PPU231 – Production and Product Service Systems

7,5 Credits

Course in Master Programme:

- Production Engineering
- Product Development

Examiner

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Purpose and aim of the course

In today's society, there is a clear trend towards servitization. New services, business models, and strategies for bringing added value to products are emerging. Cars and aerospace engines are leased, and more companies are selling services rather than physical products. This development has increased the pressure on manufacturing companies to ensure that their products can be easily maintained and upgradeable in order to fulfil their functions over an extended life span. In particular, this development is driven by the fact that when a service is sold, the company is assuming responsibility of the product and its associated risks. To remain profitable after a shift from selling products to services, companies are forced to improve their risk management and develop Product Service Systems where potential risks are managed in all life-cycle stages.

Manufacturing companies must also ensure competitiveness by achieving high production system performance. In fact, to be able to fulfil high and rapidly changing customer demands, today's production systems need to be highly flexible and efficient. Maintenance organisations play a central role in achieving high production performance, and the role of maintenance is increasing in line with the development towards more complex and automated production. Therefore, maintenance organisations must assume a larger responsibility beyond the traditional confines of fixing machines when they are broken or preventing them from becoming broken again. To adopt this new role, maintenance organisations in manufacturing companies must Production Service Systems where potential risks are managed in all life cycle stages. In fact, maintenance is a particularly high-risk activity in industry, where maintenance workers are exposed to a large variety of safety risks on a daily basis.

Therefore, this course aims at providing an in-depth understanding of Production and Product Service Systems. In particular, it focusses on designing, developing and evaluating production systems or products from a servitization perspective, and understanding its implications on the manufacturing industry. Further, the course aims to provide an understanding of how Production and Product Service Systems can add value to production systems or products throughout the whole life-cycle.

Maintenance is a central part of Production and Product Service systems, and this course therefore aims at providing theoretical and practical knowledge about both prevailing and future maintenance concepts. Further, a prerequisite for realizing Production and Product Service Systems is a thorough understanding of risk and safety. This course aims to provide such an understanding from a life-cycle perspective, which includes risk and safety concepts and practical use of engineering tools to achieve economical, ecological, and social sustainability.

E-bike Inc.

This course revolves around E-bike Inc., which is a manufacturer and provider of electrical bikes for city environments (E-bikes). The market for high end E-bikes is growing rapidly and the company must adapt to these changes in order to remain competitive in the future. Throughout the entire course, the students will gain the theoretical and practical knowledge necessary to transform the company from the current state to a desired future state. This includes developing Product Service System solutions for the E-bike product line as well as improving the production system performance in order to satisfy requirements on increased production volume and production rate.

An extended description of the E-bike Inc. case is available at the course website at Canvas.

Learning objectives

After the course, students will be able to:

- LO1: Describe and apply risk and safety concepts and use engineering tools to analyze, evaluate, and reduce risks
- LO2: Explain, implement and distinguish various prevailing maintenance concepts
- LO3: Recognize and evaluate future maintenance concepts
- LO4: Interpret, describe and evaluate Production and Product Service Systems
- LO5: Demonstrate how existing production systems or products can be designed, developed and provided as Production or Product Service Systems
- LO6: Differentiate, select and develop actions to improve production systems or products during the whole life-cycle.

Course content and organization

The course covers the following topics:

- Theoretical basics of risk and safety
- Engineering tools for analyzing, evaluating, and reducing risks
- Prevailing and future maintenance concepts
- Theory and practice of Production and Product Service Systems
- Systematic approach for improving production systems or products during the whole life-cycle

The course follows a problem-oriented pedagogy, and consists of lectures, workshops, and a project within the students' area of interest. The learning activities are:

- Lectures: Provides theoretical foundation and support for project work
- Workshops: Practical training in engineering tools
- Project: Applying skills learned throughout the course to improve productions systems or products during the whole life-cycle
- Presentation: Be able to present and defend project results to industrial stakeholders

Examination

The course examination is based on three parts: written knowledge test, workshops, and project work.

The final grade includes the students' performance on all three assessment tasks (all tasks must be approved to pass the course):

- Written knowledge test (maximum 25 points, 10 points to be approved). Approved knowledge test is necessary to pass the course and achieve a final grade.
- Graded report from 3 workshops (maximum 15 points)
- Graded report and seminar from project (maximum 60 points)

All points are summarized and the final grade is decided accordingly (total sum cannot surpass 100):
0-49 points = Fail
50-59 points = 3
60-79 points = 4
80-100 points = 5

Further details about each examination form are described below.

