Implementation of a Visual Scheduling and Booking System for a Shared Recipe Development Unit Using Lean Methodology

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Abstract *— This project focuses on improving the management of shared laboratory resources in Lab 1701 of a biopharmaceutical manufacturing site through the implementation of a visual scheduling and booking system. The objective was to increase visibility, reduce administrative burden, and improve coordination for the use of the Recipe Development Unit and sample management activities. Lean methodology was applied, including Voice of the Customer analysis and Value Stream Mapping, to evaluate the current state and design a future-state process supported by visual management and standardized work. A Smartsheet-based booking dashboard was developed and piloted with 40 laboratory users. Survey results demonstrated improved user satisfaction. Administrative processing time was reduced by approximately 60%. Statistical validation showed that, at a significance level of α = 0.05, the observed reduction was not significant due to limited sample size and high process variability, indicating the need for additional data collection to confirm long-term process improvement.*

Keywords *—Lean Manufacturing Methodology, Smartsheet, Value Stream Map, Voice of Customer.*

PROBLEM STATEMENT

In biopharmaceutical companies, it's crucial that management is aware of ongoing activities within the department, especially in regulated biopharmaceutical laboratories. Having real-time awareness of ongoing activities helps leadership anticipate conflicts, allocate resources properly, and ensure adherence to standard operating procedures.

Visualization tools such as Smartsheet and Power BI are often used by leadership to monitor key activities and maintain close oversight of operations within their department. These tools are widely used by the leadership at a biopharmaceutical company located in Juncos, Puerto Rico, especially in the Process Development Department.

For this project, we will focus on an opportunity identified in the current booking process to access and perform activities in Laboratory 1701 within this department.

Lab 1701 houses the Recipe Development Unit (RDU), an off-line equipment that supports recipe development, image collection, and process optimization. It's important to highlight that the RDU is a very expensive piece of equipment and requires specialized training to operate. A Human Machine Interface (HMI) is located right next to the machine, enabling operators to log in and ensuring that a record is kept of who is performing activities on the equipment.

The second activity performed in this laboratory is sample management. These activities take place in a designated section of the lab, equipped with specialized inspection booths with black-and-white backgrounds. These booths provide proper lighting to detect defects in syringes and vial samples and, importantly, facilitate the use of the correct inspection techniques. These activities, RDU utilization and sample management activities, can be performed simultaneously, providing flexibility but also creating a strong need for effective coordination.

Laboratory 1701 is owned by a Senior Manager who is fully accountable for all operations and activities within the facility. This creates a strong need for effective coordination with the laboratory owner, as well as clear visibility in scheduling equipment usage.

To perform an activity in Lab 1701, the operator must contact the Senior Manager to schedule an appointment, providing the intended date and time of use.

Scheduling information is recorded manually by the Senior Manager in her personal working calendar, making the process labor-intensive, highly dependent on individual availability, and susceptible to errors, omissions, and scheduling conflicts.

From the client's perspective, effective laboratory management requires a straightforward, visual, and reliable organizational tool. This tool should provide clear visibility regarding who is using the Resource Development Unit (RDU), their purpose for using it, and the timing of usage. It should also offer the same transparency for sample management activities. This visibility is crucial for supporting planning and prioritization, while also reducing administrative burdens and frequent interruptions.

Laboratory users, as secondary customers, need transparent and predictable access to shared equipment. This ensures they can avoid conflicts, delays, and uncertainty. From a Lean perspective, the current situation reflects several forms of waste. Waiting occurs when laboratory users face delays due to unclear equipment availability or prolonged approval processes for requests. Over-processing and excess motion are introduced through repeated communications and manual scheduling efforts.

Furthermore, the lack of standardized work and visual management limits process control and performance stability. By addressing the Voice of the Customer and creating a visualization tool, we can eliminate these non-value-added activities.

Research Description

This research examines the management of shared laboratory resources within Lab 1701 of a pharmaceutical manufacturing site in Juncos, Puerto Rico. The laboratory supports multiple parallel activities, including the use of a high-value Recipe Development Unit (RDU) and sample management activities, yet lacks a standardized and visual system or tool to monitor equipment usage and laboratory activities. Using Lean principles, this study analyzes the current-state process to identify wastes related to waiting, overprocessing, motion, and lack of visibility. The research proposes the design and implementation of a visual booking and activity tracking system to improve management visibility, support standardized work, and enhance coordination and decision-making within a regulated laboratory environment.

