PRODUCTION SYSTEMS ENGINEERING

Project Description 2022

Contents

1. Goals of the project

The project Production Systems Engineering (PSE) aims at providing knowledge, competences, tools and practice for designing production systems. In particular, the ability to obtain and maintain overview in a complex and multi-disciplinary project will be practiced.

This results in the following educational goals:
After this project the student:

- Is able to (re)design (a part of) a production system on a basic level by applying theory/tools and solutions from the Production Management, Systems Engineering, Statistics and FEM disciplines;
- Can obtain and maintain overview over, and between the constituting parts and disciplines;
- Has practiced integrated production system development;
- Can apply statistical knowledge into the context of Production Management;
- Can apply FEM results into the context of Production Management;
- Has practiced to make an academic poster.

Since this project takes place almost at the end of the Mechanical Engineering bachelor, it is encouraged (and valued) to apply prior knowledge and further deepen yourself.

2. Assignment

Subject
Etone Enterprises is a family-owned OEM for (precision) CNC machining, turning and milling. They are a certified company specialized in both prototype and production machining of parts used in the transport industry. They design, manufacture and assemble their own products, all in the same factory at Bornerbroek, near Almelo. At Etone Enterprises it is their goal to deliver parts that meet or exceed their customers' expectations. They serve multiple industries such as aerospace, energy, agriculture and automotive. They pride themselves in their work and always work to improve their customer satisfaction through continued on time delivery and the highest quality parts. Most of their products are made to order.

Etone Enterprises wants to enter a new market, the market of construction elements, to have a broader product portfolio. In January 2022, they found a new customer who wants to order a certain number of construction elements to built new STS (Ship to Shore) container cranes. This new customer is the Port of Ashdod, from Israel. This port handles a large volume of cargo containers annually. The Port doesn't have a design department, they work with existing crane designs. Therefore, thay have asked Etone Enterprises to analyze the design of the crane when certain load is applied (see chapter 9 for the full description). Once the design is approved, the construction elements of the crane can be manufactured. The estimated number of cranes that the Port of Ashdod will order per month is 25.

Due to entering this new market, the current building of Etone Enterprise became too small. Fortunately, Etone Enterprises was able to buy a piece of land at the XL Business Park Twente in Almelo. They will build a new manufacturing facility there, but the dimensions are not known yet. All the machines from the old factory will be moved to the new location. Probably some new machines need to be bought, because capacity at this moment seems not to be sufficient anyway. The current product portfolio, information about the new construction elements, available machines and the order pattern of 4 months (Aug, Sept, Oct, Nov) in 2021 are given in de excel file on Canvas (Datasheet PSE 2022.xlsx). These 4 months are representative for the whole of 2021.

Due to the type of sectors Etone Enterprises operates in, they are forced to have a good quality system. For example they use FMEA's to optimize their production, but also SPC is used to monitor and control their processes (C_{pk}-values > 1.5). Since January 2018 they are EN-ISO 9001:2015 and AS 9100D certified. And their goal is an OEE of at least 90% for each machine group.

The assignment is to design a production system and its layout that will be able to produce the STS container crane elements and the current product portfolio mentioned in the datasheet, assuming that the order pattern of the past is a good forecast for the future.

Designing a production system is a complex task, not all data is available so assumptions need to be made. Assumptions are OK as long as the origin can be traced and they are properly documented.

Some additional aspects:

- The new production system should perform as optimal as possible.
- Available production time: 2 shifts/day, 48 weeks/year.
- The floor space necessary for the new factory will be a result of your calculations.
- The FEM analysis that needs to be performed for the STS container crane, has to wait until week 4; you need input from the IFEM course. But to prevent a mismatch with the layout design of the

current product portfolio and the layout for the new construction elements, you should not wait until week 4 to the start designing the new production facility.

Execution

The assignment is executed by a number of teams in parallel, each consisting of 12-15 students. Each team has a mutual start-up phase, in which the requirements are defined, the system design concept is created and the sub-systems are determined. Then in the second project phase, the teams are subdivided into smaller groups of 2 (or at most 3) students. The subdivision is the group’s own responsibility. The smaller groups work on their own sub-system. The division into sub-systems has to be done before the first deadline (see *Planning* below). Naturally, it is paramount that all sub-systems fit together into a properly functioning larger system in the end.

