Hochschule Reutlingen
Reutlingen University

Curriculum & Syllabi Handbook Digital Industrial Management and Engineering, M.Sc.

http://www.esb-business-school.de

Winter Semester 2022
Study and Examination Regulations: 16.06.2020
Date: October 2022, V 07

ESB BUSINESS SCHOOL

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Content

1. Qualification Profile

Aims of the Program

Das viersemestrige internationale **Research Master Studium** mit Double Degree an der Hochschule Reutlingen ist ein innovatives, attraktives Masterprogramm und nahezu einzigartig in Deutschland. Im Gegensatz zum klassischen „Taught Master" liegt der Schwerpunkt des Studiums auf der angewandten Forschung. Zusätzlich handelt es sich beim dem Forschungsmaster um einen Double Degree Studiengang mit renommierten Universitäten aus Südafrika und USA. Sie bearbeiten in den Forschungsmodulen von Beginn an eigenständig aktuelle Forschungsthemen aus den unten aufgeführten Bereichen. Dies geschieht im intensiven Austausch mit Ihrem betreuenden Professor und Sie werden ein aktives Mitglied in einer Forschungsgruppe. Durch die begleitenden spezifischen Vorlesungen aus den Bereichen Smart Factory and Logistics, Supply Chain Management, International Supply Chain Controlling, Informations- und Kommunikationstechnologien und Systeme sowie Engineering Management und Technology im Kontext Industrie 4.0 schaffen Sie sich ein vertieftes theoretisches Know-how im Umfeld Ihres Forschungsthemas. Mit Ihrer Masterarbeit, einem Research Paper und einem öffentlichen Kolloquium schließen Sie Ihr viersemestriges Forschungsprojekt und das Studium an der Hochschule Reutlingen und beim jeweiligen Partner ab – damit sind Sie ideal vorbereitet für anspruchsvolle Aufgaben in der industriellen Forschung und Entwicklung sowie für eine mögliche, anschließende Promotion.

The four-semester international research master's programme with double degree at ESB Business School, Reutlingen University is an innovative, attractive master's programme and almost unique in Germany. In contrast to the classical input-based master's", the focus is on applied research. In addition, the research is in the form of a double degree course with international, prestigious universities in South Africa and the USA. In the research modules you will work on the latest research topics from the fields of digital industrial management and engineering. This is done in close exchange with your supervising professor; becoming an active member in their research group. Through the accompanying specific lectures in the fields of Smart Factory and Logistics, digital Supply Chain Management, International Supply Chain Controlling, Information and Communication Technologies and Systems as well as Engineering Management and Technologies in the context of Industry 4.0, you will be able to develop a deeper theoretical know-how in the field of your research topic. With your master's thesis, a journal paper and a public colloquium, you will complete your four-semester research project and your studies at Reutlingen University, as well as at the respective partner university, making you ideally prepared for challenging tasks in industrial research and development as well as for an optional subsequent doctorate.

Degree awarded (based on compulsory elective modules) based on joint programmes:

- **Module 3A:** Master of Science (MSc) in Digital Industrial Management and Engineering from Reutlingen University and Master of Engineering (MEng) in Engineering Management from Stellenbosch University
- **Module 3B**: Master of Science (MSc) in Digital Industrial Management and Engineering from Reutlingen University and Master of Science in Engineering Technology from Purdue University

Duration of studies

4 semesters (2 years) – 120 ECTS for Bachelor-degrees with 210 ECTS

Closing date for applications

- **Summer term (March - August): 15thJanuary** (Module 3A Stellenbosch University, RSA)
- **Winter term (September - February): 15thJuly** (Module 3A Stellenbosch University, RSA and 3B Purdue University, USA)

Begin of studies

Summer term and winter term

Study places

Summer term:

5 per term with the international partner Stellenbosch University SUN
(or by arrangement with the partner universities)

Winter term:

5 per term with the international partner Stellenbosch University SUN and
2 per term with the international partner Purdue University
(or by arrangement with the partner universities)

Competency Goals and Learning Objectives

Die Studierenden erwerben Handlungskompetenzen und Qualifikationen, um wissenschaftliche Probleme angewandter Forschung in der Tiefe zu behandeln und Lösungen zu entwickeln. Sie erlernen Forschungsergebnisse zu vertreten und kritisch zu hinterfragen sowie die Übernahme der Verantwortung für Forschungs- und Entwicklungsprojekte und die erzielten Ergebnisse. Die Absolventinnen und Absolventen verfügen über die Kompetenz und Fähigkeit, komplexe Forschungsthemen verständlich, auch für Nicht-Experten, aufzubereiten, zu bearbeiten und darzustellen. Sie verfügen über eine breite internationale Erfahrung, um in einem kulturell vielfältigen Umfeld zu arbeiten. Ihre prononciert interdisziplinäre und forschungsorientierte Ausbildung qualifiziert sie für Positionen an der Schnittstelle zwischen Forschung und Entwicklung sowie einer Produkt- und Prozessrealisierung in einem internationalen Arbeitsumfeld. Der „Forschungsmaster MSc Digital Industrial Management and Engineering" ist das Sprungbrett für eine Zukunft in Forschung und Entwicklung in Industrie oder Forschungseinrichtungen oder für eine Vorbereitung zur Promotion im Themenfeld der Digitalisierung in der Industrie.

The students develop skills and qualifications to tackle scientific problems of applied research in depth and to develop solutions. They learn to represent and to critically question research results, as well as the assumption of responsibility for research and development projects and the results achieved. The graduates are able to comprehend, edit and present complex research topics, even for the non-expert. They possess broad international scope to work in a culturally diverse environment. The student's pronounced interdisciplinary and research-oriented education qualifies him/her for positions at the interface between research and development, as well as product and process realization in an international work environment. The research master 'MSc Digital Industrial Management and Engineering' is the step towards a future in research and development in industry or research facilities, as well as for a doctorate in the field of digitalization in industry.

Die übergeordneten Kompetenz- (Competency Goals, CG) und Lernziele der ESB-Studiengänge leiten sich aus der Mission der ESB Business School ab und unterliegen kontinuierlichen Qualitätssicherungsprozessen.

The overall competency goals (CG) and learning objectives of ESB Study programmes are derived from the mission of ESB Business School and are subject to continuous quality assurance processes.

LANGUAGE PROFICIENCY	INTERCULTURAL COMPETENCE	ETHICAL BEHAVIOR	DOMAIN-SPECIFIC PROBLEM SOLVING COMPETENCIES
COMPETENCY GOAL 1	COMPETENCY GOAL 2	COMPETENCY GOAL 3	COMPETENCY GOAL 4
ESB graduates are proficient in at least one foreign language (admission requirement)	… are interculturally competent	… are able to manage complex, ethical and legal issues expertly in their professional field and in wider, environmental contexts.	… are aware of adequate methods and tools to meet challenges in an international business and research environment
	Measure by way of an evaluation tool or feed-back session	Embedded in Module M1 Research Methods	Assessment by way of evaluation of master' thesis

DIGITALIZATION	RESEARCH PROFICIENCY
COMPETENCY GOAL 5	COMPETENCY GOAL 6
… are able to manage complex issues in various field of industrial digitalization.	… are aware of defining adequate approaches to solve complex research tasks
Introduced in ModuleM1, M2 and M4 and assessed by way of evaluation of Master's Thesis	Introduced in odule M1, reinforced in Research Sub Projects 1 to 3 and assessed by way of evaluation of Master's Thesis

Learning Objectives - Qualification profile of graduates

Absolventinnen und Absolventen des Studienganges verfügen über Kompetenzen in Digitalisierung in der Industrie, Informations- und Kommunikationstechnologien und -systemen sowie über Soft Skills, Teamfähigkeit, interkulturelle Kompetenz, (Führungs-) Verantwortung und Handlungsfähigkeit. Entsprechend des gewählten Double-degree Partner und des bearbeiteten Forschungsthemas verfügen sie über vertiefte, aktuelle und interdisziplinäre Kenntnisse in den Bereichen Engineering Management oder Engineering Technology. Sie sind insbesondere für interdisziplinäre Forschungs- und Entwicklungsaufgaben an der Schnittstelle zwischen Wirtschaft und Technik qualifiziert. Sie sind in der Lage, Lösungen für Themenstellungen aus dem Umfeld der industriellen Digitalisierung ganzheitlich zu planen, zu entwickeln und zu validieren. Dies können sie sowohl in national lokalen wie auch international globalen Unternehmen einsetzen.

Graduates of the course are competent in digitization and information and communication technology and systems as well as soft skills, team skills, intercultural competence, (leadership) responsibility and ability to act. In accordance with the chosen specialization, graduates possess in-depth, up-to-date and interdisciplinary knowledge in the areas of Engineering Management or Engineering Technology.
Graduates of the programme are predestined for interdisciplinary research and development and tasks at the interface between industry and technology. They are able to plan, develop and validate solutions for topics related to industrial digitization in a holistic manner. This could be done both at national and international global companies.

