

# Introduction

The manufacturing industry has been growing more complex and technical in recent years, sewing industry is an important section of textile industry. It includes a wide range of operations such as cutting fabric, using different machines to assemble fabric pieces, attaching different accessories such as buttons, checking, and packaging.

This study is focused on one production line that produces one product (surgical Gowns). This line faces many problems such as: bottlenecking, product shortage and waste. These problems affect the efficiency and productivity of sewing line, so applying Simulation and Lean techniques is an effective approach to balance the production line, minimize waste and increase efficiency.

# Problem Statement

Sewing section is exposed to various problems since most tasks are complex, labor intensive and are operated over extended (long) operations.

One of the common problems in most industries is excessive Work in Process parts (WIP), as the result of bottleneck stations. WIP products lead to imbalance situation in production line, and it yields increases in costs, wasting resources and reduction in profit.

In this study, we focus on detecting the bottleneck by simulation then implement lean techniques to eliminate it and to increase the productivity of the line to reach the targeted weekly demand.

# Project Aim and Objectives

The general objective of this study is to analyze and optimize the sewing line using simulation and lean techniques. The specific objectives of the study can be summarized as follows.

Visit the factory to collect the needed data and adjust it for modeling.

Model and simulate the sewing line.

Identify the bottleneck in the production line.

Carry out scenario analysis and find out optimal solutions.

Implement the chosen solution.

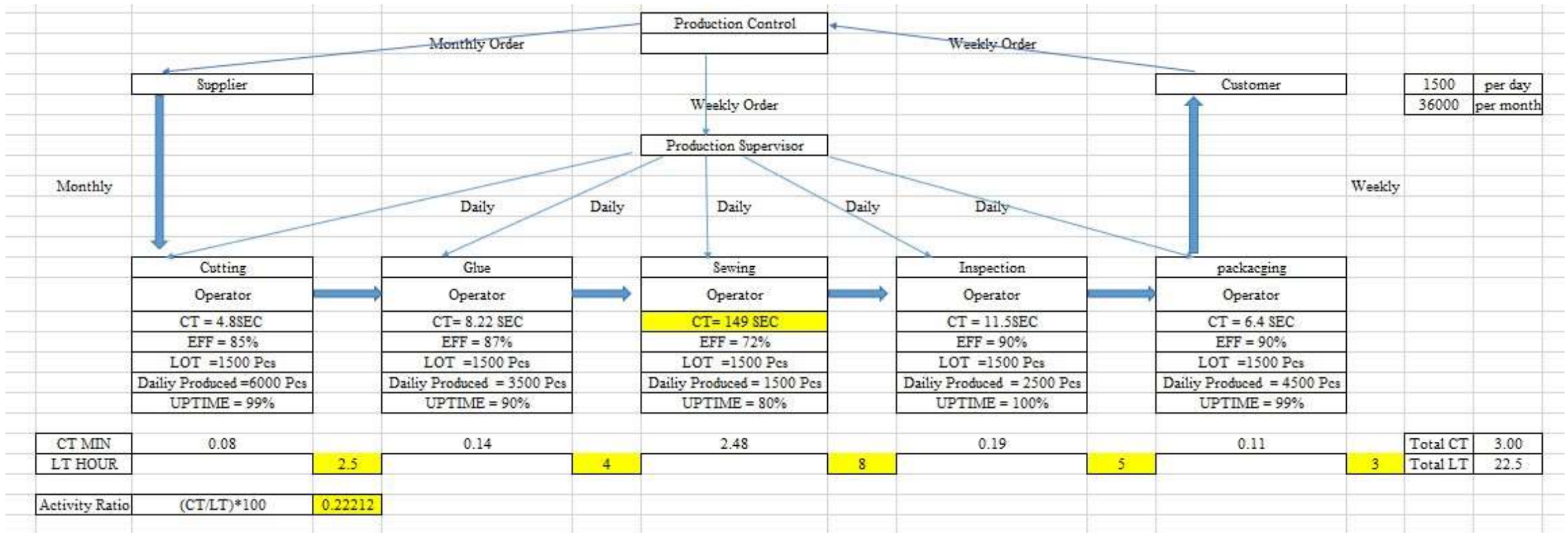
Investigate the effect of the new workflow on the existing sewing line.

