University of Michigan Health System

Cytopathology:
Identifying System Specimen Flow and Opportunities for Improvement

Project Recommendations

To: Kalyani Naik, MS, SCT (ASCP), Cytopathology Laboratory Supervisor
   Brian Smola, CT (ASCP), Lead cytotechnologist
   Corrie Pennington-Block, Lean Coach
   Kamahl Shehadeh, POA Junior
   Dr. Mark Van Oyen, IOE 481 Professor

From: Industrial and Operations Engineering 481 Project Team 4
   Bisma Haque, Industrial and Operations Engineering Senior
   Charlotte Sawyer, Industrial and Operations Engineering Senior
   Corey Greenawalt, Industrial and Operations Engineering Senior

Date: December 9, 2014
Contents

Executive Summary ......................................................................................................................... 4
  Background ................................................................................................................................. 4
  Methodology and Findings ......................................................................................................... 4
  Conclusions ............................................................................................................................... 5
  Recommendations ....................................................................................................................... 6

Introduction ................................................................................................................................ 7

Background .................................................................................................................................. 7
  Key Issues .................................................................................................................................. 9
  Goals and Objectives ................................................................................................................... 9
  Project Scope ............................................................................................................................... 9

Methods and Findings ..................................................................................................................10
  Interviews and Observations – Found significant congestion in lab ............................................. 10
  Spaghetti Chart - Found significant back and forth movement by prep techs ............................... 10
  Literature Search – Found articles on efficient specimen transfer and lean design ..................... 10
  Time Studies – Average Gyn turnaround time = ~6 days and Non-Gyn = ~1 day ......................... 11
  Distance Mapping – Gyn walk = ~0.4 miles/day and Non-Gyn = ~1.2 miles/day ....................... 15
  Machine Sizing – Machine dimensions used when creating future state layouts .......................... 15
  Value Stream Map – Gyn turnaround time = ~1% VA and Non-Gyn = ~13% VA ......................... 15

Conclusions ..................................................................................................................................16

Recommendations .......................................................................................................................17
  Gyn Workflow ............................................................................................................................. 17
  Non-Gyn/FNA Workflow ............................................................................................................. 17
  Laboratory Layouts ..................................................................................................................... 18
  Expected Impact .......................................................................................................................... 21

Future state recommendations will improve the department’s efficiency by: ...............................21

References .....................................................................................................................................22

Appendix .....................................................................................................................................23
  Appendix A: High Level Value Stream Map ............................................................................... 23
  Appendix B: Spaghetti Chart ....................................................................................................... 24
  Appendix C: Step Data for Gyn Cases ......................................................................................... 25
  Appendix D: Step Data for Non-Gyn/FNA Cases ....................................................................... 26
  Appendix E: Gyn Current State VSM ......................................................................................... 27
Appendix F: Gyn Current State Swim Lane Diagram
Appendix G: Non-Gyn/FNA Current State VSM
Appendix H: Gyn Future State VSM
Appendix I: Gyn Future State Swim Lane Diagram
Appendix J: Non-Gyn/FNA Future State VSM
Appendix K: Future State Layout 1
Appendix L: Future State Layout 2
List of Tables and Figures

Figure 1. Diagram of the flow for the specimen testing process for Gyn/Pap test ............. 8
Figure 2. Initial Spaghetti Chart – Gyn Processing .......................................................... 8
Table 1: Average turnaround times ................................................................................. 12
Figure 3: Distribution of turnaround time for Gyn cases .................................................. 12
Figure 4: Distribution of turnaround time for Non-Gyn/FNA cases ................................. 13
Figure 5: Step and courier times for Gyn Cases ............................................................... 14
Figure 6: Step times for Non-Gyn/FNA Cases ................................................................. 15
Figure 7. Gyn Future State .............................................................................................. 17
Figure 8. Non-Gyn Future State .................................................................................... 18
Figure 9: Future State Layout 1 ..................................................................................... 19
Figure 10: Future State Layout 2 ................................................................................... 20
Table 2: Decision Criteria .............................................................................................. 21
Executive Summary

