Analysis of CT Reading and Reporting Process for Emergency Patients

Final Report

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Executive Summary

Patients often arrive to the Emergency Department (ED) requiring a CT scan to diagnose their injury. The Emergency and Radiology departments expressed concern regarding the efficiency of the reading and reporting process for an emergency patient CT scan and have asked the Operations and Analysis Program team to evaluate the process and provide recommendations.

The key issue driving this project was the perception of a long overall lead time. There was also the perception that the reading rooms have non-standard procedures that significantly differ between day and night shifts. Finally, there was a perception of multiple handoffs of paperwork.

Methodology

To complete the analysis, the team conducted observations and time studies of the current process. During observations and time studies, team members watched the procedures performed in the ED CT scan room; IMACS clerk area; neuro; abdominal and thoracic reading rooms; and ED clerk area and collected data on the start and stop time of specific tasks. While observing and collecting time study information, the team also informally interviewed personnel, including CT technicians, an IMACS clerk, reading room coordinators/assistants, resident and attending radiologists, and an ED clerk. After performing observations, time studies and interviews, the team created high level value stream maps of the CT reading and reporting process found in Appendix C.

Findings and Conclusions

The following findings and conclusions were drawn from the team’s methodology:

- The ED CT scan reading and reporting is not always first in first out.
- The ED CT reading procedures are not standard between and within shifts.
- There is no standard method to notify ED physicians of results.
- ED physicians are not notified when the final report is signed on CareWeb.
- Batching the reading of scans delays the process.
- There is not always an ED dedicated radiologist during lunch.
- There are inconsistent operating hours for reading room coordinators.
- There are inconsistent operating hours for the neuro and thoracic reading rooms.

Recommendations

To reduce these problems, the Operations and Analysis team recommends the following:

1. **Elimination of IMACS clerk area:** CT images can be pushed to the corresponding reading room by the CT technician directly after the scan is completed. The patient’s paperwork would be faxed by the CT technician to the corresponding reading room coordinator. To achieve this, the IMACS work station will have to be installed in the CT scan room and each reading room. Once the reading room coordinator receives the patient’s paperwork, they can deliver it to the radiologist and pull up the patient’s comparison scans while the radiologist begins to read the ED CT scan.

2. **Create standardize preliminary notification to ED physician process:** Upon the completion of an ED CT scan preliminary report, the reading room coordinator should receive the patient’s paperwork. In Centricity, the coordinator will check that the preliminary report is complete to page the ED physician. Additionally, reading
room coordinator should change the icon to green. The preliminary report should then be faxed to the ED clerk area. To achieve this, the reading room coordinators must be given access to Centricity and a new v-form would need to be created to indicate that preliminary report is available.

3. **Apply first in first out whenever appropriate:** All reading rooms should read the ED CT scans in the order in which the patients are scanned.

4. **Eliminate batching:** Resident radiologist should not batch scans. Scans should be reviewed with an attending radiologist as soon as the preliminary report is complete.

5. **Standard work:** All reading rooms should follow more standard work.

6. **Consistent working hours:** In the neuro and thoracic reading rooms, the reading room coordinators should work until the rooms close. This will assure a coordinator is in a reading room at all times. Additionally, the neuro and thoracic reading rooms should close at the same time. They should both close at 5 pm or 6 pm. This will eliminate the 5pm – 6pm process.

7. **More efficient centricity color changing:** ED CT scan room technicians should change the icon color in Centricity immediately after an ED CT scan is completed.
Introduction

The University of Michigan’s Emergency Department (ED) provides initial treatment to patients with a broad spectrum of illnesses and injuries, some of which may be life-threatening and require immediate attention. Upon arrival in the ED, patients may require a computed tomography (CT) scan to diagnose their illness or injury. However, the Emergency and Radiology Departments have expressed concern regarding the efficiency of the current CT reading and reporting process. There is a perception that the current process is not standard and has many delays. Therefore, the Emergency and Radiology Departments would like to improve the efficiency of the reading and reporting process of a CT scan. In response, an Operations and Analysis Program team examined the current CT flow to identify waste in order to recommend how to improve the process. This report presents the team’s methodology, findings, conclusions and recommendations.

Background

The Emergency Department at the University of Michigan Hospital treats patients 24 hours a day, seven days a week. Patients may come in at any time with an illness or injury that requires a CT scan for treatment. One CT scanner is dedicated to the emergency Department to scan these patients.

There are three types of CT scans that can be performed on a patient: neuro, abdominal and thoracic. Patients may require one, two or all three types of CT scans. If a patient requires more than one type of scan, the scans are performed simultaneously.

After a CT scan of an ED patient is complete, an image management archive and computing systems (IMACS) clerk retrieves the patient’s paperwork from the CT scan room. Once the IMACS clerk processes the paperwork, they deliver it to a reading room.

A CT scan is read by a radiologist in a reading room. There are three reading rooms: neuro, abdominal and thoracic. Each type of scan is read by a radiologist in its respective reading room after the paperwork is delivered by the IMACS clerk. If multiple scans are performed, the IMACS clerk delivers duplicate paperwork to those reading rooms. After a CT scan is read, results are reported to the ED physician caring for the patient. The Emergency and Radiology departments process approximately 50 emergency CT scans a day.

Key Issues

This project was needed due to the following key issues:

- Perception of long overall lead time
- Perception that reading rooms are non-standard
- Perception that the notification process is not standard
- Perception of overall multiple handoffs
- Perception of significant difference between day shift and night shift procedures
**Goals and Objectives**
The primary goals of this project were to create a high level value stream map of the current CT process, identify waste and non-standard procedures in the process, and recommend improvements. To achieve these goals, the team has performed the following tasks:

- Observed the CT flow process from the time a scan is completed until the radiologist’s results are communicated to an ED physician
- Conducted time studies on the process in the CT scan rooms, reading rooms, IMACS area, and ED main desk area
- Gathered existing data of procedure times within the process
- Interviewed personnel involved in the process
- Created detailed value stream maps

**Project Scope**
This project included the CT reading and reporting process in the Emergency and Radiology Departments. The process begins when a CT scan of an ED patient is completed and ends when the physician receives the CT results from radiology.