# Company Profile

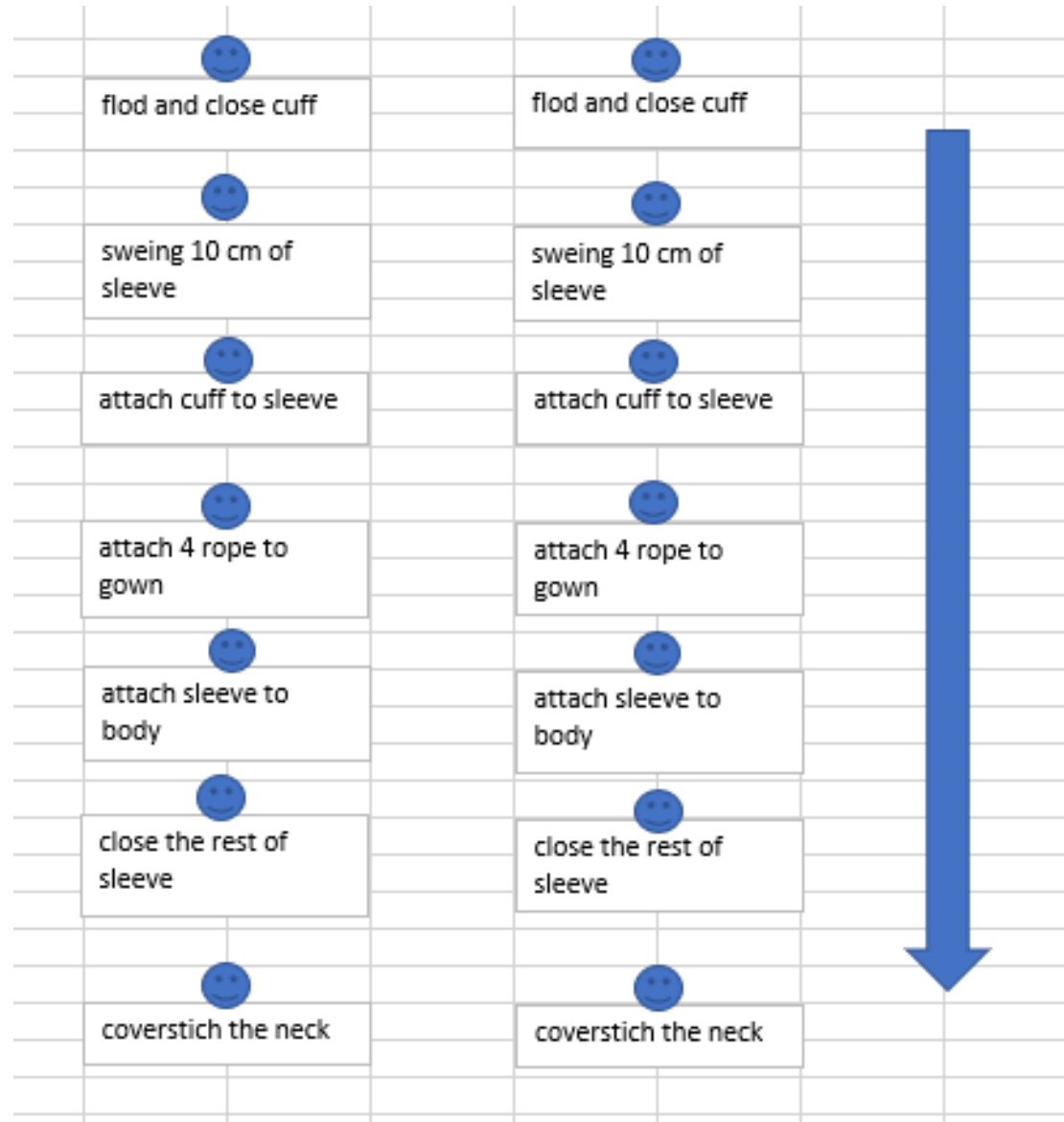
- Arabella for Medical Technologies was established in 2012 in the exclusive King Abdullah II. Arabella business objective is to manufacture a broad range of medical products used by healthcare in professionals in a variety of specialties. Our mission is to achieve the highest standards of quality in medical products by constantly optimizing our production quality with safe, cost-effective products and services.



# Construct Current VSM



# Current layout for sewing department



# Select suitable worker

work element	Description	Number of operators
1	fold and close cuff	2
2	sewing 10 cm opening	3
3	attach cuff to sleeve	3
5	attach 4 ropes to gown	1
6	attach sleeve to body	1
7	close the rest of sleeve	2
8	cover stich the neck	2
Total	-	14

