Combining Lean, Middleware, and Targeted Automated Systems to Unlock Lab Automation’s Full Potential

Case Study of a Large Medical Center’s Central Laboratory’s Journey to Automation

Connie Bishop, MT(ASCP)SH
Core Laboratory
The Journey

History

Lean

Six Sigma

Automation

Six Sigma

Lean
UNC Healthcare

Medical Center Campus

- UNCH Memorial Hospital
- UNCH Neuroscience Hospital
- UNCH Women’s Hospital
- UNCH Children’s Hospital
- UNCH Cancer Center

Chapel Hill/ Durham
Western Carolina
Eastern Carolina
Southern Carolina
Triad
Consolidation


15 supervisor positions consolidated to 5.

Consolidation process smooth resulting in one of first thriving consolidated medical center laboratories in the country.
Why Lean

From 1995 to 2007 instrumentation in laboratory expanded from 8 large analyzers to 15.

Workload increased from 1.8 million tests in 1994 to 4.9 million in 2007 with no additional FTE’s or space.

Desire to identify potential efficiencies in current state by applying lean technology to total laboratory operations.
Implementation of Lean-2007

A fanatical devotion to the elimination of waste and non-value added activities.

The integration of the factors of production including:

People, Materials and Machines into a system of data driven and well designed work units that deliver what the customer needs when it is needed the right way the first time.
To

Please do not put comments directly on the layout. Thank you.

Please submit layout comments and/or suggestions here or to a Lean Team member. Thank you.
Tools and Data to Shape the Future State

DATA
- Activity of the Product
- Activity of the Operator

DESIGN
- Cellular Layout
- Standard Work (Job Guidance)

Lean Future State

<table>
<thead>
<tr>
<th>Group</th>
<th>Activity</th>
<th>Unit</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>167</td>
<td>MOVE TRACKED RACK</td>
<td>PT</td>
<td>1</td>
</tr>
<tr>
<td>168</td>
<td>SEARCH TRACKED RACK</td>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>169</td>
<td>PICK UP SAMPLE TUBE</td>
<td>PT</td>
<td>1</td>
</tr>
<tr>
<td>170</td>
<td>INSPECT SAMPLE TUBE</td>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>171</td>
<td>UNCAP SAMPLE</td>
<td>MAN</td>
<td>2</td>
</tr>
<tr>
<td>172</td>
<td>ALIQUOT SAMPLE</td>
<td>VA</td>
<td>3</td>
</tr>
<tr>
<td>173</td>
<td>INSPECT SAMPLE AND ALIQUOT TUBE</td>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>174</td>
<td>CAP SAMPLE TUBE</td>
<td>MAN</td>
<td>3</td>
</tr>
<tr>
<td>175</td>
<td>PUT DOWN SAMPLE TUBE</td>
<td>PT</td>
<td>2</td>
</tr>
</tbody>
</table>
Tools to Shape the Future State

活动 of the Product

活动 of the Operator

Group Technology

Performance Measures

State

DATA

Lean

Future

Cellular Layout

Performance Measures

Standard Work (Job Guidance)
Potential Staffing Efficiencies Post-Lean

- Standard Work Practices
- Match Process Cycle Times to Reflect Workload
- Level Individual Workloads
Potential Staffing Efficiencies Post-Lean

- **Standard Work Practices**
- **Match Process Cycle Times to Reflect Workload**
- **Level Individual Workloads**

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**Assessment of Hourly Specimen Workload**

- **Number of Specimens**
  - 0
  - 100
  - 200
  - 300
  - 400
- **Time of Day**
  - 1
  - 3
  - 5
  - 7
  - 9
  - 11
  - 13
  - 15
  - 17
  - 19
  - 21
  - 23

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**Workflow Patterns**
Potential Staffing Efficiencies Post-Lean

Pre-Lean Configuration
- 2 stat processors
- 3 routine order entry
- 1 aliquoter
- 1 rover

Post Lean Configuration
- 5 order entry
- 1 aliquoter
- 1 distributor

Level Individual Workloads
Operator Walk Pattern: Future State
Cora – Robot Delivery
In-Lab Turnaround-Time (Received to Reported)