In Scope:
- ED CT scans between September 9th and November 5th.
- Staff involved in the process: ED CT technicians, IMACS clerks, attending/fellow/resident radiologists, reading room coordinators, ED clerks, and ED physicians.
- Areas involved in the process: ED CT scan area, IMACS area, Abdominal/Thoracic/Neuro reading rooms, and ED clerk area.

Out of Scope:
- Preparing patients for CT scan
- Transporting patients to CT room
- Non ED CT scans
- Bone (MSK) reading room
- Caring for patient while ED physician waits for CT result

**Current Process**
The team observed the current ED CT reading and reporting process. The overall process flowchart is illustrated in Appendix A. The processes in each area involved are as follow:

**ED CT Scan Room**
After the completion of a CT scan, a technician completes the patient information on IDX and pages the IMACS clerk. Another technician transports the patient back to ED room.

**IMACS Clerk Area**
The IMACS clerk walks to the CT scan room to pick up the patient’s paperwork and returns to their area. The IMACS clerk double checks that the patient’s demographics match what is in the computer system. Once the patient’s demographics are verified, the IMACS clerk searches the database for past CT scans performed on the patient. Past CT scans are used to compare with the recent scan, if necessary. Next, the IMACS clerk confirms the electronic CT image has completely loaded into the system and pushes it and the comparison scans to the correct reading room. Lastly, the IMACS clerk walks the paperwork to the corresponding reading room.

**Neuro Reading Room**
Radiologists review the scans in the reading rooms. For the neuro reading room, until 4pm, the IMACS clerk delivers the paperwork to the reading room coordinator who then delivers the paperwork to the ED resident radiologist. However, after 4pm, the IMACS clerk delivers the paperwork directly to the ED resident radiologist. Once the resident receives the paperwork, the resident reads the ED CT scan with an attending radiologist. Next, the resident dictates a preliminary report on CareWeb. Lastly, an attending radiologist finalizes and signs the report on CareWeb.

**Thoracic Reading Room**
The thoracic reading room does not have a resident review the scan. The IMACS clerk delivers the paperwork to the ED attending radiologist. The attending radiologist reads the CT scan and posts a final dictation directly into CareWeb. The attending radiologist will call the ED physician regardless of the findings.

**Abdominal Reading Room: week days 8am-5pm**
In the abdominal reading room, from 8am – 5pm the IMACS clerk delivers the paperwork to the ED resident radiologist. The resident reads the scan and writes a preliminary report. An attending radiologist then staffs (reviews) the report with the resident. After the resident dictates the final report, the report is sent to the attending staff who signs it on CareWeb.

**Abdominal Reading Room: week days 5pm-6pm**
After 5pm, radiologist no longer read out of the neuro reading room. All abdominal and neuro ED CT scans are directed to the abdominal reading room where a resident radiologist reads the ED CT scan. The IMACS clerk delivers the neuro and abdominal CT scans’ paperwork to the abdominal reading room coordinator who then gives it to the resident radiologist. The resident writes a preliminary report and faxes the results to the ED clerks. In addition, if there are positive results, the resident may call or page the ED physician to notify them. The resident’s preliminary report must be staffed out by an attending radiologist to ensure no errors were made. Until 3 am, an attending in the abdominal room staffs out the preliminary report and finalizes it on CareWeb.

**Abdominal Reading Room: every day 6pm-8am**
After 6pm, the thoracic reading room also closes. After 6pm, neuro, abdominal and thoracic ED CT scans are directed to the abdominal reading room and the same steps are applied like when the neuro reading room closes. After 3am, ED CT scans will not be staffed out until the day shift returns to the neuro, abdominal and thoracic reading rooms at 8am. The scans will be staffed out in their respective rooms.
**Abdominal Reading Room: weekend 8am-6pm**
On the weekend, from 8am – 6pm a resident in the abdominal reading room reads neuro, abdominal and thoracic scans. The IMACS clerk delivers the neuro, abdominal and thoracic scans’ paperwork to the resident radiologist. The resident reads the scan and writes a preliminary report. The preliminary report is then staffed out in its respective reading room. An attending radiologist finalizes the preliminary report on CareWeb.

**ED Clerk Area**
When the results are faxed, the ED clerk then photocopies the report for back up, and then places the backup report in a box. If the ED physician is nearby, the clerk changes the icon color to green then hands the report to the physician personally. If the ED physician is not nearby, the clerk changes the icon color to green, pages the physician then places the report into another box. The ED physician then picks up the report from the box.

**Methodology**
To complete this project, the Operations and Analysis Program team examined activities in the Emergency and Radiology departments involved in the CT reading and reporting process. In order to validate the observation data, existing data was collected from the hospital computer systems. The team’s examination included observations, interviews, and time studies. The team conducted a literature search on the function of value stream maps, how to create the maps using Microsoft Visio and previously documented process flow analysis. The team then analyzed the collected data to develop recommendations.

**Observations**
From September 22, 2007 to November 19, 2007, the team observed the CT reading and reporting process. Observations took place in the CT scan room, neuro, thoracic and abdominal reading room, IMACS clerk area, and ED clerk area. Observations were conducted during each process shift in the following:

- **CT scan room:**
  - 12am – 12pm, Monday through Friday

- **IMACS clerk area:**
  - 12am – 12pm, Monday through Friday

- **Neuro reading room:**
  - 8am – 5pm, Monday through Friday

- **Thoracic reading room:**
  - 8am – 6pm, Monday through Friday

- **Abdominal reading room:**
  - 8am – 5pm, Monday through Friday
  - 5pm – 6pm, Monday through Friday
• 8am – 6pm, Saturday through Sunday
• 6pm – 8am. Sunday through Saturday

ED clerk area:
• 5pm – 8am, Sunday through Saturday

In the initial observation of the different areas, the team identified the basic steps in the CT reading and reporting process and determined what time studies were necessary. In all subsequent observations, the team noted any additional/different steps and conducted time studies.

**Interviews**
While conducting time observations and time studies, the team informally interviewed personnel. The team interviewed a CT technician, IMACS clerk, a neuro, thoracic and abdomen attending radiologist, a neuro resident radiologist and ED clerk. The interviews helped the team further understand the CT reading and reporting process.

