

Notes:

- *Part A is “closed book”. You must return part A before proceeding with part B.*
- *Part B is open-book, open-laptop, open-Internet. You can consult any course material during this part of the exam and you can browse the Web. Part B can be submitted on paper or electronically using the “Submit” button (as a single zip file or a single PDF file)*
- *You are not allowed to share information with anyone during the exam except with the lecturer.*

Part A. Foundational Knowledge (25 points)

Distributed separately on paper

Part B. Process Modelling, Analysis & Redesign (25 points)

Buildit is a construction company specialized in public works (roads, bridges, pipelines, tunnels, railroads, etc.). Within *Buildit*, it often occurs that engineers working at a construction site (called “site engineers”) need a special type of equipment, such as a truck, an excavator, a bulldozer, a water pump, etc. *Buildit* has some heavy equipment available in its depot, but very often, it hires equipment when needed from specialized heavy equipment suppliers.

A piece of heavy equipment is called a “plant” in the construction jargon. When a site engineer needs to hire a plant, he/she sends a *Plant Hire Request* to one of the clerks at the depot. This request takes the form of a PDF document that the site engineer has to fill in. It takes on average 15 minutes for the site engineer to fill in and send the PDF file. Incoming plant hire requests usually stay about 15 minutes in the clerk’s mailbox before being processed.

The clerk at the depot first checks if an appropriate plant (owned by *Buildit*) is available at the depot for the required period of time. If it is, the request is filled within one hour and the plant is delivered to the construction site usually in 4 hours. This happens in 10% of the cases. Otherwise, the clerk checks an information system that lists all equipment offered by the suppliers and selects the most cost-effective plant that complies with the request. She then checks the availability of the selected plant with the plant’s supplier via phone or e-mail. This availability enquiry takes on

average one hour. About 20% of the times, the selected plant is not available and the clerk has to select another plant and check its availability with its supplier, and so on.

Once the clerk has found a suitable plant available for hire, she recommends that it be engaged (to “engage a plant” is the term used to say that the plant will be rented). The engagement of every plant has to be approved by a “works engineer” who also works at the depot. The works engineer usually approves plant engagement requests twice per day. Because of that, a plant engagement approval takes on average 3 hours. In 10% of the cases, the works engineer rejects the plant engagement request. Half of the rejections lead to the cancellation of the Plant Hire Request (no plant is hired at all). The other 50% of rejections are resolved by replacing the selected plant with another plant (a cheaper plant or a more appropriate for the job). In this latter case, the clerk needs to perform another availability enquiry (or several enquiries). Once the works engineer has approved the engagement, the clerk sends a confirmation to the supplier (including a Purchase Order for hiring the plant) and she records the engagement in an Excel spreadsheet that she maintains in order to keep track of all the approved plant engagements. The clerk generates the Purchase Order using the company’s financial information system (the “Finance Module” of an ERP system). It takes about 1 hour for the clerk to prepare and send the confirmation and purchase order. Most of this one hour is waiting time because the clerk is busy with other matters.

During the process, it may happen (about 10% of the times) that the site engineer decides that the plant is no longer needed. In this case, he/she asks the clerk to cancel the request for hiring the plant.

The supplier delivers it to the construction site at the required date (or in about 6 working hours if the request is urgent). The site engineer inspects the plant. If everything is in order, he/she accepts the engagement and the plant is put into use. In 10% of the cases, the plant is sent back because the plant does not comply with the original specifications of the site engineer. In this case, the supplier will typically re-deliver the correct plant later during the day or the next morning.

When the period of engagement is concluded, the supplier comes to pick up the plant. Sometimes (20% of the cases), the site engineer asks that the period of engagement to be extended. In this case, the site engineer requests an extension directly to the plant’s supplier by e-mail or phone.

On average, a plant is hired for a total period of 8 days (including extensions). Each plant hiring costs on average EUR 200 per day, but there is a lot of variation: some types of plant (e.g. submersible water pump) costs EUR 60 per day, while others (e.g. a large excavator) can cost up to EUR 400 per day.

Five working days after the plant is picked up, the plant’s supplier sends an invoice to the clerk by e-mail. After checking that the engagement corresponding to the invoice was fulfilled (by contacting the site engineer), the clerk forwards it to the financial department. It takes on average 10 days for an approved invoice to be paid. The approval of the invoice takes on average 5 days, oftentimes because site engineers are very busy and do not take the time to do their part of the approval. In about 10% of cases, the invoice is not approved, either because the site engineer states that the plant was not used to the stated period, or because the amounts in the invoice do not match the prices initially quoted, or because the invoice includes amounts for damages to the plant and the site engineer does not agree that those damages took place. These rejection cases take about 5 days to resolve. In some cases, the problem comes from

an error of the clerk or the sites engineer and the issue is resolved internally. In other cases, the problem is resolved when the supplier sends a revised invoice. This revised invoice is then approved (100% of cases) and forwarded to the financial department.

Tasks

1. Draw an “as is” BPMN process model based on the above description. **[8 points]**
2. Calculate the cycle time of the fragment of the process starting from the receipt of a Plant Hire Request, until approval (or rejection) of the corresponding engagement. Please show the arithmetic expression you used to calculate the cycle time (or provide a spreadsheet showing the calculation) **[4 points]**
3. Calculate the cycle time of the fragment of the process starting from the moment an invoice is received for the first time, until the invoice is paid. Please show the arithmetic expression you used to calculate the cycle time (or provide a spreadsheet showing the calculation) **[3 points]**
4. The company’s management team has found that the company’s total expenditure in plant hiring is very high and it has been increasing steadily. By interviewing engineers and other workers, they have found that often the plant is hired for longer than needed. Sometimes site engineers keep the plant longer than needed, because they know that if the need for the plant arises again, getting the plant hired again takes too much time. Propose 2 or 3 possible changes to address this issue? For each change proposal, briefly describe the pros and cons of the proposed change. **[6 points]**
5. The company has received several complaints from suppliers regarding the fact that payments are often received after the payment due date (which is generally 14 days after the invoice is sent). Because of these late payments, suppliers are unwilling to offer favourable prices to the construction company. Propose 1 or 2 possible changes to address this issue? For each change proposal, briefly describe the pros and cons of the proposed change? **[4 points]**