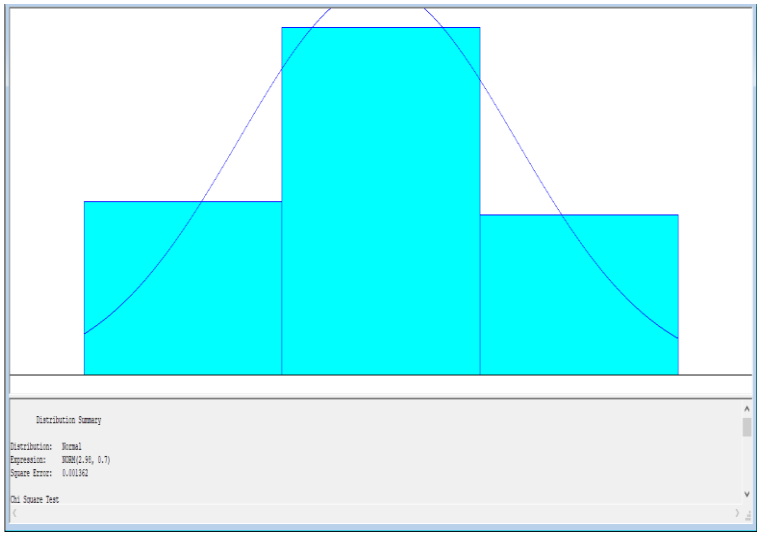
Brief introduction and the basic settings applied

This is a simulation report about Hobbiton city council's police garage where repair and maintenance work is performed on police cars, with only one mechanic and a repair bay available. This simulation was performed for a duration of one year with 10 run trials to collect the results and no warm up period. I took this decision because there were cars coming into the garage from the first day, and there is approximately 3 unscheduled cars and 13 scheduled cars coming the first week, so the simulation was working in the first week as it would in the middle of the simulation. Also, the simulation was running for 24 hours every day from Monday to Sunday, the day starting at 00:00. In addition, the mechanic was working 8 hours a day with a scheduled shift from 09:00 to 17:00. If the mechanic was working on a car and did not finish the job before 17:00, the work would continue the next day at the start of his shift. Every day at 00:00 a number of scheduled cars arrive and are left at the garage at the start of the day, unscheduled cars can arrive anytime of the day.

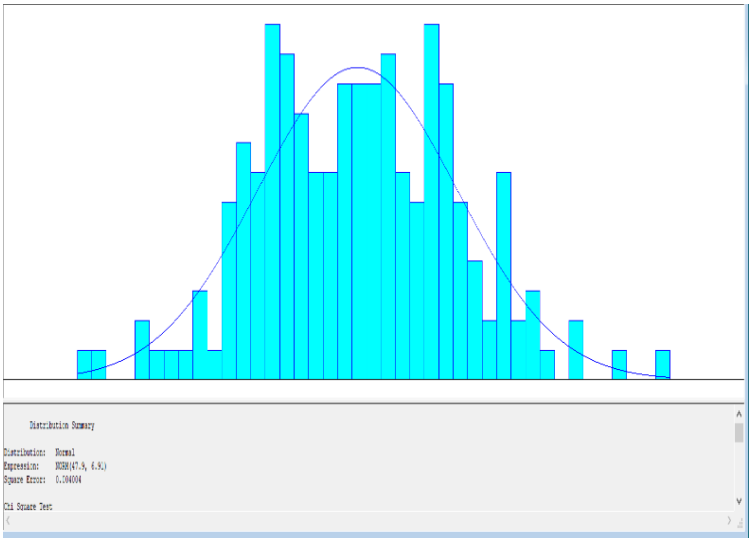
Simulation model choices and distributions

