A Pencil-Paper-People-Programs (4P) JobshopLean Simulation

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Overview of the Simulation

There appears to be no simple and effective simulation that exposes the management and workforce of a jobshop to the range of best practices that truly address their operational conditions, such as non-repetitive production of components, different manufacturing routings, low-to-medium production volumes, uncertain and/or variable demand, due dates, product routings with operations that have different setup and cycle times at their workcenters, etc. Standard Lean simulations available in the market are expensive, have a steep learning curve and **erroneously** equate a low-mix assembly factory to a jobshop! This JobshopLean Simulation uses a simple hypothetical multi-machine multi-product jobshop to teach a variety of best practices that have been proven to work in high-mix low-volume environments. Some of these best practices that our simulation will attempt to teach are:

- **Product Mix Segmentation:** P-Q Analysis and From-To Charts to identify those products that contribute most to transportation costs, P-$ Analysis or P-Q-$ Analysis to prioritize which products to make or eliminate, etc.
- **Product Mix Rationalization:** Detection of and process-re-engineering to eliminate "misfit" routings, detection and elimination of exception operations in manufacturing routings, part family formation for identification of shared machines and inter-cell flows, etc.
- **Facility Layout:** Product-Process Matrix Analysis to identify part families and design manufacturing cells, design of a U-shaped layout for a cell to produce any clear-cut stable part family, Flexible ***and*** Lean facility layouts that are part-Process and part-Cellular, impact of travel distance on the feasibility of using Transfer Batches instead of Process Batches, etc.
- **Material Handling and Shopfloor Control for Inter-Cell Flow Management:** Water striders and visual communications, locations for inventory buffers, queue management at constraint workcenters, etc.
- **Cross-training and teaming among machine operators:** A cell is not the only mechanism for cross-training employees. How about the idea of fractional cells (or layout modules)?
- **Finite Capacity Scheduling:** In what order and at what times to release jobs into the jobshop? In what order to sequence jobs in queue for processing at constraint workcenters? Which machine/s are the bottleneck/s? How do performance measures impact production schedules and shopfloor priorities ex. due dates vs. profit maximization? How can Work Order Release prevent Push scheduling as well as overloading the constraint workcenters? etc.
- .... and much more!

Here are additional distinguishing features of this simulation:

1. It has negligible cost of materials.
2. It can be easily customized to focus on certain best practices that a jobshop wishes to deploy first in their facility.

3. *It can easily incorporate features to demonstrate the absolute necessity for "Square One" improvements i.e. the elimination or reduction of standard operational problems such as scrap/rework, machine breakdown, operator absenteeism, lack of management vision, etc.*
4. It utilizes several software tools (whose demo/student versions are either available at no cost or at a reasonable price) to perform rapid what-if analyses that are essential to evaluate alternative configurations and operational policies to improve any jobshop.

In the spirit of ***continuous*** improvement, we welcome any and all feedback, criticism or suggestions to improve this simulation!

Production Data for the Facility

Part #	MANUFACTURING ROUTING FOR THE PART X[##] = Processing Time of ## for that operation performed on Machine X	Quantity (Volume)	Unit Selling Price	Revenue[1] (Sales)
1	1[24]→4[9]→8[9]→9[18]	2	$100	$200
2	1[9]→4[30]→7[50]→4[75]→8[6]→7[5]	3	$200	$600
3	1[24]→2[12]→4[96]→7[30]→8[9]→9[18]	1	$600	$600
4	1[24]→4[9]→7[30]→9[18]	3	$190	$570
5	1[24]→6[18]→10[50]→7[30]→9[18]	2	$375	$750
6	6[9]→10[30]→7[15]→8[6]→9[9]	1	$450	$450
7	6[18]→4[36]→8[48]→9[48]	2	$250	$500
8	3[144]→5[30]→2[12]→6[18]→4[96]→8[12]→9[12]	1	$275	$275
9	3[36]→5[30]→6[18]→4[9]→8[12]→9[12]	1	$500	$500
10	4[30]→7[5]→4[30]→8[6]	2	$325	$650
12	11[48]→7[40]→12[20]	1	$250	$250
13	11[48]→12[15]	1	$825	$825
14	11[72]→7[45]→10[60]	3	$225	$675
15	1[4]→7[17]→11[14]→10[13]→11[13]→12[7]	3	$700	$2100
17	11[48]→7[40]→12[20]	1	$750	$750
18	6[27]→7[45]→10[90]	3	$300	$900

