Modeling and simulating the activities in an automobile repair shop using ARENA software – part 2

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Abstract. Statistical data obtained from previous paper are collected and studied for the modeling, simulating and optimization of repair shop activities, for the time, capacity and management performance improvement. Based on the simulation’s results, there are made interpretations and proposals are obtained for the human resources rearrangement, to optimize the automobile repair shop’s overall efficiency, performance and capacity. After running the simulation, there are obtained improvements in the number of serviced vehicles covered by “Maintenance”, “Minor repairs”, “Major repairs, Bodywork and Dye-works” and “Bodywork and Dye-works” categories. Also, improvements are made in the duration for the interventions in “Minor repairs, Bodywork and Dye-works”, “Major repairs”, “Major repairs, Bodywork and Dye-works” and “Bodywork and Dye-works” categories, with problematic intervention duration in the initial simulation. The differences between the initial and the optimized simulation, regarding the length of the station’s queue shows the improvements to follow for a more balanced workload distribution and usage of resources. Such simulations can and do significantly improve the way a business performs in the market and serves its customers. Such tools as the Arena software provide insight into the process flow model and can serve as a theoretical testbed for any proposed improvements.

1. Introduction
The previous paper “Modeling and simulating the activities in an automobile repair shop using ARENA software – part 1” had collect data from auto repair services: concierge, diagnosis, mechanical repairs, bodywork and painting, maintenance and periodic technical inspections, in order to obtain a careful planning before implementation, into an experimental model.

Simulating the firm’s activities was done by using a discrete event simulations software - the Arena software [1], the simulation results being analyzed. The experimental model to be optimized is used for a continuous search for solutions and their implementation, in order to ensure available resources efficiency, that represents an important milestone in firm’s activities progress [5].

By using the Arena software simulation helps the optimisation of the automotive supply chain through knowledge management, the effects of certain decisions are easier to understand and more accessible, also a positive outcome can be guaranteed with greater certainty, by choosing the optimal solution from many possible solutions [8], [9].

The experimental model developed in Arena is focused on an automobile repair shop were the activities are done for a 9600 minutes time interval, representing 20 working days of 8 h/day, which roughly translates into an average working month. The premise is that in a certain working station a certain intervention (or operation) is made on the vehicle.
The premise is that each working station has a distinct intervention on a vehicle, with a certain duration, but a vehicle may need one or more interventions, which implies it must pass through one or more stations, which is leading to the workflow. The simulation proceeded yielded a number of 289 vehicles serviced by the automobile repair shop, in a time interval of 9600 minutes, the statistical data collected assigning a certain number of vehicles to each intervention category, also a specific intervention’s duration, so it was obtained the resultant queue at each station.

Practice’ reality shows that only the interventions durations can be adjusted, the queues are a result of the stations capacities and of the interventions’ duration at each station. Because the actual interventions durations cannot be reduced, it is necessary to examine the queues distribution according to the resource allocation, to optimize the overall automobile repair shop efficiency [10], [11].

2. Optimization
Based on the simulation’s results, the interpretations of those results and the conclusions subsequently drawn, the following rearrangement of human resources is proposed, in order to optimize the automobile repair shop’s overall efficiency, performance and capacity [7]:

- Reducing the number of concierges from 3 to 2;
- Increasing the number of mechanics from 5 to 6;
- Reducing the number of tinsmiths from 3 to 2;
- Increasing the number of dyers from 2 to 3.

Besides the aforementioned adjustments, the model and the simulation parameters are identical to the initial simulation.

After running the simulation, with the proposed improvements in place, there was a 15.22% improvement in the number of serviced vehicles (up to 333 from 289). The detailed results are shown in Tables 1, 2 and 3.

Table 1. Optimized serviced vehicles distribution.

| Intervention category                              | Serviced vehicles | Mean intervention duration [min] |
|---------------------------------------------------|-------------------|---------------------------------|
| Diagnosis                                         | 12                | 91                              |
| Diagnosis and minor repairs                       | 77                | 228                             |
| Maintenance                                       | 22                | 109                             |
| Minor repairs                                     | 34                | 185                             |
| Minor repairs, Bodywork and Dye-works             | 27                | 726                             |
| Major repairs                                     | 32                | 301                             |
| Major repairs, Bodywork and Dye-works             | 69                | 861                             |
| Bodywork and Dye-works                            | 37                | 548                             |
| Periodic technical inspection (ITP)               | 18                | 48                              |
| ITP and Minor repairs                             | 5                 | 161                             |
Table 2. Optimized station’s queue.

| Station                | Waiting time [min] | Number of vehicles waiting |
|------------------------|--------------------|---------------------------|
|                        | Min.               | Mean          | Max.               | Min. | Mean | Max. |
| Concierge              | 1.914              | 33.397        | 0.067              | 2    |
| Diagnosis              | 10.390             | 114.500       | 0.098              | 3    |
| Maintenance            | 7.319              | 33.771        | 0.017              | 1    |
| Minor repairs          | 0                  | 16.740        | 0.265              | 1    |
| Major repairs          | 34.330             | 308.610       | 0.397              | 4    |
| Bodywork               | 215.500            | 651.950       | 3.595              | 14   |
| Dye-works              | 54.660             | 272.830       | 0.809              | 5    |
| Periodic technical inspection | 0.884          | 20.336        | 0.002              | 1    |

Table 3. Optimized resource distribution and usage.

| Resource       | Degree of usage [%] | No. of interventions performed |
|----------------|---------------------|--------------------------------|
| Name           | No. | Min. | Mean | Max. |                                   |
| Concierge      | 2   | 60.94| 88.10| 86.19| 338                                |
| Mechanic       | 6   | 83.80| 85.37| 85.82| 68                                 |
| Tinsmith       | 3   | 86.10| 85.37| 85.82| 57                                 |
| Dyer           | 2   | 86.41| 142   | 136  |
| Technician     | 3   | 77.14| 136   |      |

The comparison between the initial simulation and the optimized one, regarding the number of serviced vehicles, is presented in Figure 1. It can observe a noticeable increase in the number of serviced vehicles covered by “Maintenance”, “Minor repairs”, “Major repairs, Bodywork and Dye-works” and “Bodywork and Dye-works” intervention categories.