Future Career Options

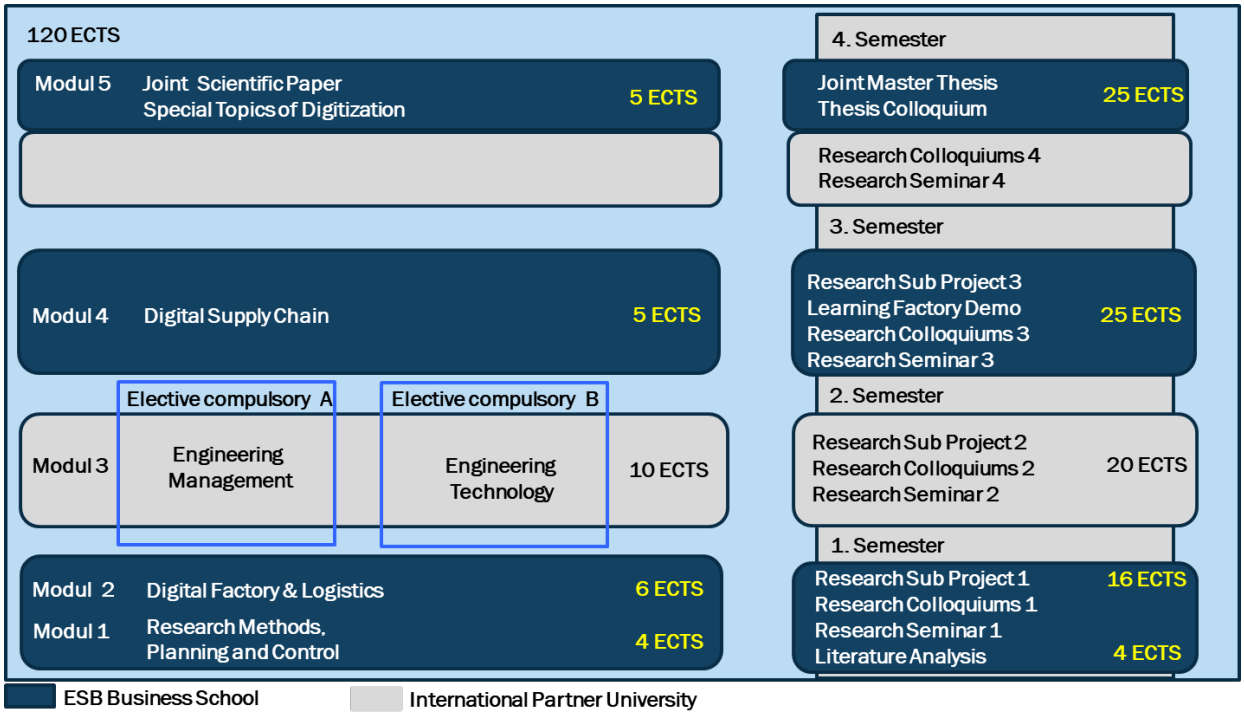
The applications of graduates within research and development are diverse in the areas of:

- Management internationaler Forschungs- und Entwicklungsprojekte/
  Management of international research and development projects
- Gestaltung von smarten Fabriken und Arbeitssystemen
  Design and implementation of Smart Factories and Work Systems
- Gestaltung von digitalen, globalen Logistiksystemen/
  Design of digital global logistics systems
- Gestaltung von internationalen Produktionsnetzwerken/
  Design of international production networks
- Geschäfts- und Produktionsprozessoptimierung
  Business and production process optimisation

2. Study Structure

Die Forschungsprojekte und unterstützenden Lehrveranstaltungen werden nach einer Einführungsphase parallel durchgeführt. Die Lehrveranstaltungen werden in Vorlesungs- und Seminarform gehalten. Dazu ergänzend stehen die Professoren und Dozenten in der konkreten Projektarbeit als Experten zur Verfügung.

The research projects and supporting courses are performed in parallel for an introductory period. The courses will be held in the form of lectures and seminars. These are supplemented by the presence of professors and lecturers as experts in the specific project work..



Picture: Overview DIME Study Programme

Die Forschungsprojektbearbeitung findet in den Forschungsteams der ESB Business School, Hochschule Reutlingen statt. Hierfür werden Arbeitsräume und –mittel zur Verfügung gestellt.

The research project processing can be done partly in industry and partly in the research team of ESB Business School, Reutlingen University. Work spaces and materials are provided.

Supporting Modules and Classes

	Module	Conduct of lectures
1	**Research Methods & Planning**	**Reutlingen University / Partner University**
	Research Methods	
	Research Project Management and Proposals	
2	**Digital Factory and Logistics**	**Reutlingen University**
	Smart Factory and Logistics	
	Information and Communication Technologies & Systems	
3	**Elective compulsory module**	
3 A	**Engineering Management**	**Stellenbosch University**
	Module related lectures	
3 B	**Engineering Technology**	**Purdue University**
	Module related lectures	
4	**Digital Supply Chain**	**Reutlingen University**
	Digital Supply Chain Management	
	International Supply Chain Controlling	
5	**Joint Scientific Paper**	**Partner University / Reutlingen University**
	Scientific Paper	
	Special Topics of Digitalisation	

3. Overview: Modules and Courses

Pflichtmodule / Compulsory modules

Code	Modules/Courses	Contact hours per week in semester				Sum SWS	Type of assessment	graded /un-graded	ECTS-Credits	Weight of grade	HS RT	Part-ner
		1	2	3	4							
MP	**Module 1 Research Methods & Planning**	**3**				**3**	**RE**	**b**	**4**	**4/115**	**x**	**x**
RM1	Research Methods	2										
RPMP	Research Project Management & Proposal	1										
DFL	**Module 2 Digital Factory & Logistics**	**6**				**6**	**KL/RE**	**b**	**6**	**6/115**	**x**	
SFL	Smart Factory and Logistics	2										
ICTS	ICTS	4										
	(Compulsory Elective module)											
EM	**Module 3 A Engineering Management**		**6**			**6**	**KL/RE**	**b**	**10**	**10/115**		**x**
	Module related lecture 1		**3**									
	Module related lecture 2		**3**									
ET	**Module 3 B Engineering Technology**		**6**			**6**	**KL/RE**	**b**	**10**	**10/115**		**x**
	Modul related lecture 1		**3**									
	Module related lecture 2		**3**									
DSC	**Module 4 Digital Supply Chain**			**4**		**4**	**KL/CA /RE**	**b**	**5**	**5/115**	**x**	
DSCM	Digital Supply Chain Management			2								
ISCC	International Supply Chain Controlling			2								
JSP	**Module 5 Joint Scientific Paper**				**3**	**3**	**PA/RE**	**u**	**5**		**x**	**x**
SP	Scientific Paper				2							
STD	Special Topics of Digitalisation				1							

Code	Modules/Courses	Contact hours per week in semester				Sum SWS	Type of assessment	graded/un-graded	ECTS-Credits	Weight of grade	HS RT	Part-ner
		1	2	3	4							
RE1	**Research Sub Project 1**	**4**				**4**	**PA/RE**	**b**	**20**	**20/115**	**x**	
RSP1	Research Sub Project 1	1										
LA1	Literature Analysis 1	1										
RC1	Research Colloquium 1	1										
RS1	Research Seminar 1	1										
RE2	**Research Sub Project 2**		**3**			**3**	**PA/RE**	**b**	**20**	**20/115**		**x**
RSP2	Research Sub Project 2		1									
RC2	Research Colloquium 2		1									
RS2	Research Seminar 2		1									
RE3	**Research Sub Project 3**			**4**		**4**	**PA/RE**	**b**	**25**	**25/115**	**x**	
RSP3	Research Sub Project 3			1								
LFD	Demonstrator Learning Factory			1								
RC3	Research Colloquium 3			1								
RS3	Research Seminar 3			1								
RE4	**Joint Thesis**				**3**	**3**	**MT/RE**	**b**	**25**	**25/115**	**x**	**x**
MTH	Joint Thesis				0							
JMC	Joint Colloquium				1							
RC4	Research Colloquium 4				1							
RS4	Research Seminar 4				1							

Abkürzungen/ Abbreviations:

b benotet/ graded
u unbenotet/ ungraded
CA Continuous Assessment
KL Klausurarbeit/ written examination
MT Master‘s Thesis
PA Projektarbeit/ Project work
RE Referat/ Presentation

4. Module / Lectures

4.1 Module 1: Research Methods and Planning

Module	**Research Methods and Planning**
Module-No.	**RMP**
Semester	1
Duration of module	1 semester
Type of module	Compulsory
How frequently is the module offered	Once per semester
Admission requirements	--
Transferability to other programmes	The course is open to international students in agreement with the respective lecturer and according to availability.
Responsible professor	Prof. Dr.-Ing. Vera Hummel
Language of instruction	English
Total number of ECTS	4 ECTS
Work load total	120h
SWS	3
Level	Graduate
Examination/type of assessment	RE
Weighting of grade within overall programme	4/115 (3,48%)
Teaching and learning methods	Presentations, Case Studies, Problem Based Learning, Self-Study
Learning outcomes	The classes familiarize students with various research methods. After successful completion of the courses, the students should have gained the following knowledge and developed the following competencies: **Professional competencies**: Tools for scientific research in R&D projects: The students are able to carry out, evaluate and translate literature and patent research into a structured overview of the 'state of the art' of science and technology. They are able to compile scientific (project) reports on a larger scale and are able to write scientific publications. **Methodological competencies** The students are familiar with state-of-the-art methods and tools for efficient research planning. They are familiar with the development of scientific project reports, as required by large R&D projects. Important aspects besides a clear structure and the content design are precision, clarity and intelligibility in the formulation. In addition, the participants will learn about the composition and writing of scientific publications aiming at compiling a scientific publication independently. Furthermore, the participants are able to present their results in the form of a scientific discourse in a comprehensible manner to a broad audience and carry out deeper, substantial discussions.

