LSS DMAIC Manufacturing Case Study for Process Simulator

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Objectives

- Understand how simulation models can be utilized within the DMAIC approach
- Examine a completed model for the application of Lean Concepts to an “as is” process
- Identify & eliminate waste in a process
- Perform analysis of model data
- Build Scenarios using Lean Concepts

DMAIC Approach

	Define	Measure	Analyze	Improve	Control
Tasks	Define customers and requirements	Define Measures	Determine Root Causes	Define Potential Solutions	Define Control Plan
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	Develop the Problem Statement, Goals, Benefits	Collect the Data	Develop the relationship between Y and critical few X's	Pilot the Solution	Implement Visual Controls and Poka-Yoke
	Define Team,	Define X's and the "Big Y"	Determine the improvement opportunities to apply Lean	Define "to be" Process Map	Determine Process Capability
	Develop Project Plan	Determine if Process is in Control		Validate the Potential Improvement	Verify Benefits, Cost Savings, Finalize Documentation
	Develop High Level Process Map	Define the Process Capability			Transition to Process Owner, Close Project, and Celebrate
Tools	Project Charter	Value Stream Map	Run Chart/Time Series	Brainstorming/Affinity Diagram	Control Plan
	ROI/Payback Analysis	* Simulation	Ishikawa Diagram/5 Whys	* Simulation	Process Capability
	Voice of the Customer	Measurement System Analysis	Cause and Effect Matrix	FMEA	Process Sigma Calculator
	Voice of the Business	Data Collection Plan	Regression Analysis	Design of Experiments	Mistake Proofing
	Stakeholder Analysis	Check Sheets	Non-Parametric Analysis	Piloting	Visual Process Control
	Communication Plan	Benchmarking	* Simulation	Pugh Matrix	* Simulation
	RACI	Value of Speed (Little's Law)	ANOVA	Process Balancing	
	SIPOC	Statistical Sampling	Components of Variation	Analytical Batch Sizing	
	* Simulation	Pareto Charts	Hypothesis Testing	Process Flow Improvement	
	Kano Analysis	Control Charts	NVA Analysis	Kanban	
		Process Capability	Queuing Theory	Stocking Strategy	
		Histograms	FMEA	Force Field Analysis	

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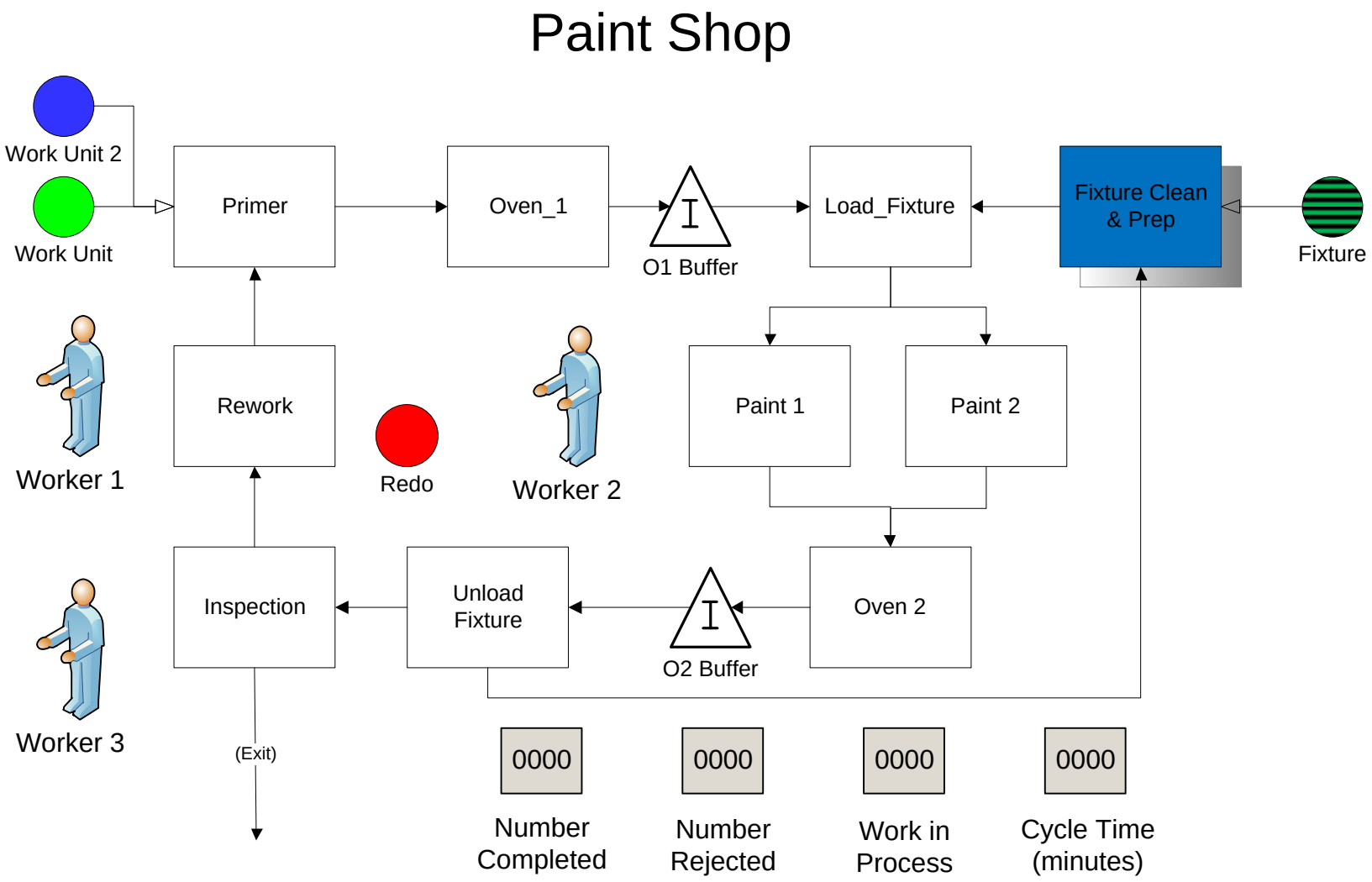
“As Is” Current State Paint Shop



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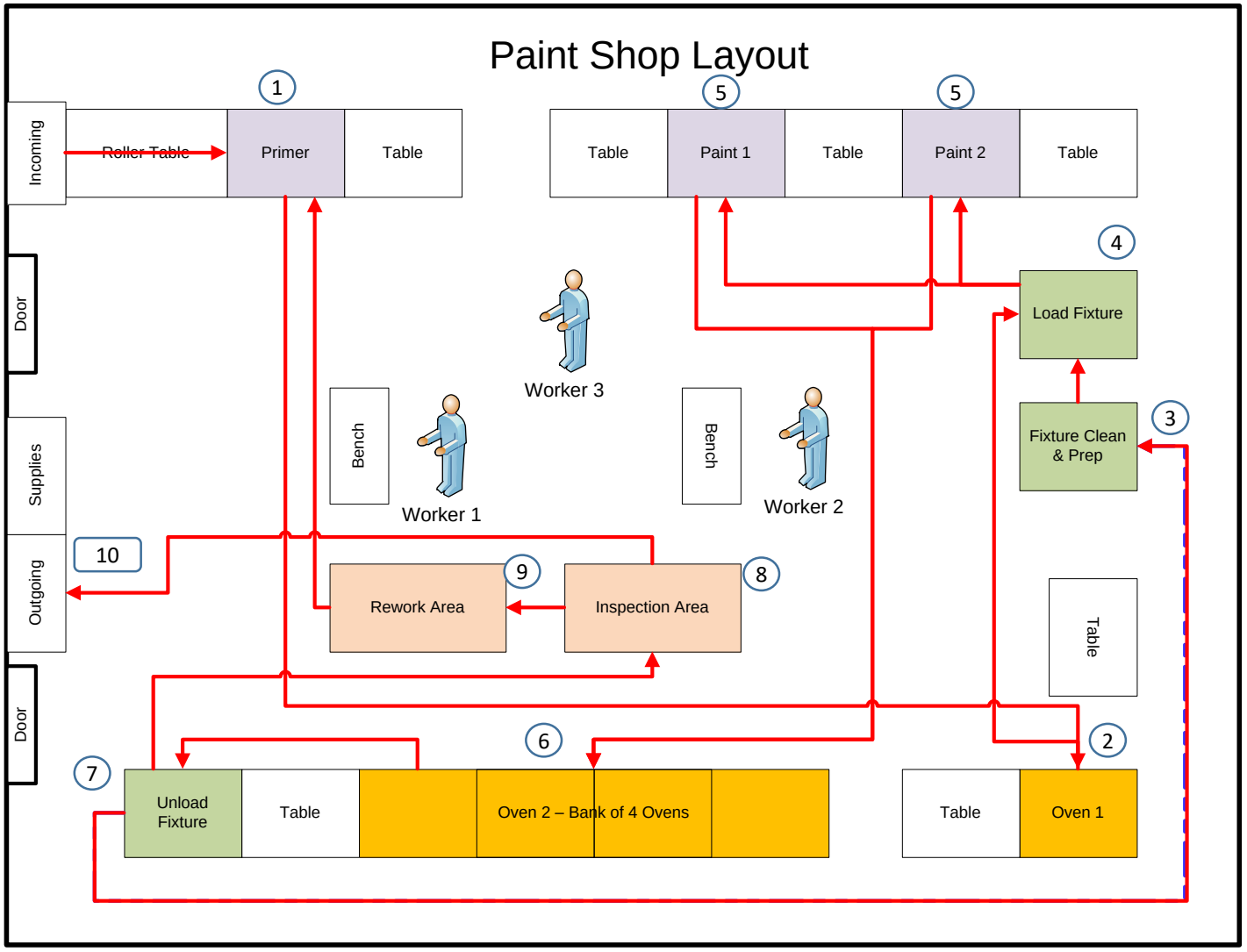
Define Tasks

- Problem Statement
  - Current average Cycle Time (CT) is ~642 minutes; customers are complaining that they need the product sooner; employees are complaining that some are working "too hard"
- Voice of the Customer / Voice of the Business
  - Customer survey says they want CT to be <= 300 minutes
  - Business is not sure if that CT can be met; however, they want orders quickly filled
- "As is" Process Flow

Paint Shop "As Is" Process Flow



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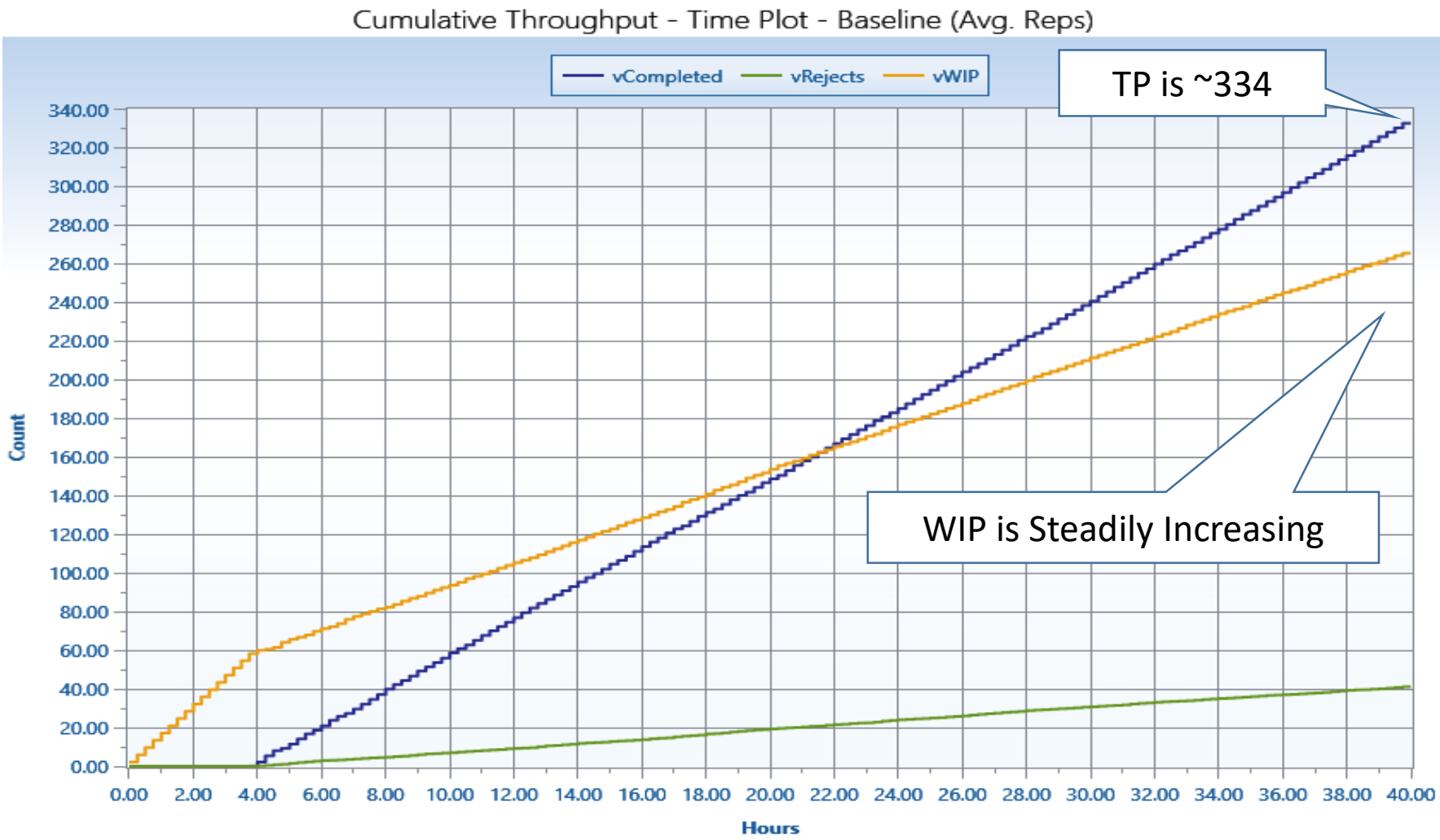
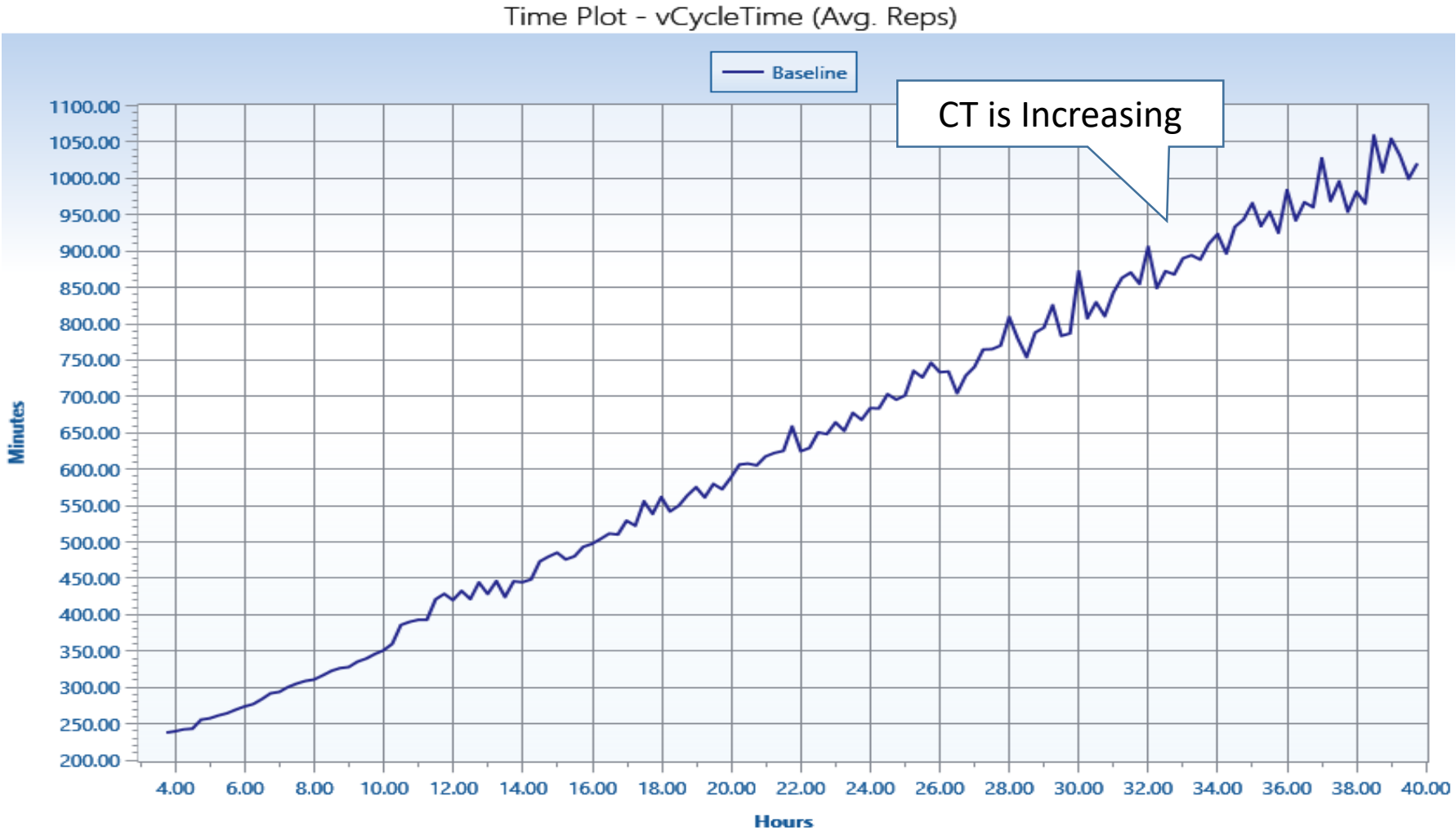
Measure Tasks

- Define Measures
- Collect the Data
- Define X's and the "Big Y"
- Determine if Process is in Control
- Define the Process Capability