**Time Studies**
The Operations and Analysis Program team conducted time studies on the steps in the CT reading and reporting process that were identified during the initial observations. Time studies began on September 24, 2007 and continued until November 19, 2007. Times were recorded at the start and finish of each step.

One team member conducted time studies in the CT scan room and neuro reading room. Another team member conducted time studies on the IMACS clerk and in the thoracic reading room. The last team member studied the abdomen reading room and ED clerk area. Time studies were conducted in each area during the different process shifts as listed under observations.

**Existing Data**
The team collected the data from the hospital computer systems; Centricity, Radiology Information System, and CareWeb. These existing data were collected from September 9, 2007 to September 22, 2007.

**Literature Search**
To understand how to create value stream maps of the different processes, the team referenced the *University of Michigan Radiation Oncology Analysis of Treatment Process & Start Times During Radiation Therapy Final Report* from fall 2006. This report included value stream maps of similar process flows. From this report, the team was able to reproduce many of the symbols and icons in the ED CT reading and reporting value stream maps. Additionally, the team used the Microsoft Visio 2007 help tool to learn how to document the value stream maps.

**Data Analysis**
The team analyzed the data to create high level value stream maps of the CT reading and reporting process. The value stream maps were used to identify waste, bottlenecks and non-standard procedures. The value stream maps were ultimately used to develop recommendations to improve the CT reading and reporting process.
Findings from Time Studies

This section discusses findings from the team’s time studies. The findings include observations, time study statistics data analysis, and ED CT reading and reporting process wastes. Observations summarize the current procedures and comments made by the data collectors during the time studies. Data analysis is a statistical summary of the process times observed. There are high level findings for the ED CT reading and reporting process along with detailed findings of each reading room.

Observations

ED CT Scan Room
- The process flow is shown in Appendix C.1.
- An ED CT scan will be performed in another CT scan room if the ED CT scan room is backed up.
- ED CT scans are performed the same during day and night shifts.

IMACS Clerk Area
- The process flow is shown in Appendix C.2.
- The IMACS clerk walks to the CT scan room immediately after being paged.
- The IMACS clerk will sometimes pick up multiple patients’ scans.
- No demographic errors have been observed during the time studies.
- ED CT scans might have thousands of images and back up the system.

Neuro Reading Room
- The process flow is shown in Appendix C.3.
- One resident radiologist is always reserved for ED CT scans.
- FIFO is applied by resident radiologists.
- Resident radiologists review ED CT scans with an attending radiologist before calling the ED physician and submitting the preliminary report to CareWeb.
- Attending radiologists are rarely batching ED CT scans before reviewing them with the resident radiologist.
- Resident radiologist stay in the NRR until preliminary reports have been dictated for all ED CT scans received.

Thoracic Reading Room
- The process flow is shown in Appendix C.8.
- One attending radiologist is reserved for ED CT scans.
- Resident radiologists to do not read an ED CT scan.
- FIFO is generally applied.
- Attending radiologists call the ED physician before signing final report onto CareWeb.
- Another attending radiologist fills in for ED dedicated radiologist during lunch.

Abdominal Reading Room
- There are four different reading and reporting process flows throughout the week.
  The process flows are:
• Week days 8am-5pm process flow is shown in Appendix C.4.
• Week days 5pm-6pm process flow is shown in Appendix C.5.
• Weekends 8am-6pm process flow is shown in Appendix C.6.
• Every day 6pm-8am process flow is shown in Appendix C.7.
  ▪ At least one resident and one attending radiologist are reserved for ED CT scans.
  ▪ Resident radiologists usually apply LIFO when reading ED CT scans, but attending radiologists usually apply FIFO.
  ▪ During week days from 5pm-6pm, only neurological and abdominal ED CT scans are routed to the abdominal reading room.
  ▪ There are some interruptions during the reading and reporting process, however the frequency and duration of these interruptions was not precisely recorded.

**ED Clerk Area**
  ▪ The process flow is shown in Appendix C.9.
  ▪ The procedure is the same for all shifts.
  ▪ When the final report is signed on CareWeb, the physician is never notified.

**Data Analysis**
This section details the data analysis of the overall processes, as well as the processes in the areas involved; ED CT scan room, IMACS clerk area, neuro reading room, abdominal reading room, thoracic reading room and ED clerk area. The overall processes are a summary of existing data and the detailed processes in each area are a summary of observation data. The median values will be used for data analysis due to some large variations in process times.

**Overall Process (every day 6pm-8am)**
Table 1 presents a summary of existing data for the overall ED CT reading and reporting process from 6pm to 8am every day.

<table>
<thead>
<tr>
<th>L/T = Time from Scan completed to IMACS clerk delivered paperwork</th>
<th>L/T = Time from paperwork delivered to icon color changed</th>
<th>L/T = Time from icon color changed to report finalized in CareWeb</th>
<th>L/T = Time from scan completed to report finalized in CareWeb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:12</td>
<td>0:36</td>
<td>7:50</td>
</tr>
<tr>
<td>Mean (µ)</td>
<td>0:15</td>
<td>0:41</td>
<td>8:23</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:11</td>
<td>0:37</td>
<td>3:34</td>
</tr>
<tr>
<td>Count (n)</td>
<td>138</td>
<td>143</td>
<td>79</td>
</tr>
</tbody>
</table>

During this shift, the final report may be finalized on the same day the scan is complete, or the next morning. On average, it takes 1 hour and 3 minutes for the preliminary report to be available to the ED physician. If the final report is read the same day, it takes about 1 hour and 46 minutes for the final report to be completed. If the final report is completed the next morning, it takes approximately 9 hours and 23 minutes. The current state value stream map with the statistics of each process step is shown in appendix B.1.
Overall Process (weekend 8am-6pm)
Table 2 presents a summary of existing data for the overall ED CT reading and reporting process from 8am to 6pm weekends.