	Social competencies: The students acquire and strengthen their communication skills, teamwork and conflict management skills and demonstrate respect and tolerance towards others.
Version (Date)	01/2020

4.1.1. Class: Research Methods

Lecturer's name; contact details see ESB website	Prof. Dr. Günter Bitsch
Language of instruction	English
Credits (ECTS)	3
Total work	90h
Contact hours per week	2 SWS
Maximum scores related to overall score of 100 for the module	66
Learning outcomes	After the course, the student has gained an overview of the key concepts in research, research ethics, planning and design of research, is skilled in data collection and data quality, quantitative and qualitative data analysis and experimental research. The student is able to choose and apply the right methods for his research topic based on many factors such as the research question, time, budget and ethical aspects. They will have the understanding that the method they choose will affect their results and how they conclude the findings. Exercises are carried out in small groups. The results are presented and discussed in the plenum. In addition to the competencies required for successful teamwork, the students gain the skills to present results in a safe and comprehensible manner in front of an auditorium and to hold a critical discussion. They also learn how to deal with both positive and negative criticism.
Contribution to AoL Competency Goal	CG2: students deal with the international dimension of collaboration in research. CG 3: After the course, the student has an overview of the key concepts in research and research ethics and legal research aspects. The most diverse factors for selecting the appropriate method such as the research questions, time, budget and ethical aspects are presented and discussed. CG3 will be assessed.
Contents/ indicative syllabus	Methods and tools of scientific work: literature research, patent research, scientific project reports, scientific publications, presentation and discussion of scientific results, good scientific practice. In addition, various research methods will be outlined and discussed: ▪ Designing Research ▪ Experimental Research

	▪ Sampling and Sample Design ▪ Quantitative and Qualitative Research Methods ▪ Surveys and Survey Design ▪ Observational Research and Secondary Data ▪ Interviews for Research ▪ Focus Groups Two key research approaches are discussed: quantitative and qualitative research as well as the different ways in which quantitative and qualitative research can be combined are explored. The formulation of research questions as a basis for research design, and which will guide your data collection and analysis, are discussed. The most diverse factors for selecting the appropriate method such as the research questions, time, budget and ethical aspects are presented and discussed.
Teaching and learning methodology	Lecture, group work, discussion,
Miscellaneous	--
Indicative reading list	▪ Williamson, K., & Johanson, G. (2017). Research methods: information, systems, and contexts. Chandos Publishing. ▪ Kornwachs, K. (2018). Philosophie für Ingenieure. Carl Hanser ▪ Chalmers, A. F. (2007). Wege der Wissenschaft: Einführung in die Wissenschaftstheorie (6., verb. Aufl.). Springer. ▪ Schwaiger, M., & Meyer, A. (2009). Theorien und Methoden der Betriebswirtschaft: Handbuch für Wissenschaftler und Studierende (1 ed.). Verlag Franz Vahlen. https://doi.org/10.15358/9783800644377 ▪ Frank, U. (2006). Towards a pluralistic conception of research methods in information systems research.

4.1.2. Class: Research Project Management and Proposals

Lecturer's name; contact details see ESB website	Prof. Dr. Günter Bitsch
Language of instruction	English
Credits (ECTS)	1
Total work	30h
Contact hours per week	1 SWS
Maximum score related to overall score of 100 points for the module	34
Learning outcomes	Students are able to design and plan comprehensive R&D projects independently. They are also able to monitor the progress of the project and to carry out project interviews in a target group-oriented manner. This is based on the learned methods and tools for R&D project management. In addition, the students are able to assess themes / projects with regard to

	their eligibility and to identify project sponsors and funding instruments that are relevant to the topic. The students have the ability to submit a promising project application for public funding. Students are familiar with the generic structure and the generic flow of larger R&D projects. They gain more profound competency in the methods of R&D project management, e.g. work planning, project structure planning, time scheduling, cost and resource planning, exploitation planning, project controlling, cockpit chart creation and project review. In addition, the participants learn the tools of the publicly funded projects from different perspectives (university, group, small and medium-sized enterprises) as well as the framework conditions and procedures for applying. Exercises are carried out in small groups. The results are presented and discussed in the plenum. In addition to the competencies required for successful teamwork, the students gain the skills to present results in a safe and comprehensible manner before an auditorium and to hold up a critical discussion. They also learn how to deal with both positive and negative criticism.
Contribution to AoL Competency Goal	CG2: Student is aware how to plan, steer and control international joint projects
Contents/ indicative syllabus	The students learn the planning, application and management of R&D projects as well as the documentation of research applications via the module 'Research Project Management and Proposals'. ▪ In the first part of the course the students will be trained mainly in methods of R&D work. ▪ The second part focuses on the planning, application and steering of major R&D projects. Participants are also introduced to the publicly funded projects and learn how to apply for a successful application. As a result, the competency focus is at the methodical level. The learned methods are used directly in the research modules 1, 2 and 3, as well as the master's thesis.
Teaching and learning methodology	Lecture, group work, and project work
Miscellaneous	--
Indicative reading list	▪ Huemer, B., Rheindorf, M., & Gruber, H. (2012). Abstract, Exposé und Forschungsantrag. Eine Schreibanleitung für Studierende und junge Forschende. Böhlau. ▪ Brühl, R. (2021). Wie Wissenschaft Wissen schafft: Wissenschaftstheorie und Ethik für die Sozial- und Wirtschaftswissenschaften (3. überarb. u. erw. Auflage). UTB.

4.2 Module 2: Digital Factory and Logistics

Module	**Digital Factory and Logistics**
Module -No.	**DFL**
Semester	1
Duration of module	1 semester
Type of module	Compulsory
How frequently is the module offered	Once per semester
Admission requirements	--
Transferability to other programmes	The course is open to international students in agreement with the respective lecturer and according to availability.
Responsible professor	Prof. Dr.-Ing. Vera Hummel
Language of instruction	English
Total number of ECTS	6 ECTS
Work load total	180h
SWS	6
Level	Graduate
Examination/type of assessment	KL1 h (Digital Factory & Logistics and Smart Factory and Logistics) / RE (ICTS)
Weighting of grade within overall program	6/115 (5,22%)
Teaching and learning methods	Presentations, workshops, Werk150, the factory of the ESB Business School; problem-based learning, self-study
Learning outcomes	The classes familiarise students with the challenges and potential of cyber-physical systems. Industry 4.0 essentially comprises the technical integration of CPS (cyber-physical systems) into the production and logistics as well as the application of the internet of things and services (the convergence of the internet with the object or the service based on digitalization) in industrial processes - including the resulting consequences for the value added, the business models, as well as the downstream services and the work organisation. After successful completion of the courses, the students should have gained the following knowledge and developed the following competencies: **Professional competencies**: Students should be able to design, implement and optimise cyber-physical systems. The students are familiar with elements of hybrid working systems, collaborative robots, autonomous working systems, assistance systems, cloud computing, social media, digital cloud-based engineering tools, business platforms, new business models, information and communication systems and the technologies, mobile and self-learning systems. **Methodological competencies** The students can use methodical, systematic solutions, considering the chosen methods, instruments, infrastructure, tools with the necessary functionality to implement innovative solutions. **Social competencies:**

	– Collaboration in teams – Constructive conflict resolution **Personal competencies:** The students recognise that there are no standard solutions for the challenges within the transformation process towards Digitalization and Industry 4.0.
Content/ indicative syllabus	See classes
Recommended reading list	▪ Schallmo, D. et al., Digitale Transformation von Geschäftsmodellen, Grundlagen, Instrumente und Best Practices, Herausgeber: Schallmo, D., Rusnjak, A., Anzengruber, J., Werani, Th., Jünger, M. (Hrsg.); ISBN 978-3-658-12388-8; Springer Gabler, 2017 ▪ Christopher Schlick, Arbeit in der digitalisierten Welt; Beiträge der Fachtagung des BMBF 2015; Campus Verlag, Frankfurt; ISBN: 978-3-593-50502-2; 2015 ▪ Canetta, Luca et. al., Digital Factory for Human-oriented Production Systems; The Integration of International Research Projects; Herausgeber: Canetta, Luca, Redaelli, Claudia, Flores, Myrna (Eds.); Investigates the impact of the digital factory; Springer Verlag; ISBN 978-1-84996-172-1; 2011
Version (Date)	02/2020

4.2.1 Class: Smart factory and Logistics

Lecturer's name; contact details see ESB website	Prof. Dr.-Ing. Vera Hummel
Class No.	SFL
Language of instruction	English
Credits (ECTS)	2
Total work	60h
Contact hours per week	2 SWS
Maximum score related to overall score of 100 points for the module	34
Learning outcomes	The term »smart factory and logistics« is explained, illustrated, and requirements are discussed by using typical sub-areas, aspects, tools and infrastructure. The students learn to design, plan, implement and optimise areas of a smart factory as well as their co-ordination in the learning factory. Along the entire value chain, they are brought to the complex theme by the generation of ideas, working in communities, principles of smart products, engineering processes and the production system as well as producing them with innovative methods and infrastructures. Smart factories and their logistics require formalisation. Necessary bonds

	from computer science, automation and electrical engineering can be allocated for this, suitable methods and infrastructure can be selected and applied with a view to the desired result. Complexity, performance characteristics and limitations of comprehensive systems and subsystems, which, according to our understanding, represent the 'state of the art' of a smart factory where logistics can be assessed and classified.
Contribution to AoL Competency goals	CG5: Students will be aware of different traditional and digital supply chains, their success factors, processes, concepts, tools and technologies and current research topics in these areas.
Contents/ indicative syllabus	Merging of the virtual and the physical worlds through cyber-physical systems and the resulting fusion of technical processes and business processes are leading the way to a new industrial age best defined by a smart factory concept. **Overview and introduction** ▪ Initial situation, vision ▪ Digitalization und Industry 4.0 ▪ International comparison ▪ System concept, challenges and potential ▪ Cyber-Physical production system ▪ Industrial communication systems **Virtual engineering, Data processing and AI** ▪ Engineering platforms ▪ Innovative engineering approaches ▪ Data analytics ▪ Machine learning **Smart Factory and Collaborative Robots** ▪ Introduction ▪ Technical assistance systems ▪ Collaborative robots ▪ Standardization, risk assessment ▪ Design of hybrid assembly systems **Exoskeletons** ▪ Introduction ▪ Exoskeleton types ▪ Design of work systems with exoskeletons **Smart Logistics and intelligent infrastructure** ▪ Introduction ▪ Intelligent Infrastructure (eKanban; iBin; iConveyor belts; etc. ▪ Standardization ▪ Design of hybrid intra logistics systems ▪ **Hybrid working systems in assembly and logistics** ▪ Introduction to the LLF ▪ Design and implement hybrid working system within the ESB LLF **Informational assistance system** ▪ Introduction ▪ Design of informational assistance system ▪ Smart devices and wearables

