Using Six Sigma and Lean Principles to Improve Laboratory Operations

Big Bang Makeover of the Clinical Laboratory:
Key Lessons for Work Flow, Analyzers, and Service Improvements

Atlanta, GA

Purpose/Objectives

- Purpose:
  - To provide an **overview of using Six Sigma** and Lean Principles in chartering, designing and **implementing a full scale Lean project** in a large laboratory setting.
- Objectives:
  - Understand how each phase of **DMAIC** was used to execute a full scale Lean design effort
  - Understand which **key Lean tools** were used in measure/design/implementation
  - Understand how **interactions** of physical, process, technological, and organizational changes **contribute to a large scale Lean effort**.

Outline

- Who we are
- Why Improving Lab Operations is Important to Quest Diagnostics
- The Journey
- Key Learnings

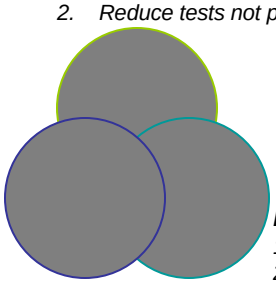
Who we are

- **Focus:**
  - Patients
  - Growth
  - People
- **Vision:**
  - Dedicated People Improving the Health of Patients Through Unsurpassed Diagnostic Insights
- **Company Background**
  - 40,000+ Employees
  - 900+ Clinical Scientist PhDs/MDs
  - Patient Service Centers
  - Rapid Response to Esoteric Laboratories
  - 145 million patient encounters annually
- **Values:**
  - Quality, Integrity, Innovation, Accountability, Collaboration, Leadership
- **Six Sigma/Lean Journey**
  - 2000✍2008

Why Improving Lab Operations is Important to Quest Diagnostics

PATIENTS

1. *Reduce Patient Anxiety Time*
2. *Reduce tests not performed*



PEOPLE

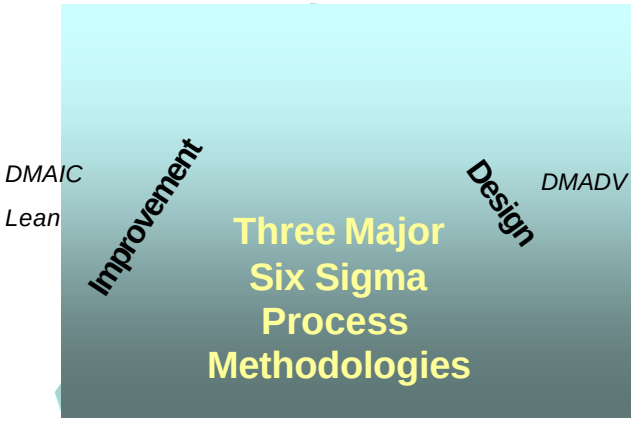
1. *Shortage of technical workforce*
2. *Staffing of night shift*
3. *Improve technical skills*
4. *Reduce potential blood exposure*
5. *Reduce ergonomic Injuries*
6. *Improve staff involvement*

GROWTH

1. *Improve equipment utilization*
2. *Improve productivity*
3. *Improve supply utilization*

The Journey

The Journey – Integrating Six Sigma



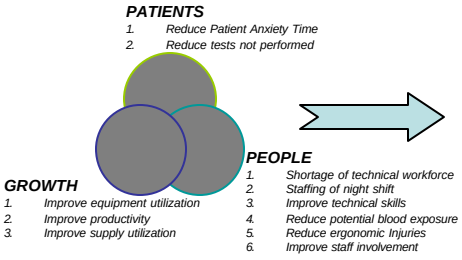
Management

Measurement

Systems Integration

Complex project required adequate training/development

Using DMAIC & Lean to ***Define*** Project



DEFINE (Project Charter)

- *Business Case*
- *Problem Statement*
- *Project Scope/SIPOC*
- *Project Goals*
- *VOC/CTQs*
- *Resources*

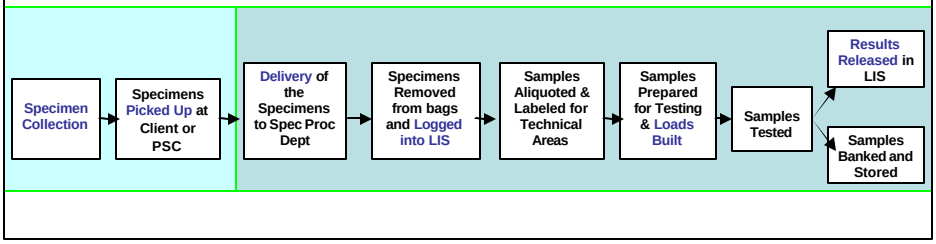
Using DMAIC & Lean to ***Define*** Project