<table>
<thead>
<tr>
<th>L/T = Time from scan completed to icon color changed</th>
<th>L/T = Time from icon color changed to report finalized in CareWeb</th>
<th>L/T = Time from scan completed to report finalized in CareWeb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:44</td>
<td>3:01</td>
</tr>
<tr>
<td>Mean (µ)</td>
<td>0:47</td>
<td>3:07</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:15</td>
<td>2:13</td>
</tr>
<tr>
<td>Count (n)</td>
<td>43</td>
<td>43</td>
</tr>
</tbody>
</table>

On average, it takes 44 minutes for the preliminary report to be available to the ED physician. It takes 3 hours and 35 minutes for the final report to be completed. The current state value stream map with the statistics of each process step is shown in appendix B.2.

Overall Process (week days 8am-5pm)
Table 3 presents a summary of existing data for the overall ED CT reading and reporting process from 8am to 5pm week days.

<table>
<thead>
<tr>
<th>L/T = Time from Scan completed to IMACS clerk delivered paperwork</th>
<th>L/T = Time from paperwork delivered to report finalized in CareWeb</th>
<th>L/T = Time from scan completed to report finalized in CareWeb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:17</td>
<td>1:04</td>
</tr>
<tr>
<td>Mean (µ)</td>
<td>0:22</td>
<td>2:12</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:17</td>
<td>2:32</td>
</tr>
<tr>
<td>Count (n)</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

On average, it takes 2 hours and 56 minutes for the final report to be completed. The current state value stream map with the statistics of each process step is shown in appendix B.3.

Overall Process (week days 5pm-6pm)
Table 4 presents a summary of existing data for the overall ED CT reading and reporting process from 5pm to 6pm week days.

<table>
<thead>
<tr>
<th>L/T = Time from Scan completed to IMACS clerk delivered paperwork</th>
<th>L/T = Time from paperwork delivered to icon color changed</th>
<th>L/T = Time from icon color changed to report finalized in CareWeb</th>
<th>L/T = Time from scan completed to report finalized in CareWeb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:10</td>
<td>0:22</td>
<td>0:32</td>
</tr>
<tr>
<td>Mean (µ)</td>
<td>0:10</td>
<td>0:25</td>
<td>0:30</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:03</td>
<td>0:12</td>
<td>0:14</td>
</tr>
<tr>
<td>Count (n)</td>
<td>8</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

On average, it takes 32 minutes for the preliminary report to be available for the ED physician. It takes about 1 hour and 11 minutes for the final report to be completed. The current state value stream map with the statistics of each process step is shown in appendix B.4.
**ED CT Scan Room**

Table 5 presents a summary of observed times in ED CT scan room.

<table>
<thead>
<tr>
<th>L/T = Time from scan completed to IDX completed and IMACS clerk paged</th>
<th>W/T = Time taken for IMACS to arrive after being paged</th>
<th>L/T = Overall Lead Time (from scan completed to IMACS clerk picked up the paperwork)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:01</td>
<td>0:04</td>
</tr>
<tr>
<td>Mean (µ)</td>
<td>0:02</td>
<td>0:04</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:02</td>
<td>0:02</td>
</tr>
<tr>
<td>Count (n)</td>
<td>21</td>
<td>33</td>
</tr>
</tbody>
</table>

The overall lead time in ED CT scan room is approximately 6 minutes, with roughly 20% process time and 80% waiting time. The current state value stream map with the statistics of each process step is shown in appendix C.1.

**IMACS Clerk Area**

Table 6 presents the summary of observed time in the IMACS clerk area.

<table>
<thead>
<tr>
<th>L/T = Time for IMACS clerk to retrieve paperwork and return to station</th>
<th>L/T = Time for IMACS clerk to process patient</th>
<th>L/T = Overall Lead Time (from IMACS clerk received page to processed patient)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:03</td>
<td>0:04</td>
</tr>
<tr>
<td>Mean (µ)</td>
<td>0:03</td>
<td>0:07</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:01</td>
<td>0:09</td>
</tr>
<tr>
<td>Count (n)</td>
<td>27</td>
<td>24</td>
</tr>
</tbody>
</table>

The overall lead time in the IMACS clerk area is approximately 8 minutes, with roughly 57% process time and 43% waiting time. The current state value stream map with the statistics of each process step is shown in appendix C.2.

**Neuro Reading Room**

Table 7 presents a summary of observed times in the neuro reading room from when the paperwork is delivered to the start of reviewing process. Table 8 presents a summary of observed time from the start of the reviewing process to attending radiologist signing the final report in CareWeb.
Table 7: Neuro Reading Room Summary  
OAP Team, Fall 2007, September 22nd – November 19th

<table>
<thead>
<tr>
<th>W/T = Time for Rad. Resident to start reading new scan</th>
<th>P/T = Rad. Resident reads scan (Batching)</th>
<th>W/T = Time for Attd to start reviewing scan after Rad. Resident finishes reading it (Batching)</th>
<th>P/T = Rad. Resident reads scan until he starts reviewing it with Attd (No Batching)</th>
<th>L/T = Time from Rad. Resident starts reading CT to start reviewing it with Attd (Combined)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:05</td>
<td>0:13</td>
<td>0:17</td>
<td>0:06</td>
</tr>
<tr>
<td>Mean (µ)</td>
<td>0:06</td>
<td>0:13</td>
<td>0:17</td>
<td>0:05</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:06</td>
<td>0:02</td>
<td>0:02</td>
<td>0:03</td>
</tr>
<tr>
<td>Count (n)</td>
<td>11</td>
<td>2</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 8: Neuro Reading Room Summary  
OAP Team, Fall 2007, September 22nd – November 19th

<table>
<thead>
<tr>
<th>P/T = Attd reviewing time</th>
<th>W/T = Time after reviewing before calling ED physician</th>
<th>L/T = Time from start of calling ED physician to dictate prelim results on CareWeb</th>
<th>L/T = Time from Rad. Resident posts prelim on CareWeb to Attd signs final report in CareWeb</th>
<th>L/T = Overall Lead Time (from IMACS clerk delivers paperwork to Attd signs final report in CareWeb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:03</td>
<td>0:04</td>
<td>0:15</td>
<td>0:56</td>
</tr>
<tr>
<td>Mean (µ)</td>
<td>0:06</td>
<td>0:04</td>
<td>0:16</td>
<td>1:13</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:05</td>
<td>0:03</td>
<td>0:09</td>
<td>0:49</td>
</tr>
<tr>
<td>Count (n)</td>
<td>12</td>
<td>9</td>
<td>7</td>
<td>13</td>
</tr>
</tbody>
</table>

The overall lead time in the neuro reading room is approximately 1 hour and 48 minutes, with roughly 40% process time and 60% waiting time. The current state value stream map with the statistics of each process step is shown in appendix C.3.