Growth in the department of Pathology at the University of Michigan Hospital (UMH) and severe space constraints have led to expansion of the Cytopathology laboratory to outside UMH. The current laboratory consists of small, scattered space between two separate buildings and has resulted in excessive waste. The Lean coach for UMH and the Cytopathology laboratory supervisor believe that this waste results from the need to transfer specimen between buildings and from congested flow in the confined workspaces. In preparation for a move to the North Campus Research Complex, the Cytopathology laboratory is undergoing a lean design process to implement efficient use of the new space, and address these issues in the current workspace. The Cytopathology department asked a team of IOE 481 students from the University of Michigan to improve the department’s turnaround time for the current and future state and develop recommendations on the design of the new space by identifying waste in its current specimen testing processes. This report presents key findings from the analysis of the Cytopathology department’s current state and recommendations on the design of its new space along with the expected future state improvements.

Background
The University of Michigan Hospital (UMH) has decided to relocate non-stat laboratories of Pathology, including Cytopathology, to the North Campus Research Complex (NCRC). The Cytopathology department is currently divided between the North Ingalls Building (NIB) and the UMH resulting in complicated workflows, leading to a departmental focus on improving work processes within Cytopathology. Some initial effort to identify waste and inefficiencies in the Cytopathology department has been made. The department made a high level value stream map of their current specimen testing process (Appendix A) as well as an initial Spaghetti Chart (Figure 2). The current average turnaround time is 6.4 days for Gynecological (Gyn) specimens and 1.6 days for Non-Gynecological (Non-Gyn) specimens while their respective goals are five days and two days. Note that these values are based on a sample of cases from the last fiscal year and are therefore subject to a degree of uncertainty. The department is always striving to reduce its turnaround time, regardless of its performance with respect to its goals.

Methodology and Findings
The team performed seven tasks to quantify the waste in the current process and used the results to develop recommendations on the design of the Cytopathology department’s new laboratory space that aim to decrease the department’s turnaround time.

- **Interviews and Observations**: The team interviewed and observed the preparatory technicians (prep tech) that create slides within the Cytopathology laboratory.
  - The resultant findings were that the machines are not placed in sequential order and prep techs frequently re-label slides and specimen.
- **Spaghetti Charts**: The team, the Cytopathology laboratory supervisor, the lead cytotechnologist, the Lean coach, and a prep tech mapped the paths the prep techs follow when creating slides on a layout of the lab floor.
  - The resultant findings were that the prep techs frequently walk between stations/machines, which leads to significant congestion in the walkways.
• **Literature Search:** The team searched scholarly articles and found three beneficial sources discussing Lean implementation in labs. The articles focused specifically on using windows for efficient transfer of specimen and the importance of 5S principles in a lab.
  o The literature search provided the team with a good background on Lean principles how they are applied in laboratory settings.

• **Time Studies:** The team used SOFT, the pathology department’s laboratory and patient information system, to collect time study data. This database includes timestamps for each specimen during each step in the workflow.
  o The resultant findings showed that the average turnaround time is 6.4 days for Gyn cases and 1.2 days for Non-Gyn/FNA cases. The average, maximum and minimum times for each step in the workflow can be seen in Appendices C and D for Gyn and Non-Gyn/FNA cases, respectively.

• **Distance Mapping:** The team measured the dimensions of the lab and used the paths from the spaghetti chart to determine the distance prep techs travel during the Gyn and Non-Gyn slide creation process.
  o The resultant findings showed that a prep tech walks about 2142.29 feet per day (0.406 miles per day) for Gyn cases and about 6564.50 feet per day (1.24 miles per day) for Non-Gyn/FNA cases.

• **Machine Sizing:** Using a list of equipment provided by the client, the team found dimensions for all of the necessary lab supplies.
  o The team used this data to fit equipment in the footprint of the future lab space at the NCRC and create two possible layouts, which can be seen in Appendices I and J.

• **Value Stream Maps:** The team broke down the current high level Value Stream Map (VSM), developed by the clients and coordinators, by specific steps and added the results from the time study and distance mapping analysis to it.
  o The VSMs were used to map out the current workflow and to determine the average value added and non-value added time for Gyn cases (1.8 hours and 142.1 hours, respectively) and Non-Gyn/FNA cases (3.72 hours and 28.65 hours, respectively).

