# Appendix J Homework #10 System Simulation (Discrete Event Simulation)

**Purpose of Homework** Learn about discrete event simulation by studying how varying service & failure rates for a 3 station model effects the system behavior.

**Advice-**Before discussing the results think about if it is more useful to the reader/client: 1) to have a case by case discussion, or 2) to hear the effects of inputs on outputs, or 3) to hear how the outputs are influenced by the inputs (that is, mean service time (for all 3 service stations or single station), variation of service time and failure rate). For part A of your report, don’t just cite results, explain why. In Part C, avoid hype, remember *good engineers speak with data* and that Ch. 30 discusses uses for discrete event programs.

**Report** –A. For cases A1-B4 discuss the results (the Outputs): 1-Time in System, (30 pts), primarily Ave. Time but if significant the Min. & Max.; 2- Queues (15 pts); and 3-Utilization Rate, (10 pts). B. Briefly discuss the behavior of case C (15 pts). C. Write 1-2 paragraphs to the head of engineering on the merits of using a simulation program like Arena to design a plant (30 pts).

**Arena Program** Discrete event simulation models can be constructed using a simulation language (code, program). This method required highly skilled programmers and took a lot of time to build the model. High-level simulator programs are now being used. With them, models are constructed via “graphical user interfaces“ by clicking and dragging preset modules. This reduces the times and skill needed to construct models and permits the user to concentrate on finding ways the system can be improve. Arena is such a typical high-level simulator program.

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| Data-453Hwk10.doe | **Inputs**-Time: Mean & Std. Dev. (Normal Dist.) | | | | **Output**-Time in System | | | **Output**-Queues, Ave./Max. | | | **Output**-Utilization Rate | | |
|  | Arrival | Service#1 Cutting | Service #2 Sewing | Service #3 Insp./Pack | Ave. | Min. | Max. | Cutting | Sewing | Inspect | Cutting | Sewing | Inspect |
| A1. Normal Service | (9, 1) | (8,1) | (8,1) | (8,1) | 29 | 22 | 56 | 0.04/1 | 0.14/2 | 0.14/2 | 0.88 | 0.89 | 0.89 |
| A2. Ditto w/ more variation | (9, 1) | (8,2) | (8,2) | (8,2) | 35 | 22 | 60 | 0.12/1 | 0.35/2 | 0.60/3 | 0.87 | 0.88 | 0.93 |
| A3. Ditto w/ slow @#2 | (9, 1) | (8,1) | (8.9,1) | (8,1) | 43 | 26 | 75 | 0.06/1 | 1.73/5 | 0.06/1 | 0.90 | 0.99 | 0.89 |
| A4. Ditto w. higher failure\* | (9, 1) | (8,1) | (8,1) | (8,1) | 31 | 22 | 75 | 0.04/1 | 0.34/3 | 0.18/2 | 0.89 | 0.91 | 0.90 |
| B1. Slower Service | (9, 1) | (8.9,1) | (8.9,1) | (8.9,1) | 60 | 28 | 96 | 0.57/2 | 2.65/5 | 0.29/2 | 0.99 | 0.99 | 0.97 |
| B2. Ditto w/ more variation. | (9, 1) | (8.9,2) | (8.9,2) | (8.9,2) | 103 | 28 | 219 | 3.95/8 | 1.59/6 | 2.78/8 | 0.998 | 0.96 | 0.98 |
| B3. Ditto w/ slow @#2 | (9, 1) | (8.9,1) | (8.95,1) | (8.9,1) | 71 | 28 | 158 | 1.41/4 | 1.99/7 | 1.35/4 | 0.999 | 0.99 | 0.98 |
| B4. Ditto w/ higher failure\* | (9, 1) | (8.9,1) | (8.9,1) | (8.9,1) | 82 | 28 | 199 | 0.57/2 | 5.10/9 | 0.29/2 | 0.99 | 0.99 | 0.97 |
| C. Low variation & failure\* | (9, 0.1) | (8,0.l) | (8,0.l) | (8,0.l) | 25 | 25 | 26 | 0/0 | 0/0 | 0/0 | 0.89 | 0.89 | 0.88 |

\*The failure rate, set in station 3, normally is 0.01 (1%), in Cases A4 & B4 it is 0.03 & in Case C it is 0.001. Route time between stations has been preset to 0.5 minutes.

**If you would like to Observe the Simulation in Arena**

Arena runs on Apple and Windows Computers. Arena 7.0 is on Canvas along with 4 Arena models: AGV Operation.doe, 453Hwk10.doe, Flexible Manufacturing.doe, & Drake Bottling.doe.

**General Instructions for ARENA Program** (limited capability “Training/Evaluation version”)

1. Copy Arena to hard drive; unzip, if doesn’t automatically install, run Autorun.exe and use STUDENT for Serial Number.
2. Copy models (AGV Operation.doe, 453Hwk10.doe, Flexible Manufacturing.doe, & Drake Bottling.doe to the Arena Examples folder which for me was in C:\Users\Public\Public Doc\Rockwell Software\ Arena\Examples Some models may already be in the folder, varies with Arena version.
3. Open Arena via Start Menu or icon or Arena.exe in the Arena folder; “OK” the Training/Evaluation Mode dialog box
4. Select “Open”, “Examples” folder, chose “AGV Operation.doe” file; typing “d” will give you a description of operation & “o” will show a schematic of the operation
5. Select “Run” (tool bar), “Go” follow on screen instructions; note animation, runs for 5000+ units; Red parts start at Drill A, then Cutting & Finishing; Blue starts at Drill B.
6. Select “Yes” for view results, note the “Throughput Time (Ave., Min., & Max; and that Min.=~ 1/10 Ave. & Ave. =~1/2 Max)
7. Close “AGV Model” and select “File” “Open” and select “453Hwk10.doe” [from Arena Examples folder]
8. To change service or failure rates click on the box below the service station and set the data per below table. “Simulate” box should be “Rep.”=1, “Length of Rep”=2400
9. Select “Run” & “Go” to run program & watch animation; to run the program quickly but without animation “Run” & “FastFwd”; to increment the program “Run”&“Step”
10. After model completes, select “Yes” to see the results, “Print” under Notepad “File”; Under “Run” Toolbar select “End”, change data and rerun model.
11. Rerunning the model requires selecting “Run” and “End”
12. Run the *Flexible Manufacturing* model noting animation.

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**MEEG653 Students ONLY**-Do Option 1, 2 or 3, for 30 points. The "temporary" total score will be divided by 1.3 to "reset" the maximum/perfect score to 100.

Option 1-make a change to an operation or the whole system and discuss the results.

Option 2-make a Design of Experiments (DOE) factorial design to see the dominate input variables and interactions and discuss the results.

Option 3-do a sensitivity analysis on above results in Cases A1-C, quantitize/quantify the output changes (results) caused by changes to input. Basically a partial differentiation but applied to discrete results rather than continuous function. Comparing A2 results with A1 would show sensitivity of results (system time,

queue, util. rate) to increase in variation of service time at all stations. Similarly compare B2 with B1 but at a higher mean service time. Comparing A4 results with A1 would show sensitivity of results (system time, queue, util. rate) to a higher failure rate. Similarly compare B4 with B1 but at a higher mean service time. Comparing B1 results with A1 would show sensitivity of results (system time, queue, util. rate) to increase in mean service time at all stations.