Thoracic Reading Room

Table 9 presents a summary of observed times in thoracic reading room.

Table 9: Thoracic Reading Room Summary  
OAP Team, Fall 2007, September 22nd – November 19th

<table>
<thead>
<tr>
<th>W/T = Time for ED CT scan to be read by Attd</th>
<th>P/T = Time for Attd to read ED CT scan and discuss with ED physician</th>
<th>W/T = Time for Attd to call ED physician after Attd completed CT read</th>
<th>P/T = Call length</th>
<th>P/T = Time for Attd to complete CT read after Attd finished discussing findings with Ed physician</th>
<th>L/T = Time for ED CT scan to be finalized after Attd reads scan and discusses results with ED physician to be finalized</th>
<th>L/T = Overall Lead Time (from IMACS clerk delivers Paperwork to Attd signs final report in CareWeb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:02</td>
<td>0:24</td>
<td>0:01</td>
<td>0:05</td>
<td>0:05</td>
<td>0:03</td>
</tr>
<tr>
<td>Mean (µ)</td>
<td>0:05</td>
<td>0:26</td>
<td>0:01</td>
<td>0:06</td>
<td>0:05</td>
<td>0:04</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:06</td>
<td>0:13</td>
<td>0:01</td>
<td>0:05</td>
<td>0:01</td>
<td>0:02</td>
</tr>
<tr>
<td>Count (n)</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

The overall lead time in the thoracic is approximately 33 minutes, with roughly 90% process time and 10% waiting time. The current state value stream map with the statistics of each process step is shown in appendix C.4.
**Abdominal Reading Room (week days 8am-5pm)**

Table 10 presents a summary of observed times in the abdominal reading room during the week days 8am-5pm shift when a resident is available. Table 11 presents times when a resident is not available; usually during lunch time.

### Table 10: Abdominal Reading Room 8am-5pm week days Summary

<table>
<thead>
<tr>
<th>W/T = Time before prelim start after paperwork arrives</th>
<th>P/T = Rad. Resident reads scan</th>
<th>L/T = Time for Attd to start reviewing scan after Rad. Resident finishes reading it</th>
<th>P/T = Attd reviewing time</th>
<th>W/T = Time for Rad. Resident to start dictation after Attd finishes reviewing</th>
<th>P/T = Rad. Resident dictation time</th>
<th>L/T = Time for Attd to sign final report in CareWeb</th>
<th>L/T = Overall Lead Time (from IMACS clerk delivers paperwork to Attd signs final report in CareWeb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:14</td>
<td>0:09</td>
<td>0:15</td>
<td>0:12</td>
<td>0:04</td>
<td>0:17</td>
<td>1:48</td>
</tr>
<tr>
<td>Mean (µ)</td>
<td>0:15</td>
<td>0:10</td>
<td>0:21</td>
<td>0:12</td>
<td>0:14</td>
<td>0:21</td>
<td>1:46</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:12</td>
<td>0:04</td>
<td>0:19</td>
<td>0:05</td>
<td>0:20</td>
<td>0:13</td>
<td>0:36</td>
</tr>
<tr>
<td>Count (n)</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

The overall lead time in the abdominal reading room during the 8am-5pm week days shift is approximately 1 hour and 48 minutes, with roughly 65% process time and 35% waiting time.

### Table 11: Abdominal Reading Room 8am-5pm week days Summary

<table>
<thead>
<tr>
<th>W/T = Time before Attd start reading scan after paperwork arrives</th>
<th>P/T = Attd reading scan, dictating report and signing in CareWeb</th>
<th>L/T = Overall Lead Time (from IMACS clerk delivers paperwork to Attd signs final report in CareWeb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:03</td>
<td>0:19</td>
</tr>
<tr>
<td>Mean (µ)</td>
<td>0:08</td>
<td>0:17</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:12</td>
<td>0:04</td>
</tr>
<tr>
<td>Count (n)</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

The overall lead time in the abdominal reading room is approximately 23 minutes, with roughly 86% process time and 14% waiting time.

The weighted average overall lead time in the abdominal reading room during this shift has a median of 1 hour and 6 minutes, with roughly 68% process time and 32% waiting time. The current state value stream map with the statistics of each process step is shown in appendix C.5.

**Abdominal Reading Room (week days 5pm-6pm)**

Table 12 presents a summary of observed times in the abdominal reading room during the 5pm-6pm week days shift.
Table 12: Abdominal Reading Room 5pm-6pm week days Summary
OAP Team, Fall 2007, September 22\textsuperscript{nd} – November 19\textsuperscript{th}

<table>
<thead>
<tr>
<th>W/T = Time for 1800 Resident to get paperwork</th>
<th>W/T = Time before 1800 Resident start prelim</th>
<th>P/T = 1800 Resident reading scan and writing prelim report</th>
<th>W/T = Time for Attd to get paperwork after prelim report is completed</th>
<th>W/T = Time before Attd start finalizing (Batching)</th>
<th>L/T = Attd Finalizing report and signing in CareWeb</th>
<th>L/T = Overall Lead Time (from IMACS clerk delivers Paperwork to Attd signs final report on CareWeb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>Mean (µ)</td>
<td>Stdev (σ)</td>
<td>Count (n)</td>
<td>Median (x)</td>
<td>Mean (µ)</td>
<td>Stdev (σ)</td>
</tr>
<tr>
<td>0:16</td>
<td>0:15</td>
<td>0:12</td>
<td>6</td>
<td>0:07</td>
<td>0:06</td>
<td>0:07</td>
</tr>
</tbody>
</table>

The overall lead time in the abdominal reading room is approximately 1 hour and 25 minutes, with roughly 38% process time and 62% waiting time. The current state value stream map with the statistics of each process step is shown in appendix C.6.