DEFINE (Project Charter)

- *Project Scope*

→ *Atlanta Lab*

SIPOC & Project Scope



Scope expanded and spanned from specimen collection to result release

Using DMAIC & Lean to ***Define*** Project

DEFINE (Project Charter)

- *Project Resources*

→ *Atlanta Lab*

Steering Committee

- Regional VP
- Six Sigma VP
- Lean MBB
- Managing Director
- Process Owners
- IT/Facilities/Safety/HR/Finance/Purchasing

Project Manager

Field Operations
- Patient Service Centers
- Logistics

Lab Operations
- Processing
- Clinical
- AP
- Microbiology
- Medical

Other Resources
- Six Sigma BBs & GBs
- Facilities Manager
- Safety Officer
- Medical Director
- IT Manager/Director
- HR Director
- Medical Director
- Materials Management
- Customer Service Director
- Architect
- Construction Manager
- Contractor

Cross functional team included local & national resources

Using DMAIC & Lean in ***Measure***

MEASURE

- *Origin of Work Streams*
- *Logistics Mode & Arrival Profile*
- *Pre-Analytical, Analytical & Post Analytical Process Steps*
- *Current Floor Plan (CAD)*
- *Inventory Turns*
- *Productivity*
- *Safety Records*
- *Quality Metrics*
- *Service Metrics*

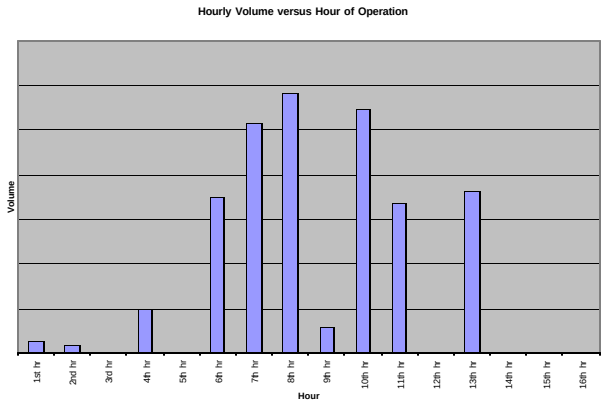
- *Product Family Matrix*
- *Current State VSMs*
  - *Daily Testing Volumes*
  - *Lead Time*
  - *Cycle Time*
  - *Batch Sizes*
  - *Staffing by Dept/Shift*
  - *WIP*
  - *Uptime*
  - *Rework %*
  - *Information Flow*

Extensive Data Collection Plan/Baseline Measurements

Using DMAIC & Lean in ***Measure***

MEASURE

- *Logistics Arrival Profile*



Uneven & late inflow limits capacity utilization

Using DMAIC & Lean in ***Measure***

MEASURE

- *Product Family Matrix*

Questions: Who, What, Where, When, How, How often, With what?

Department Name (Current)
Family Product Name
FUTURE PRODUCT FAMILY
Worklist Name
Shift performed
Delivery of specimens
Set up instrumentation, controls and reagents
Manually Build worklist
Dynamic load build
Sort department specimens
Specimen Integrity check
Aliquot specimens
Prep specimens
List the Prep steps (manual dilution, auto dilution, titration, centrifugation etc)

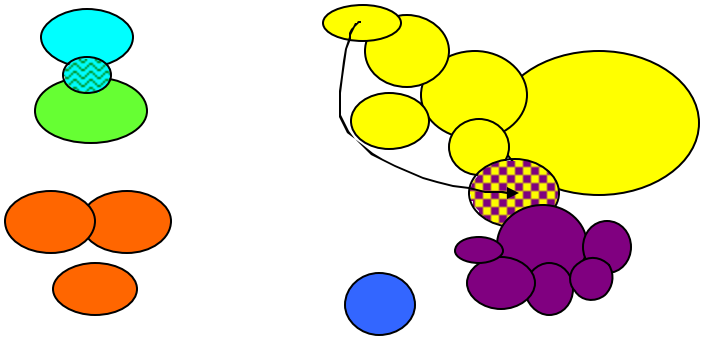
Testing performed manually or automated
Specimens placed in instrument Rack
Load Specimens and QC on to Instrument
Run and monitor instrument
Check QC, Accuracy, Outliers for repeats and Sample integrity (LIH)
Extra specimen workup (i.e. ultra centrifugation, dilution etc)
% Repeat Runs
Result Entry Mode (into LIS)
Result Release Mode: Manual release results (by batch or accession)
Print Pending list
Find additional specimen if QNS
Manual or auto bank specimens
Instrument shut down
Organize and re-supply work area

