# Coursework Assignment 1st sit

6E7Z2131 Systems Engineering for Industry

## 1CWK100

This is an assignment for MSc students of the following course/s:

- MSc Smart Systems Engineering
- MSc Engineering Project Management
- MEng Electrical/Mechanical Engineering

We hope that you enjoy doing this assignment. It is an opportunity for you to demonstrate how well you can communicate your understanding of systems engineering – manufacturing and effective decision making. For this assessment, you are required to build a digital twin of a process packing line using Witness Horizon (model) and produce a report that evalutes your solution.

## Links

The Moodle Support Page includes the support video, submission details and dropbox, answers to frequently asked questions, and the latest version of this document.

## Contacts


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## Workflow


Plan a realistic schedule of work to complete this assignment on time and to a high standard.

Your assignment is to utilise the supplied data on the available machines to be configured to meet the production demand. For this portfolio of work you will be awarded a final mark for the unit out of 100%, and we expect you to spend up to 37.5 hours on it, in total.

Your assignment is split into the following elements:

A. Develop a digital twin using Witness Horizon to represent the process packing operations described in the brief (50%).
B. A report (2500 words max) that details your solution and aligns with your Witness simulation model (50%).

A recommended sequence of steps and deadlines are as follows:

1. Develop a process map – week 4
2. Develop a model to simulate the packing process – week 6
3. Review production against set targets and review alternative control strategies – week 7
4. Optimise final model to meet the target demand – week 8.
5. Write a report describing and evaluating your solution – week 10

The Assignment Support video will talk you through the workflow and help guide your plan for success.

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## The Rice Packing Line (RPL)

A rice packing line (RPL) is being investigated for improvements that requires a smart operational strategy to be implemented as a digital twin. Management is seeking a lean manufacturing system that is responsive to the market demand and operates on the basis of make to order (MTO). Customers demand is received at the start of each productive hour and varies uniformly between 100 and 400 kg per hour. The aim is to meet the customer's demand and not to over produce or have shortfalls. The RPL operates 8-hours per day, 5 days per week. Traditionally this plant has not met its production targets. Your smart operational strategy should be one that produces the best results over a 5-day period.

### The Process

The RPL comprises of a Loader that loads rice onto a Bucket Conveyor. The Bucket Conveyor transports the rice to a vertical Hopper that stands 6m high. The Hopper stores and releases rice to a Dispenser which feeds the Packing machines. Three individual Packing machine are employed:

- Bag5 machine produces a single 5kg packet.
- Bag10 machine produces a single 10kg packet.
- Bag20 machine produces a single 20kg packet.

After the packing process, the packed rice is shipped which leaves the packing area immediately.

Unlimited amounts of processed rice is available at the arrival to the packing facility. Whenever appropriate the Loading station has the capability to shovel a 25kg load onto the Bucket Conveyor in one go consuming negexp(2) min. To maintain some constraints on the level of work-in-progress (WIP), the loading station will only operate if the total WIP held on the Conveyor and Hopper is below 550kg.

The Bucket Conveyor comprises of 20 troughs along its transporting length and operates as an indexed queuing conveyor. Each trough is capable of accommodating a 25kg load of rice. The Bucket Conveyor has an index time of either 1.25, or 1.5 or 1.75 min/part. The Bucket Conveyor is limited to a max load of 400kg. At the end of the conveyor, the trough load is emptied into the vertical Hopper.

The vertical Hopper accepts 25kg loads at a time from the conveyor and essentially stores until it is required by the Dispenser. The Hopper releases a unit load of 25kg when required. The Hopper has a maximum storage capacity of 700kg. When the maximum is reached the conveyor automatically stops transportation until the Hopper weight has dropped below 500kg. The Hopper automatically disposes of unit loads rice if it is held up to 2 hours.

The Dispenser is a device that splits the unit load (25kg) into mini loads (5kg) consuming negexp(20) seconds. It discharges the mini loads into chutes that feed the bagging machines. The Dispenser has the ability to stop and start whenever required in order to meet the hourly customer demand. Effectively the Dispenser uses an operations strategy that best utilises three packing machines in order to meet the customer's hourly demand.

The three packing machines are identical and can operate independently. However, the operating parameters are the same. The packing process time is negexp(30) seconds per 5kg and an unlimited number of consumable bags are available. Once the rice is packed, the product is immediately shipped and contributes towards the hourly production run. Overproduction in any production hour is disposed at the shipping stage.

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Four Key Performance Indicators (KPIs) are necessary to assess RPL's performance:

a. The weight balance in kg. This is the cumulative difference between the total customers demand and total production output. Ideally, the weight balance should be zero.
b. The total power consumption in kW. Ideally, this should be as low as possible.
c. The total weight of disposed rice (in kg) including packed and unpacked. Ideally, this should be as low as possible.
d. Overall Effective Efficiency (OEE). This is defined as the power consumed (Watts) per useful output (kg). Ideally this should be minimised.