**Conclusions**

The average turnaround time for Gyn specimens exceeds its goals of five days while the Non-Gyn/FNA specimens do not exceed its goal of 2 days. However, both Gyn and Non-Gyn workflows can be improved to reduce turnaround time, which the department is striving to do regardless of its performance with respect to its goals.

The general layout of the lab is crowded and disorganized due to current space constraints. The machines in the lab are not placed in sequential order and the prep techs frequently cross paths. These factors make the lab difficult to navigate through and result in a non-Lean environment.
The value added time for Gyn cases only accounts for 1.25% of the total turnaround time. A large percentage of the turnaround time for Gyn cases is from the time between processing at UH and reading at NIB, the time between being delivered from NIB back to UH for reading, the time before quality check, and the time before pathologist review. In addition, the courier only accounts for a small percentage of the time that slides are waiting between buildings, indicating that the slides are sitting on the shelves for long periods of time before and/or after they are moved by the couriers.

The value added time for Non-Gyn/FNA cases only accounts for 13.11% of the total turnaround time. A large percentage of turnaround time for Non-Gyn/FNA cases is from the time before reading, the time it takes for Histology to receive cell blocks and process them, the time before approving the interpretation, and the accessioning time. In addition, there is a significant amount of walking involved for creating Non-Gyn/FNA slides. This is due to walking between stations to scan specimen and slides between process steps.

**Recommendations**

Changes from the current state for Gyn include the following:

- All slides are created at NCRC
- A small percentage of slides travel to UH where they are read and undergo quality checks by 2 cytotechs placed there. Note that this occurs to increase the utilization of UH cytotechs. It does not need to occur if other work that will improve efficiency is assigned to them.
- Slides go through the remainder of the workflow, after slide creation, in the location where they are read
- 1 pathologist at UH reviews abnormal slides that sent for review by UH cytotechs
- Excess quality check is eliminated (follows requirement of 10%)
- Smaller batch sizes (more courier trips)
- Visual management to ensure FIFO between steps

The potential Gyn turnaround time estimate for the future state is 38.44 hours (as opposed to the current value of 143.9 hours). This was calculated after removing the weighted averages of the time it takes to travel to NIB and the time before quality check.

Changes from the current state for Non-Gyn/FNA include the following:

- All slides are created and read at NCRC
- There is direct access to Histology through the Cytopathology lab via a cubby
- Smaller batch sizes (more courier trips)
- Visual management to ensure FIFO between steps

The potential No-Gyn/FNA turnaround time estimate for the future state is 26.37 hours (as opposed to the current value of 28.37 hours). This estimate is not based on the theoretical effect of reducing batch size and providing direct access to Histology.
Introduction

The University of Michigan Hospital (UMH) and severe space constraints have led to expansion of the Cytopathology laboratory to outside UMH. The current laboratory consists of small, scattered space between two separate buildings and has resulted in excessive waste. The Lean coach for UMH and the Cytopathology laboratory supervisor believe that this waste results from the need to transfer specimen between buildings and from congested flow in the confined workspaces. In preparation for a move to the North Campus Research Complex, the Cytopathology laboratory is undergoing a Lean design process to implement efficient use of the new space, and address these issues in the current workspace. The Cytopathology department asked a team of IOE 481 students from the University of Michigan to improve the department’s turnaround time for the current and future state and develop recommendations on the design of the new space by identifying waste in its current specimen testing processes. This report presents key findings from the analysis of the Cytopathology department’s current state and recommendations on the design of its new space along with the expected future state improvements.

Background

The University of Michigan Hospital (UMH) has decided to relocate non-stat laboratories of Pathology, including Cytopathology, to the North Campus Research Complex (NCRC). The Cytopathology department is currently divided between the North Ingalls Building (NIB) and the UMH resulting in complicated workflows, leading to a departmental focus on improving work processes within Cytopathology. There has already been some initial effort to identify waste and inefficiencies in the Cytopathology department. Before the student team began work on the project, the department made a high level value stream map of their current specimen testing process (Appendix A) as well as an initial Spaghetti Chart (Figure 2). A flow diagram of the entire specimen workflow can be found below in Figure 1. Note that the figure shows the high level process flow and does not go into detail on the different steps for the different specimen types. It specifically displays the process flow for Gynecological (Gyn) cases. The specimen testing process begins with slide creation, which entails preparatory technicians (prep techs) processing specimens to create slides that are microscopically analyzed by cytotechnologists (cytotechs) and pathologists. Under the current workspace layout, the space for this slide creation is small and the machines used throughout it are not placed in a sequential manner. This makes the space difficult to navigate and leads to waste from poor flow. The congestion can be seen below in Figure 2.
Figure 1. Diagram of the flow for the specimen testing process for Gyn/Pap test