In the same time, it can be noted a considerable drop in the mean intervention duration for the interventions covered by “Minor repairs, Bodywork and Dye-works”, “Major repairs”, “Major repairs, Bodywork and Dye-works” and “Bodywork and Dye-works” intervention categories, these categories being those with the problematic intervention duration in the initial simulation.
Figure 1. Comparison between initial and optimized simulation for number of serviced vehicles

Figure 2 presents the differences between the initial and the optimized simulation regarding the length of the station’s queue. It can observe that the optimizations implemented led to a considerable shortening of queues for half of the stations, an increase in the case of two other stations and no effect whatsoever for the queues of the remaining two stations.

Overall, the queues are more evenly distributed, with no single station standing out as a “stopper” in the process flow. Even though two stations were negatively impacted by the implemented solution, percent-wise, the workload was simply shifted between the stations to ensure a more balanced workload distribution and usage of resources.

The differences in resource distribution and usage between the initial and optimized versions are fairly obvious (Figure 3). Most of the resources perform fewer interventions, with the overall number of serviced vehicles increasing, which shows a more balanced workload distribution and also prevents one or more stations from being unable to fulfil their duties in the event of a temporary surge in demand.

The mean degree of usage is also noticeably lower for most of the resources, but more evenly distributed across them, with no single resource (except the technician, whose particularities were discussed and explained already) showing a degree of usage under 50%.

The main exception to the general trend of lower degrees of usage is the tinsmith resource, which sees a significant increase in its usage and a slight increase in the number of interventions performed. The tinsmith’s degree of usage is best interpreted in relation to the dyers’, as the two stations (Bodywork and Dye-works) are closely linked. Since a more balanced workload distribution between the two resources is not possible without major adjustments to the process flows and stations’ structure, the selected rearrangement seems to be the most efficient solution.
Figure 2. Comparison between initial and optimized simulation for number of vehicles waiting

Figure 3. Comparison between initial and optimized simulation for number of interventions performed

A more complicated, but still possible to implement in the current paradigm, solution would be to train a new resource, tinsmith-dyer, with the combined skillset of the two resources and use a set of
resources, analogue to the mechanics. Still, this type of resources rearrangement provides significant challenges in a real-world scenario and was thus kept as a hypothetical solution.

3. Conclusions

Most of the decisions that have to be taken concerning the activities of a firm require careful planning before implementation. The automobile repair shop market is a highly competitive one, but one that is also filled with opportunities. Therefore, any competitive advantage can have a significant impact on the chances of success of a firm in this area of activity.

Simulating the firm's activities by using a discrete event simulations software, like the Arena software, analyzing the results of the simulation, continuously seeking and implementing solutions to optimize the experimental model and to ensure an efficient use of the available resources, represents an important milestone in ensuring that the firm's activities are progressing smoothly.

By running a simulation using the Arena software, the effects of certain decisions are easier to understand and a positive outcome can be guaranteed with greater certainty, while choosing the optimal solution from any number of possible solutions becomes more accessible.

The presented model and simulations results serve as examples of what even a relatively simple analysis can reveal about the way a business uses its available resources and how even a simple rearrangement of resources can have a significant impact on the overall performance and efficiency of said business. Such simulations can and do significantly improve the way a business performs in the market and serves its customers. Such tools as the Arena software provide insight into the process flow model and can serve as a theoretical testbed for any proposed improvements.

4. References

[1] Kelton W D 2002 Simulation with ARENA (McGraw-hill)
[2] Markovitch N A and Profozich D M 1996 Arena software tutorial Proceedings IEEE Winter Simulation Conference pp 437-440
[3] Allen T T 2011 Introduction to Discrete Event Simulation and Agent-based Modeling (London: Springer)
[4] Banks J 1998 Handbook of simulation: principles, methodology, advances, applications, and practice (John Wiley & Sons)
[5] Jeddi A R, Renani N G, Malek A and Khademi A 2012 A discreet event simulation in an automotive service context International Journal of Computer Science Issues 9 (6) pp 142
[6] Rajuwat M K and Kalita D 2018 Simulation of Queuing System for Car Service Center using Arena Simulation Software International Journal of Production Engineering 4 (2) pp 1-12
[7] Woolliscroft P, Caganova D, Cambal M, Holecek J and Pucikova L 2013 Implications for optimisation of the automotive supply chain through knowledge management Procedia CIRP 7 pp 211-216
[8] Pierreval H, Bruniaux R and Caux C 2007 A continuous simulation approach for supply chains in the automotive industry Simulation Modeling Practice and Theory 15 (2) pp 185-198
[9] Sengupta S, Deneweth M and Van Til R 2011 A better approach to modeling emergency care service Proceedings of the 2011 IEEE Winter Simulation Conference pp 1202-1210
[10] Patel V, Ashby J and Ma J 2002 Discrete event simulation in automotive final process system Proceedings of the IEEE Winter Simulation Conference (1) pp 1030-1034
[11] Gopalakrishnan M, Skoogh A and Larocque C 2013 Simulation-based planning of maintenance activities in the automotive industry 2013 IEEE Winter Simulations Conference pp 2610-2621