SIMULATION OF HYDROCARBON SALES SERVICES OF THE NATIONAL UNIVERSITY OF MEXICO FOR THE SCENARIO ANALISYS THAT IMPROVE RETURN ON EQUITY

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ABSTRACT
The National University of Mexico (UNAM) has different types of services that support the daily activities of campus, such as pre-hospital service, transport, commercial services, security, sports, cultural activities, etc. Some of these services provide sufficient funds to the University, in particular, the sale of hydrocarbons, which is not restricted to the university vehicle fleet but also offered to individuals, has a significant potential return on equity. Therefore, we examined the operation of this service to determine whether it is fully exploited. As a result of this analysis, we showed that gains not differ much from the costs because not all resources are utilized.

This paper shows a case study which analyzes the sale hydrocarbon service, using simulation techniques, to find plausible scenarios that would improve the economic benefit, by leveraging the space and resources available without investing in infrastructure.

Keywords: simulation, scenarios, servers, returns on equity, leaking profits.

1. INTRODUCTION
The system is simulated in the present work is the gas station located between University Avenue and one of the main entrances to University (Figure 1). It is owned by the UNAM, and according to the General Direction of General Services (DGSG) in 2004 attended around 774,000 users, recording a sale of 15' 465,000 liters of fuel. It has annual income about 117 million Mexican pesos (approximately 9 MM$), and approximate cost of 112 million Mexican pesos (8.6 MM$), accounting for a net gain of 5 million (0.4 MM$).

There are 3 turns: morning (11 dispatchers), Evening (10 dispatchers) and Special (7 dispatchers). Its organizational structure is as follows:

1. Responsible of the gas station
2. Manager
3. Supervisor
4. Dispatchers

Figure 1: System's satellital photo

2. CONSIDERATIONS
We consider some characteristics of the gas station obtained through observation of their behavior, among which are the following.

The station has 10 fully operable fuel pumps, which can only be accessed by University Avenue. Because of this, it is common to first fill the pumps closest to the main street and cars rarely go to the furthest. This is due to lack of personnel to properly distribute the formation of drivers.

Another feature of the system is that, for the location and size of the gas station, at most may have 3 cars in line, which occurs in the first bombs of service. This causes the saturation of the first bombs and drivers decide to continue their way.

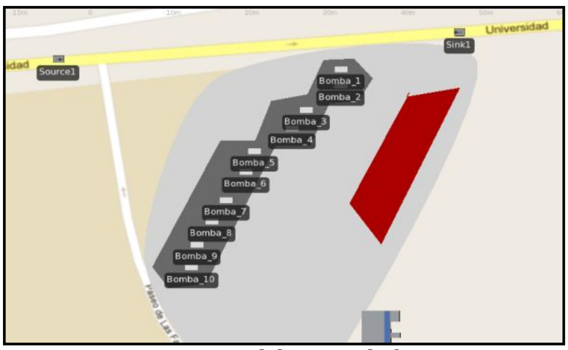

Figure 2: Model's aereal photo

3. PROBLEMATIC

The station has an infrastructure which generates costs such as maintenance and the costs of personnel working. On the other hand, we have observed that the times in which the gas station has increased demand, and thus has the major earnings, are: from 8:00 to 9:00 and from 15:00 to 16:00.

During these times the 10 bombs are available, so there are 10 dispatchers working, however, the furthest servers are idle because there is not an allocation policy and then, the demand in these pumps is not high, creating the idle staff. This causes unnecessary personnel costs. Therefore, we want to understand the behavior of the system with a smaller number of available servers from 15:00 to 16:00 hours.

4. OBJECTIVE

We want to make a simulation study for hydrocarbon sales in a gas station between the hours of 3:00 pm to 4:00 pm in order to understand the functioning of the system and thus raise some scenarios for decision making regarding the number of servers. The simulation study allows us to know some indicators such as:

- Vehicles served.
- Vehicles unattended.
- Average time of service.
- Average time in the system.
- Actual capacity of the system.
- Policies to improve performance.

Some questions we want answered are:

- Is it possible to improve the system? Under which circumstances?
- Does the system performance is adequate?