Once slides are made, residual specimens are stored in a cabinet or refrigerator in stacked tubs in the event that further processing may be required. The specimen containers must be hand marked upfront on the lid by a prep tech to identify it faster. Next, the slides are sent to cytotechs to be read. This entails cytotechs examining slides using light microscopy for the presence of abnormal cells. In order to create additional space in a space constrained environment, the department moved cytotechs to the NIB. The majority of Gyn slides are read in the NIB. There are also workstations at UMH in the reading room for cytotechs to screen Non-Gynecological (Non-Gyn) and Fine Needle Aspiration (FNA) slides and provide support for FNA procedures. Some Gyn slides are also read at UMH. All Gyn slides are placed in a bin in the reading room at
the UMH and are delivered to the NIB by a courier. Based on the expected number of slides that
the cytotechs at UMH predict they can read given the workload for that day, some are sent back
from the NIB to UMH. The distance between the cytotechs in the two buildings leads to waste
from transportation of slides and potential delays in issuing results.
If cytotechs are unable to screen the slides because they are of poor quality due to the presence of
blood in the specimen, a prep tech at the UMH must create a new slide out of the residual
specimen stored at the UMH and send it back to the cytotechs (who may be either at NIB or
UMH). This leads to waste from additional movement of materials. Once the slides are read,
some are sent for review by pathologists or read by a second cytotech while others are signed
out. Once slides have been examined and the result has been issued, slides are sent to storage in
the Medical Science Building 1 (MedSci1). The waste in the end-to-end specimen testing process
results in inefficiencies and turnaround times that may exceed the department’s goal of five days
for Gyn cases and 2 days for Non-Gyn/FNA cases. Therefore, the team quantified waste in the
Cytopathology department’s current process and developed recommendations on the design for
the new space in the NCRC that aim to improve the department’s turnaround time.

Key Issues
- The following key issues drove the need for this project:
  - Inefficient use of space creates cluster and confusion
  - Significantly high travel time of the specimen throughout processing
  - Turnaround time of the Gyn cases often exceeds the goal of five days

Goals and Objectives
The primary goal of this project was to utilize Lean principles to quantify the waste in the current
process and use the results to develop recommendations on the design of the Cytopathology
department’s new laboratory space that decrease the department’s turnaround time. The team
achieved this goal by addressing the following objectives.
- Minimize non-value added travel time of specimens and slides
- Minimize non-value added travel time of lab technicians
- Reduce congestion within workspaces
- Reduce turnaround time of Gyn and Non-Gyn/FNA cases

Project Scope
This project included only specimen processing and analysis of Gyn and Non-Gyn/FNA cases.
The workflow begins when the specimens are dropped off in the Cytopathology lab to made into
slides and ends when their orders are signed out and specimen and slides are sent for storage.
This project did not consider the quality of services within the specimen testing lab, such as the
percentage of incorrect readings, etc. It also excluded any activities not associated with the
Cytopathology lab. Specifically, the team did not study tasks or activities to collect specimens
and did not consider patient interaction. Also, any specimen work completed outside of
Cytopathology was not considered; however, any lab reconfiguration or change in the process
workflow could be extended to other areas in the future.
Methods and Findings

The team has identified waste in the current specimen testing processes and developed recommendations for the design of the new laboratory space at the NCRC. This was done by analyzing information from interviews/observations, spaghetti charts, literature searches, time studies, distance mapping, and value stream maps.

Interviews and Observations – Found significant congestion in lab
The team collectively observed prep techs creating Gyn and Non-Gyn/FNA slides for nine hours. One team member shadowed in the morning, another shadowed in the afternoon, and the final member shadowed in the evening. The shadowing allowed the team to define the phases of the slide creation process to be examined in time studies and experience the congestion and traffic in the lab first hand.