Developing the Product Family Matrix was the Foundation

Using DMAIC & Lean in ***Measure***

MEASURE

- *Product Family Matrix*

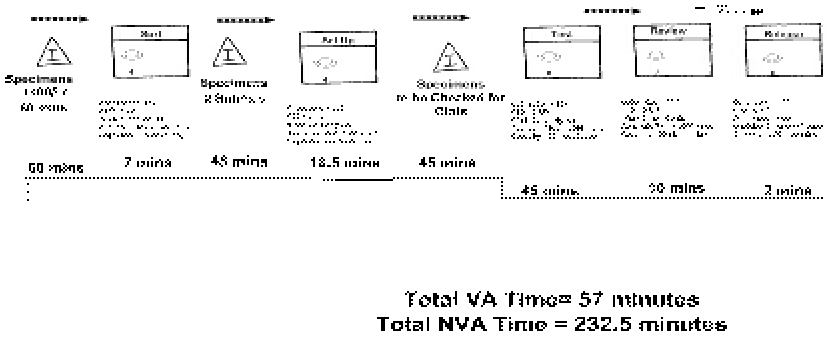


Bubble Diagrams used to develop Product Family Matrix

Using DMAIC & Lean in ***Measure***

MEASURE

- *Current State Value Stream Maps*

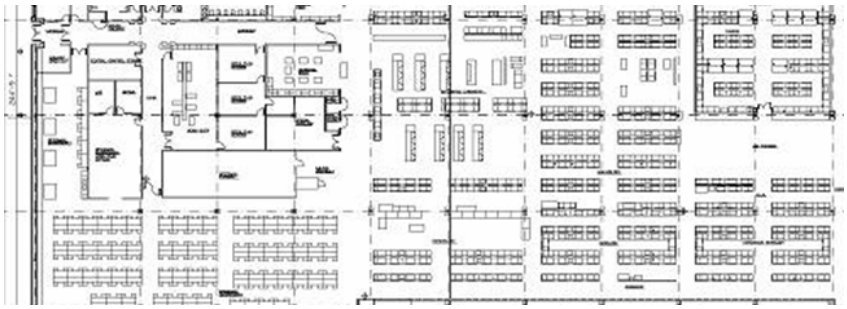


Current State Value Stream Maps identified opportunities to use Lean strategies

Using DMAIC & Lean in ***Measure***

MEASURE

- *Current State Floor Plan*

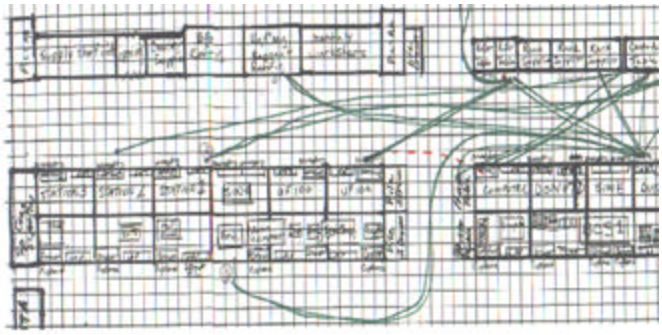


Current State Layout Design was used to evaluate flow at a high level

Using DMAIC & Lean in ***Measure***

MEASURE

- *Spaghetti Mapping*



Current State Spaghetti Diagrams were used to evaluate movement of specimens, people and materials