Areas that have to be covered are:

- Requirements and specifications based on an investigation of the problem;
- System architecture;
- Communication;
- Integration (within the sub-system, and with other sub-systems);
- Implementation (what hardware is needed and how is it organized?);
- The design of the individual elements in order to achieve optimal system performance;
- Every group (of 2-3 persons) will design at least one sub-system;
- Testing of the final integrated system.

The production system concept has to be detailed to the point that at least the following questions can be answered:

- What are the *requirements*, as seen from the producer(s) of the system, the user and other relevant stakeholders?
- What *sub-systems* are needed, what are the *interfaces*, and how are the subsystems *integrated* (the architecture of the system)?
- *How* do the system and its sub-systems *function*?
- What are the *costs* (both investment and running costs) and the *benefits*?
- How long is the *development program* and how many people are needed?
- How will the *production system look like*, in terms of layout, number of machines, quality system, logistics etc.?
- Are the *requirements met*?

This results in the following guidelines for the project deliverables (your team decides on the exact content and details):

- Requirements of the system
- Architecture of the system
- Performance and strategy of the production system
- Layout and flow of the system
- Planning and control, capacity and inventory management of the system
- Quality, maintenance and risk management of the system
- Improvement strategy for the system
- Processing of the results of the Statistics case
- Etc.

3. Planning

Large team (3 weeks)

- Investigate the problem;
- Compile the requirements (specifications and wishes);
- Investigate possible divisions into sub-systems and interfaces;
- Definition of the architecture and sub-systems, including ensuring correspondence between the sub-systems and fitness for purpose;
- Present this as a research poster in English (design review).

Small groups (5 weeks)

- (Detail) analyses;
- Define the requirements for the sub-system;
- Describe the functions and the functional behavior;
- Design (or find) the required functional components and support your choices with calculations and/or simulations;
- Define the interfaces between components;
- Create an integration plan and a test plan;
- Use the result of the Statistic case to adapt the production system caused by the influence of variability on the production system;
- Present this in a research poster in English (final review).

Man hours for the project and courses

Table 1 indicates the allocated hours for the Production Management, Systems Engineering, project assignment and Statistics. Also, the type of work is indicated; i.e. lectures, self-study and project work. Note the fact that a considerable number of the hours of the Production Management and Systems Engineering courses contribute to the project work.

Table 1: Hour-budget for the Production Systems Engineering project.

	Production Management	**Systems Engineering**	**Project Assignment**	**Statistics Case-study**	**IFEM exercise**	**Total**
Lecture	20	12	-	**-**	**-**	**33**
Study	20	12	-	**-**	**-**	**32**
Project work	16	18	49	5	2	**90**
Total	**56**	**42**	**49**	**5**	**2**	**154**

4. Project courses

Systems Engineering (1.5 EC)

- Integrated product development, including how to deal with multi-disciplinary design projects;
- Systems Thinking;
- Tools: different views on the concept, visualization of interfaces, functional block diagrams, budgets etc.
- Interface design: communication between sub-systems and externally (outside the system); Time-scales;
- Product planning: modularity, reuse;
- Design reviews.

Production Management (2.0 EC)

- Production management is the activity of managing the resources that create and deliver products by changing inputs into outputs using an “input-transformation-output” process;
- Company/manufacturing strategies;
- Designing a production system;
- Planning and control of a manufacturing system (some practicals are included);
- Maintenance;
- Relation between topics mentioned above.

Both the Statistics and IFEM courses are related, but not strictly included as part of this project. However, you need the knowledge gained in theses courses to solve some problems in this project.

5. Timetable

Below you will find the important dates/deadlines for this project.

Date	Time	Activity	Remarks
9 February	8.45 am	Start of the project	Hybrid, sign-up at Canvas.
4 March	9.00 am	Deadline poster$_1$ submission	Hand in on Canvas, but also print 1x A1, see Canvas for details. Bring this printed poster$_1$ at design review.
8/9 March		Design review (2 groups / 1 hour 45 min)	Review of system requirements, concept, and sub-system definition, based on the submitted poster$_1$. Schedule will be available on Canvas.
11 April	9.00 am	Deadline draft poster$_2$	Hand in draft version of poster$_2$ on Eduflow (see Canvas).
13 April	9.00 pm	Deadline review poster$_2$	Review poster$_2$ of a linked group on Eduflow (see Canvas).
15 April	9.00 am	Deadline final version poster$_2$ submission	Process the feedback and hand in your final version of poster$_2$ on Canvas, but also print 1 set A2's (1x A2 per sub-system), see Canvas for details. Bring these posters at the final review.
20/21/22 April		Project presentations and assessment (2 groups/2 hours)	Schedule will be available on Canvas.
19 April	8.00 am	Deadline essay SE	See Canvas organization SE for instruction.
19 April	13.45-16.45	Exam PM	See Canvas.