	▪ Application areas and exercises in Werk150 (ESB Logistics -learning factory **Innovative technologies** ▪ Digital technology platform ▪ Additive manufacturing ▪ Sensors, cameras, laser **Innovative methods and approaches (varies)** ▪ e.g Industry 5.0, Circular economy, Design Thinking, Theory of Constraints, …
Teaching and learning methodology	Lecture, demonstration, project work in Werk150
Miscellaneous	--
Indicative reading list	▪ Handbuch Industrie 4.0: Band 3: Logistik (Springer Reference Technik) von Michael ten Hompel, Thomas Bauernhansl, et al.; Springer Vieweg; 3. Aufl.; ISBN-10 3662585294; 2020 ▪ Industrie 4.0 kompakt – Wie Technologien unsere Wirtschaft und unsere Unternehmen verändern: Transformation und Veränderung des gesamten Unternehmens; Herausgeber Walter Huber; Springer-Vieweg: 2018 ▪ Industrie 4.0 in Produktion, Automatisierung und Logistik: Anwendung · Technologien · Migration; Herausgeber: Thomas Bauernhansl et al; Springer Vieweg; 2014 ▪ Industrial Digital Transformation: Accelerate digital transformation with business optimization, AI, and Industry 4.0; Packt Publishing (27. November 2020); ISBN-10 : 1800207670; 2020 ▪ Industry 4.0: Technologies, Applications, and Challenges (Emerging Trends in Mechatronics); Springer; 1st ed. 2023 Edition (21. Oktober 2022) ISBN-10 : 9811920117; 2023 ▪ Current special articles

4.2.2 Class: Information & Communication Technologies and Systems

Lecturer's name; contact details see ESB website	Prof. Dr. Günter Bitsch
Class No.	ICTS
Language of instruction	English
Credits (ECTS)	4
Total work	90h
Contact hours per week	4 SWS
Maximum score related to 100 for the modules	66

Learning outcomes	By means of networking of sensors and actuators for the Internet of Things, the students generate added value from existing business processes and implement it as new business models for Industry 4.0. They specify the exploitation potential of the networking, implement it in the IT infrastructure and apply it in the mobile technologies.
Contents/ indicative syllabus	1. Advanced Informatics / Programming Project Management Simulation Camp. • Programming languages • C, C#, Java • Scripting languages • JavaScript, Python • Programming of microcontrollers for IoT applications • Design of IT-architectures for IoT solutions • Mobile Solutions: manufacturer-specific and –independent solution approaches • Current mobile technologies: platforms, frameworks and sensors 2. Industrial process and control (for Industry 4.0 SPS, IO-Link) • Sensors and actuators • Field bus systems • Identification systems • Communication systems (local and mobile networks)
Contribution to AoL Competency goals	CG5: the module reinforces digital competencies of the students.
Teaching and learning methodology	lecture, group work, demonstration and project work
Miscellaneous	--
Indicative reading list	▪ Hanes, D., Salgueiro, G., Grossetete, P., Barton, R., Henry, J., 2017. IoT fundamentals: Networking technologies, protocols, and use cases for the internet of things, Fundamentals. Pearson Education ▪ Kurose, J.F., Ross, K.W., 2016. Computer networking a top-down approach, 7th ed. Pearson ▪ Stallings, W., Agboma, F., Jelassi, S., 2015. Foundations of modern networking SDN, NFV, QoE, IoT, and Cloud. Addison Wesley. ▪ Dastjerdi, A., Buyya, R., 2016. Internet of things: Principles and paradigms ▪ Science and Technology literature retrieved from Online-Data Base Elsevier

4.3 Elective compulsory modules

4.3.1 Module 3 A: Engineering Management (Stellenbosch University)

Module	**Engineering Management**
Module -No.	EM
Semester	2
Duration of module	1 semester
Type of module	Compulsory
How frequently is the module offered	Once a semester
Transferability for other programmes	The course is open to international students in agreement with the respective lecturer and according to availability.
Responsible professor	Konrad von Leipzig
Language of instruction	English
Total number of ECTS	10 ECTS
Work load total	300h
SWS	6
Level	Graduate
Examination/type of assessment	KL/RE
Weighting of grade within overall program	10/115 (8,70%)
Teaching and learning methods	Lecture, presentations, case studies, self-study
Content/ indicative syllabus	The module consists of lectures from the partner university. They are aligned with the focus of the foreign partner 'Engineering Management'. The lectures focus on **Data Science** covering methods, instruments and approaches to solving comprehensive challenges in Engineering Management in an effective and efficient way. Data Science is the application of computational, statistical, and machine learning techniques to gain insight into real world problems. The lecture covers the data science project life cycle, specifically to gain a clear understanding of the steps in the data science process. Each of these steps will be studied with the main purpose to gain an understanding of the requirements, complexities, and tools to apply to each of these life cycle steps. Students will understand the process of constructing a data pipeline, from raw data to knowledge. Case studies from the engineering domain will be used to explore each of the steps. Another focus of the lectures is on specific topics in **Engineering Management** within the context of the broader national and international business environment. Aspects of technology management, including contemporary models, frameworks and processes. The management of innovation, the dynamics of technological change and anticipating the techno-

	logical future. Intellectual property issue and commercialization of technology. The workplace of the future, talent management and leadership. Comprehensive case studies.
Learning outcomes	**Professional competencies**: Upon successful completion of 'Analytics and Synthesis' and 'Engineering Management', students are able to use various optimization methods and to apply them in practice. In particular, they will learn to review a number of basic statistical concepts and methods in a clear, systematic and simple way so that they are able to make critical assessments and conclusions in a stochastic context. Engineering and Technology management teaches students to understand the very important link between technology and innovation as well as basic definitions of technology. Students will have developed an understanding of the relationship between business strategy, business life cycle and product life cycle as well as the strategic impact of technology sales and how to protect the value of such technologies. They are able to develop optimised solutions based on statistical methods as well as strategic planning of innovative technologies considering their influencing variables. **Methodological competencies:** Students are able to formulate or develop complex practical optimization problems as mathematical problems (modelling) and solution methods. In addition, they are aware of basic technologies and impact on business models. They are able to assess the technologic degree and selectable technologies to support the business model. **Social competencies:** Within the module work models are prepared and discussed based on group work. **Personal competencies:** Possibilities and limits for mathematical solutions in practice are taught and the students understand the possibilities, influencing variables and limitations of technology.
Indicative reading list	▪ Decision Models in Engineering and Management; Verlag: Springer / Springer International; Publisher: Guarnieri, ISBN-13: 9783319119489; 2015
Version (Date)	04/2022

4.3.2 Module 3 B: Engineering Technology (Purdue University)

Module	**Engineering Technology**
Module -No.	**ET**
Semester	2
Duration of module	1 Semester
Type of module	Compulsory
How frequently is the module offered	Once a year
Transferability for other programmes	The course is open to international students in agreement with the respective lecturer and according to availability.
Responsible professor	Dr. Ragu Athinarayanan
Language of instruction	English
Total number of ECTS	10
Work load total	300h
SWS	6
Level	Graduate
Examination/type of assessment	KL/RE
Weighting of grade within overall programme	10/115 (8,70%)
Teaching and learning methods	Lecture, presentations, case studies, self-study
Content/ indicative syllabus	The module consists of lectures from the partner university. They are aligned with the focus of the foreign partner 'Engineering Technology'. The lectures focus on **Applied Optimization**. The course will introduce students to the basic concepts of optimization methods with particular emphasis on applications in product and process design. Unconstrained, nonlinear problems will be presented and solved using steepest descent and conjugate directions. Constrained problems will be solved using exterior penalty functions. Another focus of the lectures is on **Technology from A Global Perspective**. Research into the investigation of global technology issues and challenges faced by the practicing technologist polytechnic academic. One of these challenges is working and interacting with international technical personnel, both here and abroad. Interwoven throughout the course, includes a study of technology, invention/innovation, patents, professional ethics, project management, and country cultural diversity inside/outside the United States and Europe. The students discuss the global, grand challenges faced by all of us in engineering technology and/or other PPI technology disciplines. Students will research the global grand challenges we face as a society and/or industry, using their own research interest/desire as a basis to investigate these issues. One integral part of the

	course allows students to explore their own research and higher education passion on a global scale of impact.
Learning outcomes	**Professional competencies**: Upon completion of 'Engineering Technology Statistics for Industry' students should be able to apply various optimization methods and transfer them to practice. They are able to develop optimised solutions based on statistical methods as well as strategic planning of innovative technologies considering their influencing variables. They are able to write Research Problem Statements in the field of Engineering Technology, understand Invention, Innovation, Patents, and Intellectual Property Rights. They are aware of the impact of offshoring a product and/or commodity. The module teaches students to understand the very important link between technology and innovation as well as basic definitions of technology. **Methodological competencies:** Students are able to formulate or develop complex practical optimization problems as mathematical problems (modelling) and solution methods. They are able to understand and apply Global Project Management methods and research methods. **Social competencies:** Within the module Social Competencies of Global Challenges, knowledge on how toto maintain national security, quality of life, and sustainable future work are obtained. The concept of scientific ethics and intellectual property is understood. They are able to appropriately apply professional codes of ethics for engineers/professionals to complex, global engineering technology and business situations. They know how to describe the influences and interrelationships of ethics, cultural, and political environments of countries and their technological progress. **Personal competencies:** Students understand the possibilities, influencing variables and limitations of technology as well as of Engineering and Professional Ethics.
Indicative reading list	▪ Mark French: Fundamentals of Optimization (Springer 2018) ▪ Jasanoff, S. (2016). The Ethics of Invention. New York: W. W. Norton & Company, Inc. - ISBN 978-0-393-07899-2
Version (Date)	04/2022