[1] Revenue = Quantity * Unit Selling Price

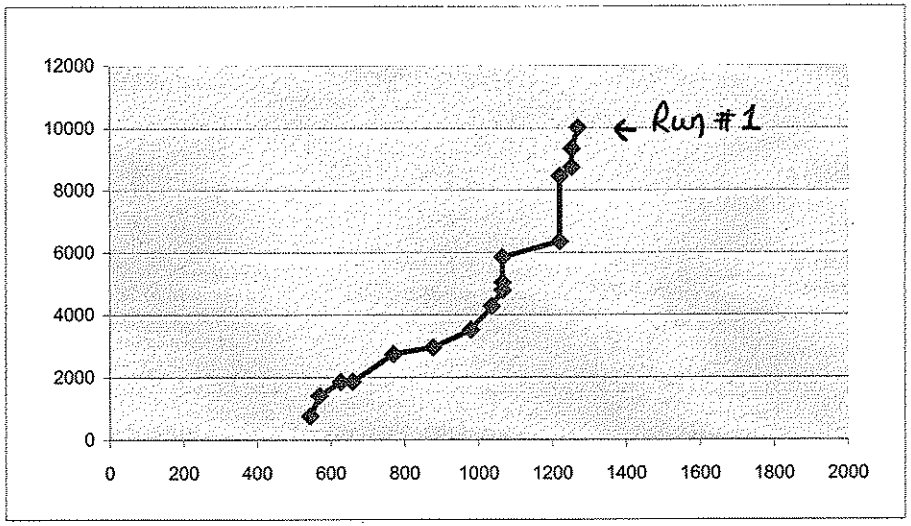
Flow Times for Jobs Processed in the Facility

PART #	FLOW TIME				EARNINGS ($)
	Start Time		Finish Time		
1	1 of 2		1 of 2		
	2 of 2		2 of 2		
2	1 of 3		1 of 3		
	2 of 3		2 of 3		
	3 of 3		3 of 3		
3	1 of 1		1 of 1		
4	1 of 3		1 of 3		
	2 of 3		2 of 3		
	3 of 3		3 of 3		
5	1 of 2		1 of 2		
	2 of 2		2 of 2		
6	1 of 1		1 of 1		
7	1 of 2		1 of 2		
	2 of 2		2 of 2		
8	1 of 1		1 of 1		
9	1 of 1		1 of 1		
10	1 of 2		1 of 2		
	2 of 2		2 of 2		
12	1 of 1		1 of 1		
13	1 of 1		1 of 1		
14	1 of 3		1 of 3		
	2 of 3		2 of 3		
	3 of 3		3 of 3		
15	1 of 3		1 of 3		
	2 of 3		2 of 3		
	3 of 3		3 of 3		
17	1 of 1		1 of 1		
18	1 of 3		1 of 3		
	2 of 3		2 of 3		
	3 of 3		3 of 3		

Route Sheet for Part #1

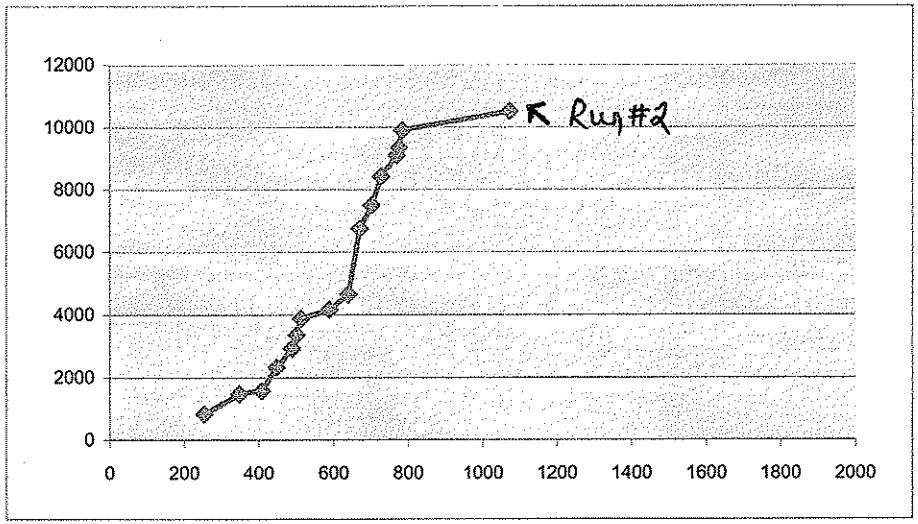
Part #1	Lot Size: 2	1 of 2	
Operation #	Machine Used	Process Time	
1	1	24	
2	4	9	
3	8	9	
4	9	18	

