Aligning Lab Automation and Lean Methods to Achieve World-Class Productivity in Your Lab

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Aligning Lab Automation and Lean Methods

Have you thought of or ever heard these statements?

- "Automation is the answer to your lab's problems."
- "Your lab will require less people to perform your workload."
- "Automation will improve (reduce) my Lab's Turn-Around-Time metrics."

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Aligning Lab Automation and Lean Methods

Is this a possibility?

"Seems that there is still not enough people to get the work done."

"I've had to introduce many manual steps to make my automation work."

"TAT hasn't improved, it's gotten worse."

Aligning Lab Automation and Lean Methods

OUCH! How can this be fixed?

First Aid!

Band-Aids…

Workarounds…

Increased expenses…

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OUCH! How can this be fixed?

Blame the vendor?

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How can this be fixed?

Open Your Lean Six Sigma toolbox!

Understand the Process

Determine Root Cause

Reduce or eliminate Root Cause

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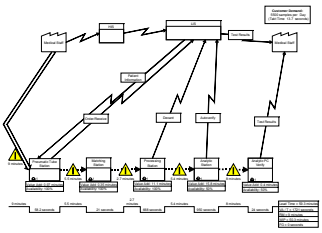
Understand the Process

Build Current State Value Stream Map

- Identify waste
- Identify bottlenecks



Implement Continuous Flow

Design Future State Value Stream Map

- Eliminate bottlenecks and waste
- Reduce batch size

Preanalytic (Front End) ~ Analytic (Automation) ~ Post-Analytic

Best Completed prior to Automation Decision

Aligning Lab Automation and Lean Methods

Study overall work flow:

- Specimen arrival patterns and volumes
- Specimen activities
- Activity timing
- Specimen wait times
- Specimen transportation
- Lab layout / staffing

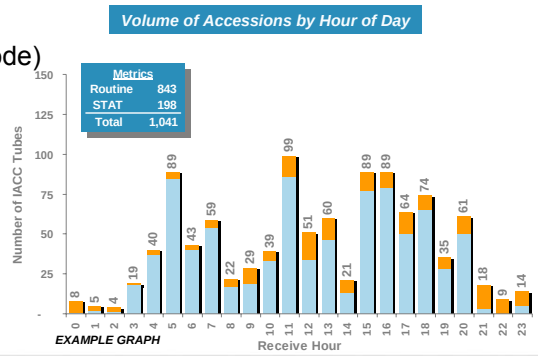
Collect data by:

- Direct observation and measurement
- Talking with people in the process
- LIS database

Aligning Lab Automation and Lean Methods - Pre-analytic

How do Specimens Arrive?

- Specimen types and volumes
- stat / routine
- Pneumatic Tube Station / Courier
- IP / OP
- Labeled / Unlabeled (barcode)
- Un-Spun vs Pre-spun
- Arrival Patterns
- Batch sizes



Aligning Lab Automation and Lean Methods - Pre-analytic

Applying Lean

Workload Leveling (based on leveled production concept)

- Smoothes out peaks in volume.
- Prevents a unbalanced amount of work being given to a worker, team or equipment or specific time, while others are idle.
- The objective is to maximize capacity utilization and level staffing.

Large batches slow processes – including automated processes!

References:
Lean thinking: banish waste and create wealth in your corporation *By James P. Womack, Daniel T. Jones*
Lean for Dummies *By Natalie J. Sayer, Bruce Williams*
http://www.strategosinc.com/workcell_balance.htm

Aligning Lab Automation and Lean Methods - Pre-analytic

Operationalize Lean: Workload Leveling

Upstream Analysis - Start at the beginning!

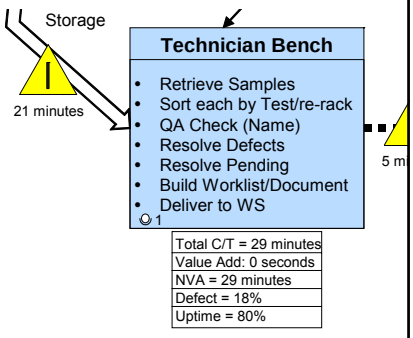
- Phlebotomy schedules and process
- Courier drop-off schedules and volumes

Adjust collection processes and schedules to smooth specimen arrival patterns

Aligning Lab Automation and Lean Methods - Pre-analytic

How are specimens handled once they arrive?

What activities must occur before the specimen can be placed on the automation?



Macro Level –
Is the activity necessary?
Can automation perform the activity?

Micro Level –
Non-value added steps
Rework
Multiple decision points

Review Activities to Reduce Complexity

Aligning Lab Automation and Lean Methods - Pre-analytic

Applying Lean: Workcell Design

- A grouping of equipment, people, and supplies.
- Activities arranged in sequential order.
- Adjusts the process to fit customer demand.
- Promotes continuous flow.
- Improves quality.
- Reduces inventory.
- Reduces turn-around-time.