The team found that the slide creation process for Gyn and Non-Gyn/FNA specimens follow a fairly consistent pattern. Special cases include rework that must be done when specimen information is not entered in the database correctly. The team also found that prep techs must re-label slides so labels are compatible with different machines and scanners. Lastly, the team found that the machines in the lab are not placed in a sequential order which results in significant back and forth movement.

Spaghetti Chart - Found significant back and forth movement by prep techs
The team, clients, and coordinators completed the Spaghetti Chart by mapping out the paths the prep techs take when creating slides on a layout of the lab floor. This allowed the team to identify congestion and see where most of the slide creation process takes place, the demographic capacity. The final version of the Spaghetti Chart can be seen in Appendix B.

The team found that there is also congestion along the back wall of the lab, near the centrifuge and T2, and significant back and forth movement between the Non-Gyn/FNA computer workstation and Hood 1.

Literature Search – Found articles on efficient specimen transfer and lean design
The team searched scholarly articles and found three valuable sources whose information from was taken into consideration when designing future state layouts for the Cytopathology laboratory. One article by Roberson, Wrenn, Poole, Jaeger, and Eltoum (1) discussed reducing turnaround time by transferring specimen through pneumatic tube systems and working in multifunctional stations. This can be applied to the Cytopathology lab to minimize the transportation time of specimen and slides.

Another article by T. Joseph [2] discussed how Lean principles relate to laboratory layout. The article went in depth about the assessment of current operations, planning for future growth, workflow, and high level design layouts.

One presentation D. Church [3] discussed what Lean is and how it is used in a specific microbiology laboratory. Examples of Lean projects were also given.
Time Studies – Average Gyn turnaround time = ~6 days and Non-Gyn = ~1 day
The team used SOFT, the pathology department’s laboratory information system database, to collect time study data. This database includes timestamps for each specimen during each step of specimen processing. The lead cytotechnologist determined six categories of specimen based on possible steps the specimens go through. These categories, along with a short description, can be seen below.

1. Gyn NILM- Gynecological tests that are negative for Intraepithelial Lesion or Malignancy– no abnormalities.
2. Gyn with Pathologist Review- Gynecological tests where the screening cytotech finds or suspects an abnormality on the initial screen and sends it to a pathologist for verification.
3. Gyn Quality Check- Gynecological tests that are NILM and selected for 10% quality control rescreen by another cytotech.
4. Gyn Quality Check with Pathologist Review- Gynecological tests that are NILM and selected for 10% quality control rescreen by another cytotech and the second cytotech finds or suspects an abnormality and sends it to a pathologist for verification.
5. Non-Gyn/FNA- Any Non-Gyn/FNA specimen that is performed via washing, brushing, or extraction due to an exfoliation or excess fluid to obtain cellular material
6. Fine-Needle Aspiration (FNA) - Any Non-Gyn/FNA specimen that is performed by insertion of a needle into a nodule or mass by a physician to obtain cellular material.

The team established that 30 or more specimens’ timestamp data from each category need to be collected to ensure accurate estimations. The project client identified specimen order numbers accordingly; the team looked up their timestamp data in SOFT, transferred it into an Excel sheet, and calculated the time for each process step and overall turnaround times.

Some process step times, where slides and specimen were being prepared in machines, were not included in SOFT. Given that these machines perform in a consistent manner, the team obtained these times through client estimations.

Next, the team used Minitab to graph the distributions of the process step times. These distributions revealed two issues with the data: outliers and high variability in some of the process steps times. To account for variability, the team found the maximum, average, and minimum process step times. To account for outliers, the team consulted with the project client to determine their root cause and if they should be included in the analysis. Based on the clients recommendations, the team found process step times with and without outliers to show the normal process step times and special cases that usually occur when specimen and slides sit over holidays. Thus, the team found six numbers for each process step: the maximum, average, and minimum times with and without the effect of outliers.