6. Assessment

Project PSE is assessed with one final mark. This mark is based on the results of the project courses, Production Management and Systems Engineering, and the project. The Statistics case-study has to be a pass and the result of the FEM analysis needs to be taken into account for the design of the factory.

Poster presentations

The project has two moments for assessments: the two poster presentations (design and final review). This includes the poster, the presentation and the discussions; also see section 7.

The first poster is made by the large team. The items to cover are listed in section 3. The mark applies to all group members. For the second presentation, each smaller group creates and presents a poster on their sub-system. In addition, a poster covering the integration and testing has to be made. The mark for the second poster only applies to the members of the small group. The protocol for the final review is presented in section 7.

All posters have to be in English and handed in through Canvas before the deadline (see section 5). On Canvas guidelines for the appropriate technical-English writing style and for making a poster are presented.

NB: A full report is **not** required for this project. Some background information to the posters may be supplemented and can be handed in together with the posters.

Production Management

Production Management will be assessed with an exam that results in a mark. See the timetable for the time and place of the exam.

Systems Engineering

Systems Engineering is assessed on the basis of an individual essay. Every student has to write a short essay (maximum 2 pages A4) on how Systems Engineering was applied in the project, what went well, and what you would have done differently. During the module one lecture is organized on how to write a good essay.

Statistics

The course Statistics itself is not assessed in the project and therefore the result of the Statistics exam does not count towards the final result of the project. The Statistics case-study on the other hand is part of the project. The knowledge gained in the Statistics course and case study should be applied in the project if applicable. The assignment is considered to be an individual assignment (made in small groups). The result will be a pass or fail. When failed: an additional assignment has to be made.

IFEM

The course IFEM is not assessed in the project and therefore the result of the IFEM exam does not count towards the final result of the project. However, the result of the FEM analysis of the STS container crane should be incorporated in the design of your factory and counts as such for your project grade.

Final mark

The four marks mentioned above result in the final mark in the following manner:

$$Final\ mark = \frac{\frac{1}{4}Poster_1 + \frac{3}{4}Poster_2}{2} + \frac{Exam_{PM}}{4} + \frac{Essay_{SE}}{4}$$

Where:

$Poster_1$ and $Poster_2$:	The first and second poster, including the presentation and discussion, respectively;
$Exam_{PM}$:	The result of the exam for Production Management
$Essay_{SE}$:	The result of the essay for Systems Engineering

Note that all items (posters, $Exam_{PM}$ and $Essay_{SE}$) have to be 5.5 or higher and the Statistics case-study has to be a pass. The result of the FEM analysis needs to be included in de project result.

In assessing the project, several facets are important, as described in this document before. The final result of project PSE includes at least (also section 2):

- Requirements and wishes and their implementation
- Concept of the system
- Sub-systems, interfaces and their integration
- Principles of operation of (sub-)system(s)
- Cost
- Length and intensity of the development program

7. Reviews

7.1 Design review

Goal of $poster_1$ is to inform your client about the design process so far and the chosen sub systems. Bring your printed A1 to the design review. The posters can be printed at Xerox at our expense, see Canvas. Be aware of printing deadline by Xerox!

Important aspects:

Poster related:

- Logical order of content
- Ratio text/pictures
- Connection between information
- Redundant information
- English language

Content related

- Quality of requirements (and wishes) (see document at Canvas)
- Correct choice of system architecture/subsystems (including interfaces)
- Correct tools/techniques presented (and used)
- Discussion/defending

Procedure during the design review:

- The groups will have some time to view each other's poster
- 2 Groups present
- First group present their poster in max 15 min + discussion round
- Second group present their poster in max 15 min + discussion round

7.2 Final review

Before the final review there will be a peer review system for $poster_2$. Each sub-system group will be linked to another subject related sub-system group to provide feedback on $poster_2$ of that group. This will by done by means of Eduflow (see Canvas). You process the feedback and hand in your final $poster_2$ at Canvas after the peer review. Also bring the printed set of A2's of your group to the final review. The posters can be printed at Xerox at our expense, see Canvas. Be aware of printing deadline by Xerox!