Part No.	$	Agg.$	Min.	Sec.	Agg. Time (Sec.)
17	750	750	9	5	545
10	650	1400	9	30	570
6	450	1850	10	28	628
2	0	1850	11	0	660
18	900	2750	12	50	770
1	200	2950	14	38	878
4	570	3520	16	20	980
5	750	4270	17	16	1036
9	500	4770	17	45	1065
12	250	5020	17	45	1065
13	825	5845	17	45	1065
7	500	6345	20	20	1220
15	2100	8445	20	20	1220
8	275	8720	20	52	1252
3	600	9320	20	53	1253
14	675	9995	21	10	1270
	0	9995			1270
	0	9995			1270
	0	9995			1270



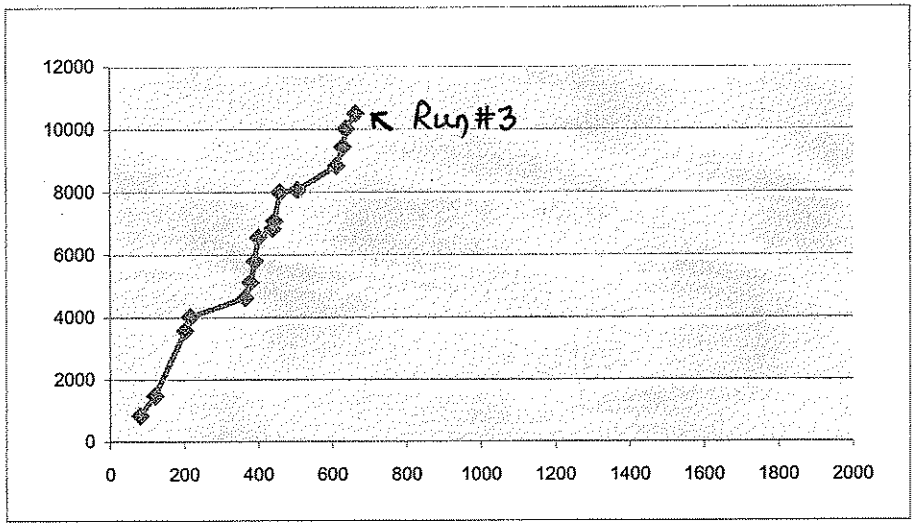
Total Earnings / Schedule Makespan	=	7.87
9995 / 1270		

Part No.	$	Agg.$	Min.	Sec.	Agg. Time (Sec.)
13	825	825	4	14	254
10	650	1475	5	49	349
1	100	1575	6	48	408
5	750	2325	7	28	448
3	600	2925	8	8	488
6	450	3375	8	21	501
9	500	3875	8	32	512
8	275	4150	9	50	590
7	500	4650	10	40	640
15	2100	6750	11	10	670
17	750	7500	11	42	702
18	900	8400	12	7	727
14	675	9075	12	50	770
12	250	9325	12	56	776
4	570	9895	13	4	784
2	600	10495	17	52	1072
	0	10495			1072
	0	10495			1072
	0	10495			1072