4.1. Specific Objectives

Simulate the behavior of the real system through different scenarios, then analyze the system to propose an allocation policy and compare this results. Finally estimate the full capacity of the system in the proposed schedule. The gap of the real system and the full capacity scenario would indicate what would be the return on equity or the loss of gains.

5. METHODOLOGY

Discrete-event simulation modeling is an accepted method for predicting the performance of complex systems like hydrocarbon sale services.

However, we have to follow an adequate methodology to gain useful understanding of the likely performance of the real system and then predict the system's behavior in some scenarios. This is where the design of simulation experiments plays an important role (Barton 2010).

In this paper, these experiments allow us to calculate the probably return equity can be gained. Next diagram shows the methodology followed for the simulation of the system.

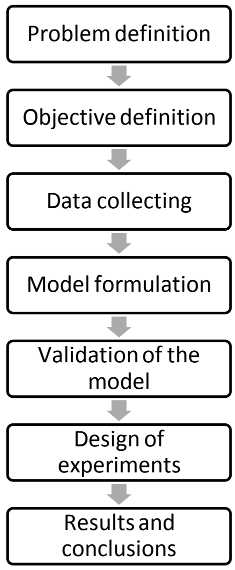

Figure 3: Methodology

6. SIMULATION

Following the methodology described above we break down each phase.

6.1. Data Collecting

It was necessary to identify the following variables in order to build the model, taking into account ten servers:

- Arrival time of vehicles.
- Service time.
- Queues
- Leisure time.

Table 1: Data collected

Data from one server chosen at random	
N°. vehicles	24
Arrival time *(minutes)*	2.45
Service time *(minutes)*	1.92
Queues	0.1
Leisure time *(minutes)*	0.5

We note that in the last three pumps (located at the bottom of the gas station), leisure time dispatchers was up to 15 minutes on average. The data collected, taking into account the 10 pumps are summarized in Table 2.

Table 2: Data collected

Data from 10 servers	
N°. vehicles	203
Arrival time *(minutes)*	16
Service time *(minutes)*	1.92
Queues	2.3
Leisure time *(minutes)*	10

This sample data help us to identify our simulation input model using to accept or reject each of the distribution families in a list of well-known alternatives.

We used EasyFit® Software to fit a distribution function to data collected, obtaining the following distributions:

1. For the arrival time of vehicles, we obtained an exponential distribution (Figure 4) with parameter:

$$\lambda = 16 \text{ seconds}$$

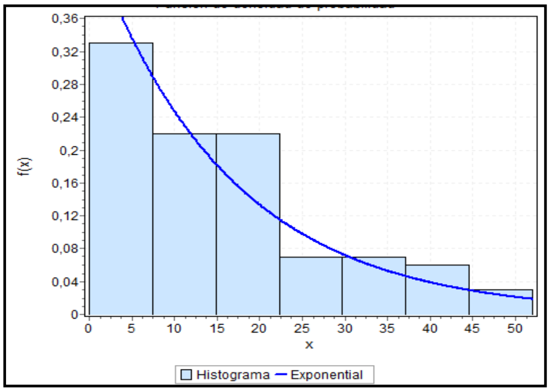

Figure 4: Distribution for arrival time of vehicles

2. For the service time, we obtained an uniform distribution (Figure 4) with parameters:

$$a = 0.94, b = 2.90 \text{ minutes}$$

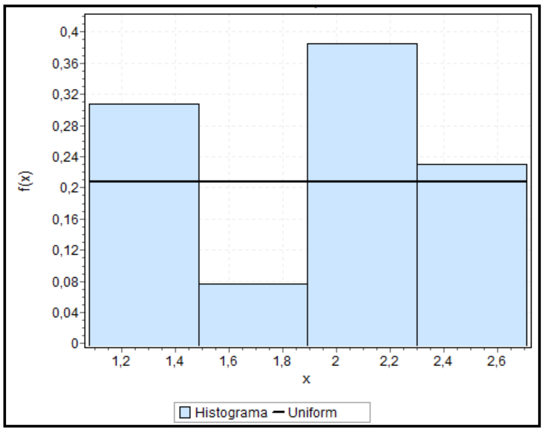

Figure 5: Distribution for the service time

6.2. Model formulation

Using previous distributions we determinate the number of distinct model settings to be run, and the specific values of each one. These include:

- Scenario I: This model is the common scenario in which the system operates.
- Scenario II: This model represents the real capacity of the system and it operates with an allocation policy. We have called it: “Ideal System”.
- Scenario III: In this model, we incorporate changes in the input process because we are not only interested in getting a good model for an input process, but also in seeing how the system will react to changes in that input (Biller 2002). For this scenario we change the parameters of the distribution for know the full capacity of the real system.

After this, we used Simio Simulation Software® to build the three different scenarios.

6.3. Scenario I

From 3:00 pm to 4:00 pm the gas station has available 10 bombs (servers), however the last two usually are empty, so we built a scenario with 8 pumps available to verify that the model behaves as close to reality.

We consider that the first 6 pumps can generate queues of at most 3 cars, because if it exceed this number is blocked University Avenue.

For the two remaining bombs, the queues can be of at most 2 cars, as the queues that are generated in the first 6 bombs do not allow larger queues on the servers 7 and 8 (the last 2 bombs).

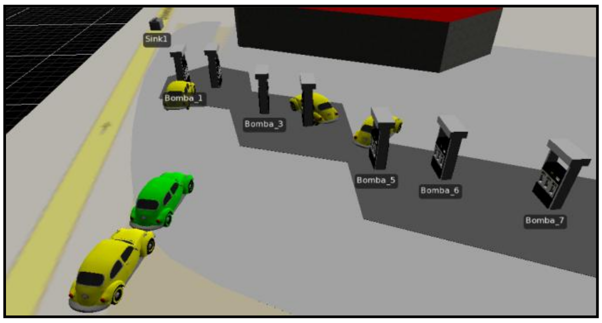

Figure 6: Simulation of Scenario I: 8 servers, the closest to reality

Table 3: Results Simulation of Scenario I

Simulation of System with 8 bombs working	
N°. vehicles generated by the source	217
N°. vehicles that were attended	161
N°. vehicles that were not attended	**56**
% vehicles that were not attended	**25.8%**

6.4. Scenario II

We built a second scenario taking into account 10 servers (Figure 7) and we created an "Ideal System", it means, the 10 servers operating according to the parameters that resulted from the data samples, as shown in the table below.

Table 4: Ideal System Parameters

Servers	**Queues (max.)**	**Distributions**	
Bombs 1to 6	3 vehicles	**Service time:** Uniform	**Arrival time:** Exponential
Bombs 7 to10	2 vehicles		

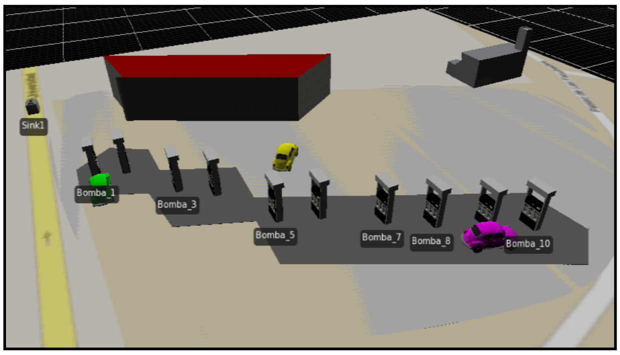

Figure 7: Simulation of Scenario II: "Ideal System"

The next table shows the results for this scenario.

Table 5: Results Simulation of Scenario II

Simulation of System with 10 bombs working	
N°. vehicles generated by the source	202
N°. vehicles that were attended	185
N°. vehicles that were not attended	**17**
% vehicles that were not attended	**8.4%**

6.5. Scenario III

In the third scenario (Figure 8), we consider that the 10 pumps are available and they can generate queues (equal that in Scenario II). The difference in this case is the reduction in the time of vehicle arrival.