Batching, Inventory and Additional Handling Eliminated or Reduced.

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Lean thinking: banish waste and create wealth in your corporation *By James P. Womack, Daniel T. Jones*
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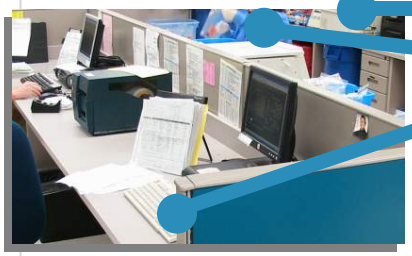
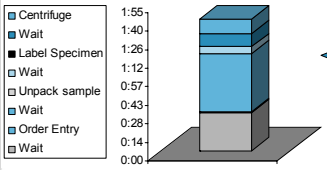
Aligning Lab Automation and Lean Methods - Pre-analytic

Operationalize Lean: Workcell Design



3. Centrifuge
2. Unpack Sample and Label
1. Data Entry
Receive, Label, Centrifuge at One Station

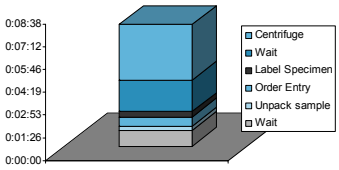
Traditional Process



Hospital #1
440 beds, 1.5 M chem. tests annually

A 1 hour 34 minute difference!

Work Cell



Hospital #2
380 beds, 1.3 M chem. tests annually

Source: Data collections performed by Abbott Consulting at two US Hospitals

Aligning Lab Automation and Lean Methods - Automation

Conventional thought:

Automation can handle everything at once!!

Pushing the work and large batches slows processes – including automated processes!

…Resulting in extended TATs…

Aligning Lab Automation and Lean Methods - Automation

Applying Lean

Push versus Pull

Push System

Work is done at historical rate.

Pull System

Work rate is based on upstream capacity or demand.

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Aligning Lab Automation and Lean Methods - Automation

Applying Lean: Why Use a Pull System?

Little's Law: $\text{Lead Time (TAT)} = \frac{\text{Work in Process}}{\text{Throughput}}$

Pull Systems

– Control and reduce Work In Process (WIP).

– Control and reduce Lead Time.

– Stabilize the process.

A Pull System reduces the amount of WIP which reduces lead time (TAT).

Aligning Lab Automation and Lean Methods - Automation

Applying Lean: Implement a Pull System for Automation

Evaluate each module for capacity and throughput

- Loading module
- Centrifuge
- Aliquotter
- De-capper
- Each type of analyzer
- Re-sealer
- Sorting or off-load module
- Storage

Theoretical Analysis for Designing a Pull System: What is the Limiting Factor (Capacity) of the Automation?

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Applying Lean: Implement a Pull System for Automation

Theoretical Analysis: Loading

Activity	Type	Max Load (tubes)	Load Time per tube (seconds)	Load Time (Max Avg) (minutes)	Time Wait (minutes)	Max Queue (tubes)	Centrifuge Countdown (minutes)
Analyze Only	PreSpun	24	12	4.8	10	24	
Centrifuge/Analyze	Unspun	24	12	4.8	10	24	
Centrifuge	Coag	48	12	9.6		na	30
Analyze Only	PreSpun	24	12	4.8	10	24	25
Receive Only	EDTA/UA	48	14	11.2		na	14
Analyze Only	PreSpun	24	12	4.8	10	24	9
Centrifuge/Analyze	Unspun	24	12	4.8	10	24	4
Centrifuge	Coag	48	12	9.6		na	30
Receive Only	EDTA/UA	48	14	11.2		na	19
Analyze Only	PreSpun	24	12	4.8	10	24	14
Centrifuge/Analyze	Unspun	24	12	4.8	10	24	9

**Example of a automation loading algorithm*

In a Pull System Entries = Exits

Aligning Lab Automation and Lean Methods - Automation

Applying Lean: Implement a Pull System for Automation

Tube Count							
Elapsed Time (hours)	Centrifuge/ Analyze	Centrifuge	Analyze Only	Receive Only	Total Tubes	Hour	Hourly Tubes
0.1	0	0	24	0	24		
0.2	24	0	24	0	48		
0.3	24	48	24	0	96		
0.4	24	48	48	0	120		
0.6	24	48	48	48	168		
0.7	24	48	72	48	192		
0.7	48	48	72	48	216		
0.9	48	96	72	48	264	Hour 1	264
1.1	48	96	72	96	312		
1.2	48	96	96	96	336		
1.3	72	96	96	96	360		
1.4	72	144	96	96	408		
1.6	72	144	96	144	456		
1.7	72	144	120	144	480		
1.8	96	144	120	144	504		
1.9	96	192	120	144	552	Hour 2	288
2.1	96	192	120	192	600		
2.2	96	192	144	192	624		
2.3	120	192	144	192	648		
2.4	120	240	144	192	696		
2.5	120	240	168	192	720		
2.7	120	240	168	240	768		
2.8	120	240	192	240	792		
2.9	144	240	192	240	816		
3.0	144	288	192	240	864	Hour 3	312

Theoretical Analysis: Tubes per Hour

Will the Pull System model meet Takt Time?