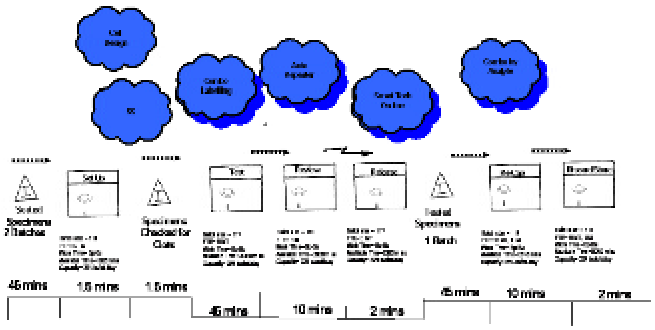
Integration of Lean Objectives

1. *Identify and Eliminate/Reduce Time-Traps/**Smooth Distribution***
2. *Identify and Eliminate/**Reduce Non-Value Added Steps***
3. ***Co-Locate Value Added Steps***
4. ***Reduce** Work in Process (**WIP**)*
5. *Reduce**/Optimize Batch** Size*
6. ***Decrease set-up time** (Cross Training is often implemented)*
7. *Reduce Complexity/**Increase Flexibility***
8. *Create a physical working environment that complements/supports the flow of work, is **safe, clean and encourages the efficient and timely flow of specimens**, supplies, ideas and information.*
9. *Create a working **environment** that forces all process steps to be **open and visible**.*

Using DMAIC & Lean in ***Analyze***

ANALYZE/DESIGN

- *Ideas for Future State*



Total VA Time=57 minutes
Total NVA Time=115 minutes

Future state focused on reduction of NVA

Using DMAIC & Lean in ***Analyze***

ANALYZE/DESIGN

- *Prioritization Matrix*

Over 300 projects were identified as "blue sky opportunities" & then prioritized:

	Weighting
Improvement Opportunity	
Product Family	
Business $ Impact - H (9) M (3) L (1)	10
Ease of Implementation - H (5) M (3) L (1)	6
$ Cost - H (1) M (3) L (5)	3
IT Resource Needed H (1) M (3) L (5)	2
Processor to other Activity (Yes/No)	
Score	
Is this a BB, GB or Nike Project?	
What is Predecessor?	

63 Green Belt & Black Belt Projects were prioritized with anticipated cost/benefit

Not every good idea could be implemented within the timeframe

Using DMAIC & Lean in ***Analyze***

ANALYZE/DESIGN

- *Major design elements selected*

- *Improve logistics Inflow*
- *Implementation of alternate front end specimen processing system*
- *Conveyance*
- *Automated Sort Aliquot*
- *Cell Design by Product Family including 5S & Lean Supply Chain (PFEP)*
- *High priority IT enhanced systems projects*
- *Organizational changes to support automation*

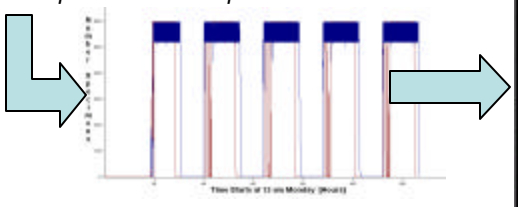
Framework for detailed design

Using DMAIC & Lean in ***Analyze***

ANALYZE/DESIGN

- *Process Model*

- *Logistics inflow/hr by work stream*
- *Processing req/hr/FTE by work stream*
- *# & type of specimens*
- *Aliquots per specimen*
- *Aliquoter & sorter specimens/hr*



	HSS & SA	Finish Time HSS	Finish Time SA	Total Equipment
HSS @ 3.6 sec/tube & SA @ 15.5 sec/tube	4 & 5	3:00 AM	Doesn't Work	9
	4 & 6	3:00 AM	Doesn't Work	10
	4 & 7	3:00 AM	10:00 AM	11
	4 & 8	2:00 AM	7:00 AM	12
	4 & 9	2:00 AM	5:30 AM	13
	4 & 10	2:00 AM	4:40 AM	14
	5 & 5	2:00 AM	Doesn't Work	10
	5 & 6	2:00 AM	Doesn't Work	11
	5 & 7	2:00 AM	10:00 AM	12
HSS @ 3.6 sec/tube & SA @ 17.5 sec/tube	4 & 8	2:00 AM	10:00 AM	12
	4 & 9	2:00 AM	7:30 AM	13
	4 & 10	2:00 AM	6:30 AM	14
HSS @ 3.6 sec/tube & SA @ 17.5 sec/tube	3 & 8	6:00 AM	10:00 AM	11
	3 & 9	6:00 AM	8:00 AM	12
	3 & 10	5:45 AM	6:00 AM	13