This decrease was considered by the following:

1. In Scenario II we consider the distributions fitted to the data collected, but those times are more suited to Scenario I, where only 8 servers are available.
2. In this case we consider that there are 10 bombs and they can generate queues, it means, we are considering 2 servers more and therefore the ability of the system under this scenario is greater than in the real system.
3. This reduction is also justified by the fact that it does not affect significantly the waiting time of drivers and does not exceed the limit of the queue, plus the demand exists because University Avenue is very busy at that time.

We suggest an exponential distribution for the arrival time of vehicles with parameter:

$$\lambda = 12\ sec.$$

It means, a 4 seconds reduction in arrival time, since in this case the vehicles can be distributed in two servers more.

Table 6: Results Simulation of Scenario III

Simulation with 10 servers and a reduction in arrival time	
N°. vehicles generated by the source	255
N°. vehicles that were attended	219
N°. vehicles that were not attended	**36**
% vehicles that were not attended	**14.1%**

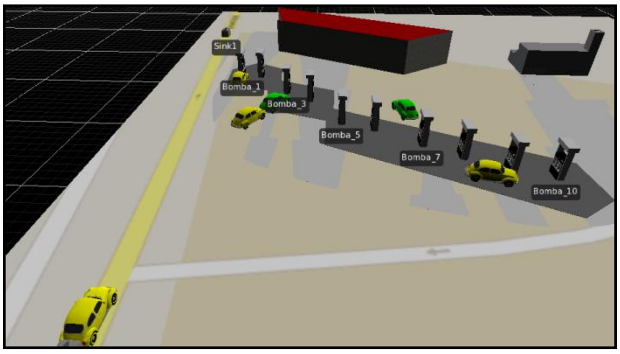

Figure 8: Simulation of Scenario III: 10 servers considering an arrival time reduction

7. VALIDATION OF THE MODEL

The simulation was validated with a group of data not used in the modeling process. We found that the gap between model and reality is not significant (Table 7), so the data model is closer to reality.

Table 7: Difference between the simulation and the system's data

Validation information	Simulation	Data collected
Average time in the server (*minutes*)	1.88	1.92
Average number of cars served per server	21	24
System's average time (*minutes*)	3.7	3

8. RESULTS

After we execute the simulation, we compared the results of the three scenarios. In the Table 8 are shown the results and the graphs below show the comparison of the three scenarios.

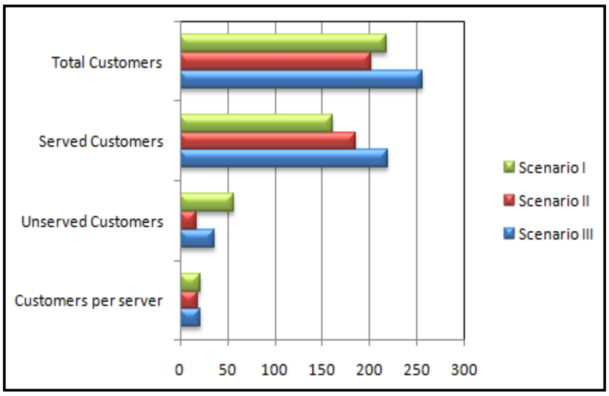

Figure 9: Comparative of three scenarios

Table 8: Results of the three scenarios

Scenarios			
Scenario	**I**	**II**	**III**
No. of servers	8	10	10
Distribution arrival time Parameters	Exponential λ=16	λ=16	λ=12
Time in server	1.8 min.	1.9 min.	1.9 min.
Customers per server	21	19	22
Average time in system	3.7	4	4.2
Total Customers	217	202	255
Served customers	161	185	219
Unserved customers %	56 25.8%	17 8.4%	36 14.1%

We note that if the 10 pumps worked, the number of clients served would be 58 more than the current system, increasing the time in the system only 0.5 minutes, which is acceptable for a client.