My simulation model contains two start points for the scheduled and unscheduled cars, the first with a fixed value of 24 for the inter-arrival times, because every day a number of cars come into the garage with a batching size of a normal distribution(1). The second having a normal distribution(2) for the inter-arrival times and a fixed batching size of 1, because every other day one unscheduled car comes into the garage. After these, there is a dummy activity acting as a waiting space and a dummy resource to control the timing of the cars to go into the garage when it is open at 09:00. They are then routed out with the unscheduled cars going out first as they have the priority to the repair bay activity, while the scheduled cars are waiting in the queue in this case. The repair bay is using a Due label and a Priority label so there could be interruption from the unscheduled cars to the scheduled cars that were being repaired, with the scheduled cars going into the interruption queue with their remaining time saved using the Due label. This label has a uniform distribution(3) for the scheduled cars and an exponential distribution(4) for the unscheduled cars. The repair bay uses the priority label as a way to prioritise the cars coming in to be fixed, with the highest priority to the unscheduled cars, followed by the interrupted cars if any and then the scheduled cars waiting in queue. The data was analysed as it was given in the excel datasets except for the unscheduled cars arrivals where I had to calculate the time difference between each car arrival into a decimal value and then converted that into hours. For example 1.66 as the first time difference is 24 hours(1day) plus 16 hours(~0.66day) which equals to a total of 40 hours between the first unscheduled car arrived and the next one. All the decisions related to the distributions were made using Arena input analyzer and excel. At first I was using StatFit instead of Arena but the results were not satisfying because of the limited amount of data I was able to input that was restricted to only 50. Down below are the images related to screenshots of each distribution numbered respectively.

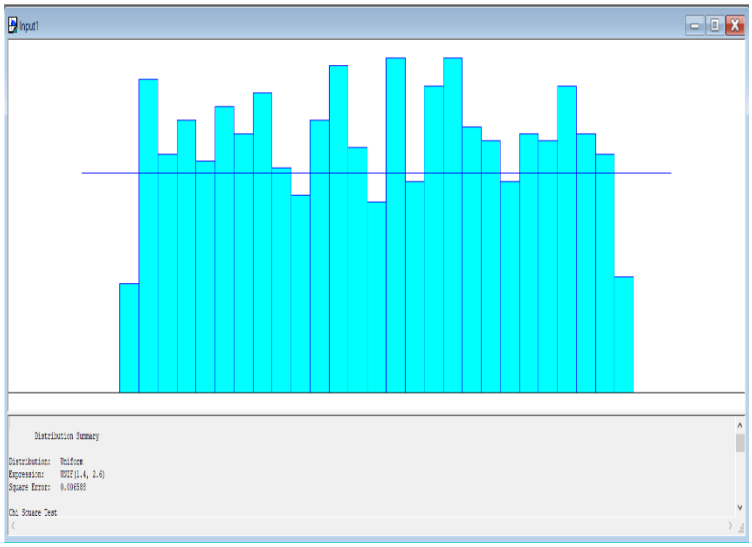
1


Distribution Summary
Distribution: Normal
Expression: NORM(2.98, 0.7)
Square Error: 0.001362
Chi Square Test

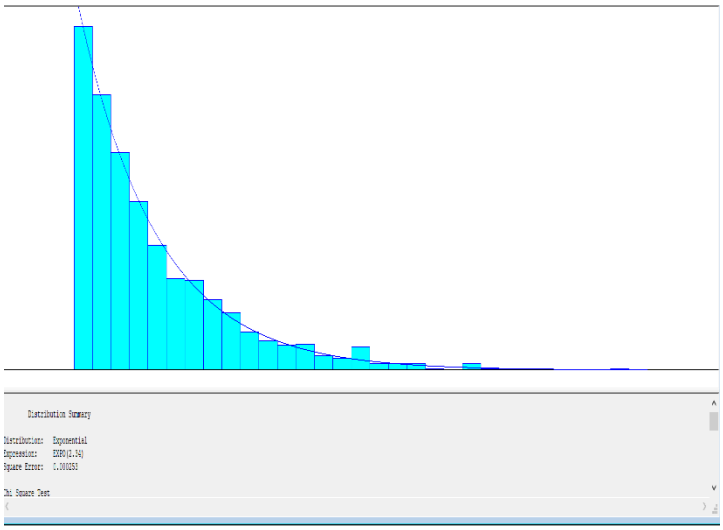
2


Distribution Summary
Distribution: Normal
Expression: NORM(47.9, 6.9)
Square Error: 0.104004
Chi Square Test

3


Input1
Distribution Summary
Distribution: Uniform
Expression: UNIF(1.4, 2.6)
Square Error: 0.004589
Chi Square Test

4


Distribution Summary
Distribution: Exponential
Expression: EXPO(1.74)
Square Error: 0.001053
Chi Square Test

Model validation

Before I start to show the results, analyse and interpret them, I should make sure my model is correct and valid to be able to get the best possible results that could represent the reality accurately. For this, I will compare the values gotten in the excel datasets to each corresponding result I got from my simulation during a year. I will show the comparison in the table down below.

