Minor Industry 4.0 with Human Touch

Official language	English	
EC amount	15	
Coordinating study	Mechanical Engineering	
Participating studies	Advanced Technology, Applied Mathematics, Business & IT, Civil Engineering, Electrical Engineering, Industrial Design Engineering, Mechanical Engineering, International Business Administration, European Public Administration, Technical Computer Science, Applied Physics, Creative Technology, Biomedische Technologie	
Lecturer(s)/Tutor(s)	Initials	Surname
	W.	de Kogel
	T.H.J.	Vaneker
	A.H.	van den Boogaard
	H.	Schiele
	B.R.H.M.	Haverkort
	K.	Hahn
	J.C.W.	van Ommeren
	M.L.	Franco Garcia

Learning goals

1. Technology

After this course the student:

- gained insight in which technologies play an important role in the development of industry 4.0
- gained insight into the challenges seen by science and industry regarding the evolving technologies

2. Business

After completion of this course, students will:

- be able to embed I4.0 in the business disciplinary context of supply management, marketing, production and organizational behavior / leadership,
- be able to explain the I3.0 state-of-the-art in theses disciplines,
- be able to critically discuss possible developments induced by I4.0 techniques and make situation specific recommendations for firms to seize the opportunities the fourth industrial revolution is offering,
- be able to discuss and explain strategic options firms have to adopt their business models to the fast changing technology induced change.

3. Computer Science

After completion of this course, students:

- Have basic knowledge about the key underlying ICT for Industry 4.0, being internet technology, internet-of-things and cyber-physical systems;
- Have basic knowledge about relevant internet protocols, such as UDP, TCP, DNS, and HTTP, and cloud computing;
- Have basic knowledge wireless technologies, such as Wifi, Bleutooth, LoRa and Zigbee;
- Can discuss about the (above) ICT and will be able to balance pros and cons and judge technical solutions proposed;
- Have basic understanding of data science techniques and tools and can apply these in simple cases;
- Can apply the above in the context of predictive maintenance strategies;
- Are aware of privacy concerns and security threats.

4. Society

- The students will be able to explain socio-technical change and elaborate specifically on the "social" during the development and introduction of new technologies.
- They will develop a critical and reflective view on technological promises and visions.
- They will be able to identify boundaries, risks and requirements of the ongoing change and develop ideas how to tackle these challenges, for example through linking alternative concepts such as circular economy to the ideas of Industry 4.0
- Students will learn how to integrate the environment concerns and the views of different

	stakeholders through the life cycle of products and services. Also from the legal and regulations perspective. 5. Project assignment • Students will be able to integrate the knowledge gained in the courses. • Students will understand the influence of technology, business, computer science and society on the value chain of the future (and in some cases the other way around). • Students can defend their work from the different perspectives.
Content description	At this moment a large change in industry takes place, the so called fourth industrial revolution. This revolution involves advances in underlying technologies, e.g. production and ICT, changes in the business models of firms and is likely to have a deep impact on our society. New manufacturing technologies, extensive digitization, interweaving of machines and organisations (Internet of Things) have a huge impact on industry. This minor "*Industry 4.0 with Human Touch"* gives an overview of several fields of interest that have implications for this fourth industrial revolution. It prepares students for their future in state of the art industries. The minor is divided in courses related to technology, computer science, business and society and at the end a project brings all these topics together. This minor consists 4 elective courses, where to choose 3 out of 4. A plenary part introduces Industry 4.0 (I4.0) and how it evolved from the industrial revolution 3 to where it is now and will be in the future. The four fields of interest, technology, business, computer science and society, will be explained and their relation with each other and with Industry 4.0. 1. Technology (3EC) (Coordinator Ir. Wieteke de Kogel) As part of the BSc minor "Industry 4.0" this course complements the business, computer science and society modules with discussing the technological component of technological change and innovation based on the example of Industry 4.0. Industry 4.0, also called Smart Industry, is amongst other things about the next generation of technologies. New modular approaches, as well as (next generation) robotics, new ways of manufacturing (for example 3D printing) and ubiquitous sensors will enable cost-effective flexible manufacturing to meet the specific demands by customers. The new autonomous cyber-physical systems got possible due to advances in the sensor technology and to some extend in the advances in robotics, in order to link the digital to the physical world. For instance, a variety of new transportation devices become possible, from small automated guided vehicles in a factory to unmanned cargo aircraft or even robots – unmanned robot-driven cargo vessels. Digital twins, additive manufacturing, robots etc. further drive I4.0 technology: • Digital twins: Devices can have a "digital twin", which is a technology allowing to represent the physical object as a digital replica of itself. All components are represented, their interconnectedness is simulated. The digital twin can be used, for instance, to run simulations and to compare similar operative systems among each other, recommending changes based on empirics. Mutual learning becomes possible. • Additive manufacturing: with additive layer manufacturing (3D printing) physical objects are produced decentral by transferring the digital plans to a printing unit which then brings forward the physical object. • Robotics & mechatronics: use of flexible robots in the automation of short series production. • Advanced Manufacturing systems: Organizational aspects of production systems of the future. Organizational changes caused by the use of new technologies. • Mass Customization and logistics; how to create mass customized products for the price of a mass produced product. Mainly focused on the hardware. These technologies complement each other. 2. Business (3EC) (Coordiator Prof. Dr. Holger Schiele) As part of the BSc minor "Industry 4.0" this course complements the technology, society and computer science modules with providing insights on and discussing possible options of the implications of I4.0 for business, based on the "Twente I4.0 vision". The content of the course is oriented along the hypotheses developed in the context of the "Twente I4.0 vision", which identified four directions:

H1: Digital market places instead of integrated supply chains [domain: supply chain management]
H2: Life-cycle solutions instead of finished products [domain: marketing]
H3: (Mass) customized production instead of standard commodity [domain: production science]
H4: Decentral co-creation networks replacing centralized steering [domain: organizational behavior]

For each of the four areas students will get introductory lectures and then complete an assignment specific to one of them, which will serve as input to a concluding conference linking the development paths.