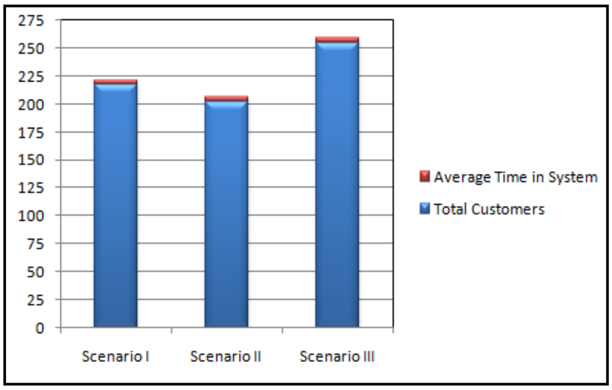

Figure 10: Relation between the customers and their average time in system

8.1. Quantitative Analysis

The gap between scenario I and scenario II indicates that the gas station's service has a loss of 24 customers approximately in the analysis schedule because they have not an allocation policy. Assuming that each car consumes an average of $100 MXN (it means 7.5 USD, approximately) the University is leaking profits of $12,000 MXN (923 USD) weekly and $624,000 MXN (48,000 USD) per year.

By other hand, the gap between scenario I and scenario III indicates that hydrocarbon sales service is not using its full capacity at all because of logistical problems. We estimate that the loss of customers is approximately 58 cars on the busiest schedule. Assuming that each car consumes an average of $100 MXN the University is leaking profits of $34,800 MXN (2,677 USD) weekly and $1'792,200 MXN (137,862 USD) per year. Table 9 shows these calculations.

Table 9: Quantitative Analysis

Return on equity	
Period	**USD**
A day	$580
A week	$3,480
Per year	$179,220

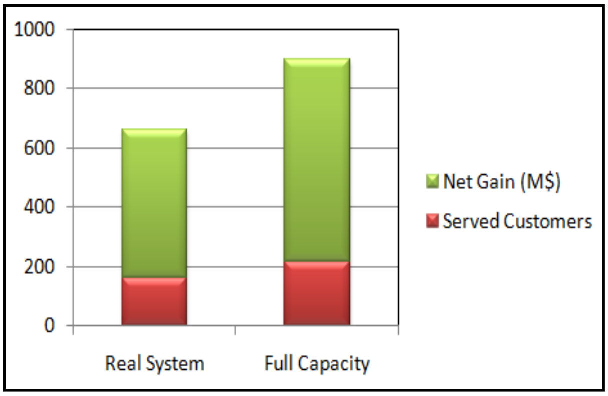

Figure 11: Despite having a small increase in the number of clients served, net earnings are significantly affected

This estimate considers only the days and hours of greatest demand (working days) and does not consider operating expenses. However, it is important to estimate and improve the return on equity.

It is important to note that the accuracy of the estimate is based on the accuracy of the modeling input. If it were necessary a more accurate figure would be necessary to expand the collection of data and use a more robust model and input (Michael 2008).

9. CONCLUSIONS

In this paper, we use Simulation for analyze the performance of the hydrocarbon sales service of the National University of Mexico; we have also could predict what would be the return on equity of the service in its full capacity. However, it should be noted that to make proper use of this tool in a case similar to that proposed in this paper, is necessary to have knowledge of both Statistic as Probability to build a correct input model, as well as an study of the system's behavior to obtain results closer to reality and improve decision-making.

We further consider that the simulation can be used in many services for improve their efficiency within the University such as: medical services, infrastructure and transport.

Thus, we used this tool to analyze and predict the service behavior and estimate information for decision-making with favorable results.

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REFERENCES

Barton, R.R. 2010. Simulation emperiment design. In Proceedings of the *2010 Winter Simulation Conference*, ed. B. Johansson, S. Jain, J. Montoya-Torres, J. Hugan, and E. Yücesan: 75-86.

Biller, B., 2002. Answer to the top ten input modelling questions, Proceedings of the *2002 Winter Simulation Conference*, volume 1: .35 – 40.

Law, A.M., Kelton W.D., 2000. *Simulation modeling and analysis*. New York: McGraw-Hill.

Michael E.K., Emily K.L., Natalie M.S., Mary W., James R.W., 2008. Introduction to modeling and generating probabilistic input processes for simulation. *Proceedings of the 40th Conference on Winter Simulation*, December: 07-10.

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