

Exercise 2-4

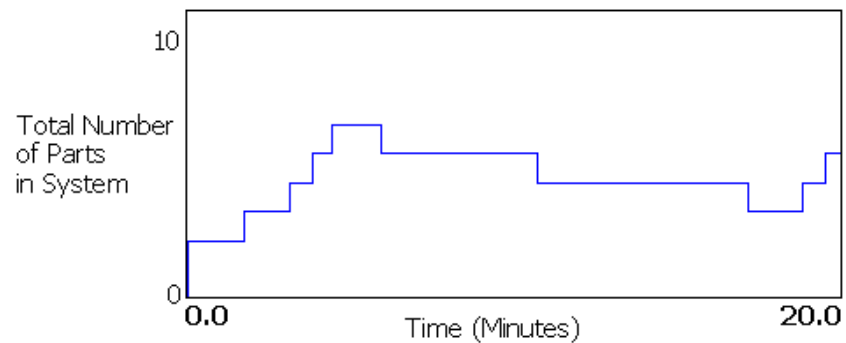
Solution file from Kelton/Sadowski/Zupick, *Simulation With Arena*, 6th edition, McGraw-Hill, 2015

This change simply adds 3 to each service time in Table 2-1, so that they become 5.90, 4.76, 6.39, 7.52, 7.46, 7.36, 5.07, 6.36, 5.37, and 8.38. The hand-simulation table then looks like this (entries whose values or positions are changed due to the new service times are shaded):

Just-Finished Event			Variables		Attributes		Statistical Accumulators									Event Calendar		
Entity No.	Time t	Event Type	$Q(t)$	$B(t)$	Arrival Times: (In Queue) In Service		P	N	ΣWQ	WQ^*	ΣTS	TS^*	$\int Q$	Q^*	$\int B$	[Entity No.,	Time,	Type]
–	0.00	Init	0	0	()	–	0	0	0.00	0.00	0.00	0.00	0.00	0	0.00	[1,	0.00,	Arr]
																[–,	20.00,	End]
1	0.00	Arr	0	1	()	<u>0.00</u>	0	1	0.00	0.00	0.00	0.00	0.00	0	0.00	[2,	1.73,	Arr]
																[1,	<u>5.90</u> ,	Dep]
																[–,	20.00,	End]
2	1.73	Arr	1	1	(1.73)	<u>0.00</u>	0	1	0.00	0.00	0.00	0.00	0.00	1	1.73	[3,	<u>3.08</u> ,	Arr]
																[1,	<u>5.90</u> ,	Dep]
																[–,	20.00,	End]
3	<u>3.08</u>	Arr	2	1	(3.08, 1.73)	<u>0.00</u>	0	1	<u>0.00</u>	<u>0.00</u>	<u>0.00</u>	<u>0.00</u>	<u>1.35</u>	2	<u>3.08</u>	[4,	<u>3.79</u> ,	Arr]
																[1,	<u>5.90</u> ,	Dep]
																[–,	20.00,	End]
4	<u>3.79</u>	Arr	3	1	(3.79, 3.08, 1.73)	<u>0.00</u>	0	1	<u>0.00</u>	<u>0.00</u>	<u>0.00</u>	<u>0.00</u>	<u>2.77</u>	3	<u>3.79</u>	[5,	<u>4.41</u> ,	Arr]
																[1,	<u>5.90</u> ,	Dep]
																[–,	20.00,	End]
5	<u>4.41</u>	Arr	4	1	(4.41, 3.79, 3.08, 1.73)	<u>0.00</u>	0	1	<u>0.00</u>	<u>0.00</u>	<u>0.00</u>	<u>0.00</u>	<u>4.63</u>	4	<u>4.41</u>	[1,	<u>5.90</u> ,	Dep]
																[6,	<u>18.69</u> ,	Arr]
																[–,	20.00,	End]
1	<u>5.90</u>	Dep	3	1	(4.41, 3.79, 3.08)	<u>1.73</u>	1	2	<u>4.17</u>	<u>4.17</u>	<u>5.90</u>	<u>5.90</u>	<u>10.59</u>	4	<u>5.90</u>	[2,	<u>10.66</u> ,	Dep]
																[6,	<u>18.69</u> ,	Arr]
																[–,	20.00,	End]
2	<u>10.66</u>	Dep	2	1	(4.41, 3.79)	<u>3.08</u>	2	3	<u>11.75</u>	<u>7.57</u>	<u>14.83</u>	<u>8.93</u>	<u>24.87</u>	4	<u>10.66</u>	[3,	<u>17.05</u> ,	Dep]
																[6,	<u>18.69</u> ,	Arr]
																[–,	20.00,	End]
3	<u>17.05</u>	Dep	1	1	(4.41)	<u>3.79</u>	3	4	<u>25.01</u>	<u>13.26</u>	<u>28.80</u>	<u>13.96</u>	<u>37.65</u>	4	<u>17.05</u>	[6,	<u>18.69</u> ,	Arr]
																[–,	20.00,	End]
																[4,	<u>24.57</u> ,	Dep]
6	<u>18.69</u>	Arr	2	1	(18.69, 4.41)	<u>3.79</u>	3	4	<u>25.01</u>	<u>13.26</u>	<u>28.80</u>	<u>13.96</u>	<u>39.29</u>	4	<u>18.69</u>	[7,	<u>19.39</u> ,	Arr]
																[–,	20.00,	End]
																[4,	<u>24.57</u> ,	Dep]
7	<u>19.39</u>	Arr	3	1	(19.39, 18.69, 4.41)	<u>3.79</u>	3	4	<u>25.01</u>	<u>13.26</u>	<u>28.80</u>	<u>13.96</u>	<u>40.69</u>	4	<u>19.39</u>	[–,	20.00,	End]
																[4,	<u>24.57</u> ,	Dep]
																[8,	<u>34.91</u> ,	Arr]
–	20.00	End	3	1	(19.39, 18.69, 4.41)	<u>3.79</u>	3	4	<u>25.01</u>	<u>13.26</u>	<u>28.80</u>	<u>13.96</u>	<u>42.52</u>	4	20.00	[4,	<u>24.57</u> ,	Dep]
																[8,	<u>34.91</u> ,	Arr]

Here are the summary results:

Performance Measure	Value	Result from Table 2-3	Change
Total production	3 parts	5 parts	Decreased
Average waiting time in queue	$25.01/4 = 6.25$ minutes per part (4 parts)	2.53 minutes per part (6 parts)	Increased
Maximum waiting time in queue	13.26 minutes	8.16 minutes	Increased
Average total time in system	$28.80/3 = 9.60$ minutes per part (3 parts)	6.44 minutes per part (5 parts)	Increased
Maximum total time in system	13.96 minutes	12.62 minutes	Increased
Time-average number of parts in queue	$42.52/20 = 2.13$ parts	0.79 part	Increased
Maximum number of parts in queue	4 parts	3 parts	Increased
Drill-press utilization	1.00 (dimensionless proportion)	0.92 (dimensionless proportion)	Increased



So, as expected, these longer “service” times make the system more congested by all measures (though, depending on the random bounce, this might not happen in every case for every measure) and reduce production over this fixed 20-minute time span.