% Routine Results Reported Within Each Time Period

- **60 min**
- **120 min**
- **180 min**
- **240 min**

**PRE-LEAN**

**POST-LEAN**
LABORATORY
Six Sigma Project
Stat Turn Around Times
2008

“How LOW CAN WE GO?”
Processing Flowchart

Measure
Analyze

Specimen rec’d in Core tube station

If ED, match requisition to specimen

If no paper req, record on ED log

Place in spec storage rack until orders arrive

Different Specimen locations

Specimen picked up from tube station, placed in processing bucket

If req, verify labels with tubes & req

Specimen receipt verified into computer system

Specimen placed into processed rack

Aliquoter picks up specimen for Hem, Chem, Coag

Specimen loaded onto robot for delivery to Hem area

Hem Tech picks up specimen

Specimen loaded into Chem centrifuge for 5 min spin

Specimen unloaded from centrifuge

Specimen aliquoted

If yes

Specimen moved to instrument rack

Specimen loaded onto “Cora” delivery robot

Specimen delivered to Core Chem analyzer for analysis

If no

If no req proceed to receipt verified

Specimen loaded into Chem centrifuge for 5 min spin

Specimen unloaded from centrifuge

Hematology Specimen

Chemistry Specimen

Coag Specimen

If Phleb draw, labels already attached, proceed to receipt verified

If Phleb draw

Floor with barcode labels

If no paper req

If req

If yes

Phleb draw

Floor with barcode labels

If req, verify labels with tubes & req

Specimen receipt verified into computer system

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Specimen unloaded from centrifuge

If Phleb draw, labels already attached, proceed to receipt verified

If Phleb draw

Floor with barcode labels

If no paper req

If req

If yes
Chemistry Processing
Original times vs 9/25 Pilot

Improve
Evening TAT’s 2008-2009

TAT's Evening 2008-2009 K

TAT's Evening 2008-2009 Hgb

% Within Limit

Routine K  Stat K  Goal 90%

Routine Hgb’s  Stat Hgb’s  Goal 90%
Why Automate?

- Patient Safety
- Employee Safety
- Valuable Human Resource Utilization
- Future Growth
Work Cell Design

Referral testing

Staff Offices

Manuals

Hematology

Coagulation

CHEM

CHEM

CHEM

CHEM

Specimen Processing

Walkin freezer

OE 5  OE 4  OE 3  OE 2  OE 1

Work Cell
Total System Design

Four Multi-platform Chemistry Analyzers

Automation

Automation Controller

Instrument Manager

BioRad Unity Quality Control System
Multi-Platform Chemistry Analyzer

Integrated chemistry system - combines dry slide, wet chemistry and immunoassays.

10 open-channels/instrument.

7 UNCH user defined assays.
  methotrexate, free phenytoin, aldolase, urine total protein, propoxyphene, IGG-csf, ceruloplasmin.
Performs testing previously performed on 10 analyzers
Automation

Front End Processing, Specimen Transport, Specimen Storage
Sample Entry/Exit Unit
Centrifuges
Decapper
Aliquoter
Recapper
Specimen Sorter and Storage
Sample Entry/Exit Unit
Controller

Brain of the automated system.

Monitors all of the automated components.

Contains test routing information for all tests performed on the chemistry analyzers.

Monitors error codes.

Sophisticated timing and rerouting programming.
Instrument Manager

Consolidates result verification for all chemistry analyzers.

Allows development of customized result verification for individual analytes based upon result and interference levels (degree of hemolysis, icteria, lipemia.

Provides flexibility in managing and organizing results by specimen information: priority, location, tests.
Biorad Unity Quality Control Data Management System

Software interfaced with Instrument Manager.

Handles approximately 800 quality controls results daily.