Abdominal Reading Room (weekend 8am-6pm)
Table 13 presents a summary of observed time in the abdominal reading room during the 8am-6pm weekend shift.

Table 13: Abdominal Reading Room 8am-6pm weekend Summary
OAP Team, Fall 2007, September 22\textsuperscript{nd} – November 19\textsuperscript{th}

<table>
<thead>
<tr>
<th>W/T = Time for 1800 Resident to get paperwork</th>
<th>W/T = Time before 1800 Resident start prelim (Batching)</th>
<th>P/T = 1800 Resident reading scan and writing prelim report</th>
<th>L/T = Time from prelim completed to Attd finalizes the report</th>
<th>LT = Overall Lead Time (from IMACS clerk delivers paperwork to Attd signs final report on CareWeb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>Mean (µ)</td>
<td>Stdev (σ)</td>
<td>Count (n)</td>
<td>Median (x)</td>
</tr>
<tr>
<td>0:07</td>
<td>0:06</td>
<td>0:07</td>
<td>7</td>
<td>3:11</td>
</tr>
</tbody>
</table>

The overall lead time in the abdominal reading room during the 8am-6pm weekend shift is approximately 1 hour and 25 minutes, with roughly 22% process time and 78% waiting time. The current state value stream map with the statistics of each process step is shown in appendix C.7.

Abdominal Reading Room (every day 6pm-8am)
Table 14 presents a summary of observed times in the abdominal reading room during the 6pm-8am every day shift.
Table 14: Abdominal Reading Room 6pm-8am every day Summary  
OAP Team, Fall 2007, September 22nd – November 19th

<table>
<thead>
<tr>
<th>W/T = Time for 1800 Resident to get paperwork</th>
<th>W/T = Time before 1800 Resident start prelim</th>
<th>P/T = 1800 Resident reading scan and writing prelim report</th>
<th>L/T = Time for Attd to get paperwork after prelim report is completed</th>
<th>L/T = Time before Attd start finalizing</th>
<th>L/T = Attd Finalizing report and signing in CareWeb</th>
<th>L/T = Overall Lead Time (from IMACS clerk delivers paperwork to Attd signs final report on CareWeb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:02</td>
<td>0:00</td>
<td>0:12</td>
<td>0:14</td>
<td>0:00</td>
<td>0:19</td>
</tr>
<tr>
<td>Mean (μ)</td>
<td>0:07</td>
<td>0:01</td>
<td>0:12</td>
<td>0:22</td>
<td>0:04</td>
<td>0:25</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:12</td>
<td>0:05</td>
<td>0:06</td>
<td>0:26</td>
<td>0:11</td>
<td>0:20</td>
</tr>
<tr>
<td>Count (n)</td>
<td>34</td>
<td>35</td>
<td>30</td>
<td>19</td>
<td>8</td>
<td>21</td>
</tr>
</tbody>
</table>

The overall lead time in the abdominal reading room during the 6pm-8am every day shift is approximately 54 minutes, with roughly 66% process time and 34% waiting time. The current state value stream map with the statistics of each process step is shown in appendix C.8.

ED Clerk Area
Table 15 presents a summary of observed times in the ED clerk area.

Table 15: ED Clerk Area Summary  
OAP Team, Fall 2007, September 22nd – November 19th

<table>
<thead>
<tr>
<th>L/T = Time for clerk to finish copying report after it arrives by fax</th>
<th>L/T = Time for clerk to change icon, page physician and place prelim into box after it is copied (physician is not nearby)</th>
<th>W/T = Time for ED physician to pick up prelim after it is placed in the box (physician is not nearby)</th>
<th>L/T = Time for clerk to hand prelim to ED physician after it is copied (physician is not nearby)</th>
<th>L/T = Weighted Overall Lead Time (from paperwork arrives by fax to ED physician receives the report)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (x)</td>
<td>0:01</td>
<td>0:00</td>
<td>0:05</td>
<td>0:02</td>
</tr>
<tr>
<td>Mean (μ)</td>
<td>0:01</td>
<td>0:00</td>
<td>0:10</td>
<td>0:02</td>
</tr>
<tr>
<td>Stdev (σ)</td>
<td>0:01</td>
<td>0:00</td>
<td>0:17</td>
<td>0:00</td>
</tr>
<tr>
<td>Count (n)</td>
<td>13</td>
<td>10</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

The weighted overall lead time in the ED clerk area is approximately 4 minutes, with roughly 25% process time and 75% waiting time. The current state value stream map with the statistics of each process step is shown in appendix C.9.

Conclusions

From our findings, the team concluded that:

- The ED CT scan reading and reporting is not always first in first out.
- The ED CT reading procedures are not standard between and within shifts.
- There is no standard method to notify ED physicians of results.
- ED physicians are not notified when the final report is signed on CareWeb.
- Batching scans delays the process.
• There is not always an ED dedicated radiologist during lunch.
• There are inconsistent operating hours for reading room coordinators.
• There are inconsistent operating hours for the neuro and thoracic reading rooms.

Recommendations

Based on the findings and conclusions, the team recommends the following to improve the ED CT reading and reporting process:

1. **Elimination of IMACS clerk area:** CT images can be pushed to the corresponding reading room by the CT technician directly after the scan is completed. The patient’s paperwork would be faxed by the CT technician to the corresponding reading room coordinator. To achieve this, the IMACS work station will have to be installed in the CT scan room and each reading room. Once the reading room coordinator receives the patient’s paperwork, they can deliver it to the radiologist and pull up the patient’s comparison scans while the radiologist begins to read the ED CT scan.

2. **Create standardize preliminary notification to ED physician process:** Upon the completion of an ED CT scan preliminary report, the reading room coordinator should receive the patient’s paperwork. In Centricity, the coordinator will check that the preliminary report is complete to page the ED physician. Additionally, reading room coordinator should change the icon to green. The preliminary report should then be faxed to the ED clerk area. To achieve this, the reading room coordinators must be given access to Centricity and a new v-form would need to be created to indicate that preliminary report is available.

3. **Apply first in first out whenever appropriate:** All reading rooms should read the ED CT scans in the order in which the patients are scanned.