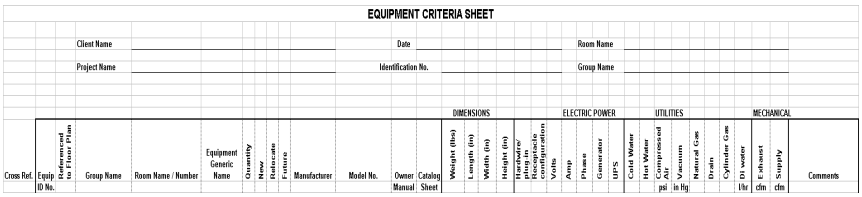
Utilized internal and external resource expertise to validate the automated sorter/aliquoter equipment requirements

Using DMAIC & Lean in ***Analyze***

ANALYZE/DESIGN

- *Equipment Criteria Sheet*

900 Items Inventoried



EQUIPMENT CRITERIA SHEET

Client Name | Date | Room Name

Project Name | Identification No. | Group Name

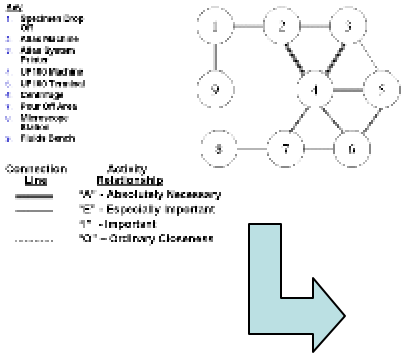
													DIMENSIONS			ELECTRIC POWER				UTILITIES								MECHANICAL			
Cross Ref.	Equip. ID No.	Reference to Floor Plan	Group Name	Room Name / Number	Equipment Generic Name	Quantity New	Relocate	Future	Manufacturer	Model No.	Owner Manual	Catalog Sheet	Weight (lbs)	Length (in)	Width (in)	Height (in)	Hardwire/ plug-in. Receptacle configuration	Volts	Amp	Phase	Generator	UPS	Cold Water	Hot Water	Compressed Air psi	Vacuum in Hg	Natural Gas	Drain	Cylinder Gas	DI water l/hr	Exhaust cfm	Supply cfm	Comments

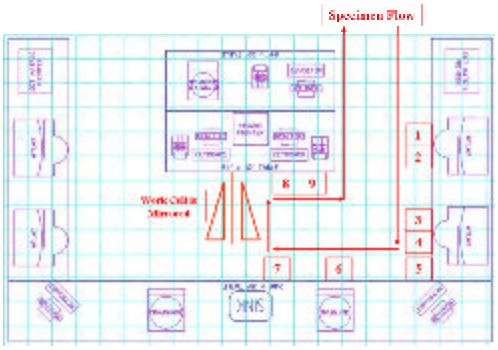
"Equipment Criteria Sheet" was utilized to document requirements in a "future state" design

Using DMAIC & Lean in ***Analyze***

ANALYZE/DESIGN

- *Systematic Layout Planning*





SLP was used to design at a product family level, cell level & bench level

Using DMAIC & Lean in ***Analyze***

ANALYZE/DESIGN

- *Ergonomic/Safety Evaluation*

Company wide 2002-2005 OSHA recordables were evaluated.

Data evaluated current state workstation designs and the benefits of future state processing work cell design, including future state integration of conveyance and automated sort/aliquot equipment.

External resource conducted analysis including posture, motion, force, duration & frequency of hands, wrists, elbows, shoulders, neck, back & legs.

Final design recommendations integrated both the recommended workflow design changes and ergonomic design elements. Modifications for workstation height, reach, and process functions were made and included in the final design.

Final workstation design incorporated ergonomic recommendations

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *Detailed Equipment Inventory was used to develop move plan*

KEY	
Letter	***Component***
A	Acid Cabinet
AS	Aspirator
B	Balance
BPS	Beckman Power Supply
C	Centrifuge (Floor Model)
CA	Cabinet (Under Counter)
C2	Centrifuge (Table Top)
CO	Convey
CT	Cart
CW	Cell Wa
CY	Cytofug