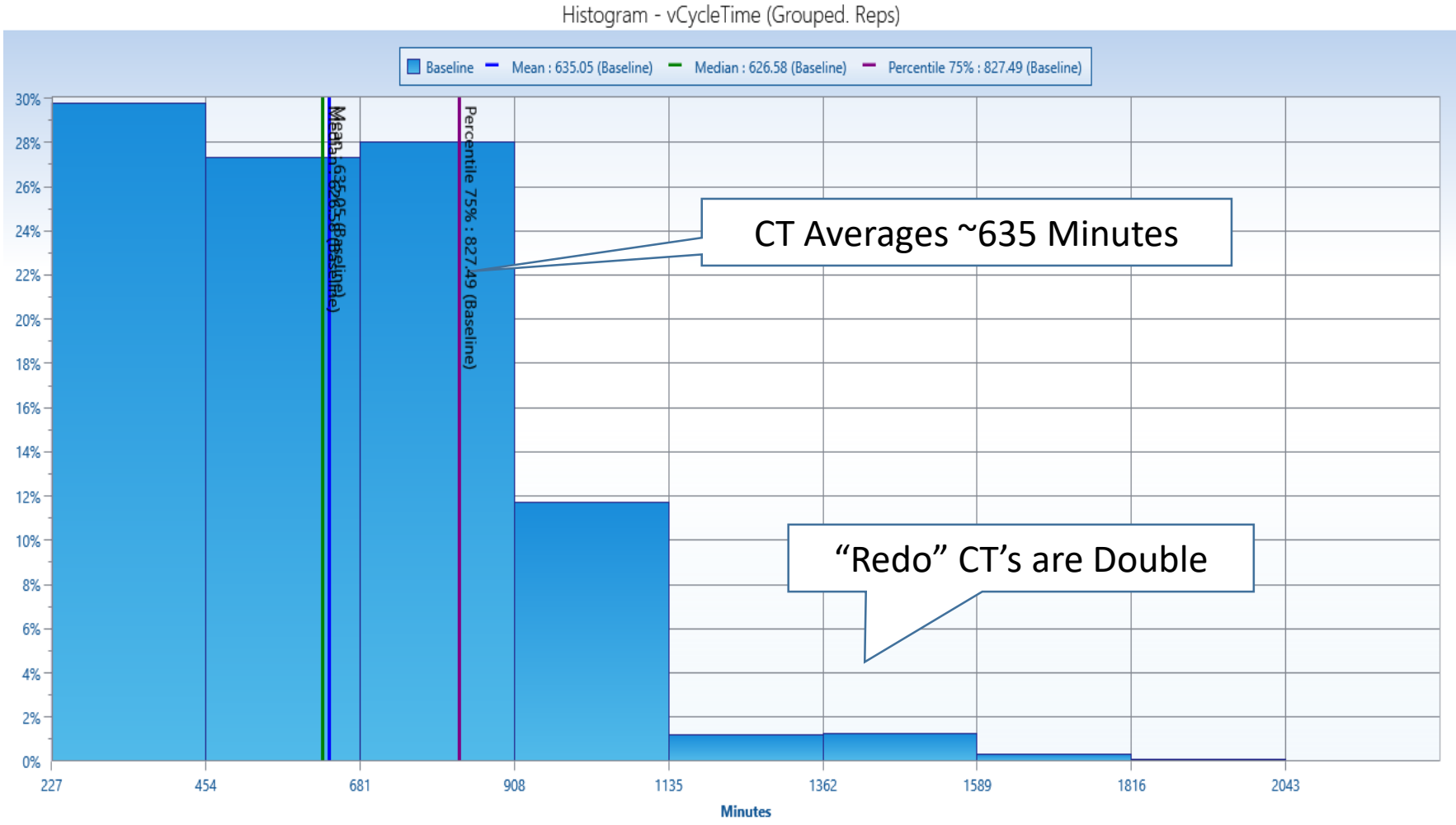
Throughput (TP) & Work in Process (WIP) Data



Cycle Time (CT) Data



Cycle Time – The “Big Y”



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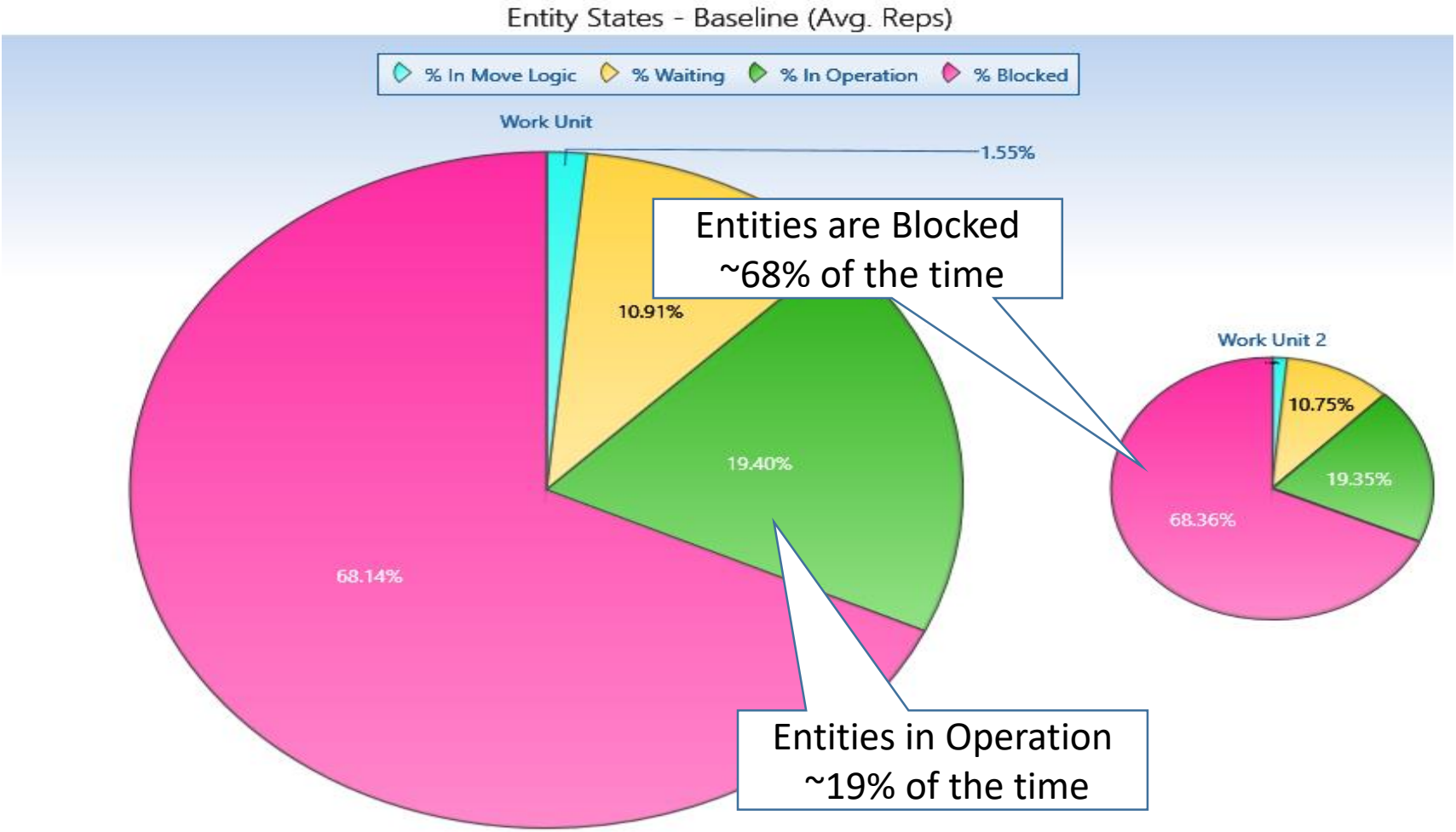
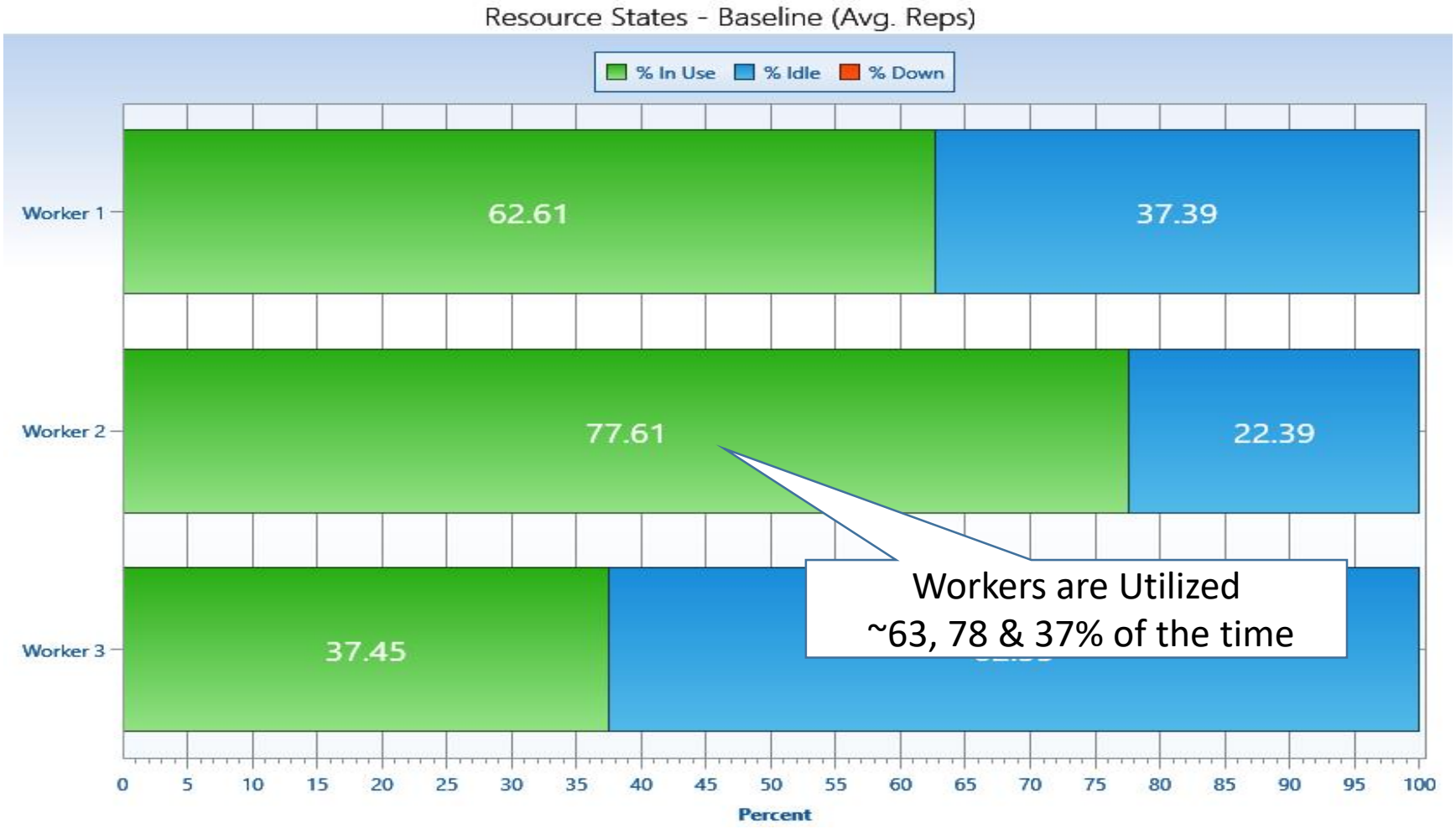
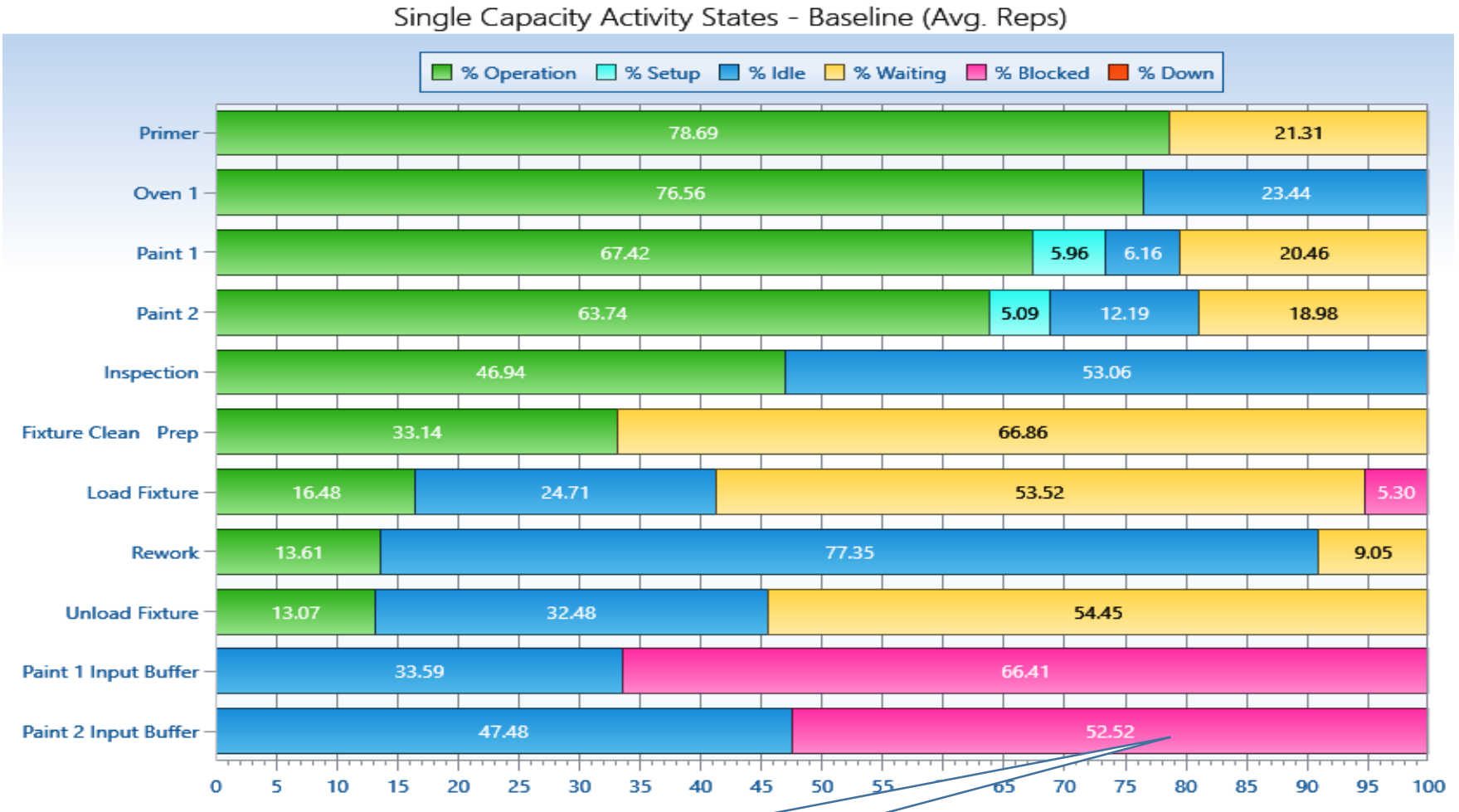
Entity Data


Entity States - Baseline (Avg. Reps)
% In Move Logic
% Waiting
% In Operation
% Blocked
Work Unit
1.55%
10.91%
19.40%
68.14%
Work Unit 2
10.75%
19.35%
68.36%
Entities are Blocked
~68% of the time
Entities in Operation
~19% of the time