4. **Eliminate batching:** Resident radiologist should not batch scans. Scans should be reviewed with an attending radiologist as soon as the preliminary report is complete.

5. **Standard work:** All reading rooms should follow more standard work.

6. **Consistent working hours:** In the neuro and thoracic reading rooms, the reading room coordinators should work until the rooms close. This will assure a coordinator is in a reading room at all times. Additionally, the neuro and thoracic reading rooms should close at the same time. They should both close at 5 pm or 6 pm. This will eliminate the 5pm – 6pm process.

7. **More efficient centricity color changing:** ED CT scan room technicians should change the icon color in Centricity immediately after an ED CT scan is completed.

Expected Impact

The recommendations are expected to result in:

• Decreased average lead time of CT reading and reporting
• Improved efficiency and consistency of communication between ED CT technicians, IMACS clerks, attending/fellow/resident radiologists, reading room coordinators, clerks and ED physicians.
• Minimized waste time
Appendix A. Flowchart
Appendix B. Overall Process Value Stream Maps

B.1: Overall Process (Every day 6pm-8am)

High Level 6pm-8am Every day

L/T = lead time
P/T = process time
WT = wait time
μ = mean
σ = standard deviation
n = count

RR received paperwork

ED Clerk (green icon)

ED Physician

CareWeb

Finalized in CareWeb

Final Report
WT = 0

Preliminary report
dated to ED clerk

RR received paperwork

Scan completed

Scan completed
High Level 8am-6pm Weekend

B.2: Overall Process (Weekend 8am-6pm)

- ED CT Scan Room
- IMACS Clerk
- Abdominal Reading Room
- Neurology Reading Room
- Thoracic Reading Room
- CareWeb
- ED Clerk (green Icon)
- ED Physician
- Final Report
- Preliminary Report
- L/T (Observed) µ = 0:39 σ = 0:12 Median = 0:31 Min = 0:16 Max = 0:56 n = 6
- L/T (Existing) µ = 0:07 σ = 0:13 Median = 0:01 Min = 0:16 Max = 0:80 n = 43
- L/T (Existing) µ = 0:47 σ = 0:16 Median = 0:44 Min = 0:20 Max = 0:39 n = 43
- Overall L/T (Existing) µ = 0:55 σ = 0:21 Median = 0:35 Min = 0:057 Max = 0:935 n = 43
- Icon color changed to green
- Process time
- Lead time
- Wait time
- Data: 9/9/07 – 9/22/07
- Observed Data: 9/28/07 - 11/19/07
- Scan completed
- RR received paperwork
- RR received paperwork
- Preliminary report faxed to ED clerk
- Finalized in CareWeb
- Finalized in CareWeb
- Finalized in CareWeb
B.3: Overall Process (Weekdays 8am-5pm)

**High Level 8am-5pm Week days**

- **Neurology Reading Room**
  - L/T (Observed)
    - $\mu = 0:46$
    - $\sigma = 0:251$
    - Median = 0:48
    - Min = 0:048
    - Max = 0:17
    - n = 11
  - Final Report
    - W/T = 0

- **Abdominal Reading Room**
  - L/T (Observed)
    - $\mu = 1:04$
    - $\sigma = 0:28$
    - Median = 0:06
    - Min = 0:23
    - Max = 1:33
    - n = 5
  - Final Report
    - W/T = 0

- **Thoracic Reading Room**
  - L/T (Existing)
    - $\mu = 0:31$
    - $\sigma = 0:05$
    - Median = 0:33
    - Min = 0:022
    - Max = 0:050
    - n = 5
  - Finalized in CareWeb

- **CareWeb**
  - L/T = lead time
  - P/T = process time
  - W/T = wait time
  - $\mu =$ mean
  - $\sigma =$ standard deviation
  - n = count

**Events:**
- Scan completed
- RR received paperwork
- Overall L/T (Existing)
  - $\mu = 0:57$
  - $\sigma = 0:155$
  - Median = 0:56
  - Min = 0:34
  - Max = 0:56
  - n = 23

Finalized in CareWeb
B4: Overall Process (Week days 5pm-6pm)

**High Level 5pm-6pm Week days**

- **Thoracic Reading Room**
  - L/T (Observed)
    - $\mu = 60:31$
    - $\sigma = 0:06$
    - Median = 60:33
    - Min = 60:22
    - Max = 60:37
    - n = 5
  - Final Report
    - W/T = 0

- **Abdominal Reading Room**
  - Final Report
    - W/T = n

- **CareWeb**
  - L/T = Finished

- **ED Clerk (green Icon)**
  - L/T (Existing)
    - $\mu = 0:12$
    - $\sigma = 0:06$
    - Median = 0:15
    - Min = 0:11
    - Max = 0:18
    - n = 8
  - RR received pasenwork
  - Preliminary Report
  - Icon color: changed to green
  - Finalized in CareWeb

- **ED Physician**
  - L/T (Existing)
    - $\mu = 0:33$
    - $\sigma = 0:14$
    - Median = 0:32
    - Min = 0:01
    - Max = 0:46
    - n = 9

- **Scan completed**
  - Overall L/T (Existing)
    - $\mu = 0:07$
    - $\sigma = 0:14$
    - Median = 0:1
    - Min = 0:06
    - Max = 0:21
    - n = 9
  - Finalized in CareWeb

- **Scan completed**
  - L/T = Lead time
  - P/T = process time
  - W/T = wait time

  - $\mu =$ mean
  - $\sigma =$ standard deviation
  - n = count
The University of Michigan Hospital, Emergency and Radiology Department, Fall 2007

C.2: IMACS Clerk Area

IMACS Clerk

receives page from CT Technician

- retrieves paperwork from ED CT scan room
- returns to IMACS station
- checks patient’s demographics
- searches for CT scan comparisons
- verifies CT images have completely loaded
- corrects patient’s information
- divides scans according to reading room
- pushes CT images to reading room if not automatically done
- delivers paperwork to reading room/s