1700 Items were catalogued to be moved

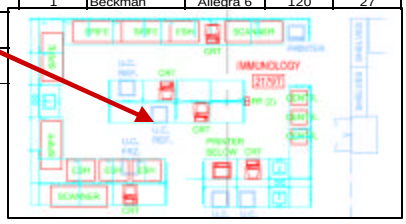
Dept. Number	***Key***	***Archetectural #***	***Elevation #***	***Equipment ID***	***Department***	***Cell Name/Section***	***Components***
25000	SH	2179B			Clin Chem	Immulite Section 1	Shelf
25003		2179B	E14	105	Clin Chem	Immulite Section 2	(1) Immulite
25004		2179B	E14	106	Clin Chem	Immulite Section 3	(2) Immulite
25005		2179B	E14	107	Clin Chem	Immulite Section 4	(3) Immulite
25006		2179B	E20	108	Clin Chem	Immulite Section 5	(4) Immulite
25007		2179B	E20	109	Clin Chem	Immulite Section 6	(5) Immulite
25008		2179B	E19	110	Clin Chem	Immulite Section 7	(6) Immulite
25009		2179B	E19	111	Clin Chem	Immulite Section 8	(1) Dynex
25010		2179B	E19	112	Clin Chem	Immulite Section 9	(2) Dynex
25011		2179B	E13		Clin Chem	Immulite Section 10	Workbench
25012	Q	2179B	E13		Clin Chem	Immulite Section 10	CRT

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *Equipment Inventory Sheet*

Equip	Group Name	Room Name / Number	Equipment Generic Name	Quantity	Manufacturer	Model No.	Weight (lbs)	Depth (in)
673	Immunology	**Immunology / 2179T**	centrifuge	1	IEC	Centra MP4	100	21
674	Immunology	**Immunology / 2179T**	centrifuge	1	Beckman	Allegra 6	120	27
675	Immunology	**Immunology / 2179T**	centrifuge					
676	Immunology	**Immunology / 2179T**	centrifuge					



"Equipment Criteria Sheet" was tied to Numbers on Architectural Plans

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *Hourly Move Schedule*

Phase 1 Move

Date: 2/8/2007-2/10/2007

Department Name: Serology

Thursday	10AM	12PM	2PM	4PM	6PM	8PM	10PM	12AM	2AM	4AM
Begin Move	Techs	Techs	Techs	Techs	Techs	Techs	Techs	Techs	Techs	Techs
2 Trifuges (B (Process Tables with wheels)	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Techs to validate				
2 Trifuges (SR) (Process Tables with wheels)		Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Techs to validate			
RCS #1	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Techs to validate					
RCS #2		Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Techs to validate				
1 Hamilton HIV	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Techs to validate				
1 ADA Tecan, 2 EVOS (Rotating)		Tempo and Resident	Tempo and Resident	Tempo and Resident	Tempo and Resident	Moved to validate				
1 Alba	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Tempo and Vendor	Techs to validate					
IT Hookup	IT	IT	IT	IT	IT	IT	IT	IT	IT	IT
Move Benches	Techs	Techs	Techs	Techs	Techs	Techs	Techs	Techs	Techs	Techs
Red Tag Items	Techs	Techs	Techs	Techs	Techs	Techs	Techs	Techs	Techs	Techs
Move Current Labs to Refrig	Facilities	Facilities	Facilities	Facilities	Facilities					

Coordination was essential– everyone had responsibilities

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *IT Project Management*

System Updates

- *New front end processing system Implementation*
- *Interface enhancements*
- *Label modifications*
- *Measurement tools (Lean Six Sigma Utility Report)*

Infrastructure Changes/Upgrades

- *Data-line/Cabling strategies*
- *Hardware changes*
- *Phone System Coordination*

IT Devices Relocated	600
Interfaced Instruments	296
Qty of Cables Demo'd	415
Qty of Cables Installed	726

52 miles of CAT5E Cable installed enabling faster data transfer and increased capacity