The team used the data from SOFT to calculate the average turnaround time for each specimen category. The results are as follows in Table 1:
Table 1: Average turnaround times

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gyn</td>
<td>6.4 days</td>
</tr>
<tr>
<td>NILM</td>
<td>5.49</td>
</tr>
<tr>
<td>Pathologist Review</td>
<td>6.70</td>
</tr>
<tr>
<td>Quality Check</td>
<td>6.23</td>
</tr>
<tr>
<td>Quality Check with Pathologist Review</td>
<td>6.87</td>
</tr>
<tr>
<td>Non-Gyn/FNA</td>
<td>1.63 days</td>
</tr>
<tr>
<td>Non-Gyn</td>
<td>1.47</td>
</tr>
<tr>
<td>Fine-Needle Aspiration</td>
<td>1.72</td>
</tr>
</tbody>
</table>

The distribution of turnaround times for Gyn and Non-Gyn/FNA cases is as follows in Figures 3 and 4, respectively.

Figure 3: Distribution of turnaround time for Gyn cases

The Gyn distribution shows that 75% of cases fall between 4.6 and 7.5 days and the range of turnaround time is from 1 to 11.75 days.
The Non-Gyn/FNA distribution shows that 75% of cases fall between 0.9 and 2.1 days and the range of turnaround time is from 0.3 to 3.8 days.

The process step times, from the beginning to the end of the workflow, and corresponding courier times for Gyn cases are as follows in Figure 5. Note that the average process step times with the outlier effect were used for this analysis. A full table of the average, best, and worst step times with and without the outlier effect, along with the percentage of step occurrences, can be seen in Appendix C.
The process step times, from the beginning to the end of the workflow, for Non-Gyn/FNA cases are as follows in Figure 6. Again, the average process step times with the outlier effect were used for this analysis. A full table of the average, best, and worst step times with and without the outlier effect, along with the percentage of step occurrences, can be seen in Appendix D.
Distance Mapping – Gyn walk = ~0.4 miles/day and Non-Gyn = ~1.2 miles/day
The team measured the dimensions of the lab and used the paths from the spaghetti chart to determine the distance prep techs travel during the Gyn and Non-Gyn slide creation process.

The results showed that a prep tech walks about 2142.29 feet per day (0.406 miles per day) for Gyn cases and about 6564.50 feet per day (1.24 miles per day) for Non-Gyn/FNA cases.

Machine Sizing – Machine dimensions used when creating future state layouts
Using a list of equipment provided by the client, the team found dimensions for all of the necessary lab supplies. The team used this data to fit equipment in the footprint of the future lab space at the NCRC and create two possible layouts.

Value Stream Map – Gyn turnaround time = ~1% VA and Non-Gyn = ~13% VA
The team broke down the current high level Value Stream Map (VSM), developed by the clients and coordinators, by specific steps in the workflow and added the results from the time study and analysis to it. The final Gyn VSM and corresponding swim lane diagram can be seen in Appendices E and F, respectively. The final Non-Gyn/FNA VSM can be seen in Appendix G. An analysis of these VSMs was used to create a future state VSM with time savings.
According the final VSM, the value added time for Gyn cases is 1.8 hours (0.01 days). The average non-value added time is 142.1 hours (5.92 days) and the range is from 21.65 hours (0.9 days) to 353.59 hours (14.73 days). The average total turnaround time is 143.9 hours (6 days) and the range is from 23.45 hours (0.98 days) to 354.67 hours (14.78 days). Note that these values were calculated using weights based on the percentage of step occurrences (i.e., 12.6%*quality check time to account for the fact that 12.6% of cases go through quality check, etc.). The end result shows only 1.25% of the turnaround time for Gyn cases is value added.

The average value added time for Non-Gyn/FNA cases is 3.72 hours (~0.16 days) and the range is from 1.32 hours (0.06 days) to 22.46 hours (0.94 days). The average non-value added time is 28.65 hours (1.19 day) and the range is from 1.45 hours (0.06 days) to 83.69 hours (3.49 days). The average total turnaround time is 28.37 hours (1.18 day) and the range is from 2.77 hours (0.12 days) to 106.16 hours (4.42 days). Again, these values were calculated using weights based on the percentage of step occurrences. The end result shows only 13.11% of the turnaround time for Non-Gyn/FNA cases is value added.

**Conclusions**

The average turnaround time for Gyn specimens exceeds its goals of five days while the average Non-Gyn/FNA specimens do not exceed its goal of 2 days. However, both Gyn and Non-Gyn workflows can be improved to reduce turnaround time, which the department is always striving to do regardless of its performance with respect to its goals.