Resource Data



Activity Data



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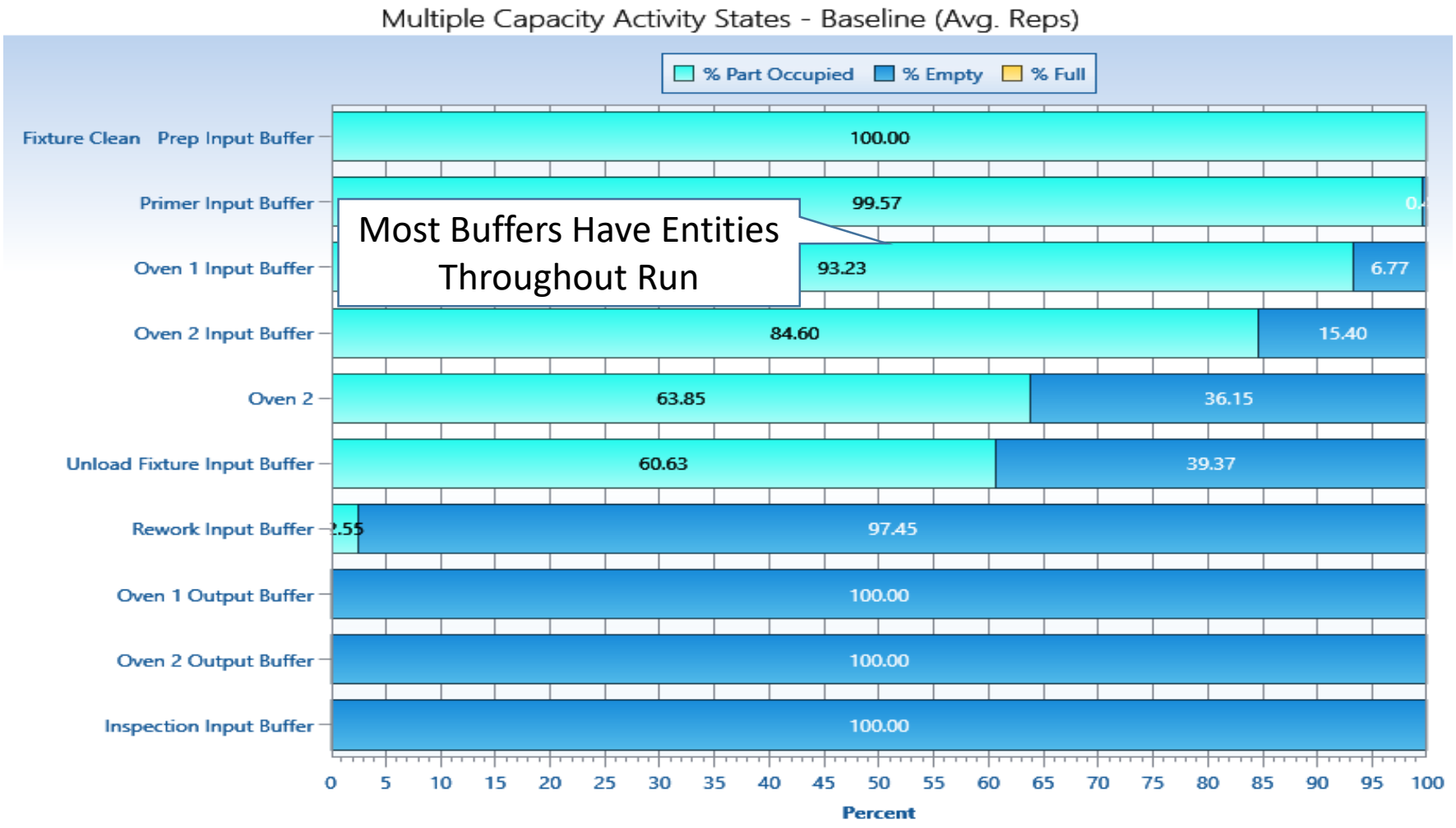
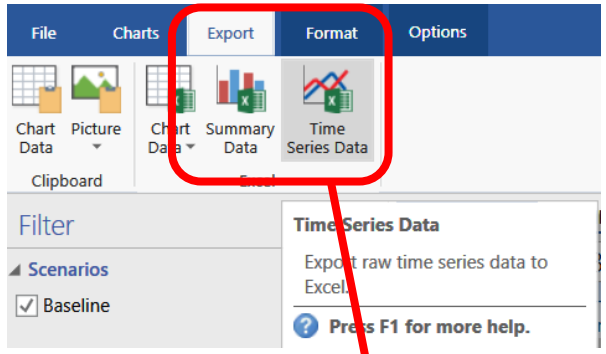
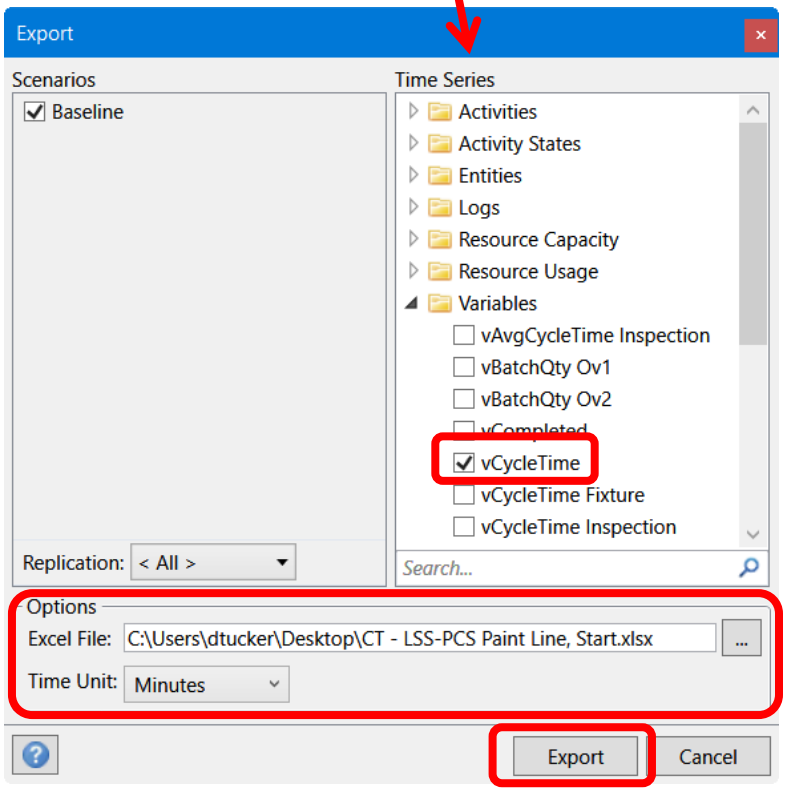
Activity Data



Exporting Data

1. Select Export menu.
2. Select Time Series Data.
3. Check the box for data item(s).
4. Set the file name & path.
5. Hit Export.
6. Open the Excel file when prompted.
7. You can then copy / paste data from Excel into other applications like Minitab.





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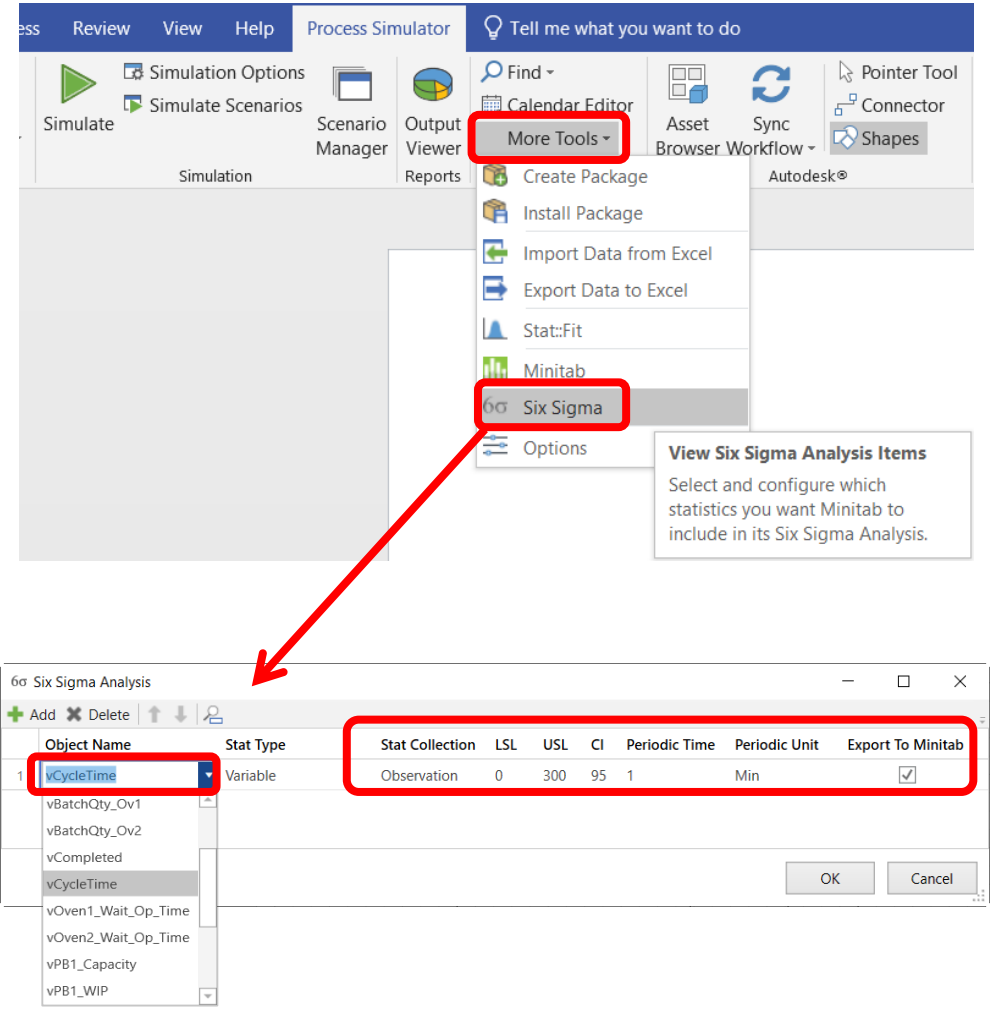
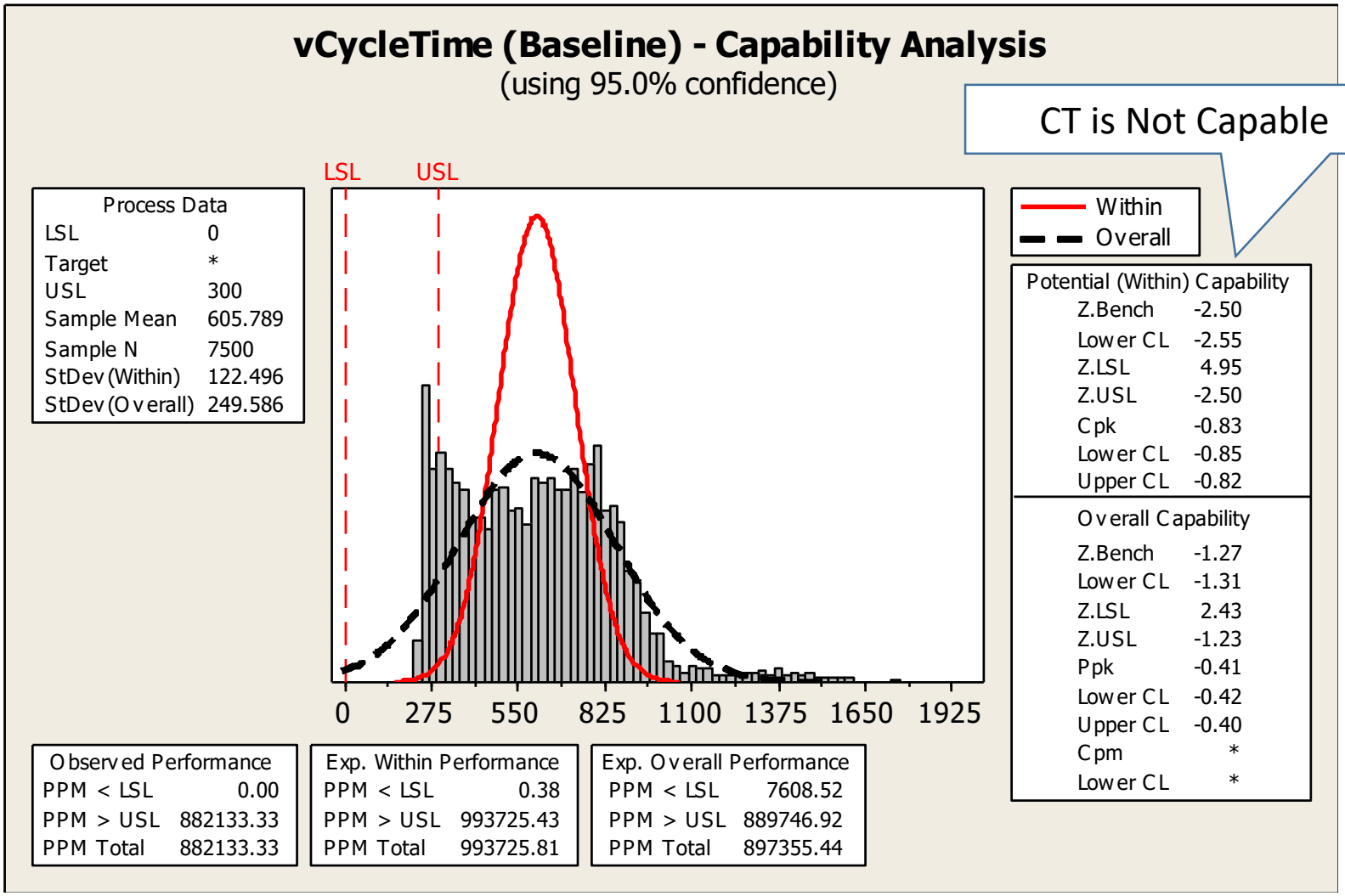
Exporting Data Using Six Sigma Feature

1. Select the Six Sigma Analysis Feature under “More Tools”.
2. Add the Parameter for the Variable, vCycleTime.
3. Pick “Observation” for Stat Collection.
4. Enter Specification Limits 0 (LSL) and 300 (USL).
5. Select the Periodic time interval and time unit.
6. Check the “Export to Minitab” box.
7. Launch Minitab.

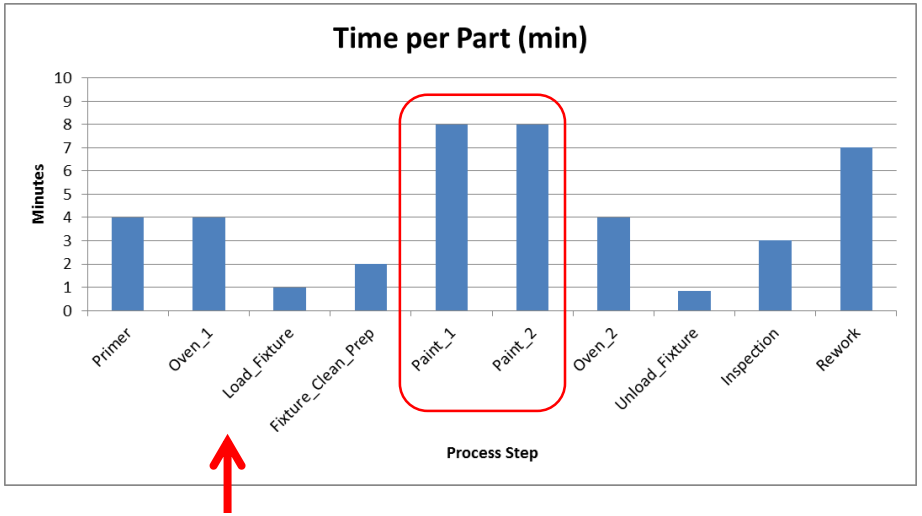


Process Capability Data for Cycle Time



Unbalanced Process Flow

A review of the Operation Times reveals that the Paint Booths have the longest time per part. Furthermore, the Booths have only a single part capacity which causes back-ups. The Batching and long operation times at both Ovens will also create delays.



Step	Time	Time Unit	Avg Time (min)	Batch Size B4	Time per Part (min)	Capacity	In Buffer	Out Buffer	Resource
Primer	T(3, 4, 5)	min	4	1	4	1	999	0	--
Oven_1	60	min	60	15	4	1 - B	999	999	--
Load_Fixture	N(60, 10)	sec	1	1	1	1	0	0	Worker 2
Fixture_Clean_Prep	U(2, 1)	min	2	1	2	1	999	0	--
Paint_1	N(8, 1)	min	8	1	8	1	1	0	--
Paint_2	N(8, 1)	min	8	1	8	1	1	0	--
Oven_2	40	min	40	10	4	4 - B	100	100	--
Unload_Fixture	N(50, 10)	sec	0.83	1	0.83	1	999	0	Worker 2
Inspection	N(3, 0.1)	min	3	1	3	1	999	0	Worker 1
Rework	T(2, 7, 15)	min	7	1	7	1	999	0	Worker 2

Current State Summary

- WIP and CT are increasing which indicates one or more process constraints
- Some Entity blockage occurs at several Activities
- Resource utilization is out of balance
- Process Cycle Time is statistically out-of-control and therefore, inconsistent
- Process is not capable of achieving customer specifications of <= 300 CT minutes
- Process flow is unbalanced and not level-loaded

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Analyze Tasks

- Determine the improvement opportunities to apply Lean concepts
- Identify Value Add versus Non-Value Add Process Steps
- Develop the relationship between Y and critical few X's
- Determine Root Causes

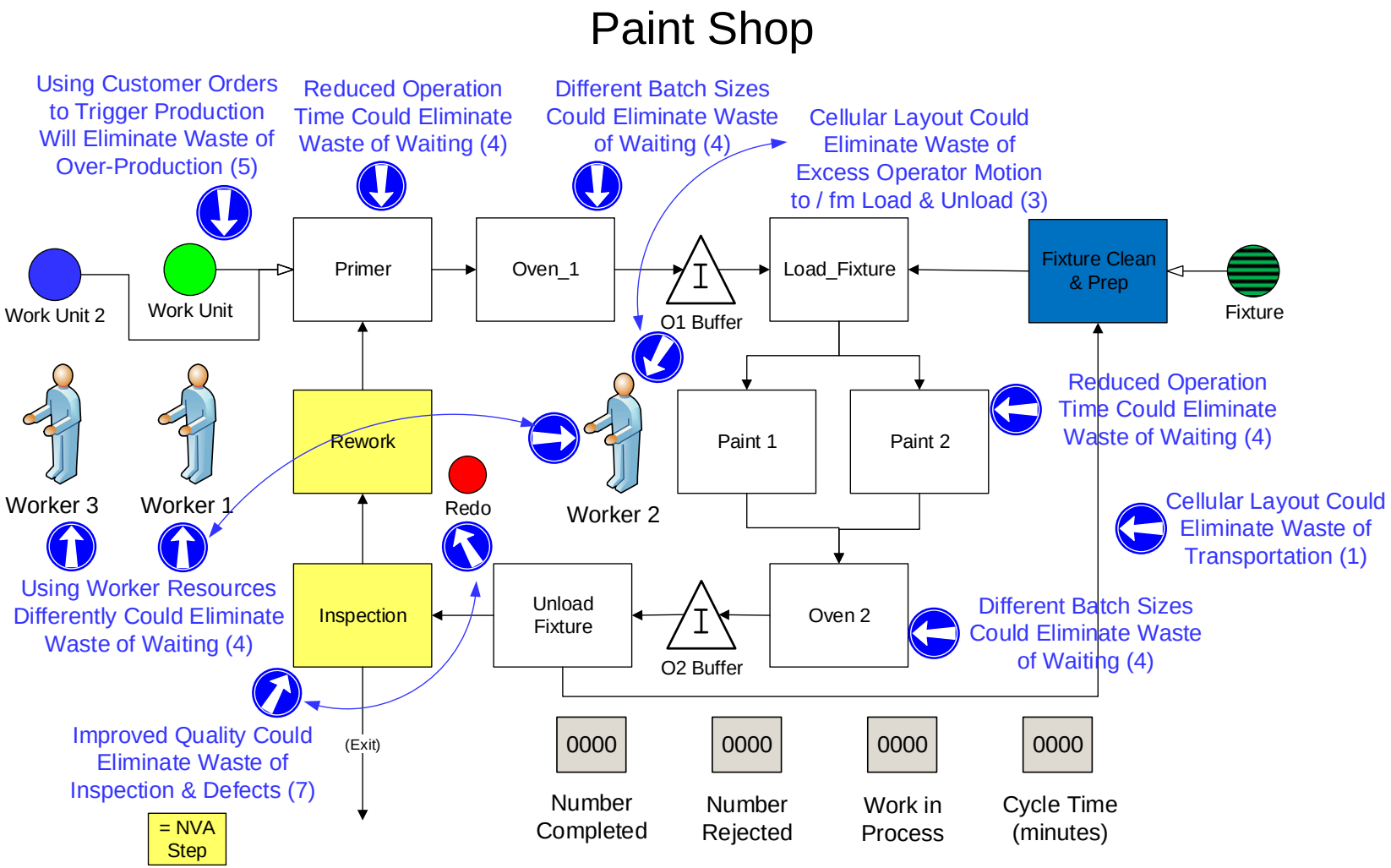
Lean Concepts

- Eliminating Waste
- Bottleneck Identification
- Queue Reduction
- Equipment Setup Reduction
- Building Pull Systems
- Process Flow Improvement