Operation name	Cycle time 1	Cycle time 2	Cycle time 3	Cycle time 4	Cycle time 5	Average cycle	capacity (number of piece / 8 hour )
fold and close cuff	8	7	9	8	9	8.2	3512.195122
	8	8	9	7	6	7.6	3789.473684
sewing 10 cm opening	9	7	8	9	7	8	3600
	7	10	7	6	9	7.8	3692.307692
	9	15	7	10	9	10	2880
attach cuff to sleeve	12	11	13	11	12	11.8	2440.677966
	12	11	10	11	11	11	2618.181818
	12	11	12	10	11	11.2	2571.428571
attach 4 ropes to gown	19	20	18	18	17	18.4	1565.217391
attach sleeve to body	22	19	20	21	18	20	1440
close the rest of sleeve	15	16	14	18	14	15.4	1870.12987
	15	16	14	19	15	15.8	1822.78481
cover stich the neck	18	20	16	21	18	18.6	1548.387097
	19	18	17	17	20	18.2	1582.417582

# Select suitable worker

Operation name	Cycle time 1	Cycle time 2	Cycle time 3	Cycle time 4	Cycle time 5	Average cycle	capacity (number of piece / one hour )
fold and close cuff	8	8	9	7	6	7.6	473.6842105
sewing 10 cm opening	9	7	8	9	7	8	450
attach cuff to sleeve	12	11	12	10	11	11.2	321.4285714
attach 4 ropes to gown	19	20	18	18	17	18.4	195.6521739
attach sleeve to body	22	19	20	21	18	20	180
close the rest of sleeve	15	16	14	18	14	15.4	233.7662338
cover stich the neck	19	18	17	17	20	18.2	197.8021978

Rang/Average	No. of cycles to time
0.1	2
0.2	7
0.3	15
0.4	27
0.5	42
0.6	61
0.7	83
0.8	108
0.9	138
1	169



Operation stage name	Cycle number	Cycle time for one piece (second)	calculation	
fold and close cuff	1	8	Cycle No. =	7
	2	7	SUM =	55
	3	7	AVG =	7.857142857
	4	8	Total normal minute =	0.104761905
	5	8	Allowance (30%) =	0.031428571
	6	9	Standard time (minute) =	0.136190476
	7	8		
sewing 10 cm opening	1	9	Cycle No. =	7
	2	7	SUM =	55
	3	8	AVG =	7.857142857
	4	9	Total normal minute =	0.104761905
	5	7	Allowance (30%) =	0.031428571
	6	7	Standard time (minute) =	0.136190476
	7	8		
attach cuff to sleeve	1	12	Cycle No. =	7
	2	11	SUM =	84
	3	13	AVG =	12
	4	12	Total normal minute =	0.16
	5	13	Allowance (30%) =	0.048
	6	11	Standard time (minute) =	0.208
	7	12		
attach 4 ropes to gown	1	19	Cycle No. =	7
	2	20	SUM =	135
	3	20	AVG =	19.28571429
	4	18	Total normal minute =	0.257142857
	5	19	Allowance (30%) =	0.077142857
	6	20	Standard time (minute) =	0.334285714
	7	19		
attach sleeve to body	1	22	Cycle No.=	7
	2	21	SUM =	143
	3	20	AVG =	20.42857143
	4	21	Total normal minute =	0.272380952
	5	20	Allowance (30%) =	0.081714286
	6	19	Standard time (minute) =	0.354095238
	7	20		
close the rest of sleeve	1	15	Cycle No.=	7
	2	16	SUM =	108
	3	14	AVG =	15.42857143
	4	18	Total normal minute =	0.205714286
	5	14	Allowance (30%) =	0.061714286
	6	15	Standard time (minute) =	0.267428571

# Cycle Time

$\text{Cycle time} = \text{Total available production time} / \text{Demand}$

**Cycle time = 8hour\*60  
minutes\*60seconds / 1500units  
per day**

**Cycle time = 19.2seconds** **19.2**

work element	Description	Number of operators	Operator S.T(SMV) (minute)	Operator S.T(SMV) (second)	Task S.T (second)
1	fold and close cuff	2	0.136190476	8.171428571	4.085714286
2	sewing 10 cm opening	3	0.136190476	8.171428571	2.723809524
3	attach cuff to sleeve	3	0.208	12.48	4.16
4	attach 4 ropes to gown	1	0.334285714	20.05714286	20.05714286
5	attach sleeve to body	1	0.354095238	21.24571429	21.24571429
6	close the rest of sleeve	2	0.267428571	16.04571429	8.022857143
7	cover stich the neck	2	0.31447619	18.86857143	9.434285714
TOTAL	-	14	1.750666667	105.04	69.72952381