Written knowledge test

Date: 20200210, 13-15, Monday

The grading scale is Fail or Pass. A minimum of 10 points is required to pass the test.

The student needs to pass the test in order to be approved in the course and achieve a final grade. The overall points from the test are included in the total grade on each student's performance. If the student fails the written knowledge test, a re-test needs to be performed in order to pass the course and achieve a final grade. The re-tests are available in the re-exam periods.

The written knowledge test covers the content in the first three weeks of the course:

1. Risk management
2. Servitization
3. Maintenance management

Specifically, the written knowledge test will be based on the literature, lectures and workshops that are covered from the introduction lecture in week 1 (200120) through the future of maintenance management lecture in week 3 (200207).

Workshops

During the course, you will perform three workshops (WS). More information concerning each workshop is available at the course portal Canvas.

WS1: Risk Management Tools

Start date: 200127, 13-17, Monday
Examination: Workshop report (submit via Canvas)
Deadline: 200207, 23.55, Friday
Maximum points = 5

WS2: Servitization

Start date: 200130, 08-12, Thursday
Examination: Workshop report (submit via Canvas)
Deadline: 200207, 23.55, Friday
Maximum points = 5

WS3: Reliability, maintainability, maintenance

Start date: 200206, 08-12, Thursday
Examination: Workshop report (submit via Canvas)
Deadline: 200214, 23.55, Friday
Maximum points = 5

Further specifications of the workshop are available in each workshop syllabus. Information about their examination and grading criteria are available in the document *"PPU231 – Workshop reporting guide".* These are available at the course web page (Canvas). The workshops utilize three different software: Windchill Quality Solutions (WQS), JMP and Anylogic. WQS and JMP are available at the computers in PSL, but Anylogic has to be downloaded individually by each student group during workshop 2 (either to PSL computers or students' personal computers). For further reading and instructions on WQS, JMP and Anylogic, see section "*Workshops*" under "*Reading directions*".

Important note: To be able to access the lab without supervision you need to fill out a security form. The form is to be found at Canvas under *contents*.

Forming of workshop groups: Students may form their own workshop groups. Note that the workshops are team efforts and all group members must participate in the work and writing the workshop reports.

Project work

The project work aims at applying the skills throughout the course to understand and implement Production and Product Service Systems. Two projects are included in the course dependent on the students' interest and programme area: one *production-oriented* and one *product-oriented* project.

The production-oriented project is aimed at improving the performance of E-Bike Inc.'s production system to ensure the company's overall productivity and profitability by applying Production Service activities.

The product-oriented project is aimed at designing and evaluating a Product Service System (PSS) for the E-bike product line, covering the identification of value and functionality, formulating and evaluating alternative PSS concepts, and propose a candidate PSS solution (mix of product and service).

Forming of project groups: Students may form their own workshop groups. However, one critical criterion for the **production-oriented** project is that each group **must** include at least one student with previous AutoMod experience from the MRP271 – Simulation of Production Systems course. Note that the project is a team effort and all group members must participate in the project and writing the final project report.

Literature

- Text book:
  Guide to safety analysis for accident prevention
  Authors: Lars Harms-Ringdal
  Springer: IRS Riskhantering (2013)

  Available as an e-book at Chalmers library or the course web page at Canvas.
- Power-point presentations available at the course homepage
- Scientific papers/e-book sources; see below. Available from Chalmers library web page or the course web page at Canvas.
- **Note:** Literature for the project work is specified in the separate project PM.

Paper1: Tukker, A., Van den Berg, C., & Tischner, U. (2006), "Product-services: a specific value proposition", *New business for old Europa: product-service development, competitiveness and sustainability*, Greenleaf, Sheffield, pp. 22-34.

Paper2: Ylipää, T., Bokrantz, J., Skoogh, A. & Gopalakrishnan, M. (2017), "Identification of maintenance improvement potential using OEE assessment", International Journal of Productivity and Performance Management, vol. 66, no. 1.

Paper3: Mobley, K. (2008), "Impact of Maintenance", *Maintenance Fundamentals*, McGraw-Hill.