7 Types of Waste (TIMWOOD)

- Unnecessary material handling or Transportation
- Excess Inventory (just in case)
- Excess or inefficient operator Motion
- Waiting for materials or resources
- Overproduction (often causes the other types of wastes)
- Over processing / Unnecessary steps
- Production of Defects (any type)

Opportunities to Reduce Waste



Lean Concepts

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  - Bottleneck Identification
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  - Equipment Setup Reduction
  - Building Pull Systems
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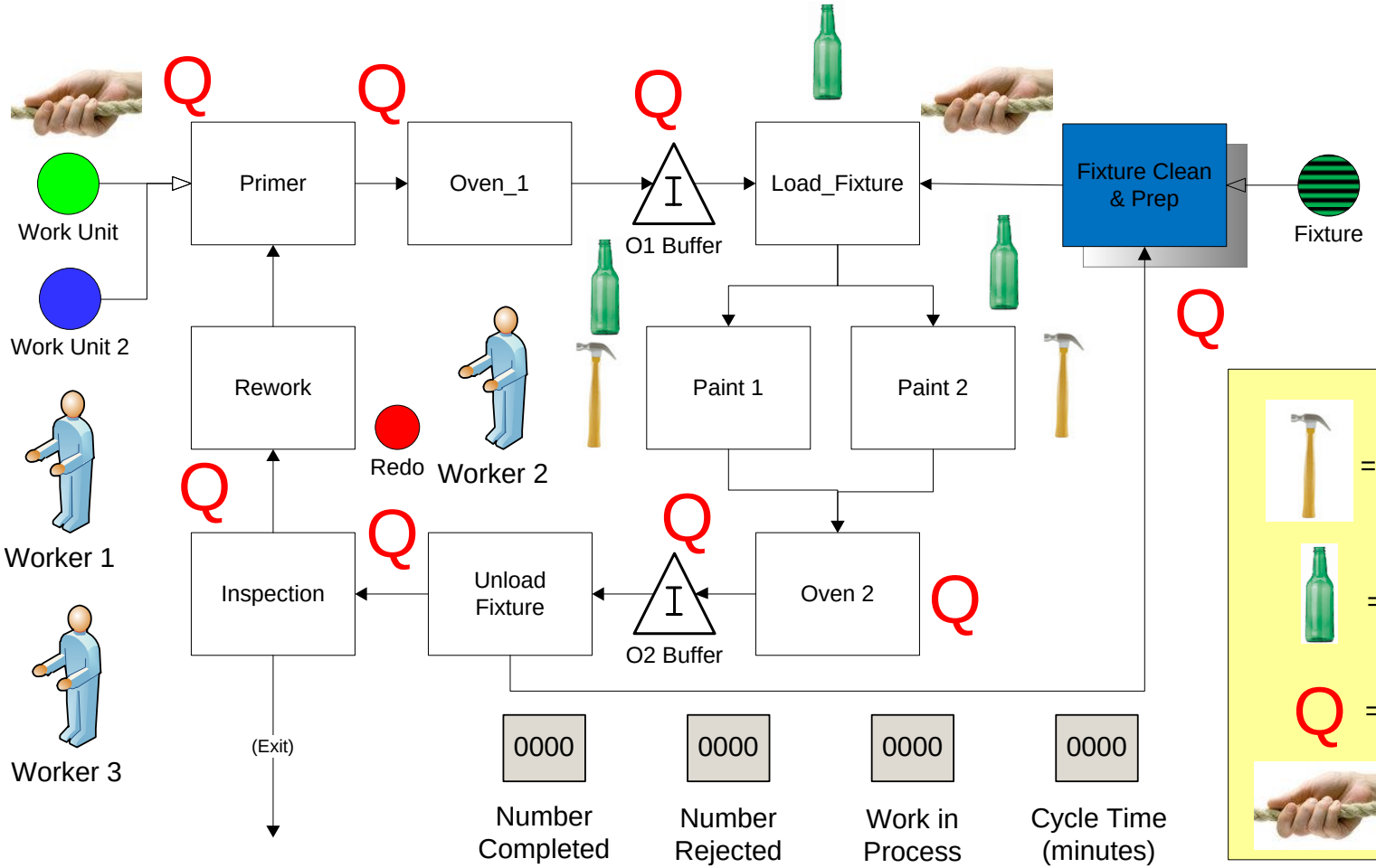
Other Lean Opportunities

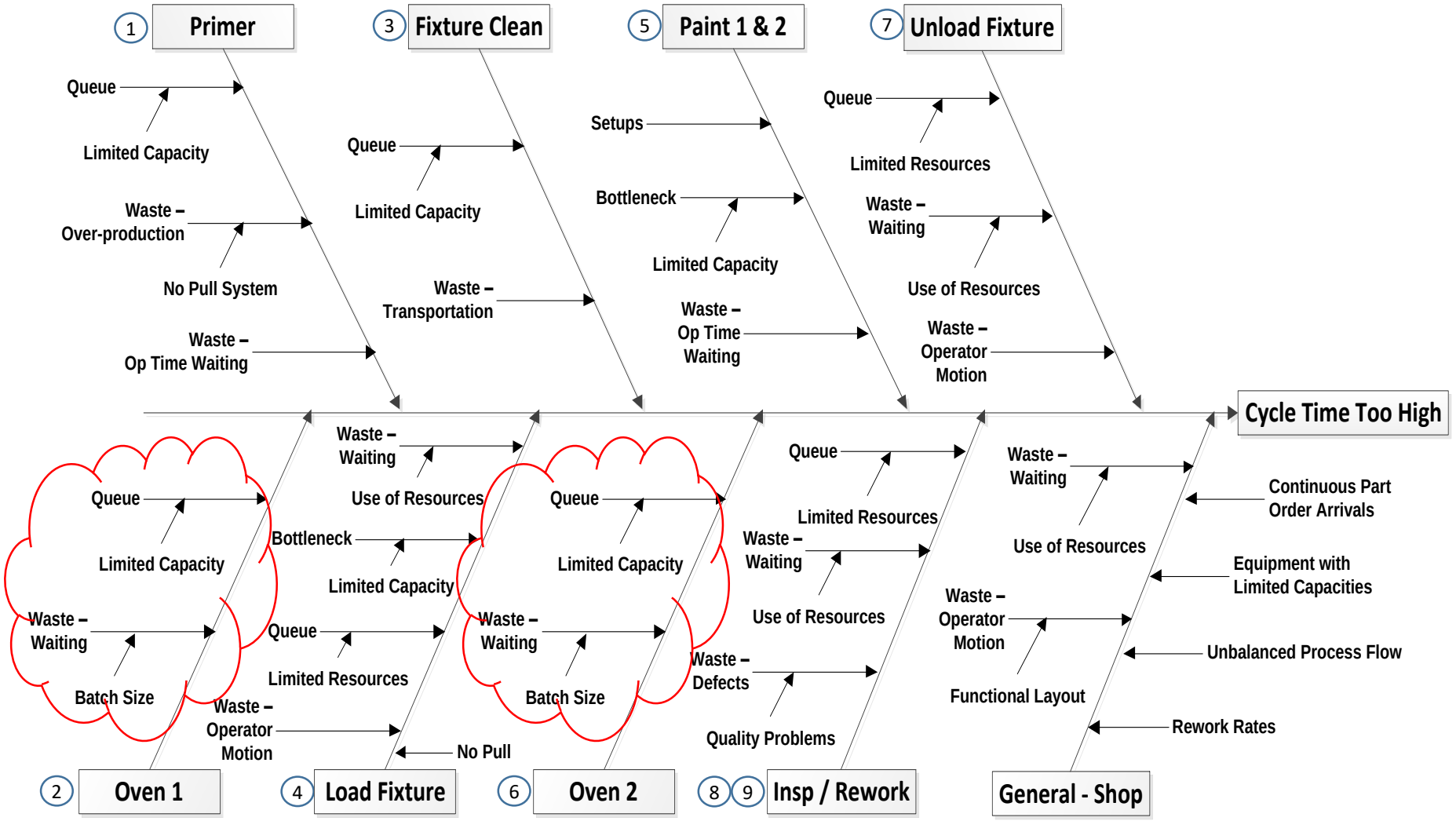
Paint Shop



Potential Causes of Long Cycle Time

- Waste
  - Over-production
  - Waiting
  - Operator Motion
  - Transportation
  - Defects & Inspection
- Bottlenecks
  - At Load Fixture
  - At Paint 1 & 2
- No Pull Systems
  - To Primer
  - To Load Fixture
- Queues
  - Primer
  - Oven 1 & 2
  - Load & Unload Fixture
  - Fixture Clean & Prep
  - Inspection & Rework
- Setups
  - Paint 1 & 2
- Traditional Shop Layout
  - Functional not Cellular
- Other

Root Cause Analysis by Step



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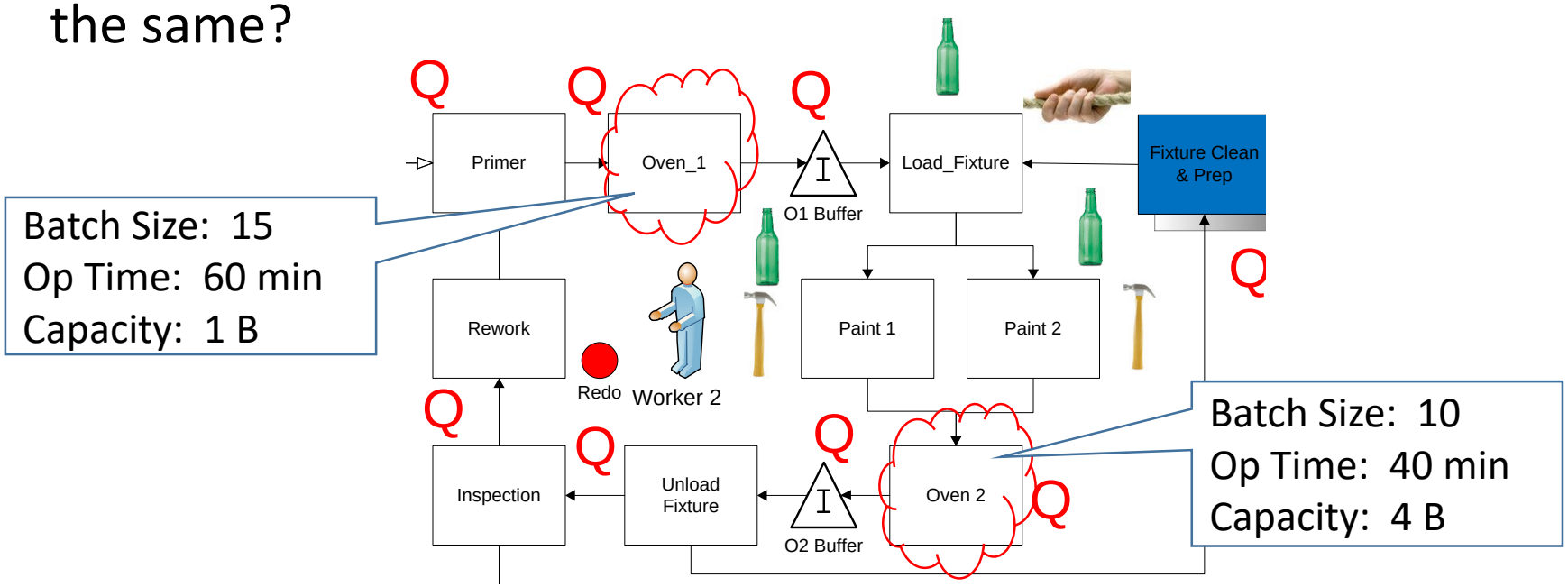
Hypothesis Testing Example

- What is the effect of Batching, Capacity, Queuing and Operation times at Ovens 1 & 2? We are told that the total time to get a part through those Ovens is about the same even though Batching, Capacity and Operation times are different.
- Is the total time for waiting and operation at the ovens about the same?



Hypothesis Testing Setup

1. Create 2 Attributes & 2 Variables.

ATTRIBUTES

Add | Delete

	Name	Type	Initial Value
1	aRework	Integer	0
2	aCycleStart	Real	0
3	aRouter	Integer	0
4	aOven1_Start	Real	0
5	aOven2_Start	Real	0
6	aEntity_type	Integer	0

VARIABLES

Add | Delete

	Name	Type	Initial Value	Statistics	Graphic
1	vCompleted	Integer	0	Time Weighted	☑
2	vRejects	Integer	0	Time Weighted	☑
3	vWIP	Integer	0	Time Weighted	☑
4	vCycleTime	Real	0	Observation	☑
5	vOven1_Wait_Op_Time	Real	0	Observation	☐
6	vOven2_Wait_Op_Time	Real	0	Observation	☐

2. Create logic for both Ovens using Logic Builder.

Logic in Routing to Oven_1

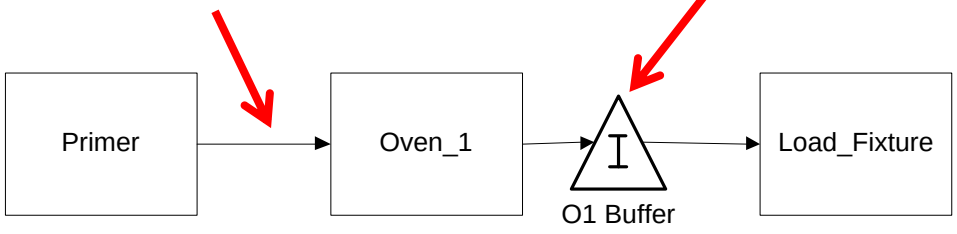
ROUTE | LOGIC

```
1  Use Worker_3 For mMove_Time min
2  aOven1_Start = Clock()
```

Logic at O1 Buffer

BUFFER | LOGIC

```
1  vOven1_Wait_Op_Time = Clock() - aOven1_Start
```



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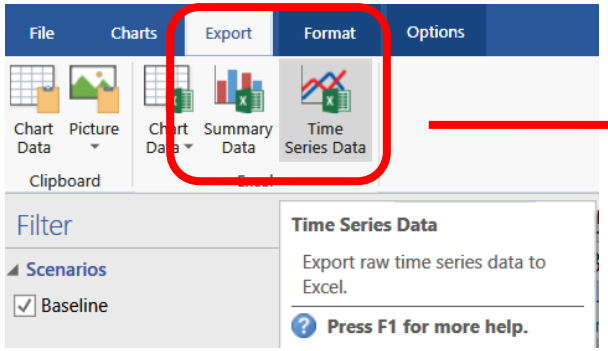
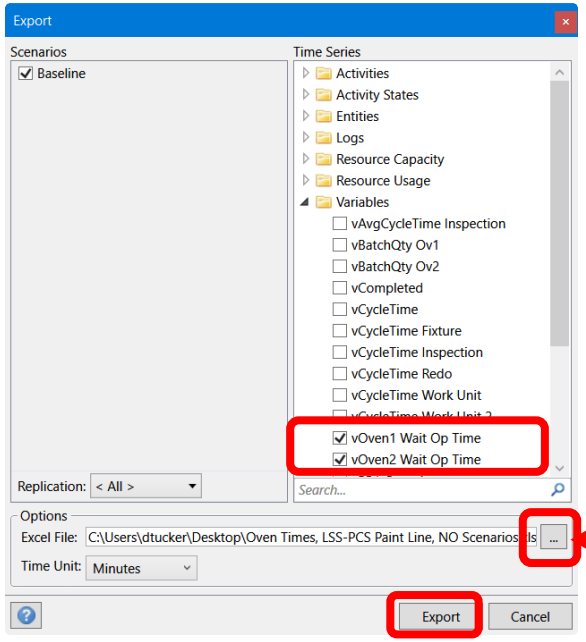
Hypothesis Testing Setup

3. Run Model for 5 replications.
4. Export the Time Series data for both Variables from the Output Viewer to Excel.





Set File Name & Path

5. Name the File & Path then hit Export button.
6. Copy the data from Excel into a Minitab worksheet.

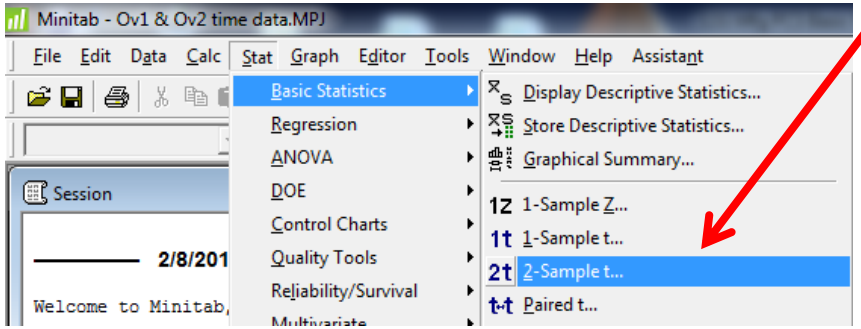
Hypothesis Testing in Minitab

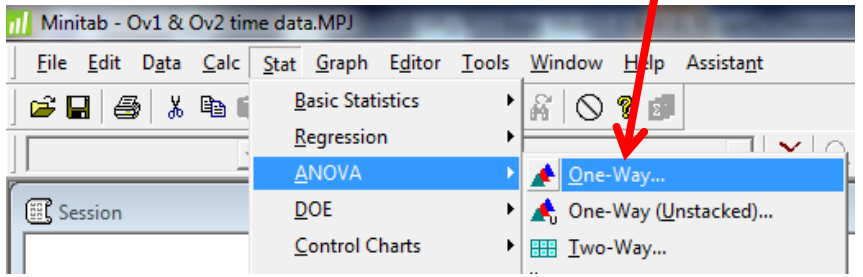
7. In Minitab, Stack the data into single columns.