# Doing of Line Balancing

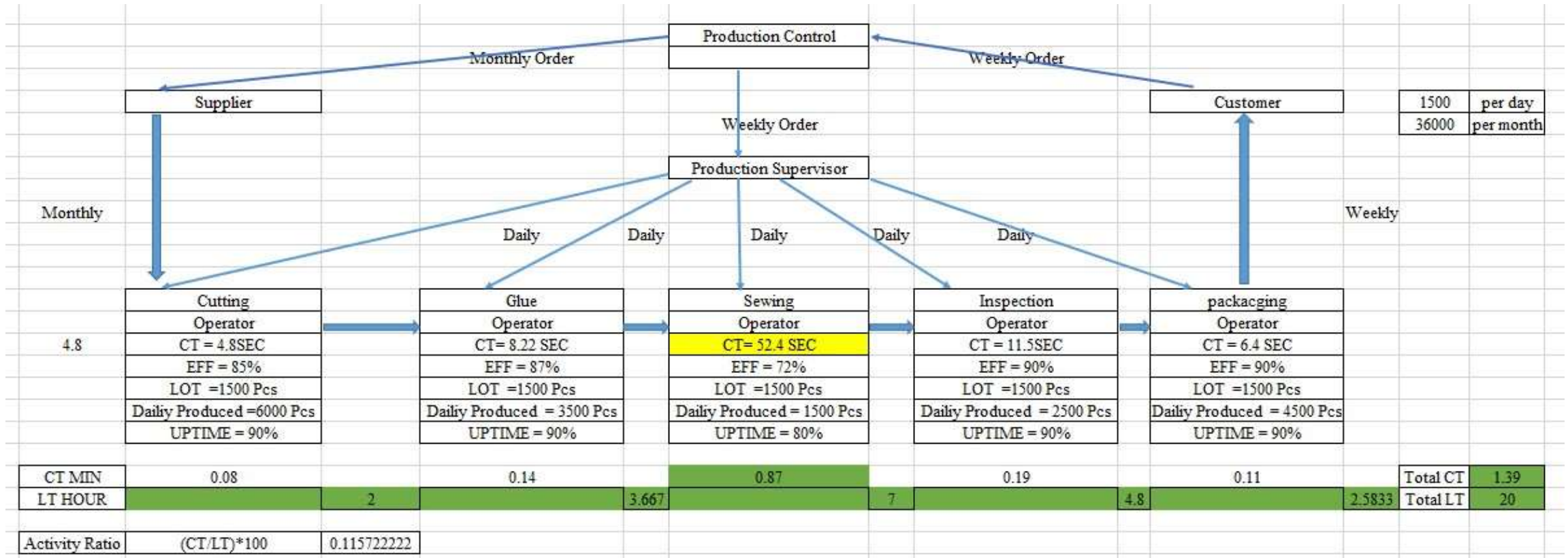
work element	Description	Number of operators	Operator S.T(SMV) (minute)	Operator S.T(SMV) (second)	Task S.T (second)
1	fold and close cuff	2	0.13	7.8	3.9
2	sewing 10 cm opening	2	0.136190476	8.171428571	4.085714286
3	attach cuff to sleeve	2	0.199333333	11.96	5.98
4	attach 4 ropes to gown	2	0.338	20.28	10.14
5	attach sleeve to body	2	0.372666667	22.36	11.18
6	close the rest of sleeve	2	0.267428571	16.04571429	8.022857143
7	cover stich the neck	2	0.303333333	18.2	9.1
<b>TOTAL</b>	-	14	1.746952381	104.8171429	52.40857143

# Identify type of waste at each department

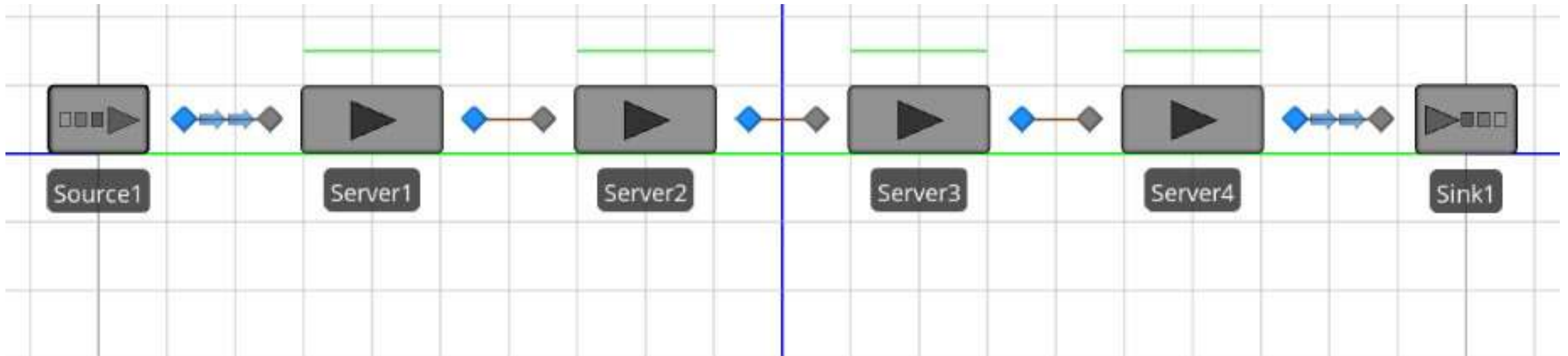
Cutting	Glue	Sewing	Inspection	Packaging
storage	storage	storage	storage	storage
30 min	20 min	60 min	15 min	25 min