4.4 Module 4: Digital Supply Chain

Module	**Digital Supply Chain**
Module -No.	**DSC**
Semester	3
Duration of module	1 semester
Type of module	Compulsory
How frequently is the module offered	Once per semester
Admission requirements	--
Transferability to other programmes	The course is open to international students in agreement with the respective lecturer and according to availability.
Responsible professor	Prof. Dr. techn. Daniel Palm
Language of instruction	English
Total number of ECTS	5 ECTS
Work load total	150h
SWS	4
Level	Graduate
Examination/type of assessment	KL1 h (Digital Supply Chain Management) / CA (International Supply Chain Controlling)
Weighting of grade within overall programme	5/115 (4,35%)
Teaching and learning methods	Presentations, case studies, problem-based learning, self-study
Learning outcomes	The classes familiarise students with supply chain management and supply chain controlling. Students will gain the following competencies: **Professional competencies**: – Understand the concepts and methods of supply chain management and supply chain controlling – Know the supply chain actors and their interaction – Understand mechanisms of collaboration in supply chains – Know how to achieve the supply chain fit in delivering products, services or hybrid / smart products to the customer – Understand the differences between traditional and digital supply chains and the new concepts of digitized supply chain management **Methodological competencies** – Methods to plan, control and optimize information, material and cash flow in the supply chain – Scientific methods (delimitation, problem formulation, reasoning, validation) – Literature research **Social competencies:** – Awareness of ethics and social responsibility in sourcing and supply chain management – Collaboration in teams

	– Constructive conflict resolution **Personal competencies:** – Scientific presentation and defence – Scientific discussions – Narrowing the scope and abstracting
Content/ indicative syllabus	See classes
Indicative reading list	See classes
Version (Date)	02/2020

4.4.1 Class: Digital Supply Chain Management

Lecturer's name; contact details see ESB website	Prof. Dr. techn. Daniel Palm
Class No.	DSCM
Language of instruction	English
Credits (ECTS)	3
Total work	90h
Contact hours per week	2 SWS
Maximum score related to overall score of 100 points for the module	60
Learning outcomes	Graduates should understand the concepts of supply chain management in a holistic way. How the single concepts or methods interact and how to combine them in a value chain to achieve the supply chain fit in delivering products, services or hybrid / smart products to the customer. Students are aware of different traditional and digital supply chains, their success factors, processes, concepts, tools and technologies and to-date research topics in these areas. They have the ability to assess the strategic fit of supply chains and to identify strengths and weaknesses from an ecological, economic and social point of view on an international level. They have the qualification to analyze complex issues and to present them in a systematic and scientific way. They have the qualification to plan, implement and optimize supply chains and to analyse new supply chain concepts.
Contribution to AoL Competency Goal	CG3: Students gain an awareness of ethics and social responsibility in sourcing and supply chain management
Contents/ indicative syllabus	– Supply Chain types – Industry Specific Supply Chains (Automotive, Retail, Electronics…) – Goal conflicts in Supply Chains – Supply Chain Integration – Inventories and Lean Concepts – Products, Services, Digitalization of Business Models – Digitalization of Supply Chain Management

	– Collaboration in Supply Chains – Supply Chain Strategies and Coordination – Supply Chain Control – IT Systems in Enterprises and Supply Chains
Teaching and learning methodology	Lecture, group work, simulation game and project work
Miscellaneous	--
Indicative reading list	▪ Chopra, Sunil; Meindl, Peter: Supply Chain Management. Strategy, Planning, and Operation. PEARSON, 7th Edition (2018)

4.4.2 Class: International Supply Chain Controlling

Lecturer's name; contact details: ESB website	Prof. Dr. Andreas Taschner
Class No.	ISCC
Language of instruction	English
Credits (ECTS)	2
Total work	60h
Contact hours per week	2 SWS
Maximum score related to overall score of 100 points for the module	40
Learning outcomes	After successful completion of the class, students are familiar with the concept of Controlling in general and its tasks in modern business. They know how to apply the main controlling tools and instruments in typical business situations. Students understand the challenges that controlling is faced with in a modern business environment that is characterized by: ▪ Increasing inter-company collaboration (supply chains) ▪ Increasing internationalization ▪ Increasing digitization Students understand how this three-fold development affects controlling functions and controlling tools. They are able to critically reflect the fit of standard controlling methods for international supply chains and know how to adapt these methods in order to increase fit. Students are familiar with the current research standards in supply chain controlling research and are able to derive appropriate research questions for future research projects.
Contribution to AoL Competency Goal	CG2: Students gain awareness of how to increase inter-company collaboration (supply chains) and internationalisation
Contents/ indicative syllabus	1. Fundamental concepts Management Accounting & Control (MAC) Information Management

	Goals of MAC The typical MAC system 2. Standard Supply chain controlling concepts and tools Supply chain cost and supply chain performance Cost management in supply chains Information management in supply chains Supply chain performance management 3. Current research standards, challenges of supply chain controlling Transfer pricing in collaborative settings Revenue and profit-sharing models in collaborative settings Cross-company performance models Digitization and MAC
Teaching and learning methodology	Lecture, group work, and project work
Miscellaneous	--
Indicative reading list	▪ Merchant & Van der Stede (2017): Management Control Systems, 4th ed., FT Press ▪ Martin Christopher (2016): Logistics & Supply Chain Management, 5th ed., FT Press ▪ Robert N Anthony, Vijay Govindarajan, Frank G.H. Hartmann, Kalle Kraus and Göran Nilsson (2014): Management Control Systems: European Edition, McGraw-Hill ▪ Richard E. Crandall, William R. Crandall, Charlie C. Chen (2014): Principles of Supply Chain Management, 2nd ed., CRC Press

4.5 Module 5: Joint Scientific paper

Module No./ code	**JSP**
Semester	4
Duration of module	1 Semester
Type of module	Compulsory
Courses included in the module	Scientific Paper; Special Topics of Digitalisation
How frequently is the module offered	Once a year
Admission requirements	--
Level	Graduate
Transferability of the module to other programmes	The module is not suitable for other programs.
Responsible professor/ module coordinator	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Total number of ECTS	5 ECTS
Total workload and breakdown	120h
Learning outcomes of the module	Production of research paper; knowledge about publication methods; communication skills; research specific topics of digitalisation.
Examination/ type of assessment	PA/RE
Weighting of grade in relation to the overall programme	5/115

4.5.1 Scientific paper

Class No./ Code	**SP**
Type of course	Compulsory
Lecturer's name	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Language of instruction	English
Credits (ECTS)	4 ECTS
Work load	120h
Contact hrs/week (SWS)	2
Learning outcomes	**Professional competencies:**

	Individual structuring and creation of scientific research report as well as a scientific publication for the respective extensive research work. **Methodological competencies** Important aspects besides the structure and content design are precision, clarity and intelligibility in the formulation. In addition, the participants learn about the structure and writing of scientific publications with the aim of compiling a scientific publication independently (see competency) within the fourth semester. Furthermore, the participants are able to present their results in the form of a scientific lecture in a comprehensible manner to a wide audience, but at the same time also to carry out deeper essential discussions. **Social competencies:** Students acquire or strengthen their communication skills, both in language and in writing **Personal competencies:** Identification of relevant findings from one's own very extensive research work, which is of great interest to the relevant scientific community circles, and thus a publication medium
Contribution to AoL Competency Goal	The course contributes to the competency goal CG4: students will be able to apply and reflect appropriate research methods.
Content/ indicative syllabus	– identification of content relevant to the publication – selection of representative representational media (writing, image) – selection of appropriate technical periodical – development paper structure – elaboration of the contents of the scientific paper – internal evaluation in the research group – internal consultation with the supervising professor – inquiry and acceptance of the paper – processing of external review process – revision according to the corresponding review process
Teaching and learning methods	Paper, discussions, presentations
Miscellaneous	--
Indicative reading list	Depending on research subjects
Version (Date)	02/2020