	Results from the excel datasets	Results from the simulation
Number of Scheduled Arrivals	1088	1083
Number of Unscheduled Arrivals	183	182
Mean time of Scheduled Services	1.99	1.96
Mean time of Unscheduled Services	2.33	2.24

As we can see in the table, the numbers from the datasets look very similar to the numbers that I got in the simulation, which shows that the model and the workflow of the created simulation is valid and represent the reality sufficiently.

I obtained a 95% confidence interval for the utilisation of the mechanic with an average value of 88.5%.

	Minimum	Average	Maximum
Number of scheduled cars waiting for service	0	1	11
Waiting time of scheduled cars for service (hours)	0	10.9	75
Number of unscheduled cars waiting for service	0	0	1
Time schedule cars spent with the mechanic (hours)	0	1.9	2.6
Time scheduled cars spent in garage, including interrupted time (hours)	4	19.3	86.4

In the table above, there is a maximum of 11 scheduled cars waiting for service with a waiting time of 75 hours, this happens when there is an unscheduled car that is being fixed in the repair bay with a stacked queue of scheduled cars. On the average, only one scheduled car is waiting for 11 hours. If there is no pressure on the garage, then the scheduled cars have no waiting time and pass directly to get fixed in the repair bay. For the unscheduled cars, as they are highly prioritized,

they have a maximum queue size of just one car with an average of zero which explains that most of the time there is no unscheduled car waiting to be fixed as they always go through to be fixed as an emergency. Next is the time scheduled cars take to be fixed which has a mean of 1.9 hours and maximum time of 2.6 hours. In this case the minimum value should be around 1.4 but in my simulation the result was at an abnormal value of zero. After checking the data using the transaction log in simul8 and putting those values in excel, I found out that there was only 35 cars out of 1100 that had a service time lower than 1.4, which describes to a merely 3% of the total cars arriving. The last result is for the amount of time scheduled cars stayed in the garage which goes to a high 86.4 hours affected by the unscheduled car that is getting fixed taking the most time possible. Averagely, 19 hours is what it took for most of the cars to enter the garage and finish the whole process with a minimum of 4 hours.

Investigation

When the number of unscheduled cars is doubled from 183 to 360, there is no effect on the service time of the scheduled cars, no relation between these two variables. But there is a relation with the number of the scheduled cars in queue and the number of interrupted cars, which goes higher in both cases to a max of 33 and 313 cars respectively. Also, the utilization of the mechanic goes to a very high 99% because he has even more work to do with the added unscheduled cars coming in.

If the number of both arriving cars is doubled, the mechanic is working 100% of the time, there is an overload of work on the garage, the number of queue times is very high with barely half the cars getting fixed during the year, 1119 scheduled cars waiting to get fixed.

If only the number of the scheduled cars is doubled to 2170 cars a year, there is 918 cars waiting to be repaired, which shows that whenever the number of scheduled cars is doubled there is a waiting problem with half the cars not getting fixed, with only the unscheduled cars getting fixed first as they have the priority.

The maximum number of cars that could arrive at this garage without overcrowding it and having all the cars fixed is at an approximation of 1160 scheduled cars and 220 unscheduled cars.

Recommendation

After presenting the results and trying some scenarios that could happen in the future, I would recommend the garage to not schedule more than 1160 cars a year as that would risk the mechanic of failing to fix all the arriving cars, assuming we do not know exactly how many unscheduled cars could arrive as they are emergency cases. Other than this, I find the system of this garage to be efficient and working well.