

**Exercise 1**

Asset Co. is organizing a special theatre event in Sol city. The capacity of the theatre is 1000 seats.

Asset Co. wants to maximize the revenue from this event so it decided to offer two different tickets: a discounted price ticket that people can buy from 100 days to 35 days before the event at 200€ and a full price ticket that people can buy from 34 days to the day before the event at 400€.

The company certainly fills the theatre selling only discounted ticket. The demand of full price tickets follows a normal distribution with mean 300 and the probability of 20% that the demand is lower than 200.

The company will offer a welcome “aperitivo” to all the people that will participate to the event: the Asset Co. will pay the catering company 20€/person in advance (as a non-refundable commitment to the catering company) and other 25€/person, after the event, only per each person that actually enjoyed the aperitivo.

The company will offer to full price ticket buyers also a dinner in a famous restaurant of Sol city: the company will pay the restaurant two weeks before the event. The cost of the dinner is 60€/person.

To all the participants the company will give the program of the theatre event and a special coin of the event. Each program costs 10 € and the programs are offered and provided by a sponsor to Asset Co. The company will give two different kinds of coin: a silver coin to full price ticket that costs 35€ and a copper coin to discounted price ticket that costs 15€. All the coins will be ordered and paid by Asset Co. two weeks before the event.

The company will give to full price tickets buyer a gadget of the Theatre event: gadgets will be paid one week before the event, respectively 12€ each.

The company has rented the theatre for 30000€ and bought from “Edison” company a special light system for the theatre at 10000€.

At the end of the theatre event and before the dinner there will be the possibility to visit the “Sol’s City” Hall for all the participants. Basing on historical data the Asset expects that 60% of the full price tickets buyers will buy some souvenir for 50€.

**Data interpolation is not requested. You can take the value that is closest to the one you desire.**

**Question 1)** Define how to allocate the number of tickets to be reserved for the different categories of price (Compute the Protection Level).

**Question 2)** Calculate with which probability the Asset Co. will be able to make with the event a profit higher than 40000€.

**Question 3)** Imagine the situation with a 10% no show (for discounted tickets only) and the possibility to sell the seats that are remained empty (both because they have not been sold and because they are linked to a no-show phenomenon) with a last-minute fee with the special price of 150€ the same day of the event, knowing that in this way it would be possible to sell without problems all the ones offered. To the buyers of the last-minute ticket will be offered the same services of discounted rate tickets but they will not receive the coin. It is assumed that the last-minute buyers have the same behavior of discounted ticket buyer.

ROBIN-HOOD is a small enterprise that produces mechanical pieces for the robotics industry.

The company has to supply 24 units per hour to its customers.

The production system is simple because company ROBIN-HOOD works only one product and the production process is composed of 3 stages: milling, machining and finishing.

The pieces enter the production system first in the milling department, which is composed of one single milling machine.

There aren't scraps in the milling stage, but on average 25% of the pieces processed by the milling machine are defective: these pieces have to be reworked by the same milling machine without any priority. After reworked piece is 100% good.

Next step is the Machining department that is composed of 2 machines, each one with own queue. The 2 machining machines have an automatic quality control directly on board which is able to detect all defective units. Defective units are 20% of the pieces processed by the machining machines. These defective units are reworked by the machining machine without any priority and after that they are 100% good.

After the machining stage, the pieces are transferred to finishing stage that is formed by 2 departments: "advanced department" that is dedicated to process the pieces that were reworked in the machining stage; "standard department" that is dedicated to process pieces that resulted good after the first machining process.

The standard department is composed of a single queue that serves all the 3 machines, while the advanced department is composed by only one machine.

In the finishing stage there aren't quality problem and finished pieces are delivered to the customer. The company works 8 hours per day.

In the table below, the values of the service rate of the different resources. For these resources, we can assume the arrival and the service rates follow a negative exponential distribution.

