Simio Spring 2016 Student Competition

Aerospace Manufacturing Problem

Simio
Forward Thinking

Problem Overview

An aerospace manufacturer is evaluating planned changes to their final assembly systems. Their process line has multiple work stations, each with a statement of work consisting of 5 to 20 aggregated tasks. Each task has unique requirements for labor, tools and material handling. The system is schedule driven, so any work not completed at the time the line pulses will be "traveled" downstream since airplanes simply go from one location to the next according to the cycle time, regardless of whether or not all the work is finished by the specified time. Production policies regarding this traveled work is one of the items to be evaluated during this project. The manufacturing process is labor-intensive with a steep learning-curve, and work in process is costly. Therefore, process improvement in the areas of labor productivity and reduction of work in process is critical.

The process currently has two established product types and the company plans to add a new product type to the process. There is a possibility that an additional production line could be added to support the addition of the third product type.

The analysis will include the final assembly of 75 airplanes, where the probability of an airplane being product type 1 is 60% and the probability of an airplane being product type 2 is 40%. Assume that the system starts empty and idle. A new airplane is introduced to the line every 4 days and therefore each airplane must move to the next location every 4 days, regardless of whether or not all of the work at that location is finished. Any work not completed at that point must be addressed at the next location and is considered "traveled work". The traveled work is addressed at the next location, however it is done by the mechanics from the previous location since they are trained in those particular tasks. The current cell's tasks can be done concurrently with any traveled work that arrives at the work cell. There is no buffer space built into the production systems – airplanes simply go from one location to the next according to the cycle time and if the tasks are completed before the cycle time, the airplane waits at that location and does not move forward until the specified time.

This final assembly model contains five work cell locations that are in series and following is an example of the tasks required at the first of the five work cells. In this example, there are 19 tasks that must be performed. Some of the tasks can be done in parallel but others must wait for certain tasks to be completed before they may begin. For example, the first three tasks can all be performed at the same time. The next two tasks can also be performed at the same time, but only after the first three have all been completed. The Sequence # field can be used with Simio's Task Sequence feature, if desired, to dictate the precedence rules of each work cell location. The data for the remaining locations can be found in the Excel data file that was provided with this problem.

Work Cell Location #1

Seq #	Task	LaborHours Part Type1	LaborHours PartType2	Mechanics Required
1	T-Clips to assembly	Random.Triangular(1.98,2.2,2.42)	Random.Triangular(1.98,2.2,2.42)	2
1	Upper Web	Random.Triangular(1.98,2.2,2.42)	Random.Triangular(1.98,2.2,2.42)	3
1	Upper TV Chord Assembly	Random.Triangular(2.07,2.3,2.53)	Random.Triangular(2.07,2.3,2.53)	2
2	Tv-Guid Fittings	Random.Triangular(10.3,12.1,13.4)	Random.Triangular(10.3,12.1,13.4)	3
2	T-Clips indexed	Random.Triangular(1.53,1.7,1.87)	Random.Triangular(1.53,1.7,1.87)	2
3	Guide Splice Operation	Random.Triangular(1.62,1.8,1.98)	Random.Triangular(1,1.2,1.45)	2
4	CRES Splices to the upper chord	Random.Triangular(1.8,2,2.2)	Random.Triangular(1.8,2,2.2)	3
4	Load drill bars	Random.Triangular(16,18,19)	Random.Triangular(14,16,18)	2
4	Drill holes to Upper T-Chord Assembly	Random.Triangular(1.89,2.1,2.31)	Random.Triangular(1.89,2.1,2.31)	2
5	Drill holes to Guide Fittings	Random.Triangular(2.34,2.6,2.86)	Random.Triangular(2.34,2.6,2.86)	2
6	Remove Drill bars	Random.Triangular(9,10,11)	Random.Triangular(9,11,12)	4
6	Temp fastener	Random.Triangular(1.71,1.9,2.09)	Random.Triangular(1.71,1.9,2.09)	2
7	Drill holes into the Guide fittings	Random.Triangular(1.35,1.5,1.65)	Random.Triangular(1.35,1.5,1.65)	5
7	Straps into Guilde Fittings	Random.Triangular(5,6.5,7.2)	Random.Triangular(5,6.5,7.2)	2
8	Disassemble and Deburr Chord	Random.Triangular(0.72,0.8,0.88)	Random.Triangular(0.72,0.8,0.88)	2
9	Fillet Relef Bulkhead	Random.Triangular(21,25.2,27)	Random.Triangular(9,11.5,14)	3
10	Countersink hole locations in Guide Fittings	Random.Triangular(1.53,1.7,1.87)	Random.Triangular(1.53,1.7,1.87)	2
10	Inspect Holes	Random.Triangular(0.72,0.8,0.88)	Random.Triangular(0.72,0.8,0.88)	2
11	Clean	Random.Triangular(0.45,0.5,0.55)	Random.Triangular(0.45,0.5,0.55)	4