The final review itself is a presentation session with 2 groups at a time (total duration 2 hours). During these presentations each group will get time to present their results (20 minutes) and defend it (40 minutes). Who is presenting is up to you.

For grading we will look at all the aspects mentioned throughout this description (also see Canvas).

8. Contact information

In contrast to the preceding projects, no tutor is provided to the teams. Each team has to organize itself. The teachers involved are available for discussions if necessary. Prepare yourself for such a discussion and if possible provide the teacher with relevant information (beforehand)!

Teacher	Office	e-mail	Role
Maarten Bonnema	HR-W230	g.m.bonnema@utwente.nl	Teacher SE Examiner PSE
Wieteke de Kogel	HR-W252	w.dekogel-polak@utwente.nl	Coordinator PSE Teacher PM Examiner PSE
Nelly Litvak	ZI 4031	n.litvak@utwente.nl	Teacher Statistics
Javad Hazrati Marangalou	HR-N146	j.hazratimarangalou@utwente.nl	Teacher IFEM
Roberto Reyes Garcia	HR-W237	j.r.reyesgarcia@utwente.nl	Examiner PSE Coordinator module 11

9. FEM analysis STS container crane

As described in chapter 2, Etone Enterprises wants to enter a new market: the manufacturing of construction elements. Their first customer is the Port of Ashdod in Israel. The Port orders the (steel) elements necessary for the Ship To Shore (STS) container crane in the picture at the right from Etone Enterprises.

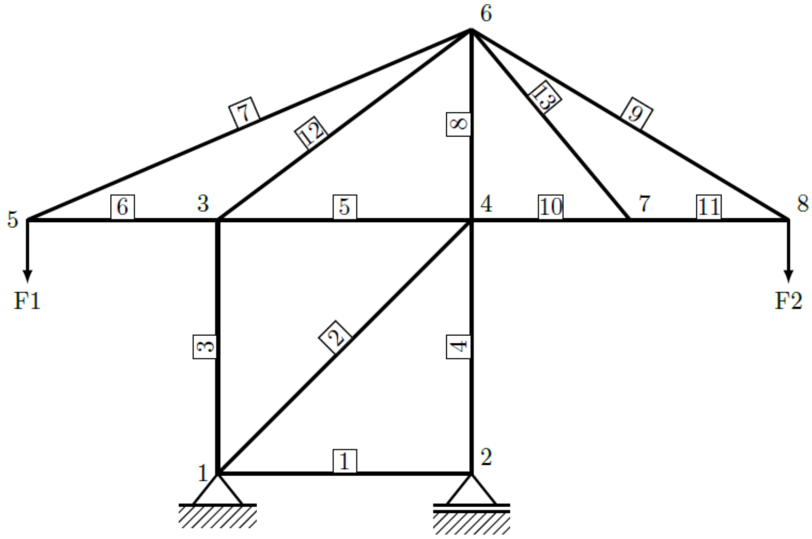
Etone Enterprises is responsible to evaluate the construction before they start manufacturing.

The 2D structure below represents the crane in the picture. All trusses are connected with hinges. Based on the load case given below, analyze the initial design of the STS crane using the finite element method and calculate the following values: deformation, strains and stresses in each truss element.

For this purpose, use the MATLAB code that you developed during the first exercise of the IFEM course to analyze the stadium or bridge structure.

After calculation of the stresses and strains, check whether you can enhance (make it light weight) the structure by eliminating (an) unnecessary truss element(s). *Note that element [1] can't be removed from the structure for operational purposes. Maximum allowed displacement at the boom tip (node 8 in figure below) in the horizontal direction is 4 mm.*

Take the outcome of this FEM analysis into account while designing your factory.



Truss	Code in PSE datasheet
1	CON-053-01
2	CON-053-02
3	CON-053-03
4	CON-053-04
5	CON-053-05
6	CON-053-06
7	CON-053-07
8	CON-053-08
9	CON-053-09
10	CON-053-10
11	CON-053-11
12	CON-053-12
13	CON-053-13

node	x (m)	y (m)
1	0	0
2	20	0
3	0	20
4	20	20
5	-10	20
6	20	30
7	30	20
8	40	20

element	A (mm^2)
1, 3-6, 8-11	2400
2, 7, 12, 13	1600

$\sigma_y = 500$ MPa
$E = 210000$ N/mm^2
F1 = 100 kN
F2 = 250 kN

 = free in x-direction, constrained in y-direction.