Paper4: Pintelon, L. & Parodi-Herz, A. (2008), "Maintenance: An Evolutionary Perspective", *Complex Systems Handbook*, Springer, London.

Paper5: Bokrantz, J., Skoogh, A., Berlin, C. and Stahre, J. "Maintenance in Digitalised Manufacturing: Delphi-based scenarios for 2030", International Journal of Production Economics, vol. 191, pp. 154-169.

Paper6: Isaksson, O., Larsson, T., & Öhrwall, A. (2009), "Development of product-service systems: challenges and opportunities for the manufacturing firm", Journal of Engineering Design, vol. 20(4), pp. 329-348.

Reading directions

Reading directions for lectures and workshops are to be found in the tables below (note that not all activities have reading directions). Chapter numbers (Ch) refer to the course textbook and paper numbers to the scientific papers listed earlier in this syllabus. In addition, all PowerPoint-materials from the lectures are also included in the course literature (necessary for both exercises and examination).

Important note: This course puts great emphasis on reading, understanding and applying the theoretical literature. Therefore, reading the literature is necessary in order to pass the course examination.

Reading directions: lectures

Date	Lecture	Reading
Production and Product Service Systems		
Thursday, 200123, 08-10	Servitization in industry	Paper 1
Thursday, 200123, 10-12	Production Service Systems	Paper 2
Thursday, 200213, 08-10	Development of Product Service Systems	Paper 6
Risk Management and Safety		
Friday, 200124, 15-17	Basic principles of risk and safety	Ch 3.1
Friday, 200124, 15-17	Risk Management Methodology	Ch 3.2, 3.4
Friday, 200124, 15-17	Risk Management Tools	Ch 4.3-4.4, 5.4 (*overview*) 10.1-10.3, 10.7 (*FTA*) 12.2 (*FMEA*), 15.5 (*choosing tools*)
Maintenance Management		
Monday, 200203, 13-15	Maintenance fundamentals	Paper 3
Monday, 200203, 15-17	Maintenance concepts	Paper 4
Friday, 200207, 15-17	The future of maintenance management	Paper 5

Reading directions: workshops

W	Time	Activity	Reading
	Workshops		
4	Monday, 200127, 13-17	WS1: Risk Management Tools	Risk Management lecture reading directions, WQS[1] WS1:
4	Thursday, 200130, 08-12	WS2: Servitization	WS2: Maney (2014), Legnani et al. (2010)
5	Thursday, 200206, 08-12	WS3: Reliability, maintainability, maintenance	WQS[1] WS3:

WQS[1] – "Reliability: A Practitioners Guide" (available at Canvas)
WS1:
Reliability Block Diagrams: Chapter 2 (pp. 33-38) & Appendix B (pp. 325-328)
Additional reading (if interested):
FMEA: Chapter 6 (pp. 169-171 & 174-175)
FTA: Chapter 5 (pp. 131-146)

WS2:
The reading directions for WS2 include two practical examples of using simulation for analyzing services:
Maney, J. (2014), "Using JMP to Assess Risk in Financial Predictions by Using Monte Carlo Simulations", JMP Discovery Summit. Presentation available on Canvas, and video presentation is available on YouTube: https://www.youtube.com/watch?v=fnT4ADhz6L0.
Legnani, E., Cavalieri, S., Marquez, A. C., & Díaz, V. G. (2010), "System Dynamics Modeling for Product-Service Systems - A case study in the agri-machine industry". In *Proc. of APMS*. (available at Canvas).

WS3:
Weibull analysis: Chapter 7 (pp. 201-208)

For further instructions and support for using WQS software during workshop 1&3:
"WQS Getting Started" (available at Canvas)
FMEA: pp. 51-62
FTA: pp. 65-77
Reliability Block Diagrams: pp. 79-92
Weibull analysis: pp. 103-113

Reading directions: project

Reading directions for the project work are specified in the project PMs.