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *GB/BB Project Plan*

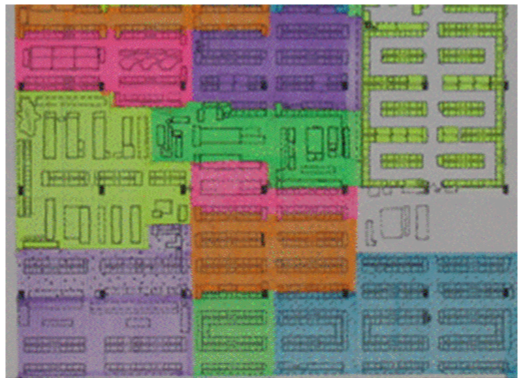
Project	WO.	Rank	Activity [from original VSM]	Lean Pilot Project Alignment Phase (0,1,2,3,4,5,6,P)	Project Type (GB, BB, FT, IT, Kaizan)	Project Leader	Process Owner	Instantis #	Status 3/1
Technical Operations 5S	1a	A	Adopt 5S - AU5480	II	GB	[illegible]	[illegible]	8482	Follow 5S principles to clean and organized department
Cell Redesign	3a	A	Cell Redesign - Urinalysis	1	GB	[illegible]	[illegible]	10009	Cindy to check to see if this is completed
Cell Redesign	3g	A	Cell Redesign - CK	1	GB	[illegible]	[illegible]	9993	GB Shirley M
Cell Redesign	3h	A	Cell Redesign - PFLP	1	GB	[illegible]	[illegible]	9993	GB Shirley M
Cell Redesign	3k	A	Cell Redesign - Immunocap	1	BB	[illegible]	[illegible]	9993	
Cell Redesign	3m	A	Cell Redesign - Hepatitis	1	GB	[illegible]	[illegible]	10011	Sally will try to find Ortho Documentation
Cell Redesign	3o	A	Cell Redesign - Primus	1	GB	[illegible]	[illegible]	10012	
Cell Redesign	3p	A	Cell Redesign - HPLC	1	GB	[illegible]	[illegible]	10013	
Cell Redesign	3q	A	Cell Redesign - Alk Phos	1	GB	[illegible]	[illegible]	10014	
Cell Redesign	3r	A	Cell Redesign - Manual RIA	1	GB	[illegible]	[illegible]	10015	
Improve Centaur TAT	4a	A	Implement New Instrument Module(NIM) Ingetra	1, 3	GB	[illegible]	[illegible]	9951	Met with Debbie B on 2/26. RFS is off "Hold" status. There is nothing else that can be done at the RU level
Improve Centaur TAT	4b	A	Implement Multiworklist QC Barcode	1, 3	GB	[illegible]	[illegible]	9951	Done

Projects tracked monthly to ensure coordination & on time completion

Using DMAIC & Lean in ***Improve***

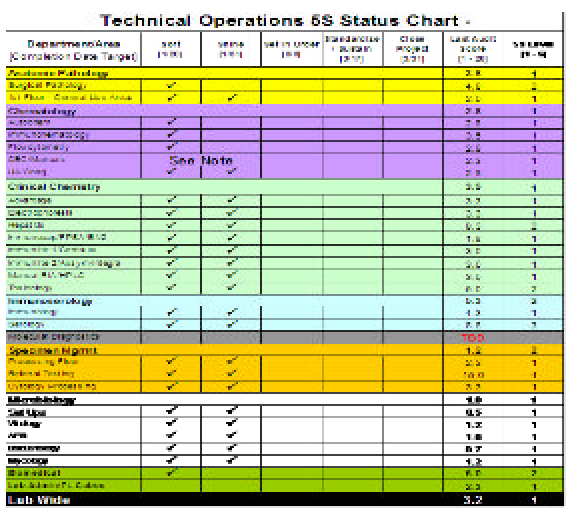
IMPLEMENT/IMPROVE

- *5S Discipline*



5S ownership is at a sub-department level—this concept was launched in 2005 and refined during & following construction

Using DMAIC & Lean in ***Improve***



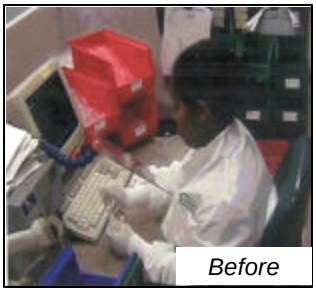
Sort resulted in disposing of ***18 cubic yards*** of unneeded items.

Original 5S Plan—improvements were made to ensure consistency and integrate the new product family organization

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *Processing Workstations/Conveyors*



Before

After

The majority of sorting, aliquoting & decapping is now automated

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *Organizational Changes/Job Reporting Structure*

New Department: Automated Tech Ops

Job Responsibilities:

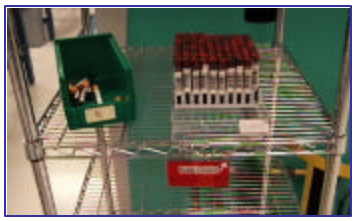
- *Running automated sorter aliquoters*
- *Troubleshooting routine problems*
- *Documenting maintenance/downtime/problems/tubes not processed by the aliquoter or sorter (bad labels, slant gels, etc.)*

Key learning – operators need to have aptitude for technology

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *Automated Sort Aliquot*



'Lab Ready'
- Specimens in instrument racks
- Specimens in direct bins

'Default Rack'

Default rack specimens represent defects that require staff to intervene.