There is a feeder line that brings airplane wings into this production line so that they can be combined at Work Cell location 3. None of the tasks at Work Cell 3 can begin until a set of wings is available at this Work Cell. Wing sets arrive about 72 hours apart – assume they are normally distributed with a standard deviation of 5 hours and they are produced during all three shifts, Monday through Friday. Assume there is space for the wing sets to wait if they arrive and cannot be used immediately by Work Cell 3.

The first six tasks in Work Cell 3 require an overhead crane. The crane must be available to be used by Work Cell 3 before the first task (Operator obtains crane & attach) begins and it must stay at Work Cell 3 until the sixth task (Install Tack Fastener) is finished. A second production line would require coordination of this overhead crane because it would need to be shared between Work Cell 3 in both lines.

There are currently 8 mechanics working at each work cell location during each shift. The facility is currently following the Two Shift work schedule where all of the mechanics work first shift and second shift. The third shift is not currently being used. Assume that each mechanic stops working on their task immediately when their shift ends. The specifics of the work schedule are as follows:

First Shift: 6:00am – 10:00am / 10:30am-2:30pm
Second Shift: 2:30pm – 6:30pm / 7:00pm – 10:00pm
Third Shift: 11:00pm – 3:00am / 3:30am – 6:00am

Assume the existing 8 mechanics are skilled at each task and they are past any learning curve, but any additional staff would have a 90% learning curve for all process times. You may use a standard learning curve equation, such as Wright's model.

This manufacturer would like to evaluate how it currently handles traveled work and if there are any efficiencies to be gained by making process changes to traveled work. For example, should they continue to pull mechanics from the previous location to work on traveled work or should they use mechanics at the current location? Or should they use a combination of the two groups of mechanics? It should be noted that if mechanics at the current location are used for traveled work, the time required to finish each traveled work task is increased by 20% to account for the inefficiencies and learning curves.

This aerospace manufacturer plans to introduce a third product type to this final assembly facility and they are evaluating whether or not the new product can be run on the existing production line or if they will need to add a second, identical line. Production will increase from 75 airplanes to 100 airplanes, where the additional 25 airplanes are this new product type. They would like to try and complete this new level of demand in the same amount of time. Therefore, if this new product type is added to the existing production line, the cycle time would need to be reduced from 4 days to 3.5 days.

System Improvements and Analysis

- Can the current production line handle this change or should a second production line be considered?
- The addition of a third shift could be considered and the addition of more mechanics at each location, however, because of space requirements, each work cell can have a maximum of 12 mechanics.
- Overtime could be considered as an option. The first two shifts can be run on Saturdays and/or Sundays.
- Labor hours for this new product type are unknown therefore assume they are the same as Product Type 1.

Challenges:

- Consider allowing for a different number of mechanics at each work location to see if the total number of required mechanics can be reduced.
- The manufacturer is willing to consider dedicating certain mechanics to only work on traveled work as opposed to mechanics that are shared between the standard work cell tasks and the traveled work. Would this policy change allow for any improvements, such as a reduction in the total number of mechanics or an opportunity to reduce the cycle time?
- Analysis and details on whether or not improvement in the arrivals of the wing sets would improve this system.
- Any other suggestions for improvement are welcomed and encouraged.