4.5.2 Class: Special Topics of Digitalization

Class No./ Code	**STD**
Type of course	Compulsory
Lecturer's name; contact details: See ESB website	Study Dean
Language of instruction	English/German
Credits (ECTS)	1
Work load	30h
Contact hours per week	1 SWS**
Learning outcomes	Before graduation, the students will once again deal with the most current topics of digitalization. The goal is to intensify the awareness for raising challenges, processes and solutions for digitization once more.
Contribution to AoL Competency Goal	The course contributes to CG5: Digitalization
Contents/ indicative syllabus	The seminar addresses the most diverse topics from the digitization in industry from production, logistics, engineering, management, as well as ICT
Teaching and learning methods	Attend presentations on innovative approaches and participate in the discussion of future solutions.
Miscellaneous	** This lecture event will be organized once a year

4.6 Research Sub Project 1

Module	**Research Sub Project 1**
Module No.	**RE1**
Semester	1
Duration of module	1 semester
Type of module	Research project
How frequently is the module offered	Once per semester
Admission requirements	--
Transferability for other programs	The module is not suitable for other programs.
Responsible professor	Study Dean
Language of instruction	English
Total number of ECTS	20 ECTS
Work load total	600 h
SWS	4 SWS
Level	Graduate
Examination/type of assessment	PA (Research Sub Project and Seminar /RE (Literature Analysis) and Research Colloquium

	The regular discussions with the supervisor of the ongoing research sub project 1 progress with the student are accompanied by a documentation. Documentation may include a report or power point presentation or discussion notes.
Weighting of grade within overall programme	20/115 (17,39%)
Teaching and learning methods	Problem- and project-oriented learning
Learning outcomes	**Professional competencies:** The students analyze the chosen research area and work their way through the careful review of the state of science and technology including a detailed literature research in the respective field. In addition, they acquire the corresponding theoretical basics. In the establishment of possible experimental and /or stimulatory conditions for the conductance of the planned research work, students learn to use appropriate research techniques and methods, as well as simulation methods and to evaluate them subsequently for their purposes. They learn about the appropriate infrastructure of the LLF including control and measurement technology, digital engineering methods and tools as well as procedures and tools of the experimental data evaluation and evaluation. In carrying out the preliminary investigations or feasibility studies, students acquire knowledge in scientific experimentation, that is, planning and reproducible performance and evaluation of scientific experiments. This is also the selection and acquisition of appropriate samples to score, also giving the students expertise in the careful sample preparation. The results gained teach them to interpret the data from which the necessary next steps for the Research Sub Project 2 can be derived. **Methodological competencies:** The methods, tools and instruments learned in the 'Research and Planning' module are applied to the specific research project. In the processing students learn about the instruments for efficient use in conducting and evaluating literature research. In the research project planning phase, they learn the efficient application of different innovation and R&D planning tools. The creation of a project structure plan includes resource planning, as well as the planning of the time sequence of the R&D project, for example in the form of a Gantt diagrams including deliverables and milestones. The students acquire expertise in the writing an interim scientific report for a more comprehensive research project based on their concrete examples. In addition, the students acquire competency in experimental planning and engineering during the planning of the experimental or simulation work, e.g. In the form of statistical experiment scheduling. **Social competencies:** Students learn to work in research groups. They acquire or strengthen their ability to communicate, ability to work as a team, manage conflicts, as well as perseverance, but also respect and tolerance towards other group members. Interdisciplinary competency transfer takes place in that they learn to think about other problems, to raise understanding and to

	deepen their knowledge by means of targeted research. They strengthen their competence in self - responsible action and in the acquisition of responsibility. In addition, the students are trained in good scientific practice. **Personal competencies:** The students recognize that project and research work require a high degree of tolerance and discipline in the project team as well as in the face of external stakeholders.
Content/ indicative syllabus	See classes
Indicative reading list	The list of literatures is defined according to the selected research topic. In addition, further recommendation will be a result of the literature analysis.
Version (date)	05/2022

4.6.1 Research Project 1

Lecturer's name; contact details see ESB website	Prof. Anja Braun OR Prof. Günter Bitsch OR Prof. Vera Hummel OR Prof. Daniel Palm OR Prof. Dominik Lucke
Class No.	RSP1
Language of instruction	English
Credits (ECTS)	14 ECTS
Total work	420h
Contact hours per week	1 SWS*
Maximum score related to overall score of 100 points for the module	73
Learning outcomes	The students will be trained to fulfil the requirements of good scientific practice. The students should comprehend the problem, analyse the current research standards in science, derive the research gap, define the research design and formulate the research questions.
Contribution to AoL Competency Goal	CG4: Students are taught how to identify research gaps based on existing challenges/ problems and to derive a solution approach.
Contents/ indicative syllabus	The contents are generally derived in consultation with the responsible professor for the selected research subject. The research sub project 1 consists of the following tasks: – Formulation of the objective of the research work – Formulation of research questions – Review of the research standards including detailed literature research – Structuring the work, and creation of a project structure plan as well as a time schedule

	– Definition of research milestones – If necessary, establish the experimental / simulation conditions for carrying out the research work – Carry out preliminary investigations or feasibility studies
Teaching and learning methodology	Lecture, group work, discussions
Miscellaneous	* The workload of 420 hours includes a 1 h weekly review (15 contact hours in total) and 405 hours of self-study. Contact hours and self-study are slightly variable according to the respective research subject.
Indicative reading list	The list of literature is defined according to the selected research topic. In addition, further recommendation will be a result of the literature analysis.

4.6.2 Class: Literature Analysis

Lecturer's name; contact details see ESB website	Prof. Anja Braun OR Prof. Günter Bitsch OR Prof. Vera Hummel OR Prof. Daniel Palm OR Prof. Dominik Lucke
Class No.	LA1
Language of instruction	English
Credits (ECTS)	4 ECTS
Total work	120h
Contact hours per week	1 SWS
Maximum score related to overall score of 100 points for the module	21
Learning outcomes	The students gain further depth in the chosen research subject by carefully researching the state of science and technology, including a detailed literature research. In the processing stage, the students learn to use instruments for the efficient execution and evaluation of literature researches to their specific questions. In addition, the students are trained in a good scientific practice.
Contribution to AoL Competency Goal	The course contributes to CG4: students learn to retrieve, compile and critically assess research literature.
Contents/ indicative syllabus	▪ Identification of relevant research media (library, online databases…) ▪ Selection of software support for later administration-relevant literature ▪ Time planning ▪ Definition of the fields of interest with the corresponding keywords (international literature) ▪ Performance of the analysis ▪ Review the findings with respect to 'state of the art' literature and findings ▪ Process the literature with the selected software

	▪ Deduction of the findings for the forthcoming research work
Teaching and learning methodology	Lecture, group work, discussions
Miscellaneous	--
Indicative reading list	Literature and Literary Studies in the Twenty-First Century; Publisher Ansgar Nünning, Alexander Scherr; WVT Wissenschaftlicher Verlag Trier; ISBN: 3868219269; 2021

4.6.3 Class: Research Colloquium 1

Lecturers name; contact details see ESB website	Prof. Anja Braun OR Prof. Günter Bitsch OR Prof. Vera Hummel OR Prof. Daniel Palm OR Prof. Dominik Lucke
Class No.	RC1
Language of instruction	English
Credits (ECTS)	1 ECTS
Total work	30h
Contact hours per week	1 SWS
Learning outcomes	The students will learn to present in front of an auditorium, as well as discuss the results and assert themselves in a discussion. The student can select suitable methods for the presentation and discussion of the research project and address specific questions concerning the progress of the research project. The student is able to defend research outcomes developed in an intercultural and interdisciplinary plenum and can integrate the received input for the research sub project 2 that builds upon it. They also learn how to deal with both positive and negative criticism. In addition, the students take part in good scientific practice.
Contents/ indicative syllabus	The final research colloquium will take place at the end of the semester. In order to evaluate the chosen research approach and the intermediate results and to prepare for the final colloquium, a *midterm colloquium* will take place in the middle of the semester. The content of the colloquium depends on the respective question. These may include the following areas: ▪ Complex systems ▪ Simulation, Artificial Intelligence, Distributed Systems ▪ Digital Supply Chain ▪ Digital Logistics ▪ Digital Production Systems ▪ Digital Management
Teaching and learning methodology	Discussions
Miscellaneous	--

4.6.4 Class: Research Seminar 1

Lecturers name; contact details see ESB website	Students take part at a research seminar with the respecting supervising professors. Prof. Dr. Vera Hummel, Prof. Dr. Daniel Palm, Prof. Dr. Anja Braun, Prof. Dr. Dominik Lucke, Prof. Dr. Günter Bitsch on a regular basis.
Class No.	RS1
Language of instruction	English
Credits (ECTS)	1 ECTS
Total work	30h
Contact hours per week	1 SWS
Maximum score related to overall score of 100 points for the module	6
Learning outcomes	After the course, the student can select suitable methods for research projects and address specific questions concerning the course of studies (digitization, industry, management). The student is able to analyse complex problems and develop solutions.
Contents/ indicative syllabus	The content of the research seminar consists on the various respective research projects carried out in this study programme. These may include, the following areas: – Complex systems – Simulation, Artificial Intelligence, Distributed Systems – Digital Supply Chain – Digital Logistics – Digital Production Systems – Digital Management
Teaching and learning methodology	Presentation and discussions
Miscellaneous	--

4.7 Research Sub Project 2

Module	**Research Sub Project 2**
Module No.	**RE2**
Semester	2
Duration of module	1 semester
Type module	Research project
How frequently is the module offered	Once per semester
Access requirements and previous knowledge	Research sub project 1
Transferability for other programmes	The module is not suitable for other programmes.
Responsible professor	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Language of instruction	English
ECTS	20 ECTS
Work load total	600 hours
SWS	3 SWS
Level	Graduate
Examination/type of assessment	PA (Research Project 2 and Research Seminar/RE (Research Colloquium) The regular discussions with the supervisors of the ongoing research sub project 2 progress with the student and are accompanied by documentation. Documentation may include a report or power point presentation or discussion notes
Weighting of grade within overall module	20/115 (17,39%)
Teaching method	Project- and problem-based learning
Learning outcomes	**Professional Competences** The student compiles substantial new insights into the respective research subject, which go well beyond current research standards. In the process, the student is increasingly becoming an expert in his/her field under the guidance of the supervisors and in discussion with the members of the respective research group. The student learns how to deal with methods, experimental facilities, simulation tools for the trial and the scientific evaluation of the results. In the discussion with supervisors and members of the respective research group, the student learns to critically evaluate the results obtained and, based on this, to derive the further successful work. **Methodological Competences:** In essence, the student acquires expertise in methodological-scientific experimentation and investigations the structured-analytical evaluation of the achieved scientific results. In the preparation of the scientific interim report, the student acquires, based on the Research Sub Project 1, in-depth expertise in the self-responsible creation of scientific project reports for extensive R&D projects.