Process	Service rate (1 resource)
Milling	40 pieces/hour
Machining	20 pieces/hour
Standard Finishing	9 pieces/hour
Advanced Finishing	10 pieces/hour

**Question 1)** Do the map of the production flow of the enterprise, highlighting all the significant parameters and the main information that you consider important to include (included the number of pieces that enter and come out of the system). In addition, **create a table** with all the relevant parameters for each stage (**Arrival rate, Service rate,  $\rho$ , Type of queue,  $W_s$  (in minutes)**). You can consider as negligible the time for the quality control check downstream of milling and machining stages.

**Question 2)** Calculate the expected throughput time of the system as well as the throughput times for each path.

**Question 3)** During the day, how much time is milling machine inactive?

**Question 4)** Calculate the probability that a product which just joined one queue of the machining stage exits from same stage in less than 15 minutes.

**Question 5)** Calculate how many resources are necessary to decrease the standard finishing  $W_s$  until 8 minutes.

## Lean Management, Value Stream Map

## LEAN MANUFACTURING

29/6/2015 EXAM

SIMON-GIGI is a company that produces brake pincers for several motorcycle firms.

A pincer is composed by two identical parts that press on wheel disc when the driver brakes.

The range of this product family is composed by 500 variants of pincers, 10 different diameters and 50 different shapes.

The average demand for the company is 100 pcs /day. The demand is affected to variability, it happens that it fluctuates daily until + or - 50%. On average are requested every day 40 different variants (all the diameters and 8 different shapes). The company has 5 days to satisfy customer order.

The company is composed by 5 stages: stage-1 and stage-2 works on 3 shifts the others work on 2 shifts. Each shift is 8 hours and there are 2 breaks of 15 minutes per shift. All the stages are completely dedicated to this product family.

There is a raw material stock upstream the first stage that covers 12 days of customer demand.

**Production process:**

**Stage-1 [Heat treatment]:** the gross parts of the pincer are processed by a heat treatment machine. There is only one machine and one operator in this stage. The operator prepares the load for the heat treatment machine (1,5 min) and then it loads the machine, supervises the H.T. machine that works the part and unloads it when the heat treatment process is finished (2,5 min.).

**Stage-2 [cutting]:** a cutting machine cut the parts of the pincer. There is only one machine and one operator in this stage. The jobs of the operator are loading the machine, supervising it and making the setup.

**Stage-3 [milling]:** there is an operator that works on the milling machine the cut part. The operator takes a cut part and machines it to reach necessary shape.

**Stage-4 [assembly]:** in this stage there are two operators that work in parallel on two different tables. Each operator does all the activities to complete the assembly job. In this phase the two parts are assembled and it is made the pincer. This is the last production step. When the operator finishes to assembly a piece, he sends it to the testing stage.

**Stage-5 [testing]:** this stage is composed by only one machine and one operator that testes a finished unit. The tested unit goes to the warehouse ready to be shipped.

Stage-1 and stage-2 make the setup when the diameter of the pincer changes. Other stages make the setup if it changes the shape of the pincer. There are not scraps in any processes.

Process	Cycle Time (min.)	Changeover (min.)	Uptime (%)	Inventory (downstream)
Heat Treatment	1,5+ 2,5 (per part)	80	100	2000
Cutting	4 (per part)	40	90	1400
Milling	3 (per part)	5	95	1800
Assembly	13 per operator (per pincer)	5	100	700
Testing	5 (per pincer)	0	95	1000

The company receives everyday customer orders.

Company daily schedules the shipping department for two finished pieces deliveries. The production control function issues a weekly production plan for each stage.

Two times per week the heat treatment department informs production control about the raw material inventory level. The production control places a raw materials order to the supplier each two weeks and, once per month it makes a forecast about the consumption of raw-materials and sends it to the supplier. The supplier deliveries the day after the SIMON-GIGI order.

**Q1) (3 points) Compute the EPE for each stage.**

**Q2) (4 points) Draw the current state map for the SIMON-GIGI production system.**

**Q3) (7 points) Create a future state of the system:**

- Which is the tacked time of the company?
- Where the company is able to introduce the continuous flow and where is necessary use a supermarket pull?
- Which are the minimum interventions to do in order to reach an inventory level (raw-material and WIP) that does not exceeds 1600 pieces? (2 parts count as one piece).

## Operations Management

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