacturing industry**

Study period 2020-08-31 - 2020-11-08

- **Simulation of production systems**

Study period 2020-08-31 - 2020-11-08

- **Big Data and Cloud Computing for Industrial Applications**

Study period 2020-11-09 - 2021-01-17

- **Industrial maintenance development**

Study period 2020-11-09 - 2021-01-17

For more information, visit mdh.se/premium

Production engineering courses spring 2021

(5 credits/course)

- **Optimization of production systems**

Study period 2021-01-18 – 2021-03-28

- **Visualization for industrial applications**

Study period 2021-01-18 – 2021-03-28

- **Industry 4.0 – Introduction**

Study period 2021-03-29 - 2021-06-06

- **Industry 4.0 – Realisation**

Study period 2021-03-29 - 2021-06-06

- **Industrialization and Time-to-Volume**

Study period 2021-03-30 - 2021-06-08

For more information, visit mdh.se/premium

Questions & Answers