	Social competences Deepening of the competences acquired in Research Sub Project 1, which are developed to a higher level **Personal competence:** The students recognise that research work requires a high degree of tolerance and discipline, as well as in the face of all stakeholders.
Contents/ indicative syllabus	See classes
Indicative reading list	The list of literature is defined according to the selected research topic. Further input can come from the research seminar 1
Miscellaneous	--
Version (Date)	05/2022

4.7.1 Research Project 2

Lecturer's name; contact details see ESB website	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Class No.	RSP2
Language of instruction	English
Credits (ECTS)	18
Total work	540
Contact hours per week	1*
Maximum score related to overall score of 100 points for the module	94
Learning outcomes	The student compiles substantial new insights into the respective research subject, which go well beyond the current research standards. In the process, the student will increasingly becoming an expert in his field under the guidance of his supervisors and in discussion with the members of the respective research group. The student will earn how to deal with methods, experimental facilities, simulation tools for the trial and the scientific evaluation of the results. In the discussion with supervisors and members of the respective research group, the student will learn to critically evaluate the results obtained and, based on this, to derive further successful work.
Contribution to AoL Competency Goal	CG4: Students are taught to utilise the developed solution approach to close the identified research gap. They will have achieved a first experience with problem solving or research findings and will have drafted basic ideas towards possible solutions.
Contents/ indicative syllabus	Research sub project 2 is linked to Research Sub Project 1 and contains the following aspects and tasks: – Carry out the experimental / investigational / simulation work – Review and evaluate the research results – The central component is the elaboration, processing and evaluation of the research results, based on the prerequisites established and

	feasibility studies carried out in Research Sub Project 1. In this module of the research sub project 2, an adaptation or expansion of the work may be necessary.
Teaching and learning methodology	Lecture, group work, discussions
Miscellaneous	* The workload of 420 hours includes a 1 h weekly review (15 contact hours in total) and 405 hrs. of self-study. Contact hours and self-study are slightly variable according to the respective research subject.
Indicative reading list	The list of literature is defined according to the selected research topic. In addition, further recommendation will be a result of the literature analysis.

4.7.2 Class: Research Colloquium 2

Lecturer's name; contact details see ESB website	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Class No.	RC2
Language of instruction	English
Credits (ECTS)	1
Total work	30h
Contact hours per week	1 SWS
Learning outcomes	The students will learn to present in front of an international auditorium, as well as discuss the results and assert themselves in a discussion. The student can select suitable methods for the presentation and discussion of the research project and address specific questions concerning the progress of the research project. The student is able to defend research outcomes, developed in an intercultural and interdisciplinary plenum and can integrate the received input for the research sub project 3 that builds upon it. They also learn how to deal with both positive and negative criticism. In addition, the students take part in good scientific practice.
Contents/ indicative syllabus	The final research colloquium will take place at the end of the semester. In order to evaluate the chosen research approach and the intermediate results and to prepare for the final colloquium, a *midterm colloquium* will take place in the middle of the semester. The content of the colloquium depends on the respective question. These may include the following areas: ▪ Complex systems ▪ Simulation, Artificial Intelligence, Distributed Systems ▪ Digital Supply Chain ▪ Digital Logistics ▪ Digital Production Systems

	▪ Digital Management
Teaching and learning methodology	Presentation, Discussions
Miscellaneous	--

4.7.3 Class: Research Seminar 2

Lecturer's name; contact details see ESB website	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Class No.	RS2
Language of instruction	English
Credits (ECTS)	1
Total work	30h
Contact hours per week	1 SWS
Maximum score related to overall score of 100 points for the module	6
Learning outcomes	Students are trained in comparable competences as in the research seminar 1. Due to the progress of the work, the competences are deepened and raised to a higher level. By exchanging knowledge with the students/experts of other disciplines or research areas on a higher level than in the research seminar 1, the students expand their professional horizons. They are able to establish cross-links between the various research topics and the findings obtained and to use them for their own work.
Contribution to AoL Competency Goal	CG 2: The student is able to defend work which was done in an intercultural and interdisciplinary plenum:
Contents/ indicative syllabus	The content of the research seminar 2 consists of the various respective research projects carried out in this study programme. These may include the following areas: ▪ Complex systems ▪ Simulation, Artificial Intelligence, Distributed Systems ▪ Digital Supply Chain ▪ Digital Logistics ▪ Digital Production Systems ▪ Digital Management
Teaching and learning methodology	Presentation and discussion
Miscellaneous	--

4.8 Research Sub Project 3

Module	**Research Sub Project 3**
Module No.	**RE3**
Semester	3
Duration of module	1 semester
Type of module	Research project
Access requirements and previous knowledge	Research sub project 1+2
How frequently is the module offered	Once per semester
Transferability for other programmes	The module is not suitable for other programs.
Responsible professor	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Language of instruction	English
Total number of ECTS	25 ECTS
Work load total	750h
SWS	5 SWS
Level	Graduate
Examination/type of assessment	PA (Research Project 3 and Research Seminar 3/RE (Learning Factory Demonstrator and Research Colloquium) The regular discussions with the supervisors of the ongoing research sub project 3 progress with the student and are accompanied by documentation. Documentation may include a report or power point presentation or discussion notes
Weighting of grade within overall programme	25/115 (21,74%)
Teaching and learning methods	Problem- and project-oriented learning
Learning outcomes	**Professional Competences** The student compiles substantial new insights into the respective research subject, which go well beyond current research standards. In this process, the student becomes increasingly expert in his/her field under the guidance of the supervisors and in discussion with the members of the respective research group. The student learns how to deal with methods, experimental facilities, simulation tools for the trial and the scientific evaluation of the results. In the discussion with supervisors and members of the respective research group, the student learns to critically evaluate the results obtained and, based on this, to derive further successful work. **Methodological Competences:** The student acquires expertise in methodological-scientific experimentation and investigations the structured-analytical evaluation of the

	achieved scientific results. In the preparation of the scientific interim report, the student acquires, based on the Research Sub Project 2, in-depth expertise in the creation of scientific project reports for extensive R&D projects. The student is solely responsible for his scientific project report. **Social competences** Deepening of the competences acquired in Research Sub Project 2, which are developed to a higher level **Personal competence** The students recognize that research work requires a high degree of tolerance and discipline especially in the face of all stakeholders.
Content/ indictive syllabus	Research sub project 2 is linked to Research Sub Project 3 and contains the following aspects and tasks: ▪ Extend the experimental / investigational / simulation work ▪ Review and evaluate the research results The central component is the elaboration, processing and evaluation of the research results carried out in Research Sub Project 2.
Contribution to AoL Competency Goal	CG4: Students have the ability to define, based on existing problems/challenges, the relevant research questions. They should define an appropriate solution approach and be aware of the required steps towards the solution.
Indicative reading list	The list of literature is defined according to the selected research topic.
Miscellaneous	--
Version (date)	01/2020

4.8.1 Research Project 3

Lecturer's name; contact details see ESB website	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Class No.	RSP3
Language of instruction	English
Credits (ECTS)	18 ECTS
Total work	540
Contact hours per week	1 SWS*
Maximum score related to overall score of 100 points for the module	75
Learning outcomes	By verifying their solution approaches, the students will have identified whether the research objective can be achieved and have started to check the applicability through initial validation activities.
Contents/ indicative syllabus	Research sub project 3 is linked to Research Sub Project 2and 1 and contains the following aspects and tasks: ▪ Carry out the experimental / investigational / simulation work

	▪ Review and evaluate the research results ▪ The central component is the elaboration, processing and evaluation of the research results, based on the prerequisites established and feasibility studies carried out in Research Sub Project 1. In this module of the research sub project 2, an adaptation or expansion of the work may be necessary.
Teaching and learning methodology	Lecture, group work, discussions
Miscellaneous	* The workload of 420 hours includes a 1 h weekly review (15 contact hours in total) and 405 hrs. of self-study. Contact hours and self-study are slightly variable according to the respective research subject.
Indicative reading list	The list of literature is defined according to the selected research topic.