**Example of automation loading capacity*

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This is Theoretical…

How is this Operationalized?

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Operationalize Lean: Implement a Pull System for Automation

Run trials

- ✓ Collect metrics.
- ✓ Evaluate results.
- ✓ Share key learnings.
- ✓ Implement across all shifts or trial again with adjustments.

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Operationalize Lean: Implement a Pull System for Automation

Be sure to engage Staff!

- Adds creativity and ideas to design of Pull System.
- Ensures compliance with implementation.

Aligning Lab Automation and Lean Methods – Post Analytic

Post Analytic - Resulting Tests

Applying Lean: Reduce Waste and Non-Value Added Activity

Reduce waste of Inventory:

–Tests waiting to be manually resulted.

Reduce waste of Intellect:

–Reviewing normal results.

Implement Auto-Verification

Aligning Lab Automation and Lean Methods – Post Analytic

Post Analytic - Archiving Specimens

Applying Lean: Reduce Waste and Non-Value Added Activity

Reduce waste of Intellect:

–Manually organizing specimens for storage.

–Manually retrieving specimens for add-ons or send-outs.

Automate Storage and Retrieval

–Stand-alone archiving software
–Middleware
–Storage module on Automation

Case Study: Implementation of Lab Automation

Purpose

To identify turn-around-time improvements resulting from the implementation of front end automation in a hospital laboratory.

Data Source

Approximately 30 days per year (October/November) of LIS data.

Accessions include Chemistry only, IA only, Chemistry and IA combined.

Outcome

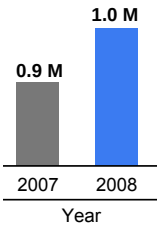
STAT and Routine testing:

→ Decreased TAT Mean and Variation (SD): Xbar

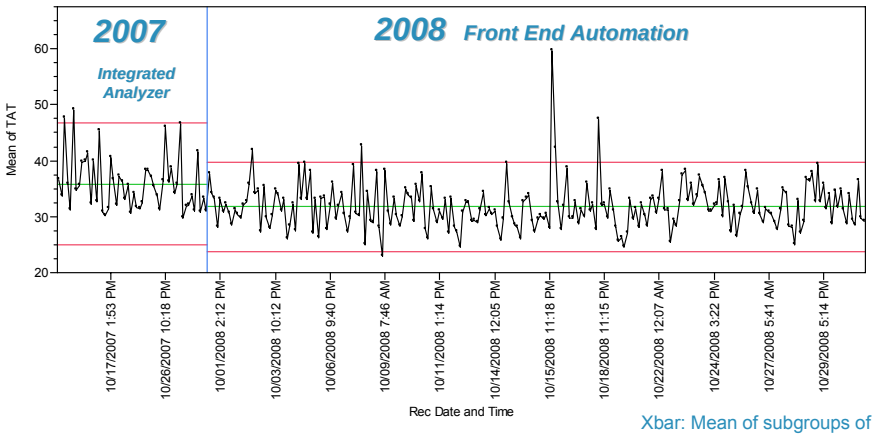
→ Decreased TAT Variation: Variability Charts