Data

WorkCell1				
Seq #	Task	LaborHours Part Type1	LaborHours PartType2	Mechanics Required
1	T-Clips to assembly	Random.Triangular(1.98,2.2,2.42)	Random.Triangular(1.98,2.2,2.42)	2
1	Upper Web	Random.Triangular(1.98,2.2,2.42)	Random.Triangular(1.98,2.2,2.42)	3
1	Upper TV Chord Assembly	Random.Triangular(2.07,2.3,2.53)	Random.Triangular(2.07,2.3,2.53)	2
2	Tv-Guid Fittings	Random.Triangular(10.3,12.1,13.4)	Random.Triangular(10.3,12.1,13.4)	3
2	T-Clips indexed	Random.Triangular(1.53,1.7,1.87)	Random.Triangular(1.53,1.7,1.87)	2
3	Guide Splice Operation	Random.Triangular(1.62,1.8,1.98)	Random.Triangular(1,1.2,1.45)	2
4	CRES Splices to the upper chord	Random.Triangular(1.8,2,2.2)	Random.Triangular(1.8,2,2.2)	3
4	Load drill bars	Random.Triangular(16,18,19)	Random.Triangular(14,16,18)	2
4	Drill holes to Upper T-Chord Assembly	Random.Triangular(1.89,2.1,2.31)	Random.Triangular(1.89,2.1,2.31)	2
5	Drill holes to Guide Fittings	Random.Triangular(2.34,2.6,2.86)	Random.Triangular(2.34,2.6,2.86)	2
6	Remove Drill bars	Random.Triangular(9,10,11)	Random.Triangular(9,11,12)	4
6	Temp fastener	Random.Triangular(1.71,1.9,2.09)	Random.Triangular(1.71,1.9,2.09)	2
7	Drill holes into the Guide fittings	Random.Triangular(1.35,1.5,1.65)	Random.Triangular(1.35,1.5,1.65)	5
7	Straps into Guilde Fittings	Random.Triangular(5,6.5,7.2)	Random.Triangular(5,6.5,7.2)	2
8	Disassemble and Deburr Chord	Random.Triangular(0.72,0.8,0.88)	Random.Triangular(0.72,0.8,0.88)	2
9	Fillet Relef Bulkhead	Random.Triangular(21,25.2,27)	Random.Triangular(9,11.5,14)	3
10	Countersink hole locations in Guide Fittings	Random.Triangular(1.53,1.7,1.87)	Random.Triangular(1.53,1.7,1.87)	2
10	Inspect Holes	Random.Triangular(0.72,0.8,0.88)	Random.Triangular(0.72,0.8,0.88)	2
11	Clean	Random.Triangular(0.45,0.5,0.55)	Random.Triangular(0.45,0.5,0.55)	4