The general layout of the lab is crowded and disorganized due to current space constraints. The machines in the lab are not placed in sequential order and the prep techs frequently cross paths. These factors make the lab difficult to navigate through and result in a non-Lean environment.

A large percentage of the turnaround time for Gyn cases is from the time between processing at UH and reading at NIB, the time between being delivered from NIB back to UH for reading, the time before quality check, and the time before pathologist review. In addition, the courier only accounts for a small percentage of the time that slides are waiting between buildings, indicating that the slides are sitting on the shelves for long periods of time before and/or after they are moved by the couriers.

A large percentage of turnaround time for Non-Gyn/FNA cases is from the time before reading, the time it takes for Histology to receive cell blocks and process them, the time before approving the interpretation, and the accessioning time. In addition, there is a significant amount of walking involved for processing Non-Gyn/FNA cases due to walking between stations to scan specimen and slides between process steps.
Recommendations

Gyn Workflow

The recommended future workflow for Gyn is as follows in Figure 7. It can also be seen in Appendix H and the corresponding future swim lane diagram can be seen in Appendix I.

Changes from the current state for Gyn include the following:

- All slides are created at NCRC
- A small percentage of slides travel to UH where they are read and undergo quality checks by 2 cytotechs placed there. Note that this occurs to increase the utilization of UH cytotechs. It does not need to occur if other work that will improve efficiency is assigned to them.
- Slides go through the remainder of the workflow, after slide creation, in the location where they are read
- 1 pathologist at UH reviews abnormal slides that sent for review by UH cytotechs
- Excess quality check is eliminated (follows requirement of 10%)
- Smaller batch sizes (more courier trips)
- Visual management to ensure first-in-first-out between steps
- Quality check performed same day

The potential turnaround time estimate for the future state is 38.44 hours (as opposed to the current value of 143.9 hours). This was calculated after removing the weighted averages of the time it takes to travel to NIB and the time before quality check.

Non-Gyn/FNA Workflow

The recommended future workflow for Non-Gyn/FNA is as follows in Figure 8. It can also be seen in Appendix J.
Changes from the current state for Non-Gyn/FNA include the following:

- All slides are created and read at NCRC
- There is direct access to Histology through the Cytopathology lab via a cubby
- Smaller batch sizes (more courier trips)
- Visual management to ensure first-in-first-out between steps

The potential turnaround time estimate for the future state is 26.37 hours (as opposed to the current value of 28.37 hours). This estimate is not based on hard data, but instead on the theoretical effect of reducing batch size and providing direct access to Histology.

Laboratory Layouts
Two recommended future laboratory layout alternatives can be seen below in Figures 9 and 10. Larger versions can be seen in Appendices K and L.
Layout 1 has the following features:

- Approximately double the space
- Multifunctional work stations
- Sequential specimen flow
- Two stainers
- First-in-first-out management
- Strategic trash can placement (to reduce the changes of specimen/slides accidentally falling into the trash)
Layout 2 has the following features:

- Approximately double the space
- Pass through windows to Histology and Virology
- Multifunctional work stations
- Sequential specimen flow
- Two stainers
- First-in-first-out management
- Strategic trash can placement (to reduce the changes of specimen/slides accidentally falling into the trash)
The team created a set of criteria to use in the evaluation of both layouts. The decision criteria, as well as the evaluation of the layouts, are shown below in Table 2.

### Table 2: Decision Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight</th>
<th>Current</th>
<th>Layout 1</th>
<th>Layout 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficient flow of staff</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Possible staff work overlap</td>
<td>20%</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Efficient flow of specimens/slides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Reduction in travel</td>
<td>30%</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Maintain security and traceability of specimens/slides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Opportunities for specimen/slide misplacement or mislabel</td>
<td>25%</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Flexibility of space for future expansion and innovation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Modular set up</td>
<td>10%</td>
<td>1</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>• Number of permanent placements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pleasant environment for staff</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Noise</td>
<td>10%</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>• Natural light</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conceptual cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Cost of equipment</td>
<td>5%</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100%</td>
<td>1.95</td>
<td>4.35</td>
<td>4.2</td>
</tr>
</tbody>
</table>