Defects can arise from:
- Clots in specimens
- Slanted gel in the barrier tube
- Barcode failure

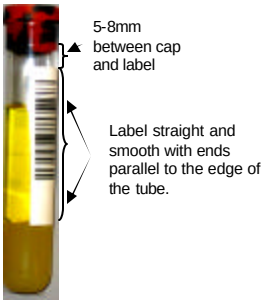
Two Streams of Output – 'Lab Ready' and 'Default Rack'

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *Automation requirements*

- Consistent & accurate label placement
- Consistent bar code print quality
- Adequate volume/no large clots
- Round bottom primary tubes
- Flat gel spin for serum separator tubes
- Consistent feedback process if specifications not met
- Technical aptitude of sorter/aliquoter operators
- Quality/Operational/Service Metrics

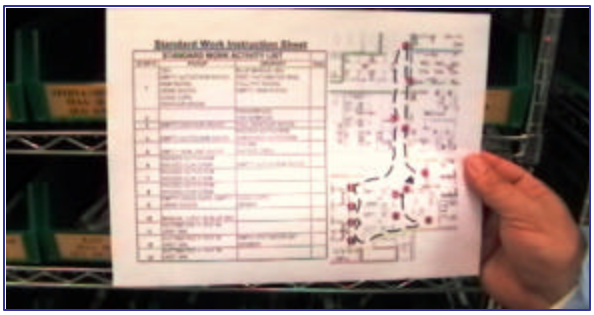


Automation no longer "hides" sub optimized processes

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *Standard Work Instructions*



Standard Worksheet
Provides specific instructions including:
- Step by step details
- Delivery route
- Delivery times

Departments know exactly when specimens will be picked up and when and where they will be delivered

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *Technical Areas*

Work can be seen across the building; Aisles open

Using DMAIC & Lean in ***Improve***

IMPLEMENT/IMPROVE

- *Technical Areas*

Work cells organized – 5S

Supplies in work cells

Using DMAIC & Lean in ***Improve***

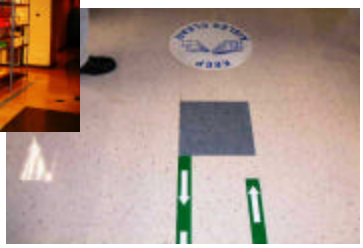
IMPLEMENT/IMPROVE

- *Lean Supply Chain*

Pass Thru Refrigerator

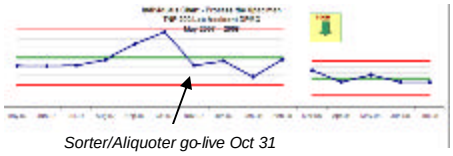
Supermarket

Delivery Aisles



Using DMAIC & Lean in ***Control/Verify***

Lab Accidents — ***42% Improvement***



Automated Aliquoter volumes more consistent

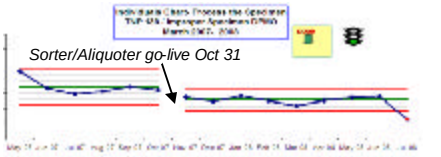
Turn Around Time — ***33% Improvement***

Kaizen Process flow changes important

Manual Req Processing — ***35% Improvement***

Productivity gains offset by adds for automation

Improper Specimens — ***33% Improvement***

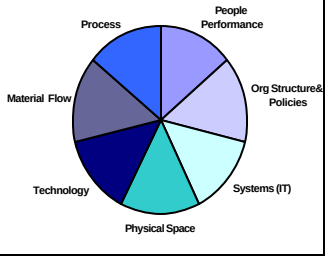


Auto sort beneficial; June 08 IT enhancement

Automation & Lean Process Changes Improve Quality

Lessons Learned

- *This project was successful due to the **people** in Atlanta that remained **committed and focused**.*
- *The **Six Sigma culture** (with trained Green Belt resources) supported the completion of 63 projects. **Leadership** from the top was essential.*
- ***Team structure** and project management oversight is critical in a project of this magnitude.*
- ***Organizational structures/policies** may need to be changed to support the new work content and processes.*
- ***Technology** changes alone are **not enough** to create a lean environment.*
- *Employees need **coaching/training/mentoring** during the change event.*
- *Succession plan necessary – team members changed--the **project** must be **structured & supported** in a way to continue progress.*



Questions?