4.8.2 Learning Factory Demonstrator

Lecturer's name; contact details see ESB website	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Class No.	LFD
Language of instruction	English
Credits (ECTS)	5 ECTS
Total work	30h
Contact hours per week	1 SWS
Maximum score related to overall score of 100 points for the module	19
Learning outcomes	After completing the course, students can design the appropriate demonstrator for their research, identify the required infrastructure and integrate it into the overall concept of the learning factory.
Contents/ indicative syllabus	The learning factory exemplifies a production operation with all assembly- and logistics side process steps of a variant-rich small batch and single piece production between product and process development, as well as all incoming and outgoing goods with the entire value-added process. The assembly and logistics system infrastructure includes i.e. flexible, mobile storage systems, manual assembly stations, driverless transport systems and a conveyor system. Furthermore, various collaborative robot systems for the realisation of MRK applications, a pick-by-light system for employee assistance and an industrial IO-Link communication system with various sensors and programmable logic controllers for solving automation tasks. The LLF also has an app and cloud-based collaborative engineering, planning and simulation platform and a constantly evolving Manufacturing Self-Execution System (MSES) specifically designed for transformable scenarios in the context of Industry 4.0. LLF is integrated into research projects as an experimental, validation and demo environment

	in the context of a 'pilot factory for Industry 4.0', and as an innovative form of 'designing smarter factories' It is also a research object itself.
Teaching and learning methodology	Scenarios, presentations, workshops, demonstrators
Miscellaneous	--

4.8.3 Class: Research Colloquium 3

Lecturer's name; contact details see ESB website	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Class No.	RC3
Language of instruction	English
Credits (ECTS)	1 ECTS
Total work	30h
Contact hours per week	1 SWS
Learning outcomes	The students will learn to present in front of an international auditorium, as well as discussing the results and asserting themselves in a discussion. After the course, the student can select suitable methods for research projects and address specific questions concerning the course of studies (digitization, industry, engineering, management). The students able to analsze complex problems and develop solutions. The student is able to defend research outcomes, developed in an inter-cultural and interdisciplinary plenum and can integrate the received input for the research sub project 4 that builds upon it. They also learn how to deal with both positive and negative criticism. In addition, the students take part in good scientific practice.
Contents/ indicative syllabus	The final research colloquium will take place at the end of the semester. In order to evaluate the chosen research approach and the intermediate results and to prepare for the final colloquium, a *midterm colloquium* will take place in the middle of the semester. The content of the colloquium depends on the respective question. These may include the following areas: ▪ Complex systems ▪ Simulation, Artificial Intelligence, Distributed Systems ▪ Digital Supply Chain ▪ Digital Logistics ▪ Digital Production Systems ▪ Digital Management
Teaching and learning methodology	Presentation, discussions
Miscellaneous	--

4.8.4 Class: Research Seminar 3

Lecturers' names; contact details see ESB website	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Class No.	RS3
Language of instruction	English
Credits (ECTS)	1 ECTS
Total work	30h
Contact hours per week	1 SWS
Examination/ type of assessment	PA
Maximum score related to overall score of 100 points for the module	4
Learning outcomes	Thestudents are trained in comparable competences as in the research seminar 2. Due to the progress of the work, the competences are deepened and raised to a higher level. By exchanging knowledge with the students/experts of other disciplines or research areas on a higher level than in the research seminar 2, the students expand their professional horizons. They are able to establish cross-links between the various research topics and the findings obtained and to use them for their own work.
Contents/ indicative syllabus	The content of the research seminar 3 consists on the various respective research projects carried out in this study programme. These may include, the following areas: ▪ Complex systems ▪ Simulation, Artificial Intelligence, Distributed Systems ▪ Digital Supply Chain ▪ Digital Logistics ▪ Digital Production Systems ▪ Digital Management
Teaching and learning methodology	Presentation and discussions
Miscellaneous	--

4.9 Research Sub Project 4 (Joint Thesis)

Modul	**Research Sub Project 4**
Modul-No.	**RE4**
Semester	4
Duration of module	6 months
Type of module	Compulsory
How frequently is the module offered	Once per semester
Access requirements and previous knowledge	Research sub project 1-3
Transferability for other programmes	The joint thesis is assessed and approved by the respective collaborating international partner
Responsible professor	The first examiner is the professor according to the research modules and the second examiner is professor or senior lecturer of the partner university:
Teaching language	English
Total number of ECTS	25 ECTS
Work load total	750
SWS	3 SWS
Level	Graduate
Examination/type of assessment	MA Thesis (80%) + RE Defense (20%)
Weighting of grade within overall programme	25/115 (21,74%)
Teaching and learning methods	Seminar, documentation, self-study
Learning outcomes	**Professional competences:** The students are able to discuss their current results scientifically and relate them to current research standards. They are able to verify their work hypotheses, possibly to falsify them and to derive them from further experimental and/or simulative studies. In combination with the results obtained in the research modules 1, 2, and 3 the students are able to finalise their validation activities and discuss their entire work in a holistic manner and to present it in written form (in their master's thesis) and as a presentation (for the defense of the work). **Methodological competencies:** The students are familiar with the application of the appropriate research methods, which are aligned to the specific task. Research management is to be applied and mastered on the basis of the scope of the task (see also the module description of the research modules 1, 2 and 3, as well as the module research planning and management). **Social competence:**

	The students improve their social competency by intensive communication with their supervisors and members of the respective research group. **Personal competence:** Processing of a comprehensive task with full and sole responsibility.
Content/ indicative syllabus	The master's thesis is based on the research modules 1, 2 and 3 (see also the module description there). The supervision of the master's thesis takes place together with a professor or senior lecturer of the respective partner. The colloquium will be done together with the partner university.
Indicative reading list	Topic related
Version (Date)	01/2020

4.9.1 Joint Master Thesis

Lecturer's name; contact details see ESB website	The first examiner is the professor according to the research modules and the second examiner is professor or senior lecturer of the partner university
Class No.	MTH; JMC
Language of instruction	English
Credits (ECTS)	23+2 ECTS
Total work	690
Contact hours per week	1 SWS*
Maximum score related to overall score of 100 points for the module	94
Learning outcomes	The aim of the master's thesis is the detailed processing of complex contexts as well as the critical examination of the research topic of the subject area, in order to formulate suggestions for the further scientific treatment of the subjects in the field of digital industrial management and engineering.
Contribution to AoL Competency Goal	CG3: The student has analyzed, summarized and published his research results in the context of ethics on a project-specific basis. CG4: Students have the ability to derive, based on existing problems/challenges, the appropriate solution approach and have developed respective solutions. CG 5 and 6 are assessed by evaluation of the thesis.
Contents/ indicative syllabus	The master's thesis is based on the two research modules 1, 2 and 3 (see also the module description). The scientific topic is to be presented by the students independently and conclusively. The course competences acquired in the master's degree are to be applied. In particular, the following content should be continued on the basis of research modules 1, 2 and 3: ▪ In-depth, holistic discussion of the results from the research modules 1, 2 and 3

	▪ Implementation of further advanced experimental / investigative / stimulatory studies, including discussion
Teaching and learning methodology	Lecture, group work, discussions
Miscellaneous	--
Indicative reading list	The list of literatures is defined according to the selected research topic. In addition, further recommendation will be a result of the literature analysis.

4.9.2 Class: Research Colloquium 4

Name of lecturer; Contact details. see ESB website	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Class No.	RC4
Language of instruction	English
Access requirements and previous knowledge	RSP1-3
Credits (ECTS)	1 ECTS
Total work	30
Contact hours per week	1 SWS
Learning outcomes	Upon completion of the course, the student can select suitable methods for research projects and address specific questions concerning the course of studies (digitization, industry, engineering, management). The student is able to analyze complex problems and develop solutions. The student will have learnt to present in front of an international auditorium, as well as discuss the results and assert themselves in a discussion. The student is able to defend research outcomes developed in an intercultural and interdisciplinary plenum. They have also learned to deal with both positive and negative criticism.
Contents/ Indicative syllabus	The Master Thesis Colloquium will take place at the end of the semester. In order to evaluate the chosen research approach and the intermediate results and to prepare for the final colloquium, a *midterm colloquium* will take place in the middle of the semester. The content of the colloquium will depend on the respective question. These may include the following areas: ▪ Complex systems ▪ Simulation, Artificial Intelligence, Distributed Systems ▪ Digital Supply Chain ▪ Digital Logistics ▪ Digital Production Systems ▪ Digital Management

Teaching and learning methodology	Presentation, Discussions
Miscellaneous	--

4.9.3 Class: Research Seminar 4

Lecturer's name; contact details see ESB-website	Responsible professor of Reutlingen University and responsible professor of Stellenbosch University or responsible professor of Purdue University
Class No.	RS4
Language of instruction	English
Access requirements and previous knowledge	Successful completion and preparation of the defence of the Master Thesis
Credits (ECTS)	1 ECTS
Total work	30
Contact hours per week	1 SWS
Maximum score related to overall score of 100 points for the module	6
Learning outcomes	Students are trained in comparable competences as in the research seminar 3. Due to the progress of the work, the competences are deepened and raised to a higher level. By exchanging knowledge with the students/experts of other disciplines or research areas on a higher level than in the research seminar 3, the students expand their professional horizons. They are able to establish cross-links between the various research topics and the findings obtained; and to use them for their own work. In addition, they acquire the ability to summarize the important results and discussion contributions in the form of a scientific publication.
Contents/ indicative syllabus	The content of the research seminar 3 consists on the various respective research projects carried out in this study programme. These may include, the following areas: ▪ Complex systems ▪ Simulation, Artificial Intelligence, Distributed Systems ▪ Digital Supply Chain ▪ Digital Logistics ▪ Digital Production Systems ▪ Digital Management
Teaching and learning methodology	Presentation and discussions