Schedule PPU231 2020

W	Time	Room	Activity	Resp.
3	***Introduction, Servitization, Risk Management***			
	Monday, 200120, 13-15	HC4	Introduction to Servitization and Digitalization Introduction to E-bike Inc.	TY, JB, OI, MP
	Monday, 200120, 15-16	HC4	Course plan and administration	TY, JB
	Thursday, 200123, 08-10	HC4	Servitization in industry	OI/MP
	Thursday, 200123, 10-12	HC4	Production Service Systems	AS
	Friday, 200124, 15-17	HC1	Risk Management and Safety	TY
4	***Risk Management and Servitization***			
	Monday, 200127, 13-17	PSL	WS1: Risk Management Tools	TY, AI

	Thursday, 200130, 08-12	PSL	WS2: Servitization	MP, JB
5	***Maintenance Management***			
	Monday, 200203, 13-14	HC1	Sustainable circle – smart manufacturing	Guest - Anders
	Monday, 200203, 14-15	HC1	Sustainable circle – smart manufacturing	Guest
	Monday, 200203, 15-17	HC1	Maintenance concepts / fundamentals	TY
	Thursday, 200206, 08-12	PSL	WS3: Reliability, maintainability, maintenance	TY, AI
	Friday, 200207, 15-17	HC1	The future of maintenance management	TY
	Hand-ins during W5 (not later than Friday 200207 at 23.55) • Workshop 1 report (Risk Management Tools) • Workshop 2 report (Servitization) *Read "PPU231 - Workshop reporting guide" for instructions* Workshops are solved in groups during the lab sessions under the guidance of supervisors. All group members should be involved in solving the workshop problems and writing the report – the workshops are a team effort!			
6	***Production and Product Service Systems (Project work week #1)***			
	Monday, 200210, 13-15	SB Multisal	Written knowledge test[1]	TY
	Monday, 200210, 15-17	HC1	Project introduction	TY, OI, MP, AI
	Thursday, 200213, 08-10	HB1	Development of Product Service Systems	MP
	Thursday, 200213, 10-12	HB1	Integrated Product and Production System Development	MP
	Friday, 200214, 15-17	PSL	Student project planning	
	Hand-ins at the end of W6 (not later than Friday 200214 at 23.55) • Workshop 3 report (Reliability, maintainability, maintenance) The workshops are team efforts and all group members must participate in the work and writing the workshop reports.			
7	***Project work week #2***			
	Schedule for project work #2 to #4 (Production and Product) are specified in separate project PMs			
8	***Project work week #3***			
	Schedule for project work #2 to #4 (Production and Product) are specified in separate project PMs			
9	***Project work week #4***			
	Schedule for project work #2 to #4 (Production and Product) are specified in separate project PMs			
10	***Project finalization***			
	Monday, 200309, 13-15	EA	Joint workshop on product-production changes	AI, MP, TY
	Monday, 200309, 15-17	PSL	Project work (last session)	AI, OI, MP
	Thursday, 200312, 08-12	Vasa 3, 4, 5	**Project seminar**[2]	TY, AI, OI, JM, MP
	Hand-ins at the end of W10 (not later than Friday 200322 at 23.55) • Final project report *Read "PPU231 – Project grading template"* for instructions As in the workshops, the project work is a team effort and all group members must participate in the project work and writing the final report.			

Written knowledge test starts at **13:00 sharp**. Room is announced in due time.

2 All students must attend the project seminar session. Both projects (production and product) will be presented during this session.

AS – Anders Skoogh, TY – Torbjörn Ylipää, JB – Jon Bokrantz, MS – Mukund Subramaniyan, OI – Ola Isaksson, MP, Massimo Panarotto, JM – Jacob Muller, AI – Adriana Ito, NM – Ninan Mathew, CL- Camilla Lundgren

Learning Objectives – Activities Matrix

The activities matrix shows the connections between course elements. Each learning objective is connected to the learning activities and assessment tasks throughout the course.

Learning objectives	Learning activity												Assessment tasks			
	Introduction lecture	Servitization in industry lecture	Production Service Systems lecture	Risk Management and Safety lecture	W1: Risk Management Tools	W2: Servitization	Maintenance fundamentals lecture	Maintenance concepts lecture	W3: Reliability, maintainability, maintenance	The future of maintenance management lecture	Development of Product Service Systems lecture	Integrated Product and Production Development lecture	Written knowledge test	Workshops	Project	Presentation
LO1	□	□		•	•	•							•	•	•	
LO2		□		□	□		•	•	•		□		•	•	•	
LO3			□	□	□	□				•		□	•	•	•	
LO4		•	•			•				□	•	•	•	•	•	•
LO5							□				•	•	□		•	•
LO6				□		□		□	□			□	□	□	•	•