Worksheet 2 ***

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16-T	C17
	Ov1_R1	Ov1_R2	Ov1_R3	Ov1_R4	Ov1_R5		Ov2_R1	Ov2_R2	Ov2_R3	Ov2_R4	Ov2_R5		Ov1_ALL	Ov2_All		OvN_RN	Time
1	130.214	127.897	130.763	129.739	127.980		84.071	85.704	88.628	83.983	84.230		130.214	84.071		Ov1_R1	130.214
2	125.208	122.903	125.959	123.797	123.798		77.463	79.804	81.017	76.504	77.154		125.208	77.463		Ov1_R1	125.208
3	120.600	117.546	120.946	118.199	119.080		70.696	73.804	78.449	72.144	72.513		120.600	70.696		Ov1_R1	120.600
4	115.441	112.272	116.283	113.056	113.907		67.190	70.305	71.514	67.177	69.285		115.441	67.190		Ov1_R1	115.441
5	110.606	107.344	111.139	108.563	108.263		61.266	63.658	69.138	63.563	63.401		110.606	61.266		Ov1_R1	110.606
6	105.030	102.634	105.357	103.920	103.501		56.073	61.177	59.853	56.347	59.285		105.030	56.073		Ov1_R1	105.030
7	100.056	98.054	99.741	98.932	98.678		51.040	52.273	57.853	52.343	52.110		100.056	51.040		Ov1_R1	100.056
8	94.682	93.414	95.104	94.663	93.602		49.040	51.273	50.433	47.797	49.268		94.682	49.040		Ov1_R1	94.682

8. Select and run the Hypothesis Test using the data.





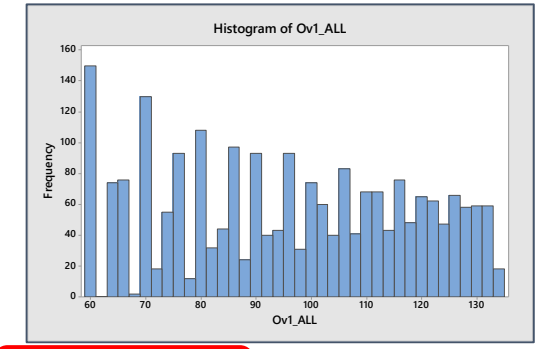
Minitab: 2 Sample t-Test Results

Two-sample T for Ov1_ALL vs Ov2_All

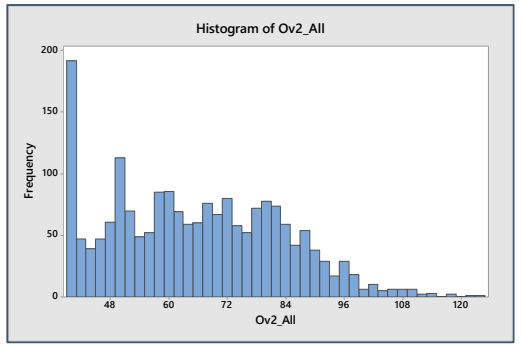
	N	Mean	StDev	SE Mean
Ov1_ALL	2250	95.6	22.0	0.46
Ov2_All	1920	65.6	17.4	0.40

Difference = μ (Ov1_ALL) - μ (Ov2_All)
Estimate for difference: 29.997
95% CI for difference: (28.801, 31.192)
T-Test of difference = 0 (vs ≠): T-Value = 49.20 P-Value = 0.000 DF = 4145

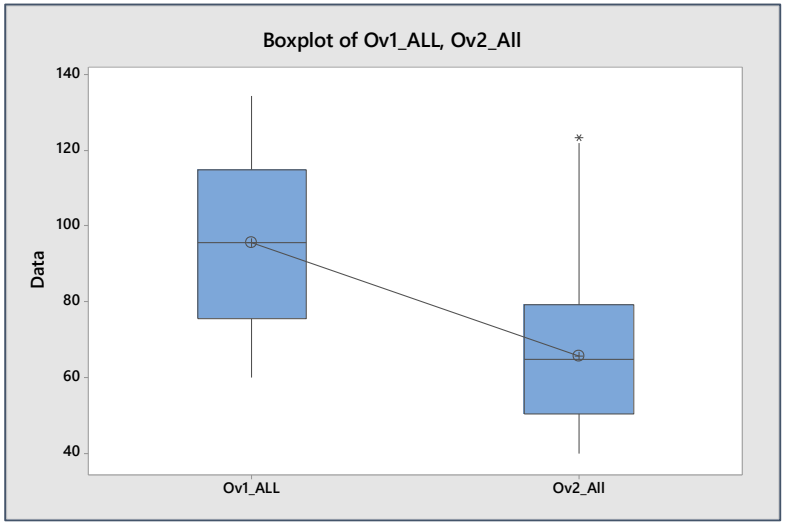
Oven_1

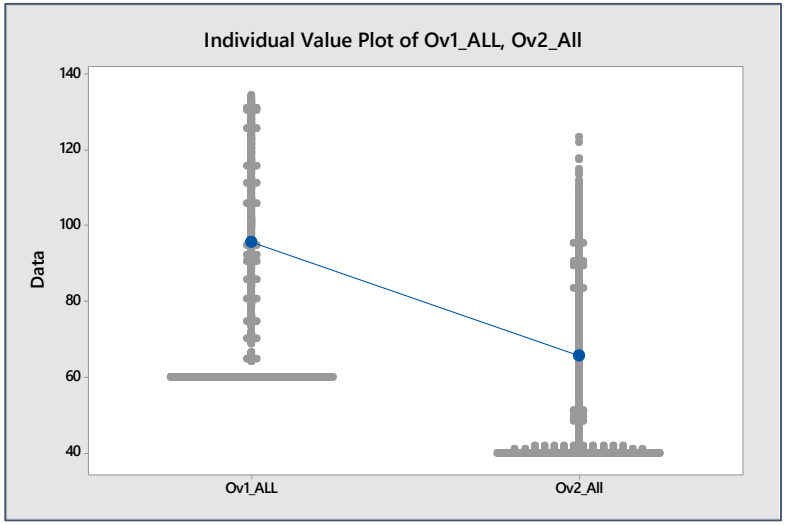


Oven_2



Total Time at Ovens NOT the Same





Minitab: One Way ANOVA Results

One-way ANOVA: Time versus OvN_RN

Null hypothesis All means are equal
Alternative hypothesis At least one mean is different
Significance level α = 0.05

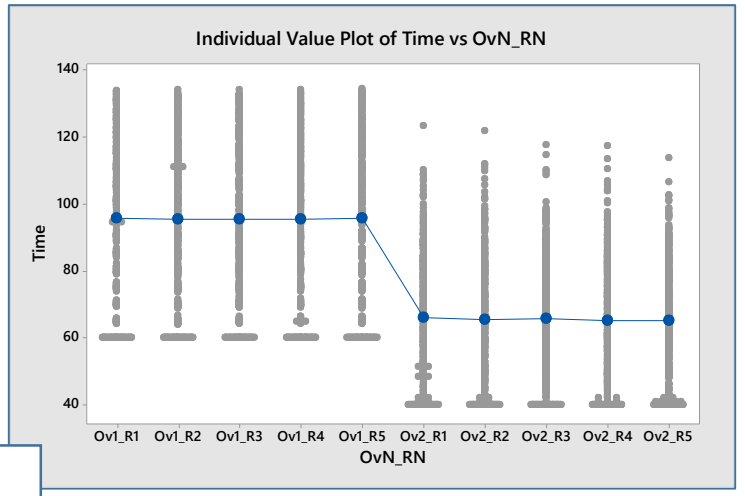
Analysis of Variance

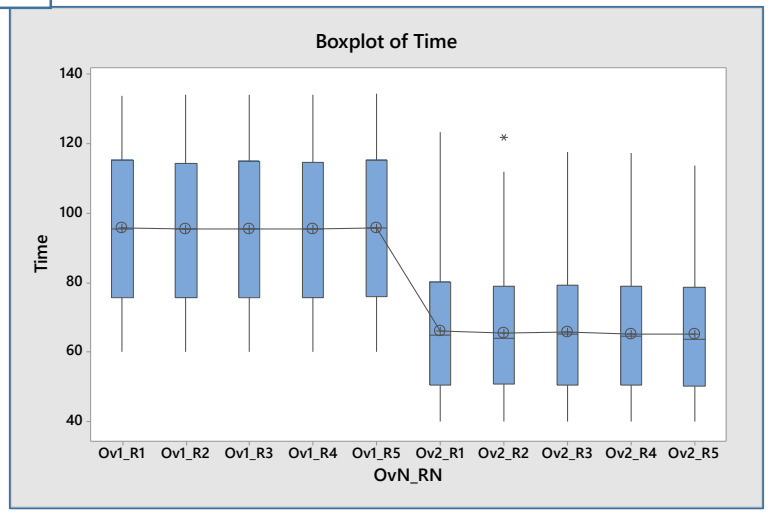
Source	DF	Adj SS	Adj MS	F-Value	P-Value
OvN_RN	9	932415	103602	258.99	0.000
Error	4160	1664065	400		
Total	4169	2596480			

S	R-sq	R-sq(adj)	R-sq(pred)
20.0004	35.91%	35.77%	35.61%

OvN_RN	N	Mean	StDev	95% CI
Ov1_R1	450	95.66	22.09	(93.81, 97.50)
Ov1_R2	450	95.36	21.93	(93.51, 97.21)
Ov1_R3	450	95.49	21.89	(93.64, 97.34)
Ov1_R4	450	95.57	21.96	(93.72, 97.42)
Ov1_R5	450	95.70	22.00	(93.85, 97.54)
Ov2_R1	370	66.013	18.006	(63.974, 68.051)
Ov2_R2	380	65.606	17.705	(63.595, 67.618)
Ov2_R3	390	65.820	17.222	(63.834, 67.805)
Ov2_R4	390	65.295	17.102	(63.309, 67.280)
Ov2_R5	390	65.081	16.984	(63.096, 67.067)

Total Time at Ovens NOT the Same





Critical Few X's & the Big Y

- The "Big Y" is Cycle Time per part
- Some Critical X's (things that could be changed to possibly reduce CT):
  - Operation & Waiting Times
  - Batch Sizes
  - Capacities of Equipment
  - Use of Resources
  - Arrival of Parts
  - Rework Rates
  - Shop Layout

DMAIC Approach

	Define	Measure	Analyze	Improve	Control
Tasks	Define customers and requirements	Define Measures	Determine Root Causes	Define Potential Solutions	Define Control Plan
	Define Sponsor	Validate the Measurement System	Identify Value Add versus Non-Value Add Process Steps	Assess Potential Solutions	Develop Training Materials, Processes, Procedures
	Define Process Owner and other Stakeholders	Define the Data Collection Plan	Identify sources of Variation	Develop Proposed Solution	Implement Statistical Process Controls
	Develop the Problem Statement, Goals, Benefits	Collect the Data	Develop the relationship between Y and critical few X's	Pilot the Solution	Implement Visual Controls and Poka-Yoke
	Define Team,	Define X's and the "Big Y"	Determine the improvement opportunities to apply Lean	Define "to be" Process Map	Determine Process Capability
	Develop Project Plan	Determine if Process is in Control		Validate the Potential Improvement	Verify Benefits, Cost Savings, Finalize Documentation
	Develop High Level Process Map	Define the Process Capability			Transition to Process Owner, Close Project, and Celebrate
Tools	Project Charter	Value Stream Map	Run Chart/Time Series	Brainstorming/Affinity Diagram	Control Plan
	ROI/Payback Analysis	* Simulation	Ishikawa Diagram/5 Whys	* Simulation	Process Capability
	Voice of the Customer	Measurement System Analysis	Cause and Effect Matrix	FMEA	Process Sigma Calculator
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	SIPOC	Statistical Sampling	Components of Variation	Analytical Batch Sizing	
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	Kano Analysis	Control Charts	NVA Analysis	Kanban	
		Process Capability	Queuing Theory	Stocking Strategy	
		Histograms	FMEA	Force Field Analysis	

Improve Tasks

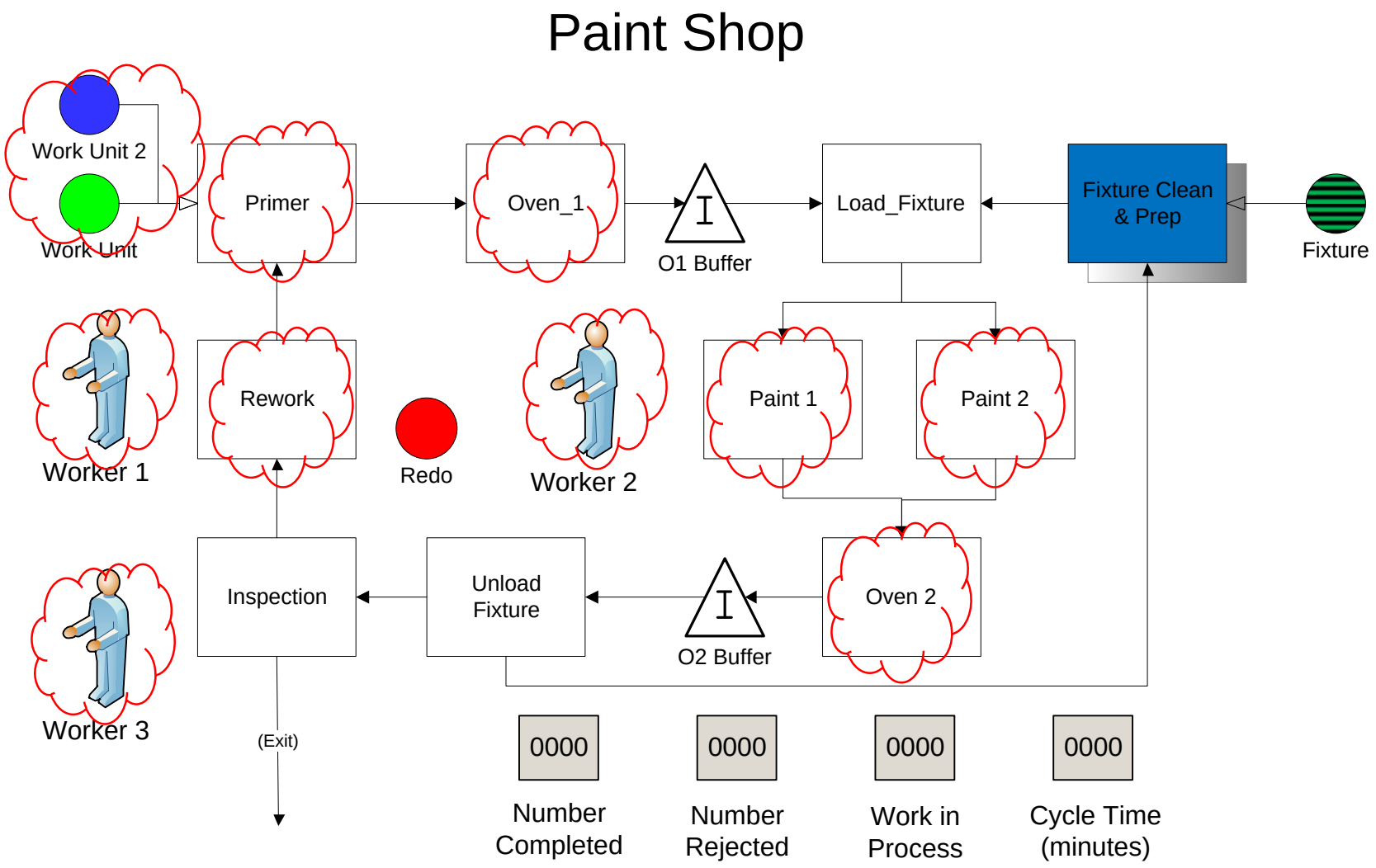
- Define Potential Solutions
- Assess Potential Solutions
- Develop Proposed Solution
- Pilot the Solution
- Validate the Potential Improvement
- Define “to be” Process Map

Potential Solution Ideas

- Reduce Primer & Paint Booth Times
- Increase Capacities of Primer & Paint Booths
- Increase or optimize Oven Batch sizes
- Use extra, unused Oven 2 Capacity to help Oven 1
- Increase Resources (X)
- Make quality changes to reduce rework %
- Reduce Inspections (X)
- Dedicate each Paint Booth to only 1 part color to reduce Setups
- Change Shop Layout to minimize or eliminate transporting parts
- Change Resource use for operation and / or transportation tasks
- Only “Pull” parts into the shop as new orders arrive

(X) = Management says “No!”