→ Improved Process Sigma

Annual Volume of Chemistry and Immunoassay Accessions



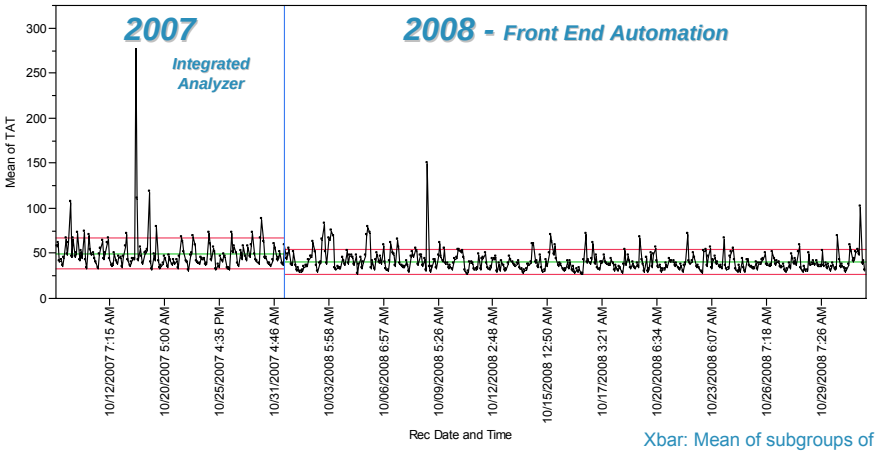
Xbar Chart of TAT - STAT



Xbar: Mean of subgroups of 20

Mean: 11% Improvement

Xbar Chart of TAT - Routines

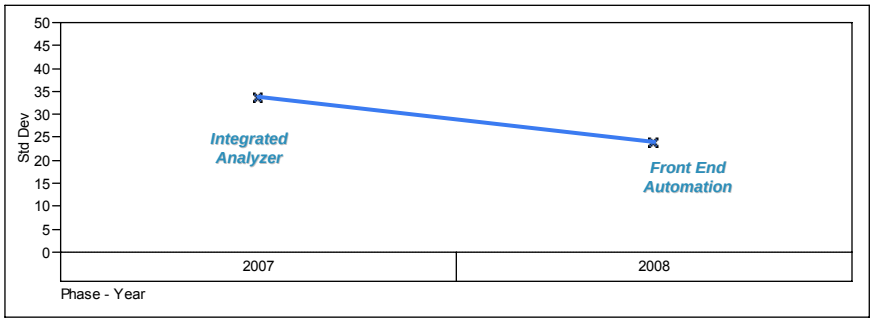


Xbar: Mean of subgroups of 20

Mean: 19% Improvement

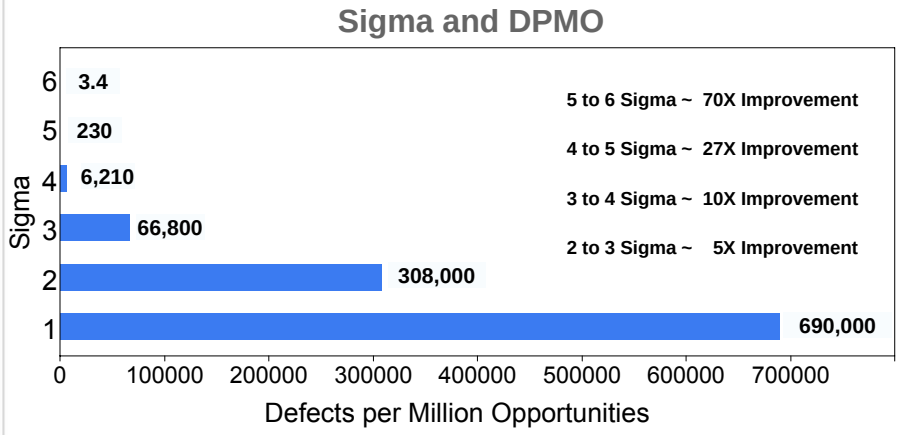
Variability Chart – Standard Deviation

	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	Minimum	Maximum	Observations
Phase - Year[2007]	44.06619	33.75522	0.42942	43.22438	44.908	4	469	6179
Phase - Year[2008]	36.73193	23.90005	0.237791	36.26582	37.19805	4	460	10102



Standard Deviation: 29% Improvement

Six Sigma Metrics



Achieving Higher Sigma is Progressively Difficult

Six Sigma

↓ Defects = ↑ Process Sigma =

↓ Phone Calls to Lab = ↓ Length of Stay =

↑ Patient Care Provider Satisfaction

Six Sigma

Metric Definitions:

– Sample = Chemistry and Immunoassay Accessions

– Routine Defects = TAT > 60 min

– STAT Defects = TAT > 45 min

– DPMO = Defects per Million Opportunities

Six Sigma Metrics

Front End Automation has reduced defects in TAT as measured by the Process Sigma for Accession TAT

Process Sigma Summary			
STAT	2007	2008	% Improve
Sample	1,028	4,584	
# Defects	181	513	
Defect Ratio	18%	11%	36%
DPMO	176,070	111,911	
Sigma Level	2.43	2.72	

Process Sigma Summary			
Routine	2007	2008	% Improve
Sample	2,987	7,687	
# Defects	492	507	
Defect Ratio	16%	7%	60%
DPMO	164,714	65,956	
Sigma Level	2.48	3.01	

Major North American Health System, customer sites are not identified for proprietary reasons. Data collected from customer's Laboratory Information System; 2006,2007,2008. Analyzed using JMP software.

Aligning Lab Automation and Lean Methods

Applying Lean - Summary

	Increase Resources	Decrease Waste and Non-Value Add	Pull Systems, Workload Leveling
Lead Time (TAT)	↓	↓	↓
Cost	↑	↓	↔