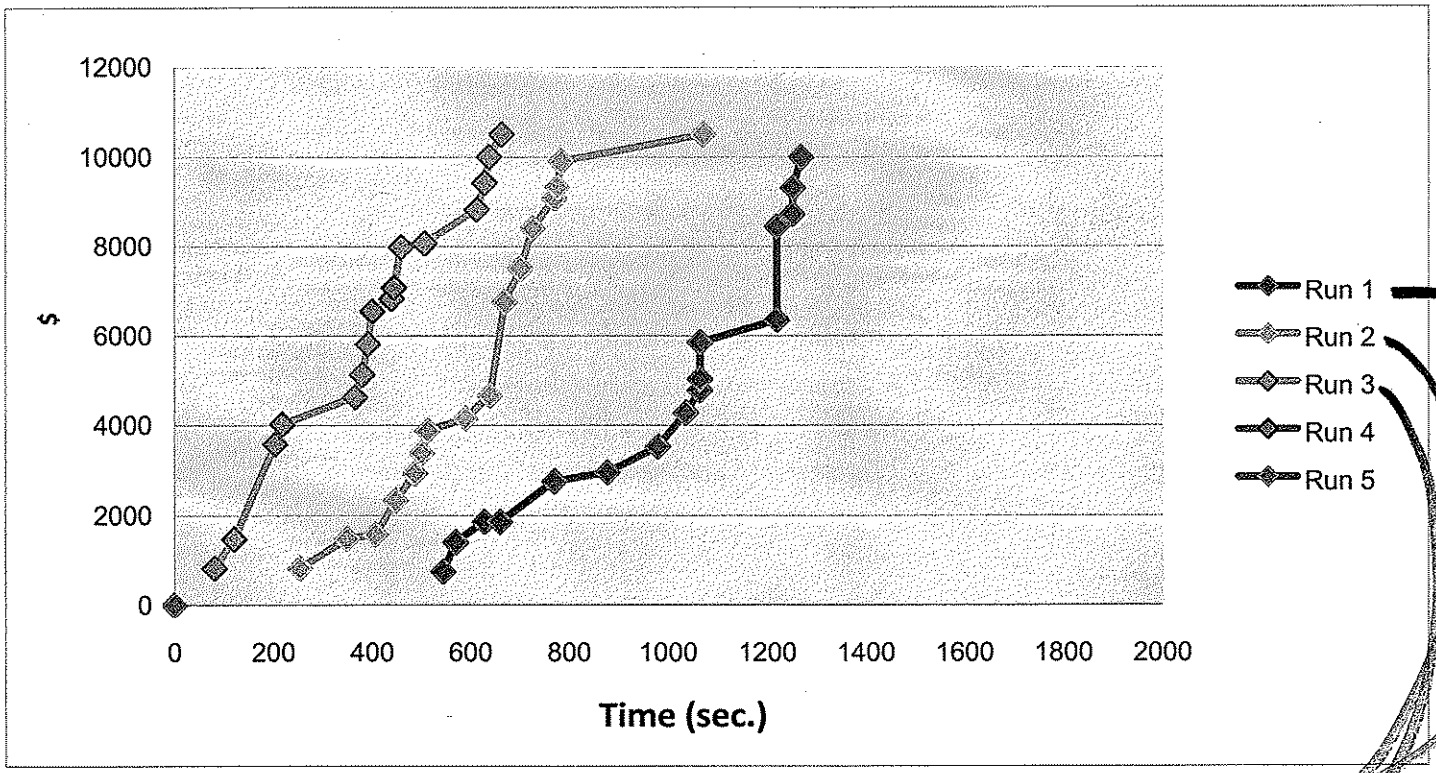


Total Earnings / Schedule Makespan	10495 / 1072	=	9.79

Part No.	$	Agg.$	Min.	Sec.	Agg. Time (Sec.)
13	825	825	1	21	81
10	650	1475	2	1	121
15	2100	3575	3	24	204
6	450	4025	3	38	218
3	600	4625	6	6	366
9	500	5125	6	20	380
14	675	5800	6	32	392
17	750	6550	6	41	401
8	275	6825	7	20	440
12	250	7075	7	25	445
18	900	7975	7	39	459
1	100	8075	8	27	507
5	750	8825	10	13	613
2	600	9425	10	29	629
4	570	9995	10	38	638
7	500	10495	11	4	664
	0	10495			664
	0	10495			664
	0	10495			664



Total Earnings	10495	=	15.81
Schedule Makespan	664		



	Total Earnings	Schedule Makespan (Sec)	Ratio	Improvement
Run 1	9995	1270	7.87	
Run 2	10495	1072	9.79	24%
Run 3	10495	664	15.81	101%
Run 4	0	0	#DIV/0!	#DIV/0!
Run 5	0	0	#DIV/0!	#DIV/0!