Current State Paint Shop – Solution Areas

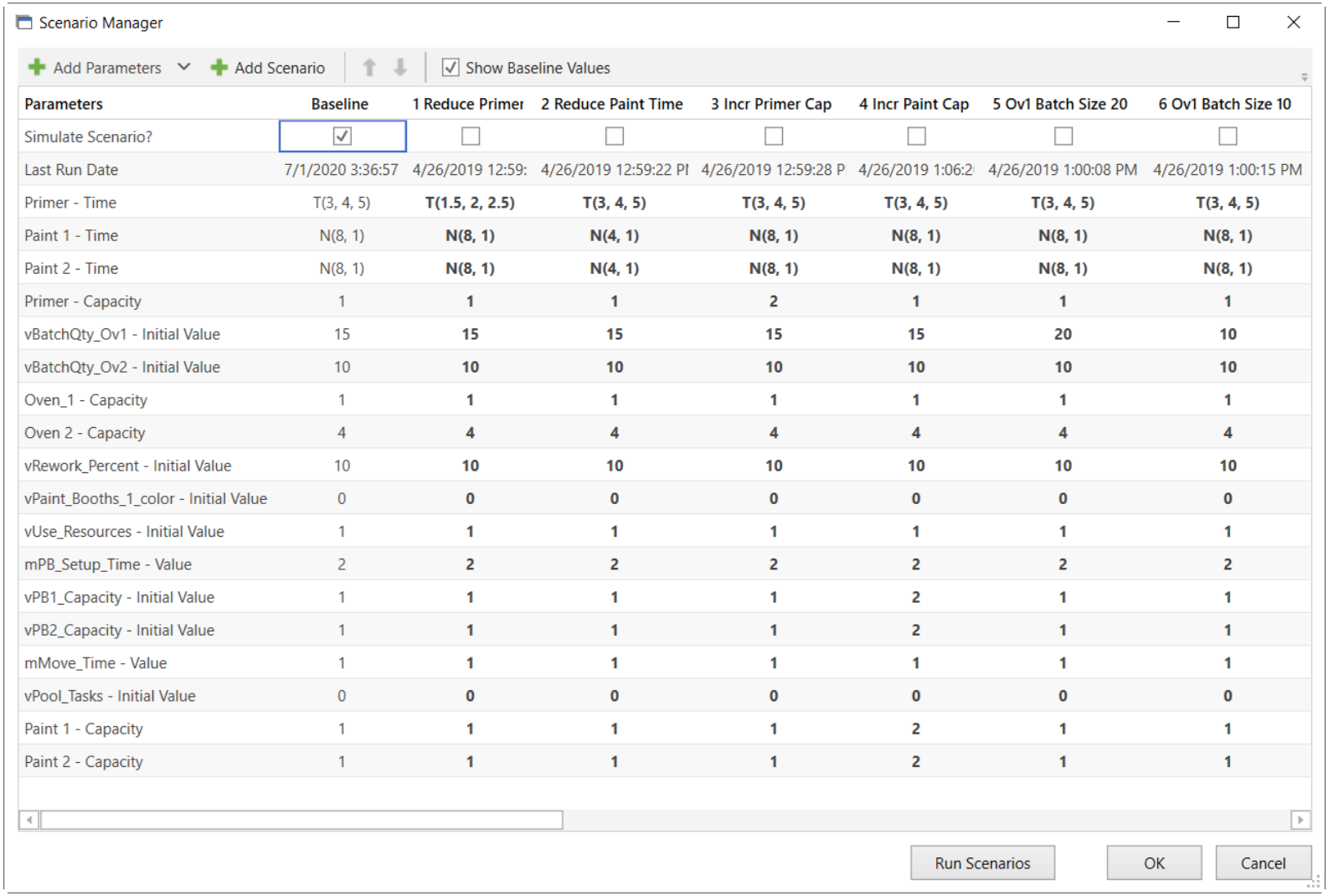


List of Scenarios

1. Reduce Primer time by 50%
2. Reduce Paint time by 50%
3. Increase Primer Capacity by 1
4. Increase Paint Booths' Capacity by 1 each
5. Increase Oven 1 Batch Size to 20
6. Reduce Oven 1 Batch Size to 10 (like Oven 2)
7. Increase Oven 2 Batch Size to 15
8. Change Oven 1 & 2 Capacities so Oven 2 helps Oven 1; (Oven 1 Cap. = 2 Batches, Oven 2 Cap. = 3 Batches)
9. Reduce Rework rate to 5%
10. Dedicate Paint Booths to 1 color each to eliminate setups
11. Pool Workers 2 & 3 for part moves
12. Pool All Workers for part moves
13. Use No Workers for part moves (in cellular shop)
14. Pool All Workers for All Tasks & Moves
15. Pool All Workers for All Tasks & No Moves (in cellular shop)

Which 3 Scenarios would you choose?

Scenario Manager



Parameters	Baseline	1 Reduce Primer	2 Reduce Paint Time	3 Incr Primer Cap	4 Incr Paint Cap	5 Ov1 Batch Size 20	6 Ov1 Batch Size 10
Simulate Scenario?	☑	☐	☐	☐	☐	☐	☐
Last Run Date	7/1/2020 3:36:57	4/26/2019 12:59:	4/26/2019 12:59:22 PI	4/26/2019 12:59:28 P	4/26/2019 1:06:2	4/26/2019 1:00:08 PM	4/26/2019 1:00:15 PM
Primer - Time	T(3, 4, 5)	**T(1.5, 2, 2.5)**	**T(3, 4, 5)**	**T(3, 4, 5)**	**T(3, 4, 5)**	**T(3, 4, 5)**	**T(3, 4, 5)**
Paint 1 - Time	N(8, 1)	**N(8, 1)**	**N(4, 1)**	**N(8, 1)**	**N(8, 1)**	**N(8, 1)**	**N(8, 1)**
Paint 2 - Time	N(8, 1)	**N(8, 1)**	**N(4, 1)**	**N(8, 1)**	**N(8, 1)**	**N(8, 1)**	**N(8, 1)**
Primer - Capacity	1	**1**	**1**	**2**	**1**	**1**	**1**
vBatchQty_Ov1 - Initial Value	15	**15**	**15**	**15**	**15**	**20**	**10**
vBatchQty_Ov2 - Initial Value	10	**10**	**10**	**10**	**10**	**10**	**10**
Oven_1 - Capacity	1	**1**	**1**	**1**	**1**	**1**	**1**
Oven 2 - Capacity	4	**4**	**4**	**4**	**4**	**4**	**4**
vRework_Percent - Initial Value	10	**10**	**10**	**10**	**10**	**10**	**10**
vPaint_Booths_1_color - Initial Value	0	**0**	**0**	**0**	**0**	**0**	**0**
vUse_Resources - Initial Value	1	**1**	**1**	**1**	**1**	**1**	**1**
mPB_Setup_Time - Value	2	**2**	**2**	**2**	**2**	**2**	**2**
vPB1_Capacity - Initial Value	1	**1**	**1**	**1**	**2**	**1**	**1**
vPB2_Capacity - Initial Value	1	**1**	**1**	**1**	**2**	**1**	**1**
mMove_Time - Value	1	**1**	**1**	**1**	**1**	**1**	**1**
vPool_Tasks - Initial Value	0	**0**	**0**	**0**	**0**	**0**	**0**
Paint 1 - Capacity	1	**1**	**1**	**1**	**2**	**1**	**1**
Paint 2 - Capacity	1	**1**	**1**	**1**	**2**	**1**	**1**

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*Note: Scenario 4 requires you to temporarily delete the Setup time at both Paint Booths which become Multi-Capacity Locations. Setup time is only for Single Capacity Locations.

Scenario Results for Work Unit Exits

Note Average Time in System

Entity Summary (Avg. Reps)

Scenario	Replication	Name	Total Exits	Current Quantity In System	Average Time In System (Min)	Average Time In Move Logic (Min)	Average Time Waiting (Min)	Average Time In Operation (Min)	Average Time Blocked (Min)
15 Pool ALL Workers Tasks w No Moves	Avg	Work Unit	210.88	66.04	356.38	0.00	51.45	116.80	188.13
13 No Worker Moves	Avg	Work Unit	203.16	74.92	387.42	0.00	53.32	116.85	217.25
14 Pool ALL Workers Moves & Tasks	Avg	Work Unit	173.00	105.40	519.42	6.04	61.37	116.80	335.21
9 Reduce Rework	Avg	Work Unit	184.44	105.12	532.06	8.76	62.59	116.82	343.89
12 Pool ALL Workers Moves	Avg	Work Unit	172.88	107.16	540.21	5.72	63.78	116.79	353.92
11 Pool Workers 2 & 3 Moves	Avg	Work Unit	172.60	107.92	542.40	7.35	63.95	116.79	354.31
4 Incr Paint Cap	Avg	Work Unit	164.80	116.48	560.62	9.55	63.51	116.80	370.76
2 Reduce Paint Time	Avg	Work Unit	166.60	115.60	561.79	9.37	64.12	112.80	375.50
1 Reduce Primer Time	Avg	Work Unit	159.44	124.60	579.04	9.39	56.20	114.80	398.64
3 Incr Primer Cap	Avg	Work Unit	156.00	125.76	581.29	9.52	56.43	116.82	398.52
10 Paint Bs 1 color	Avg	Work Unit	158.24	124.04	588.95	9.31	65.07	116.83	397.74
8 Chg Ov1, 2 Caps	Avg	Work Unit	157.16	124.64	602.83	9.34	65.70	116.85	410.94
Baseline	Avg	Work Unit	157.16	124.64	602.83	9.34	65.70	116.85	410.94
5 Ov1 Batch Size 20	Avg	Work Unit	158.08	124.88	617.82	9.23	78.21	116.82	413.56
6 Ov1 Batch Size 10	Avg	Work Unit	151.32	133.68	618.76	9.12	53.11	116.83	439.70
7 Ov2 Batch Size 15	Avg	Work Unit	155.28	125.76	620.30	9.45	79.66	116.85	414.34

Scenarios Combining Factors

- You could build 5 additional Scenarios with the following Factor Combinations:
  - Combination 1 = Scenarios: 15, 9, 3, 1, 4 & 2
  - Combination 2 = Scenarios: 14, 9, 3, 1, 4 & 2
  - Combination 3 = Scenarios: 13, 9, 3, 1, 4 & 2
  - Combination 4 = Scenarios: 12, 9, 3, 1, 4 & 2
  - Combination 5 = Scenarios: 11, 9, 3, 1, 4 & 2

*Note: Scenario 4 requires you to temporarily delete the Setup time at both Paint Booths which become Multi-Capacity Locations. Setup time is only for Single Capacity Locations.

Combination Scenario Results for Work Unit Exits

Note Average Time in System

Entity Summary (Avg. Reps)

Scenario	Replication	Name	Total Exits	Current Quantity In System	Average Time In System (Min)	Average Time In Move Logic (Min)	Average Time Waiting (Min)	Average Time In Operation (Min)	Average Time Blocked (Min)
16 Comb1- 15,9,3,1,4,2	Avg	Work Unit	246.28	40.44	236.68	0.00	42.18	110.83	83.67
18 Comb3- 13,9,3,1,4,2	Avg	Work Unit	246.08	40.92	240.29	0.00	43.73	110.83	85.72
17 Comb2- 14,9,3,1,4,2	Avg	Work Unit	236.20	49.48	288.58	6.49	46.36	110.83	124.90
15 Pool ALL Workers Tasks w No Moves	Avg	Work Unit	210.88	66.04	356.38	0.00	51.45	116.80	188.13
20 Comb5- 11,9,3,1,4,2	Avg	Work Unit	220.48	68.72	364.28	7.68	49.57	110.85	196.17
19 Comb4- 12,9,3,1,4,2	Avg	Work Unit	217.04	71.56	373.53	6.01	49.78	110.83	206.92
13 No Worker Moves	Avg	Work Unit	203.16	74.92	387.42	0.00	53.32	116.85	217.25
14 Pool ALL Workers Moves & Tasks	Avg	Work Unit	173.00	105.40	519.42	6.04	61.37	116.80	335.21
9 Reduce Rework	Avg	Work Unit	184.44	105.12	532.06	8.76	62.59	116.82	343.89
12 Pool ALL Workers Moves	Avg	Work Unit	172.88	107.16	540.21	5.72	63.78	116.79	353.92
11 Pool Workers 2 & 3 Moves	Avg	Work Unit	172.60	107.92	542.40	7.35	63.95	116.79	354.31
4 Incr Paint Cap	Avg	Work Unit	164.80	116.48	560.62	9.55	63.51	116.80	370.76
2 Reduce Paint Time	Avg	Work Unit	166.60	115.60	561.79	9.37	64.12	112.80	375.50
1 Reduce Primer Time	Avg	Work Unit	159.44	124.60	579.04	9.39	56.20	114.80	398.64
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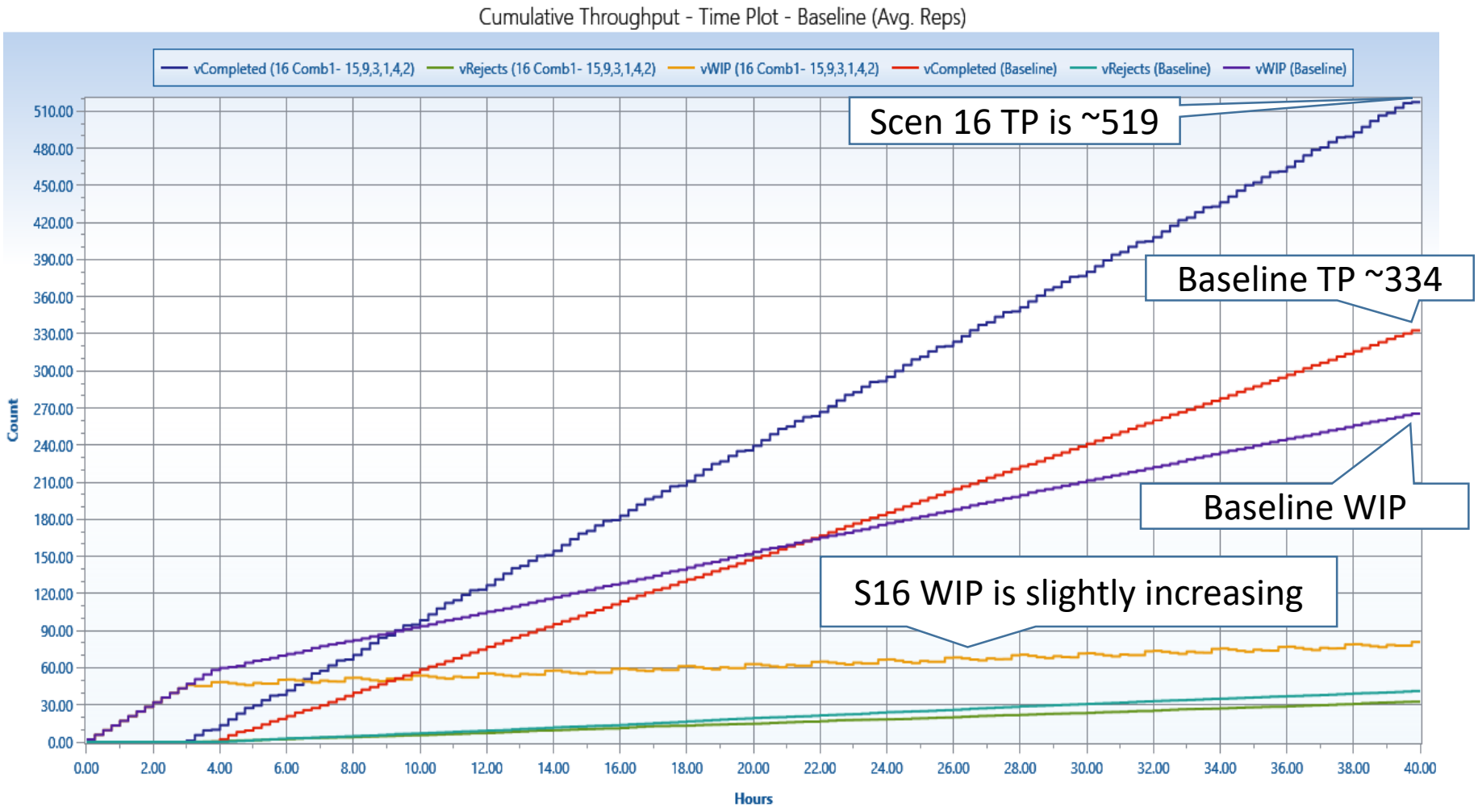
7 Ov2 Batch Size 15	Avg	Work Unit	155.28	125.76	620.30	9.45	79.66	116.85	414.34

Recap of Best Scenario # 16

- Combination 1 = Scenarios: 15, 9, 3, 1, 4 & 2
  - 15: Pool All Workers Tasks with No Moves
  - 9: Reduce Rework from 10% to 5%
  - 3: Increase Primer Capacity from 1 to 2
  - 1: Reduce Primer Time by 50%
  - 4: Increase Paint Booth Capacity from 1 to 2
  - 2: Reduce Paint Time by 50%

Are any of your top 3 Scenarios listed here?