Data

WorkCell2				
Seq #	Task	LaborHours Part Type1	LaborHours PartType2	Mechanics Required
1	LH BULKHEAD ASSY	Random.Triangular(1.98,2.2,2.42)	Random.Triangular(2.1,2.8,3.17)	2
1	Operator turn table and rotate to position	Random.Triangular(5,6.5,7.2)	Random.Triangular(4.3,5.5,6.8)	3
2	Scanner	Random.Triangular(2.07,2.3,2.53)	Random.Triangular(2.07,2.3,2.53)	2
2	TV-CHORD ASSY RH and close clamps	Random.Triangular(2.07,2.3,2.53)	Random.Triangular(2.07,2.3,2.53)	2
2	RH BULKHEAD ASSY	Random.Triangular(1.53,1.7,1.87)	Random.Triangular(1.4,1.7,1.8)	3
3	Operator turn table and rotate to position	Random.Triangular(16.2,18,19.8)	Random.Triangular(16.2,18,19.8)	2
3	Scan twice	Random.Triangular(1.8,2,2.2)	Random.Triangular(1.8,2,2.2)	3
4	Position upper subassembly	Random.Triangular(12,13.5,13.9)	Random.Triangular(9,11.2,13.6)	2
4	Rotate table	Random.Triangular(1.89,2.1,2.31)	Random.Triangular(1.89,2.1,2.31)	2
5	Scan	Random.Triangular(8.4,10.1,12.6)	Random.Triangular(8.4,10.1,12.6)	3
5	Drill Pilot hole	Random.Triangular(0.9,1,1.1)	Random.Triangular(1,2.2,4.1)	2
6	Locate Fire Shield splice	Random.Triangular(12,15,17)	Random.Triangular(13.2,15,17.5)	3
6	Install Tack Fastener	Random.Triangular(1.35,1.5,1.65)	Random.Triangular(1.35,1.5,1.65)	2
7	Rotate table	Random.Triangular(5,6.5,7.2)	Random.Triangular(5,6.5,7.2)	4
8	Scan	Random.Triangular(0.72,0.8,0.88)	Random.Triangular(0.72,0.8,0.88)	2
8	Drill Pilot hole	Random.Triangular(16,18,19.5)	Random.Triangular(16,18,19.5)	4
9	LH Chords	Random.Triangular(1.53,1.7,1.87)	Random.Triangular(1.4,1.9,2.3)	2
10	Measure gap	Random.Triangular(7,11,12.5)	Random.Triangular(7,11,12.5)	3
11	LWR BULKHEAD ASSY	Random.Triangular(0.45,0.5,0.55)	Random.Triangular(0.45,0.5,0.55)	1
11	Drill LH and RH holes	Random.Triangular(1.71,1.9,2.09)	Random.Triangular(1.71,1.9,2.09)	1

Data

WorkCell3				
Seq #	Task	LaborHours Part Type1	LaborHours PartType2	Mechanics Required
1	Install Tack Fastener	Random.Triangular(1.98,2.2,2.42)	Random.Triangular(1.33,2.25,2.98)	2
1	Stack light turns Green	Random.Triangular(5,6.5,7.2)	Random.Triangular(4.2,5.4,6.23)	3
1	Attach clips wing set RH	Random.Triangular(2.07,2.3,2.53)	Random.Triangular(2.07,2.3,2.53)	2
2	Attach clips wing set LH	Random.Triangular(2.07,2.3,2.53)	Random.Triangular(2.1,2.45,2.58)	2
2	Splice the LWR/RH Chords	Random.Triangular(1.53,1.7,1.87)	Random.Triangular(1.53,1.7,1.87)	2
3	Install Tack Fastener	Random.Triangular(1.62,1.8,1.98)	Random.Triangular(1.2,1.34,1.6)	2
4	Tools dump Zone 2 Clamps	Random.Triangular(1.8,2,2.2)	Random.Triangular(1.2,3.3,4.1)	3
4	Robot Syncing	Random.Triangular(12,13.4,14.2)	Random.Triangular(15,16.4,17)	2
4	Drill 8 holes	Random.Triangular(1.89,2.1,2.31)	Random.Triangular(1.89,2.1,2.31)	2
5	Tool dump Zone 4 Clamps	Random.Triangular(2.34,2.6,2.86)	Random.Triangular(2.44,2.65,3.6)	2
6	Robot Syncing	Random.Triangular(4,6.3,7.1)	Random.Triangular(3.3,5.4,6.1)	5
6	Drill 8 holes	Random.Triangular(12,15,17)	Random.Triangular(10,12,15)	2
7	Tool dump Zone 6 Clamps	Random.Triangular(1.35,1.5,1.65)	Random.Triangular(1.35,1.5,1.65)	4
7	Robot Syncing	Random.Triangular(2,4.3,5.2)	Random.Triangular(5,6.5,7.2)	2
8	Drill 10 holes	Random.Triangular(0.72,0.8,0.88)	Random.Triangular(0.72,0.8,0.88)	2
9	Tool dump Zone 8 Clamps	Random.Triangular(16.25,18,19.5)	Random.Triangular(16.25,18,19.5)	3
10	Robot Syncing	Random.Triangular(1.53,1.7,1.87)	Random.Triangular(1.44,2.3,3.1)	2
10	Drill 8 holes	Random.Triangular(3,4,5)	Random.Triangular(3.5,4.5,5.5)	3
11	Tool dump Zone 10 Clamps	Random.Triangular(0.45,0.5,0.55)	Random.Triangular(0.45,0.5,0.55)	1