These four KPIs can be combined to form the Smart KPI using the simple equation

$$Smart\ KPI = \frac{\{a + b + c\}}{d}$$

All the operations are automatic and do not require any manual intervention. However, the Loader, Conveyor, Dispenser and Packing machines are subject to downtime e.g. planned maintenance and the occasional machine failure, as detailed in Table 1.

| | Name | Power[1] (kWh) | Service[2] | MTTF[3] | MTTR[4] |
|---|---|---|---|---|---|
| 1 | Loader | 5.5 | 15 min every 30 operations | 20 hrs | 0.8 hrs |
| 2 | Conveyor | 2.5 x Index Time | | 30 hrs | 1.2 hrs |
| 3 | Dispenser | 4.5 | 30 min every 25 operations | 25 hrs | 0.6 hrs |
| 4 | Bag5 | 2.2 | 12 min every 1.5 hrs | 12 hrs | 1.5 hrs |
| 5 | Bag10 | 3.2 | 18 min every 2.5 hrs | 14 hrs | 0.9 hrs |
| 6 | Bag20 | 4.2 | 15 min every 2 hrs | 15 hrs | 1.3 hrs |

**Table 1: Machine operational data**

[1] Power consumption during busy state.
[2] Maintenance activity of a fixed duration.
[3] Mean Time To Failure (MTTF) is implemented using an exponential distribution.
[4] Mean Time To Repair (MTTR) is implemented using a normal distribution, with a mean value and standard deviation being 10% of the mean value.

## What are you expected to do.

Develop a simulation model of the RPL and operate for five days. Devise and explore different operational strategies employed by the dispensing machine. Compare and contrast important KPI's for each smart strategy. Explore relevant regulatory requirements governing these processes in relation to health and safety.

## Deliverables

The deliverables will include:

1. A single simulation model (Witness Horizon) representing your final solution to the cwk brief. [50%]
2. A concise report (2500 words max) the evaluates your solution and aligns with the Witness Horizon model highlighting the key strategy and KPIs. [50%]

## Report Template

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It is expected that the report will cover many technical elements and business aspects. All these can be linked up to constitute the following format:

- Abstract: Executive summary.
- Introduction: Provide a *short* synopsis of the situation.
- Analysis: Include detailed analysis of the Rice Packing Line, manufacturing capability, productivity and issues you would foresee, contrasting them against the probable benefits. Include any risks associated with the control and configurations devised. Also identify a suitable health safety framework for the manufacturing operations.
- Recommendations: Briefly and concisely, specify what you think would work and why. Format and phrase the actual recommendations appropriately to your goal.
- Conclusion: Summarize very briefly the salient points of your recommendation.
- References (No Appendices!)

## Assumptions

1. Index time of the conveyor is set once at the start of operations and remains constant throughout the five days.
2. Assume that processing variability is controlled by the use of Pseudo Random Numbers (PRN). The PRN is given by the total weight of packed rice at that instant plus the last three digits of your student ID number. For example, packed rice = 120 kg, Student ID = 312 then the PRN = 432.
3. Assume a weeks production equates to 5 working days, operating on a single 8 hr shift per day.
4. When a machine fails due to a breakdown, the part currently being processed needs to be disposed and scrapped.
5. Staffing costs and resources can be ignored.

## Pass Criteria

### What you need to do to achieve a pass at threshold level (Mark of 50%)

***A model and report that operates and resembles the key stages of the rice packing line as detailed above.***

### What you need to do to achieve a pass above threshold level (Mark above 50%)

***To gain extra credit, additional features could be included to improve the operations beyond the minimal specification. Simple additional features could include: -***

- *Intuitive dashboard*
- *Animation appropriate to the operations*
- *Hourly production output*
- *Key performance indicators*
- *appropriate regulatory health & safety requirements.*

***Advanced features could include: -***

- *Smart KPI*

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- *Bottle-neck identifiers and waste management*

## Supporting Learning Resources and Activities

| | | |
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| | | |

## Assessment Notes

- *The assignment has been developed to assess your ability to make effective decisions. There are no right/wrong answers. Ultimately a strategy that leads to higher profitability is the most optimum.*
- *Make sure that your report contains any novel features of the solution especially those implemented in the simulation model e.g. operational strategy, decision-making.*
- *A short summary is needed to establish the relevant regulatory requirements governing these operations in the context of systems engineering with a focus on health & safety.*
- *The quality of your model its behaviour and the way that you evaluate your solution in the report will contribute to the grading of your management of information, your professionalism, and your communication skills.*

# Marking

## Formative Feedback

Members of the teaching team and will answer queries about the assignment during the timetabled sessions (see your personal timetable for details). The advice given during these sessions and feedback on any work you present will not count towards your final grade.

Outside timetable sessions, please email questions to the Unit Teaching Team, the Engineering Programme Support Tutors EngPST@mmu.ac.uk or your Personal Tutor. The teaching team will **not** use their office hours to provide one-to-one or small group assignment support, but a selection of emailed questions, and questions asked during the timetabled classes will be added to the assignment's FAQs page.