Throughput (TP) & Work in Process (WIP) Data



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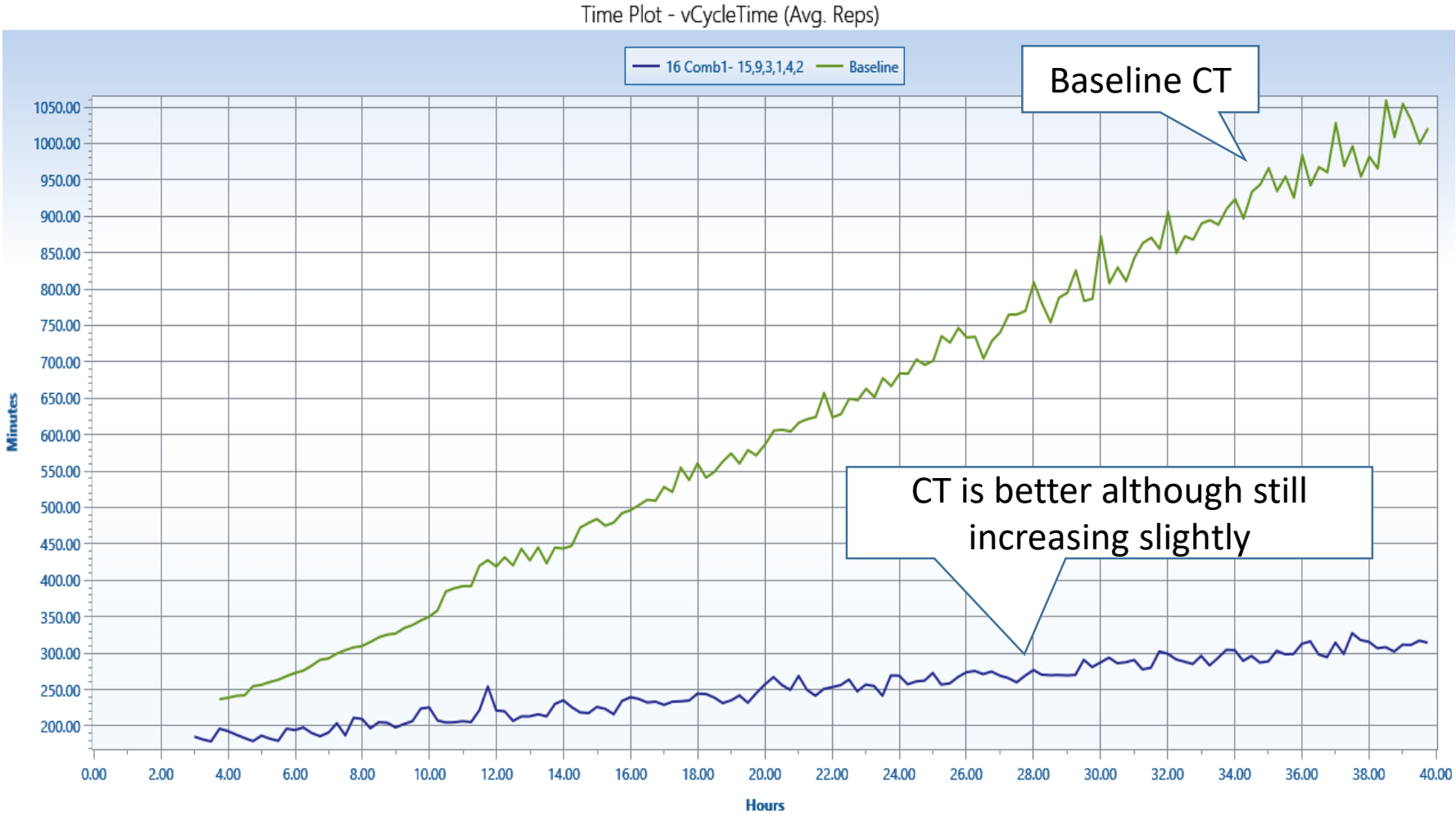
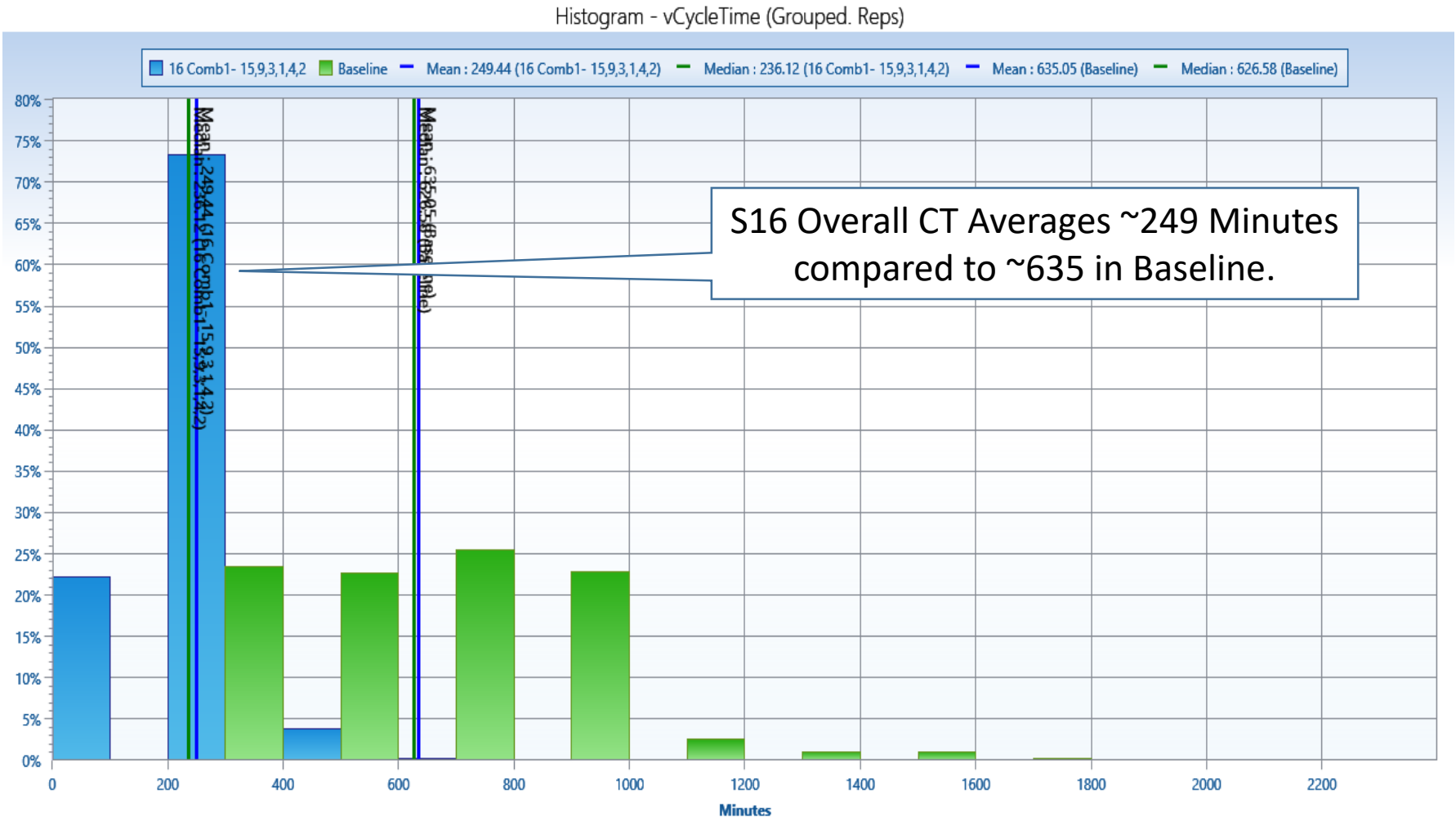
Cycle Time (CT) Data



Cycle Time – The "Big Y"



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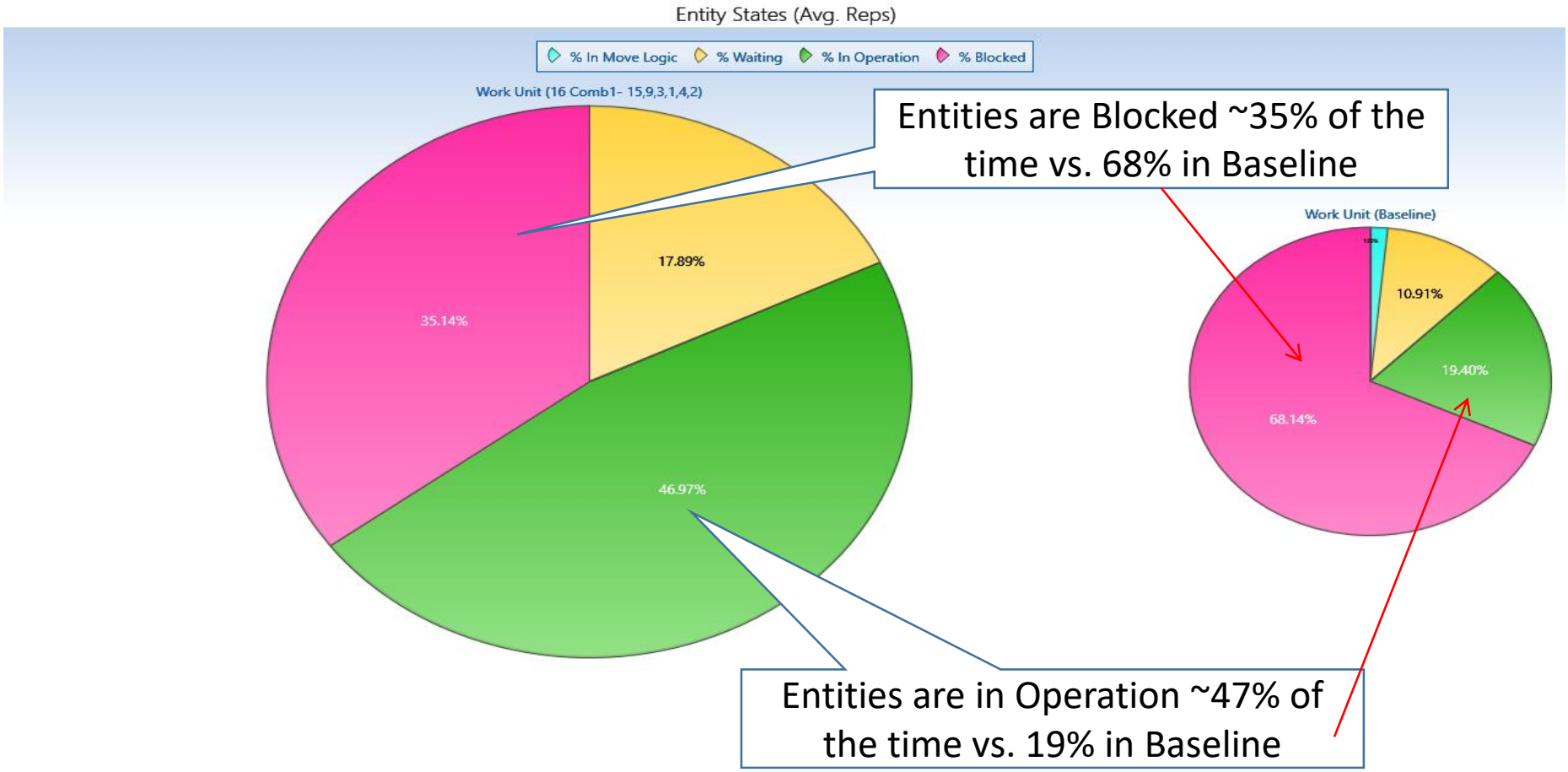
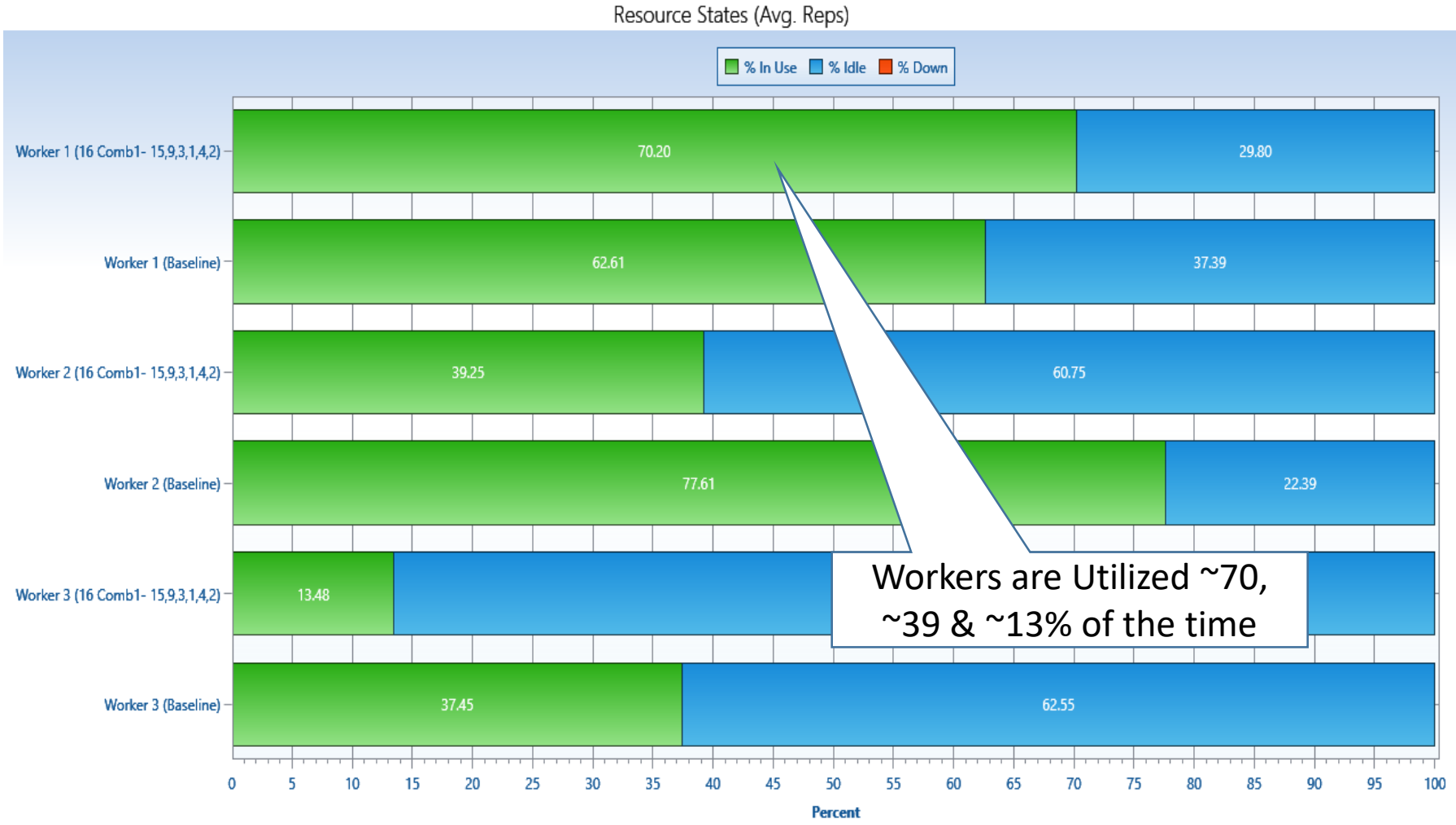
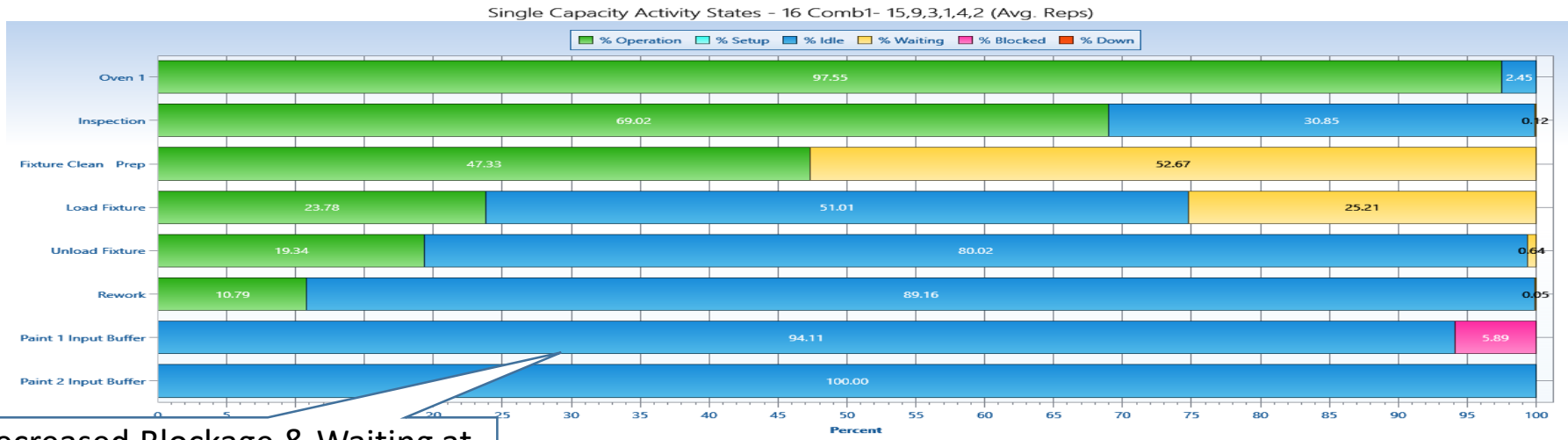
Entity Data


Entity States (Avg. Reps)
% In Move Logic
% Waiting
% In Operation
% Blocked
Work Unit (16 Comb1- 15,9,3,1,4,2)
17.89%
35.14%
46.97%
Work Unit (Baseline)
10.91%
19.40%
68.14%
Entities are Blocked ~35% of the time vs. 68% in Baseline
Entities are in Operation ~47% of the time vs. 19% in Baseline