Data

WorkCell4				
Seq #	Task	LaborHours Part Type1	LaborHours PartType2	Mechanics Required
1	Operator Unloads	Random.Triangular(1.88,2.62,2.82)	Random.Triangular(1.33,2.25,2.98)	2
1	Get inner assembly	Random.Triangular(5.2,6.54,7.12)	Random.Triangular(4.2,5.4,6.23)	4
2	Close Inner Barrel Clamps	Random.Triangular(2.07,2.3,2.53)	Random.Triangular(2.07,2.3,2.53)	2
2	Open Lift assist clamps	Random.Triangular(2.1,2.45,2.58)	Random.Triangular(2.1,2.45,2.58)	2
3	Locate Aft Bulkhead Assy	Random.Triangular(1.53,1.7,1.87)	Random.Triangular(1.53,1.7,1.87)	2
3	Close Manual clamps	Random.Triangular(1.62,1.8,1.98)	Random.Triangular(1.2,1.34,1.6)	2
3	Locate & close clip	Random.Triangular(18,20,22)	Random.Triangular(13.2,15.3,16)	4
4	Drill Bulkhead to Inner Angle	Random.Triangular(1.6,1.8,1.9)	Random.Triangular(1.6,1.8,1.9)	2
4	Open DJ clps	Random.Triangular(1.89,2.1,2.31)	Random.Triangular(1.89,2.1,2.31)	2
5	Remove DJ	Random.Triangular(2.34,2.6,2.86)	Random.Triangular(2.44,2.65,3.6)	2
6	Open manual clamps	Random.Triangular(0.9,1,1.1)	Random.Triangular(0.9,1,1.1)	2
6	Remove BLKD assys	Random.Triangular(12,15,17)	Random.Triangular(10,12,15)	3
6	Opens inner barrel	Random.Triangular(1.35,1.5,1.65)	Random.Triangular(1.35,1.5,1.65)	2
7	Deburr AFT BLKD	Random.Triangular(5,6.5,7.2)	Random.Triangular(5,6.5,7.2)	4
8	Inspection of Holes	Random.Triangular(0.72,0.8,0.88)	Random.Triangular(0.72,0.8,0.88)	2
9	Attach MHE	Random.Triangular(16.25,18,19.5)	Random.Triangular(16.25,18,19.5)	4
9	Press button	Random.Triangular(1.53,1.7,1.87)	Random.Triangular(1.44,2.3,3.1)	2
10	Close clamps	Random.Triangular(0.9,1,1.1)	Random.Triangular(0.9,1,1.1)	3
11	Unload inner barrel	Random.Triangular(0.45,0.5,0.55)	Random.Triangular(0.45,0.5,0.55)	1
11	Move inner barrel	Random.Triangular(1.71,1.9,2.09)	Random.Triangular(1.71,1.9,2.09)	3

Data

WorkCell5				
Seq #	Task	LaborHours Part Type1	LaborHours PartType2	Mechanics Required
1	Robot moves to position 1	Random.Triangular(1.98,2.2,2.42)	Random.Triangular(1.98,2.2,2.42)	2
1	Turntable rotates	Random.Triangular(1.98,2.2,2.42)	Random.Triangular(1.98,2.2,2.42)	3
2	Robot moves to its target position	Random.Triangular(2.07,2.3,2.53)	Random.Triangular(2.07,2.3,2.53)	2
2	Perform local drill	Random.Triangular(2.25,2.5,2.75)	Random.Triangular(2.25,2.5,2.75)	2
3	Secure final fastener	Random.Triangular(1.53,1.7,1.87)	Random.Triangular(1.53,1.7,1.87)	2