IMACS Clerk

L/T
μ = 00:03
σ = 00:01
median = 00:03
min = 00:02
max = 00:07
n = 27

L/T
μ = 00:07
σ = 00:09
median = 00:03
min = 00:01
max = 00:47
n = 24

Overall L/T
μ = 00:11
σ = 00:09
median = 00:08
min = 00:03
max = 00:52
n = 24

SA = Siemens archive
L/T = lead time
P/T = process time
W/T = wait time
μ = mean
σ = standard deviation
n = count

paperwork
location
operator
C.3: Neuro Reading Room

The University of Michigan Hospital, Emergency and Radiology Department, Fall 2007

NEURO READING ROOM

WT
\[ \mu = 0.0517, \quad \sigma = 0.0002, \quad \text{Median} = 0.017, \quad \text{Min} = 0.005, \quad \text{Max} = 0.019, \quad n = 2 \]

WT batching (80%)

No batching (20%)  WT = 0

P/T batching
\[ \mu = 0.0013, \quad \sigma = 0.0002, \quad \text{Median} = 0.013, \quad \text{Min} = 0.001, \quad \text{Max} = 0.005, \quad n = 2 \]

P/T (no batching)
\[ \mu = 0.0005, \quad \sigma = 0.0003, \quad \text{Median} = 0.003, \quad \text{Min} = 0.000, \quad \text{Max} = 0.0013, \quad n = 12 \]

hall physician and discuss results

NRR chooses Prelim report to RIS (CareWeb)

WT
\[ \mu = 0.0004, \quad \sigma = 0.0003, \quad \text{Median} = 0.0004, \quad \text{Min} = 0.0001, \quad \text{Max} = 0.0010, \quad n = 9 \]

dictates the prelim report

WT = 0

NRR chooses Self-Curr

NRR finalizes the report and signs on CareWeb

NRR

\[ \mu = 0.045, \quad \sigma = 0.05, \quad \text{Median} = 0.14, \quad \text{Min} = 0.05, \quad \text{Max} = 0.46, \quad n = 11 \]

Overall WT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WT [ \mu = 0.0517, \quad \sigma = 0.0002, \quad \text{Median} = 0.017, \quad \text{Min} = 0.005, \quad \text{Max} = 0.019, \quad n = 2 ]</td>
<td></td>
</tr>
<tr>
<td>P/T batching</td>
<td>[ \mu = 0.0013, \quad \sigma = 0.0002, \quad \text{Median} = 0.013, \quad \text{Min} = 0.001, \quad \text{Max} = 0.005, \quad n = 2 ]</td>
</tr>
<tr>
<td>P/T (no batching)</td>
<td>[ \mu = 0.0005, \quad \sigma = 0.0003, \quad \text{Median} = 0.003, \quad \text{Min} = 0.000, \quad \text{Max} = 0.0013, \quad n = 12 ]</td>
</tr>
<tr>
<td>WT batching (80%)</td>
<td></td>
</tr>
<tr>
<td>No batching (20%)</td>
<td>WT = 0</td>
</tr>
<tr>
<td>Overall LT</td>
<td>[ \mu = 0.045, \quad \sigma = 0.05, \quad \text{Median} = 0.14, \quad \text{Min} = 0.05, \quad \text{Max} = 0.46, \quad n = 11 ]</td>
</tr>
</tbody>
</table>

\( \mu \) = mean
\( \sigma \) = standard deviation
\( n \) = count

NRR = Neuro Reading Room
RIS = Radiology Information System
CW = CareWeb
LT = lead time
P/T = process time
WT = wait time

Call IMACS Clerk

P/T = impact
ABDOMINAL READING ROOM
week days 8am-5pm

- Rad res/fellow receives paperwork
- Rad res/fellow reads scan
- Call/page physician
- Rad attending receives paperwork
- Rad attending dictates the report
- Rad attending signs final report on CareWeb then places paperwork into “Dictated” tray
- Rad attending staffs the report with Rad res/fellow
- Rad res/fellow delivers paperwork

**ARR = Abdominal Reading Room**
**RIS = Radiology Information System**
**CW = CareWeb**

**L/T = lead time**
**P/T = process time**
**W/T = wait time**

\[
\mu = \text{mean} \\
\sigma = \text{standard deviation} \\
n = \text{count}
\]
ABDOMINAL READING ROOM
every day 6pm-8am

1. **Arrives** (ARR) at 6pm
   - Calls ED physician
   - Waiting for Rad attending to arrive

2. **Rad attending** (1800 assistant) logs in and places paperwork into “1800 ER Studies” tray.

3. **1800 ER Studies** rad res picks up paperwork from tray.

4. **1800 ER Studies** rad res faxes prelim to ED, then staples it with paperwork and places into tray next to fax machine.

5. **1800 ER Studies** rad res faxes report to ED, then places into attending tray.

6. **ED rad attending** picks up paperwork from tray.

7. **ED rad attending** signs final report on CareWeb then places paperwork into “Dictated” tray.

8. **ARR** delivers paperwork to IMACS Clerk.

9. **IMACS Clerk** waits for Rad attending to arrive in the morning.

10. **Rad attending** dictates report on CareWeb then places paperwork into “Dictated” tray.

**Operational Statistics**:
- **WT** (Batching):
  - \( \mu = 00:07 \)
  - \( \sigma = 00:12 \)
  - Median = 00:02
  - Min = 00:00
  - Max = 01:05
  - \( n = 34 \)

- **P/T** (Process Time): P/T = immed.

- **L/T** (Lead Time) :
  - \( \mu = 00:22 \)
  - \( \sigma = 00:26 \)
  - Median = 00:14
  - Min = 00:00
  - Max = 01:29
  - \( n = 19 \)

- **W/T** (Wait Time) :
  - \( \mu = 00:01 \)
  - \( \sigma = 00:05 \)
  - Median = 00:00
  - Min = 00:00
  - Max = 00:23
  - \( n = 35 \)

- **P/T** = immed.

**Note**:
- **ARR** = Abdominal Reading Room
- **RIS** = Radiology Information System
- **CW** = CareWeb
- **L/T** = lead time
- **P/T** = process time
- **WT** = wait time
- \( \mu \) = mean
- \( \sigma \) = standard deviation
- \( n \) = count

**Abbreviations**:
- **ARR**
- **RIS**
- **CW**
- **ARR**
- **RIS**
- **CW**