### Expected Impact

- Future state recommendations will improve the department’s efficiency by:
  - Placing machines in a manner that minimizes the travel of specimens and slides
  - Utilizing the demographic capacity to improve flow and reduce congestion
  - Improving turnaround time of lab orders
  - Reducing batch size
  - Demonstrating the need for personnel to be in close proximity by assessing the waste created by slide transportation to the NIB
References


Appendix

Appendix A: High Level Value Stream Map
Appendix B: Spaghetti Chart
Appendix C: Step Data for Gyn Cases

<table>
<thead>
<tr>
<th>Step</th>
<th>With Outlier Effect</th>
<th>Without Outlier Effect</th>
<th>Percentage of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Best</td>
<td>Average</td>
<td>Worst</td>
</tr>
<tr>
<td>Accessioning</td>
<td>0.05 hr</td>
<td>0.05 hr</td>
<td>0.05 hr</td>
</tr>
<tr>
<td>To Processing</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Processing</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>To NIB</td>
<td>14.54</td>
<td>101.35</td>
<td>258.1</td>
</tr>
<tr>
<td>NiB Reading</td>
<td>0.125</td>
<td>0.125</td>
<td>0.125</td>
</tr>
<tr>
<td>To UH</td>
<td>11.32</td>
<td>95.79</td>
<td>223.14</td>
</tr>
<tr>
<td>UH Reading</td>
<td>0.125</td>
<td>0.125</td>
<td>0.125</td>
</tr>
<tr>
<td>To Quality Check</td>
<td>16.85</td>
<td>32.96</td>
<td>74.13</td>
</tr>
<tr>
<td>Quality Check</td>
<td>0.125</td>
<td>0.125</td>
<td>0.125</td>
</tr>
<tr>
<td>To Pathologist Review</td>
<td>0.18</td>
<td>17.18</td>
<td>70.1</td>
</tr>
<tr>
<td>Pathologist Review</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
</tbody>
</table>
## Appendix D: Step Data for Non-Gyn/FNA Cases

<table>
<thead>
<tr>
<th>Step</th>
<th>With Outlier Effect</th>
<th>Without Outlier Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Best</td>
<td>Average</td>
</tr>
<tr>
<td>Accessioning</td>
<td>0.05 hr</td>
<td>1.38 hr</td>
</tr>
<tr>
<td>To Transfer To Tube</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Transfer Specimen to Tube</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>To Label Tube</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Label Tube</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>To Centrifuge</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Centrifuge</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>To Pour Off Liquid</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Pour Off Liquid</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>To Diff Quick</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Diff Quick</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>To T2000</td>
<td>0.13</td>
<td>0.79</td>
</tr>
<tr>
<td>T2000</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>To Stain Slide</td>
<td>0.14</td>
<td>0.95</td>
</tr>
<tr>
<td>Stain Slide</td>
<td>0.67</td>
<td>0.67</td>
</tr>
<tr>
<td>To CoverSlip</td>
<td>0.14</td>
<td>0.95</td>
</tr>
<tr>
<td>CoverSlip</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>To Prepare Cell Block</td>
<td>0.1</td>
<td>0.46</td>
</tr>
<tr>
<td>Prepare Cell Block</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>To Process Cell Block at UHIST AND Process Cell Block at UHIST</td>
<td>0.72</td>
<td>3.81</td>
</tr>
<tr>
<td>To Reading</td>
<td>0.4</td>
<td>19.49</td>
</tr>
<tr>
<td>Reading</td>
<td>0.125</td>
<td>0.125</td>
</tr>
<tr>
<td>To Pathologist Review</td>
<td>0.4</td>
<td>2.54</td>
</tr>
<tr>
<td>Pathologist Review</td>
<td>0.08</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Appendix E: Gyn Current State VSM
Appendix F: Gyn Current State Swim Lane Diagram
Appendix G: Non-Gyn/FNA Current State VSM
Appendix H: Gyn Future State VSM
Appendix I: Gyn Future State Swim Lane Diagram
Appendix J: Non-Gyn/FNA Future State VSM
Appendix K: Future State Layout 1
Shown with and without walls
Appendix L: Future State Layout 2
Shown with walls