# Updated VSM



# Simulation modeling



The model run for 8 hours to simulate the current system and results cleared in the figure below:

Average						Drop Column Fields Here
Object Type ▲	Object Name ▼	Data Source ▲	Category ▲	Data Item ▲	Statistic ▲	Average Total
Server	Server2	[Resource]	Capacity	ScheduledUtilization	Percent	99.9132
			ResourceState	TimeProcessing	Average (Hou...	7.9977
					Occurrences	1.0000
					Percent	99.9715
					Total (Hours)	7.9977
			TimeStarved		Average (Hou...	0.0023
					Occurrences	1.0000
					Percent	0.0285
					Total (Hours)	0.0023
		OutputBuffer	Throughput	NumberEntered	Total	1,544.0000
				NumberExited	Total	1,544.0000
Sink	Sink1	[DestroyedEntities]	FlowTime	TimeInSystem	Average (Hou...	2.9899
					Maximum (Ho...	5.9482
					Minimum (Hou...	0.0486
					Observations	1,539.0000



# Validation

- average produced unit of medical gown is 1539 gown while the actual system produces on average 1500 gown unit, the difference can be represented as error percentage  $((1539-1500)/1500) * 100 = 2.6\% < 5\%$  which is high accuracy level and model is valid and can be used to predict the future state of the actual system since the model valid and represent the actual system.

# improve simulation modeling

Object Type ▲ ▼	Object Name ▼ ▲	Data Source ▲ ▼	Category ▲	Data Item ▲ ▼	Statistic ▲ ▼	Average Total
Server	Server2	[Resource]	Capacity	ScheduledUtilization	Percent	99.9132
			ResourceState	TimeProcessing	Average (Hou...	7.9977
					Occurrences	1.0000
					Percent	99.9715
					Total (Hours)	7.9977
				TimeStarved	Average (Hou...	0.0023
					Occurrences	1.0000
					Percent	0.0285
					Total (Hours)	0.0023
		OutputBuffer	Throughput	NumberEntered	Total	4,390.0000
				NumberExited	Total	4,390.0000
Sink	Sink1	[DestroyedEntities]	FlowTime	TimeInSystem	Average (Hou...	1.0872
					Maximum (Ho...	2.1529
					Minimum (Hou...	0.0218
					Observations	4,385.0000

# Results and discussion

## VSM Discussion

Department	Cycle time min		Leadtime hour		Cycle time min	Leadtime hour
	current			future		
Cutting	0.08		2.5		0.08	2
Glue	0.14		4		0.14	3.666666667
Sewing	2.48		8		0.87	7
Inspection	0.19		5		0.19	4.8
packaging	0.11		3		0.11	2.583333333
total	3.00		22.5		1.388667	20.05
	Cutting	Glue	Sewing	Inspection	Packaging	
	storage	storage	storage	storage	storage	
	30 min	20 min	60 min	15 min	25 min	

# Line Balancing Discussion

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TOTAL	-	14	1.746952381	104.8171429	52.40857143

## Conclusion

Department	Cycle time Improvement	Lead Time Improvement	Stature
Cutting	0	25	No Improvement
Glue	0	9.090909091	No Improvement
Sewing	64.83221	14.28571429	Improvement
Inspection	0	4.166666667	No Improvement
packaging	0	16.12903226	No Improvement
total	53.69053	12.21945137	

work element	Description	Task S.T (second)	Task S.T (second)	Improvement
1	fold and close cuff	4.085714286	3.9	26.2800418
2	sewing 10 cm opening	4.085714286	4.085714286	
3	attach cuff to sleeve	4.16	5.98	
4	attach 4 ropes to gown	20.05714286	10.14	
5	attach sleeve to body	21.24571429	11.18	
6	close the rest of sleeve	8.022857143	8.022857143	
7	cover stich the neck	9.434285714	9.1	
total		71.09142857	52.40857143	