## What is being assessed?

| Learning outcomes | | Evidence |
|---|---|---|
| Unit Learning Outcomes | 1. Appraise systems engineering methods to solve complex problems in systems engineering and assess their limitations | Simulation Model and Report |

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| | 2. Critique research data and use appropriate systems engineering analysis tools to tackle unfamiliar problems, such as those with uncertain or incomplete data or specifications, by the appropriate innovation, use or adaptation of system engineering techniques | Simulation Model and Report |
| | 3. Determine relevant regulatory requirements governing engineering activities in the context of systems engineering | Report |
| **Assessment Criteria** | USD 1: Apply skills of critical analysis to real world situations within a defined range of contexts. (30%)<br><br>*AHEP3 outcomes evidenced EA3m, EA5m, EA6m* | |
| | USD 2: Demonstrate a high degree of professionalism* eg initiative, creativity, motivation, professional practice and self management. (50%)<br><br>*AHEP3 outcomes evidenced EA3m, EA6m* | |
| | USD 6: Find, evaluate, synthesise and use information from a variety of sources. (20%)<br><br>*AHEP3 outcomes evidenced EA3m, EA6m* | |

To pass this assessment you have to fully achieve the unit learning outcomes by completing all the tasks and submitting the deliverables to an adequate standard. Since your degree is accredited, you also need to demonstrate evidence of obtaining UK SPEC AHEP-3 outcomes at pass threshold levels. These are listed in full within the Appendix of this assessment brief.

Your grade will be determined by how well you meet the assessment criteria (see the detailed grading criteria for this assignment, below).

This assignment will be marked out of 100 and contributes 100% of overall unit grade.

## Assessment Grading Criteria:

| | **USD1** | **USD2** | **USD6** |
|---|---|---|---|
| Deliverable> | Report | Simulation Model | Report |
| Weighting> | 30% | 50% | 20% |
| Grade range | Apply skills of critical analysis to real world situations within a defined range of contexts | Demonstrate a high degree of professionalism* eg initiative, creativity, motivation, professional practice and self management. | Find, evaluate, synthesise and use information from a variety of sources |
| 86%-100% | Novel and complex problems are evaluated thoroughly with reference to theory and practice, generating original solutions, expressed with clarity | There is evidence of the ability to work autonomously and creatively with reference to professional standards and values, reflecting critically on their own practice. | A complex and innovative project is designed, planned and carried out meticulously to gather and synthesise useful information from a wide range of appropriate primary and secondary sources to produce original outcomes of publishable standards |

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| 70%-85% | Novel and complex problems are evaluated with reference to theory and practice, generating original solutions | There is evidence of the ability to work autonomously and imaginatively with reference to professional standards and values, reflecting critically on their own practice. | A complex project is designed, planned and carried out thoroughly to gather useful information from a wide range of appropriate primary and secondary sources and synthesise the results to produce workable outcomes |
| 60%-69% | Novel and complex problems are solved confidently with reference to theory and practice | There is evidence of the ability to work autonomously with reference to professional standards and values, reflecting critically on their own practice. | A project is carefully planned and carried out to gather useful information from appropriate primary and secondary sources and synthesise the results |
| 50%-59% | Novel and complex problems are solved with reference to theory and practice | There is evidence of the ability to work with reference to professional standards and values, reflecting critically on their own practice. | A project is planned and carried out to gather information from appropriate primary and secondary sources and synthesise the results |
| 45%-49% | Attempts to solve novel and complex problems are partial, with limited reference to theory and practice | There is evidence of a limited attempt to work as an autonomous professional who reflects on their own practice | Partial attempt to plan and/or carry out projects which gather information from appropriate primary and secondary sources |
| 20%-44% | Attempts to solve novel and complex problems are inadequate, with little reference to theory and practice | There is limited evidence of any attempt to work as an autonomous professional who reflects on their own practice | Limited attempt to plan and/or carry out projects which gather information from appropriate primary and secondary sources |
| 0%-19% | There is little or no evidence of any attempt to solve novel and complex problems with little or no reference to theory and practice | There is little or no evidence of working as an autonomous professional who reflects on their own practice | Little or no attempt to plan and/or carry out projects which gather information from appropriate primary and secondary sources |

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## Re-assessment

Note that opportunities to repeat assignments are not automatically provided, and when they are, the marks obtained may be capped. For more information about the regulations, please contact the Student Hub.

If you think you are at risk of failing this assignment, please seek advice as soon as possible form your Personal Tutor or the Support Tutors – with enough notice, there are many ways in which we can support you and help you to get back on track.

## Appendix

### Summary of AHEP-3Learning Outcomes Evidenced

| | |
|---|---|
| **EA3m** | Ability to apply quantitative and computational methods, using alternative approaches and understanding their limitations, in order to solve engineering problems and implement appropriate action |
| **EA6m** | Ability to extract and evaluate pertinent data and to apply engineering analysis techniques in the solution of unfamiliar problems |
| **EA5m** | Ability to apply quantitative and computational methods, using alternative approaches and understanding their limitations, in order to solve engineering problems and implement appropriate action |