Offers flexibility in managing and reviewing results.
Highlights of GO-LIVE!
In-Lab Turn Around Time
Received to Reported

Pre-Automation Turn Around Times

Post Automation Turn Around Times

# Routine Potassiums
Turn Around Time-Minutes N=3645

# Routine Potassiums
Turn Around Time-Minutes N=3706
### Routine and Stat Turn Around Times

<table>
<thead>
<tr>
<th></th>
<th>Dry Slides</th>
<th>Troponin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td>37 minutes</td>
<td>48 minutes</td>
</tr>
<tr>
<td>Stat -enGen</td>
<td>30 minutes</td>
<td>41 minutes</td>
</tr>
<tr>
<td>Stat Centrifuged</td>
<td>22 minutes</td>
<td>34 minutes</td>
</tr>
<tr>
<td>Before Placed On enGen</td>
<td></td>
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</tbody>
</table>
Automation Outcomes

Improved laboratory test turn around times.
Focused highly skilled technologist resource on test interpretation and problem solving.
Improved patient safety due to bar-coded specimen aliquots.
Improved employee safety due to less exposure to patient specimens.
Reallocated technologists to other growth areas of laboratory.
Improvement Activities are Continuous

Specimen processing optimized: centrifuge batch size customized to workload, centrifuge specimen wait time decreased.

Specimen routing further customized for UNCH samples.

Instrument manager redesigned for UNCH dashboard.

Ortho inventory management system implemented.
Inventory Management System

Remotely monitors reagent usage via e-connectivity.

Projects reagent order based upon usage patterns and minimal stock levels.

Levels reagent usage from month to month.

Provides management tools for budget review.

Coordinated with in-house developed instrument loading programs.
Goal - Establish A Baseline

Without stable and standardized processes, you cannot have sustainable improvement.

Steve Friedland-Ortho Diagnostics
Core Laboratory Green Belt Project

Redesign of specimen processing AFTER Automation
Plot and Analyze Frequency Data – Box plots

Arrival to Receipt in SCC BY SHIFT

Days
Evenings
Midnight

Minutes

0
20
40
60
80
100
ANALYZE Verify Root Cause: No FIFO vs. FIFO

![Graph showing Lab Specimens Arrival to Rec'd in SCC - FIFO vs NO FIFO]
IMPROVEMENT NOTED BY SHIFT
BEFORE & AFTER THE PILOT

p value <0.001

**Improvement Noted By Shift (Days & Evenings) Before vs After the Pilot**

Minutes

Days/Before | Days/After | Evenings/Before | Evenings/After

Goal: 30 min

** and *** indicate statistical significance.
EVENING SHIFT
BEFORE & AFTER PILOT

Improvement

Arrival in Lab to Received in SCC - EVENING Shift
Before and After Pilot (Minutes)

Before Pilot
- mean = 22.6 minutes
- sd = 15.1
- Process sigma = 2.09

After Pilot
- mean = 7.9 minutes
- sd = 7.0
- Process sigma = 3.6

UCL = 18.5
\bar{x} = 7.9
LCL = -2.7
DAY SHIFT
BEFORE & AFTER PILOT

Arrival in Lab to Received in SCC - DAY Shift
Before and After Pilot (Minutes)

Before
Mean = 20.2 min
sd = 15.3
Proc sigma = 2.34

After
Mean = 7.9 minutes
sd = 6.4
Process Sigma = 3.87

UCL = 15.8
X̄ = 7.9
LCL = 0.0
MIDNIGHT SHIFT
BEFORE & AFTER PILOT

**Observation**

**Before**
- Mean = 10.8 minutes
- sd = 8.9
- sigma = 3.6

**After**
- Mean = 7.4 minutes
- sd = 2.0
- sigma = 6
- 100% < goal of 30 minutes

**Individual Values**

**UCL**
- Before: 24.8
- After: 13.4

**LCL**
- Before: 1.3
- After: 1.4

**X**
- Before: 10.8
- After: 7.4
Lessons Learned

Engage stakeholders early. Teach how to engage appropriately. Empowerment does not occur immediately and takes practice.

Communicate often and early. Communication is a two-way street.

Be transparent, but don’t breed fear by emphasizing the uncertainties.

Utilize pilots to remove the fear of taking risks.

Do not automate a bad process.

Celebrate small successes.

Change is on-going. Pride in achievements can be barriers to future changes.

Accept that everyone does not embrace change, but set expectations. Career coaching may be necessary.

Creating a new culture takes time and patience. Allow time for good-byes.
The Journey Continues

What’s in our suitcase:

- Excellent human resources
- Experience
- LEAN
- Six-Sigma
- Automation

What’s in our future?

- Affordable Health Care Act
- Accountable Care Organizations

Quality Patient Care