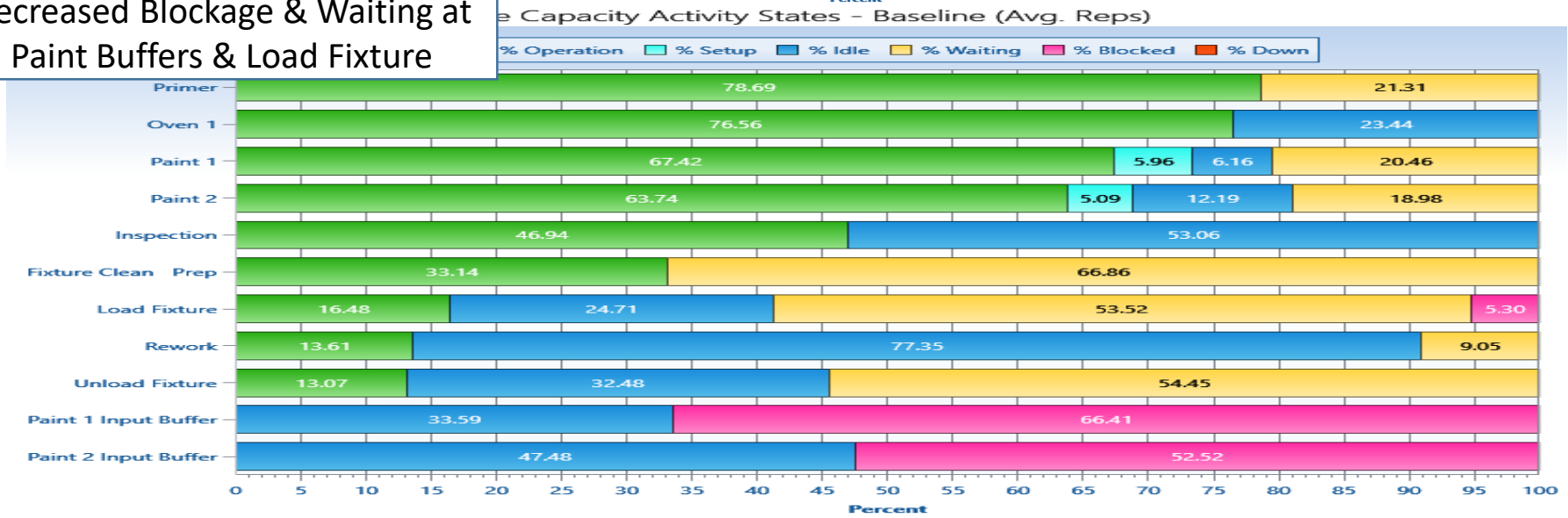
Resource Data



Activity Data



Decreased Blockage & Waiting at Paint Buffers & Load Fixture



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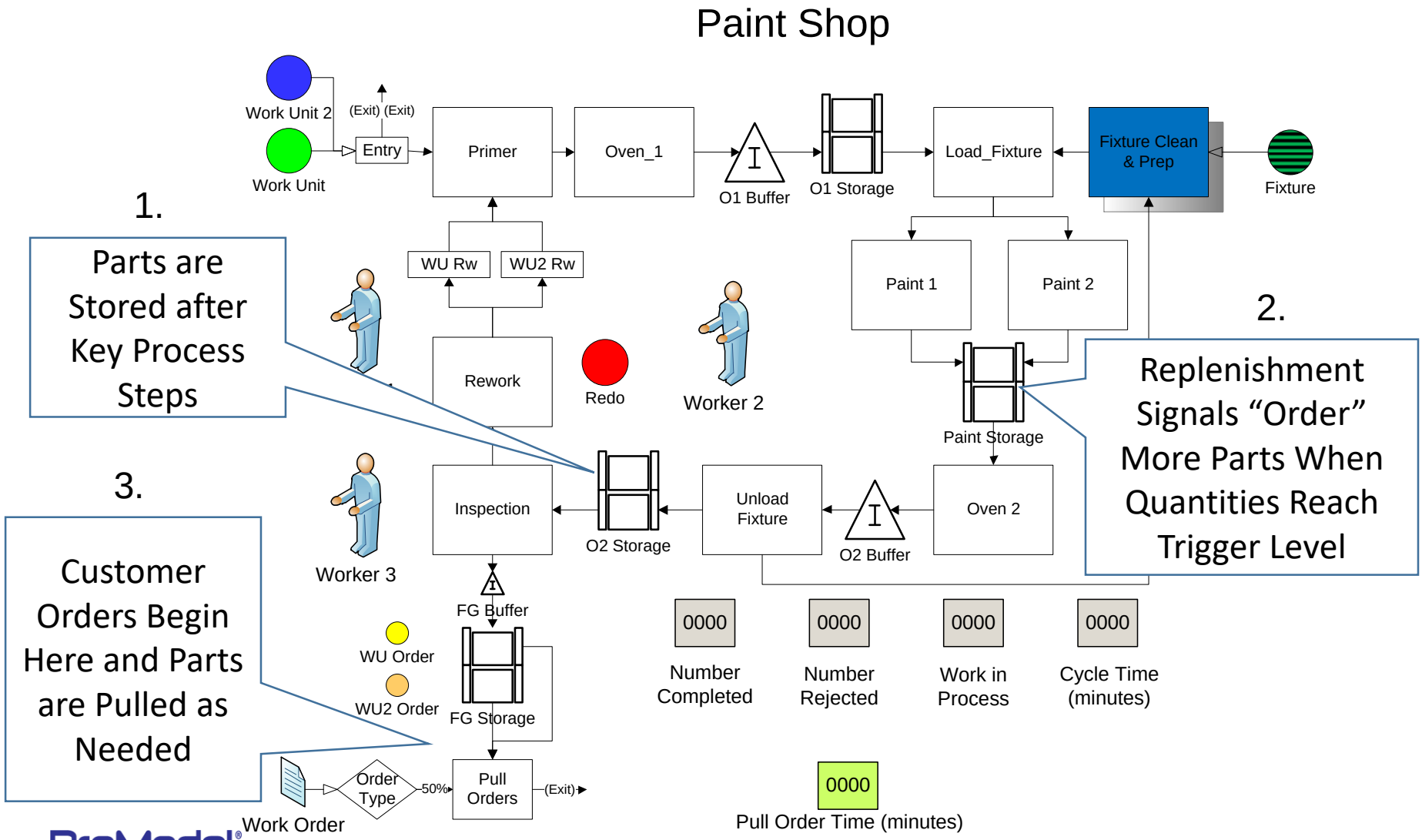
Proposed Paint Shop Pull System



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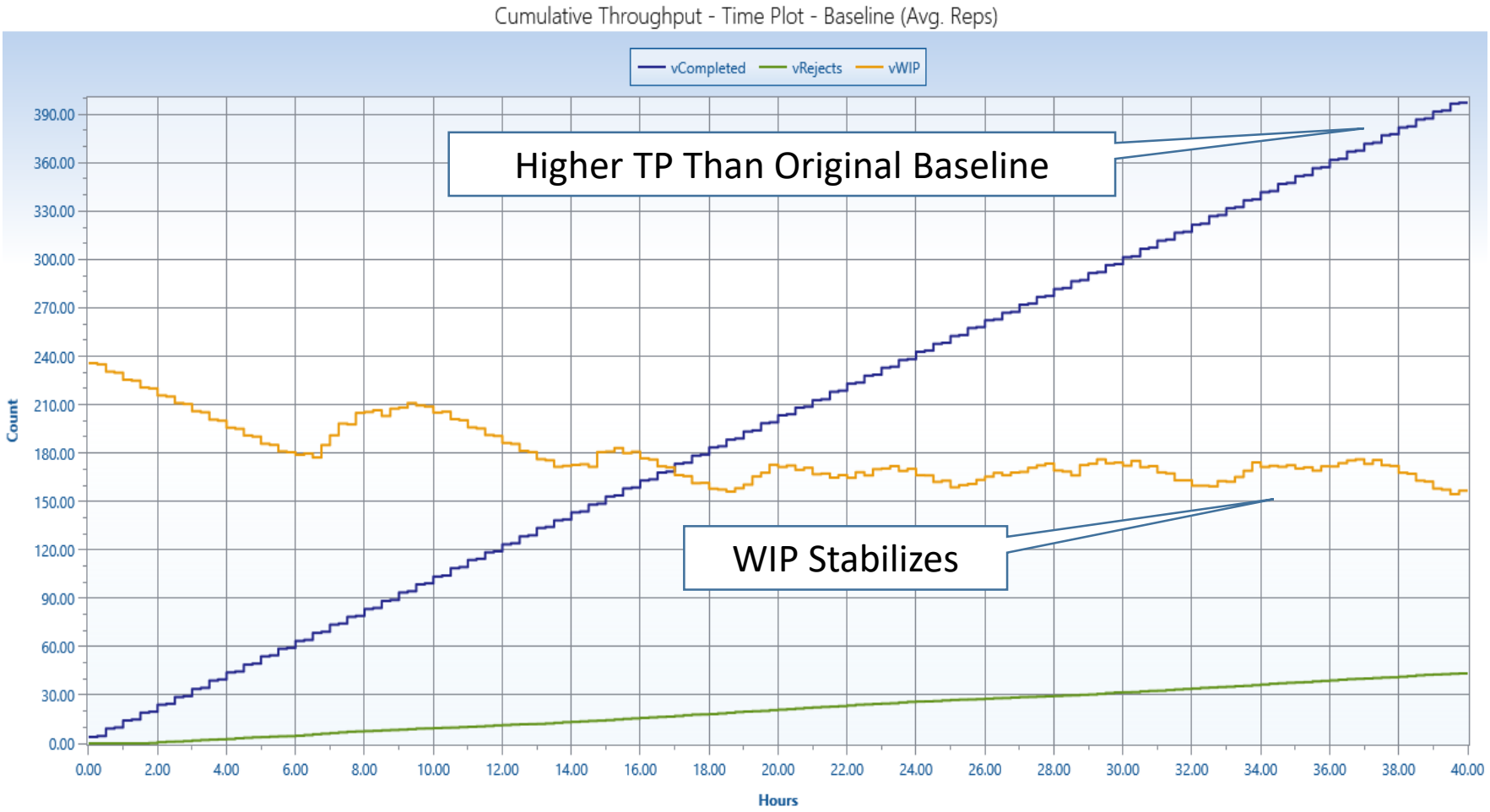
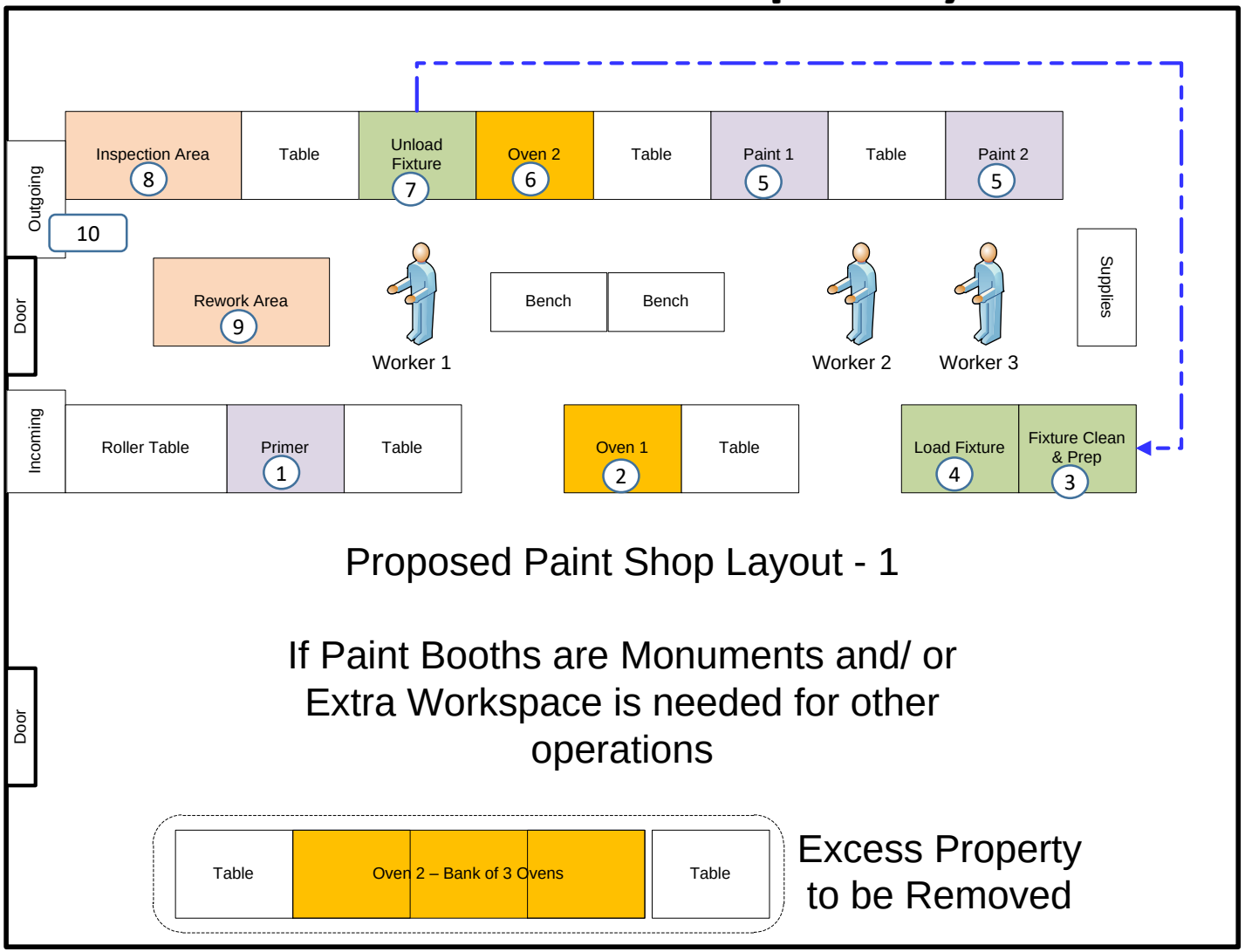
Pull – Baseline with Orders Every 30 Minutes



The Power of Pull Systems

- WIP goes up; however, it stabilizes!
- Cycle Time is higher; however, it also begins to stabilize!
- If Customer Work Orders arrive every 30 minutes then the amount of time to fill a Work Order drops to only 2 minutes (which is the actual pick time)!!
- Voice of the Customer / Voice of the Business
  - Customer survey says they want CT to be <= 300 minutes
  - Business is not sure if that CT can be met; however, they want orders quickly filled

Future State Paint Shop Layout 1



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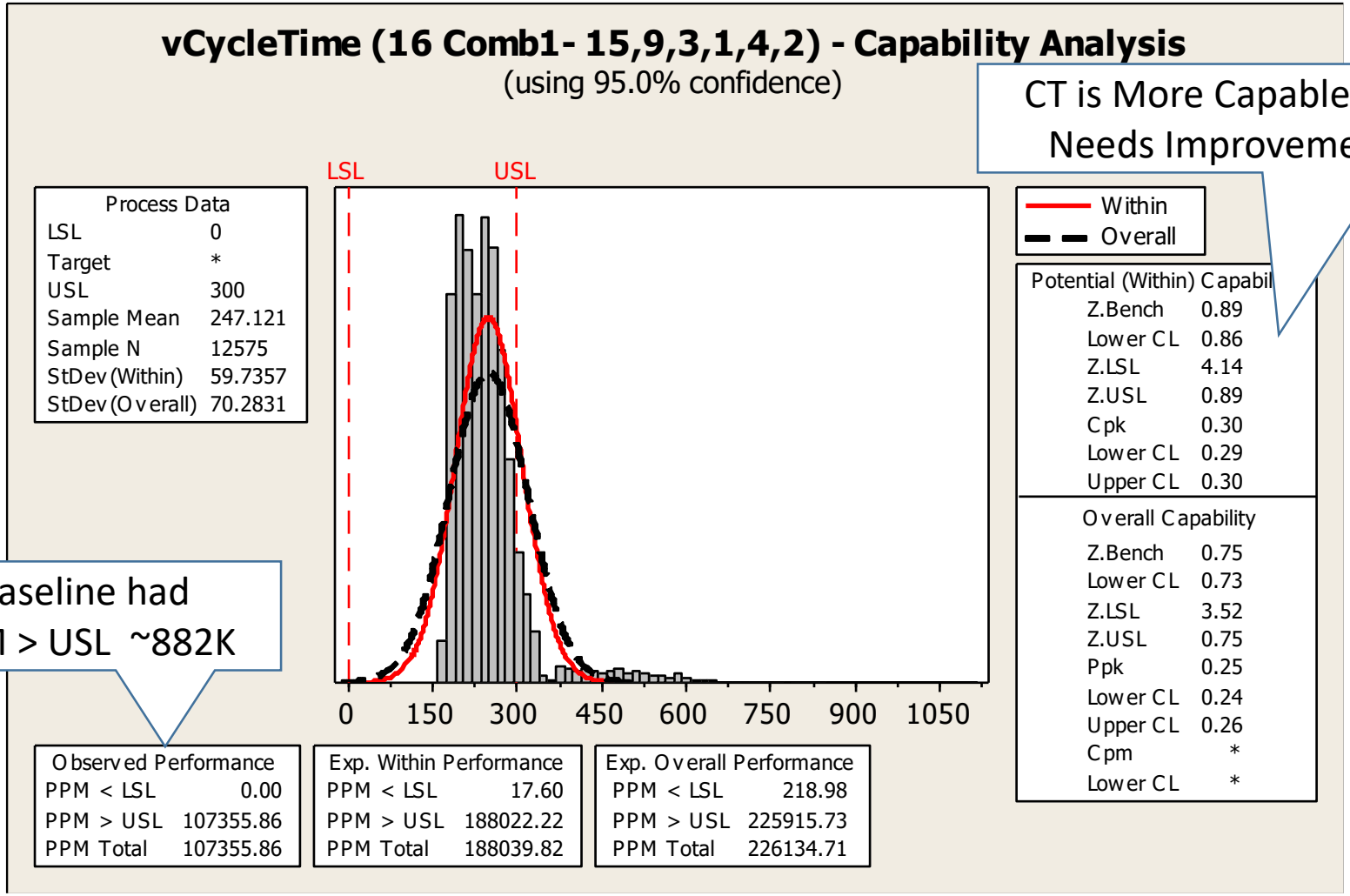
	Kano Analysis	Control Charts	NVA Analysis	Kanban	
		Process Capability	Queuing Theory	Stocking Strategy	
		Histograms	FMEA	Force Field Analysis	

Control Tasks

- Implement Statistical Process Controls
- Determine Process Capability
- Verify Benefits, Cost Savings, Finalize Documentation

Process Capability Data Scenario 16 – No Pull



CT is More Capable But Needs Improvement

Baseline had PPM > USL ~882K

Summary

- Simulation models can be a vital part of any LSS or other Process Improvement effort.
- DMAIC is a good approach for utilizing simulation models to help Define, Measure, Analyze, Improve, and Control any process.
- Process Simulator is a flexible, robust predictive analytics tool for process improvement!

Wrap Up

Thanks for Attending!
Any Questions?

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