In detail:
H1: Introduction into supply chain management, historical development from integrated firms to network firms, strategic management embedding (relational view of the firm), introduction to I3.0 applications in the supply chain (e-procurement, e-markets, advanced planning, ERP backbone), introduction of changes induced to I4.0 technologies such as blockchain and its influence on supply chains, discussion of possible applications such as machine-to-machine ordering and autonomous negotiation and their operative and strategic implications
H2: Introduction to marketing, digital marketing and solution selling, introduction to I3.0 applications in marketing (CRM, sales portals, product configurators), introduction of changes induced by I4.0 technologies such as digital twins, discussion of possible applications such as smart products and life-cycle selling and their operative and strategic implications
H3: Introduction to production science, historical development from assembly lines to production islands to agile production, mass customization concepts, introduction to I3.0 applications in production (process automation, central planning systems), introduction of changes induced by I4.0 technologies such as cyber-physical systems, machine-to-machine communication and 3D printing (additive layer manufacturing), discussion of possible applications such as mass customized products and their operative and strategic implications
H4: Introduction to organizational behavior, from central leadership models to self-organized teams, from scientific management to intrapreneurship, reaction to digital work environment, introduction to I3.0 applications in firms (IT support of decision making), introduction of changes induced by I4.0 technologies such as electronic market places, discussion of possible applications such as self-managed teams with autonomous workers as suppliers and their operative and strategic implications

3. Computer science (3EC) (Coordinator Prof. Dr. Ir. Boudewijn Haverkort)

As part of the BSc minor "Industry 4.0" this course complements the technology, business and society modules with discussing the computer science component of technological change and innovation based on the example of Industry 4.0.

Topics that will be discussed in the course:

- Internet-of-things and cyber-physical systems: what are these, and how do they form part of Smart Industry/Industry 4.0
- First principles of data science
- Methods and techniques for predictive maintenance (together with Applied Mathematics)
- Blockchain, cyber security

4. Society (3EC) (Coordinator Dr. Katrin Hahn)

As part of the BSc minor "Industry 4.0" this course complements the technology, business and computer science modules with discussing the social component of technological change and innovation based on the example of Industry 4.0.

The visions and promises of Industry 4.0 develop an optimistic picture of highly productive, resource efficient and interconnected companies and industries. However, the promised improvements of industrial production go along with a series of requirements and risks. The module gives a general theoretical understanding of socio-technical change and links this with the ongoing changes in industry. The following sessions will discuss requirements, boundaries and risks of the new production and consumption system and introduces alternative ideas, such as circular economy to tackle them and to take over responsibility. Even further, sustainable approaches to the production and consumption will also be discussed through different type of managerial instruments from the resources management perspective but also from the social responsibility angle. In particular by framing the companies' performance under international frameworks such as the Paris agreement of 2015 and the Sustainable Development Goals.

5. Project assignment (6EC)

Combination of the 4 disciplines. The assignment will be conducted by groups of 4 or 5 students. Every student followed 3 out of the 4 courses, but in every project group students are present in such a way that

	all courses are covered. Preferably the students per group do also have mixed educational backgrounds, so this is a multi-disciplinary project. The content will change every year, but will be related to the value chain of the future.			
The module will be taught in period	☐ 1A ☒ 1B ☐ 2A ☐ 2B ☐ Year			
Course structure	Type:			Obligatory attendance:
	☒	*(ASM)*	Assessment	☒ yes ☐ no
	☒	*(OPDR)*	Assignment	☐ yes ☒ no
	☒	*(CQ)*	Colloquium	☒ yes ☐ no
	☒	*(EXC)*	Excursion	☒ yes ☐ no
	☒	*(HC)*	Lecture	☐ yes ☒ no
	☒	*(PRS)*	Presentation(s)	☒ yes ☐ no
	☒	*(PJO)*	Project unsupervised	☐ yes ☒ no
	☒	*(PJB)*	Project supervised	☒ yes ☐ no
	☒	*(RES)*	Seminar	☒ yes ☐ no
	☒	*(WC)*	Tutorial	☐ yes ☒ no
	☒	*(ZGB)*	Self study without guidance	☐ yes ☒ no
	☒	*(OVO)*	Other	☐ yes ☒ no
Exam	☐ 1A ☒ 1B ☐ 2A ☐ 2B ☐ Year			Resits (if applicable): ☐ 1A ☐ 1B ☐ 2A ☐ 2B ☐ 3A ☐ 3B
Course materials	Course material/Book			Required / Recommended
	t.b.d. (no books, but book chapters, papers etc.)			☐ / ☐
Entry requirements	Mandatory			Recommended
	-			-
Additional info	This minor consists 4 elective courses, where to choose 3 out of 4.			

Name module part in English **Max. 40 characters**	Type of assessment [1]	Weight (whole %)	EC
Technology	OPDR-PRES	20	3
Business	OPDR-PRES	20	3
Computer Science	OPDR-PRES	20	3
Society	OPDR-PRES	20	3
Project assignment	OPDR-PRES	40	6
NOTE: Students have to choose only 3 out of the 4 courses			
	Total	100	15