Research Objectives

The objective of this proposal is to design and implement a visual booking and tracking system using Smartsheet for RDU equipment usage and sample management activities that align with Lean principles by improving management visibility, establishing standardized work, reducing identified waste, and supporting proactive, data-driven decision-making. The proposed system will function as an organizational and management tool that enhances efficiency, accountability, and overall laboratory performance

Research Contributions

This project introduces a centralized booking page for leadership to replace the current manual, person-dependent scheduling process. By standardizing and visualizing appointment scheduling, the project reduces delays, errors, and reliance on a single individual. The solution eliminates repetitive back-and-forth communication between operators and leadership, significantly reducing waiting time to secure appointments. It improves transparency through a shared and efficient scheduling process while supporting Lean principles by reducing non-value-added activities such as waiting, motion, and overprocessing.

Research Background

The pharmaceutical industry serves a critical role in providing healthcare solutions, and it is continuously seeking innovative process improvements to enhance efficiency and reduce waste. Particularly in biopharmaceutical organizations, which often navigate complex regulatory environments, the Lean methodology has

emerged as a practical approach to streamline operations. Originally rooted in manufacturing principles, Lean has now been effectively adapted for use in administrative, laboratory, and support environments [1]. By integrating Lean principles, biopharmaceutical organizations can enhance coordination, visibility, and consistency—elements vital for optimizing shared laboratory spaces where multiple users rely on the same resources. Central to Lean methodology is the emphasis on making work visible and predictable through the implementation of standardized processes and visual management tools. These practices not only facilitate better planning but also contribute to reducing uncertainty and variability within operations. Visual management plays a pivotal role in Lean systems by allowing both users and managers to quickly assess the status of operations. For example, dashboards and visual calendars effectively translate operational data into accessible formats, which in turn support timely and informed decision-making. By consistently capturing and analyzing scheduling data, organizations can discern trends and uncover opportunities for continuous improvement, thereby embedding a culture of ongoing enhancement within their operations. The adoption of Lean methodology has expanded beyond traditional manufacturing environments and has been widely embraced across various sectors, including healthcare and service industries [2]. It serves as a methodical approach focused on improving efficiency while eliminating waste. Originating from the Toyota Production System, the core objective of Lean is to deliver maximum value to customers by removing non-value-added activities and establishing stable, predictable processes. Taiichi Ohno, the key figure behind the Toyota Production System, identified seven forms of waste that organizations must diligently address to optimize their workflows [3]:

1. Defects: Deviations from expected standards that can lead to rework and increased costs.
2. Overproduction: This occurs when organizations produce more items than necessary, resulting in excess inventory that does not align with customer needs.
3. Waiting: Time wasted when production is halted due to delays in previous steps of the process, preventing a smooth workflow.
4. Transportation: Moving materials or products unnecessarily adds no value; hence, minimizing transportation costs and efforts is crucial.
5. Motion: Any unnecessary movements made by individuals or machines can lead to inefficiencies; reducing these motions can streamline operations.
6. Inventory: Excess or unprocessed inventory represents a significant waste of resources that can be improved through effective inventory management practices.
7. Overprocessing: Performing unnecessary steps in processing materials or components that do not add value to the end product.

In highly regulated industries like biopharmaceutical manufacturing, applying Lean principles has become increasingly relevant for both production and administrative functions. A fundamental concept within Lean is standardized work, which establishes a consistent and repeatable method for performing tasks across various operational areas. Standardization serves to reduce variability, enhance product quality, and improve the identification of problems when they arise [4].

In laboratory environments, the absence of standardized scheduling and effective communication can lead to inefficiencies. Tools such as dashboards, visual calendars, and status boards empower managers to quickly assess capacity levels and implement corrective actions when necessary. By applying Lean principles to the management of shared resources, organizations can improve resource utilization, enhance collaboration among teams, and foster better communication channels.

A variety of Lean and Six Sigma tools can be used for almost anything and are not limited to manufacturing environments. Some Lean Manufacturing and Six Sigma tools are:

1. Voice of the Customer: This tool captures and clarifies customer needs and expectations [5].

2. Value Stream Mapping: A visual tool that maps the flow of information and materials, allowing organizations to identify areas for improvement and eliminate waste effectively [6].
3. Standardization: As a core pillar of Lean Six Sigma, standardization establishes consistent and repeatable work methods. This focus on reducing variation enhances quality control and drives sustainable process improvements, ranging from operational efficiency to increased customer satisfaction [4].

By incorporating these tools and principles, biopharmaceutical organizations can strengthen their competitive position and keep improving and excelling despite strict regulatory requirements and the demand for efficiency, ultimately reaching operational excellence. for this project, we will integrate these tools to develop a visual and booking system that allows upper management to monitor their activities within the department. Our focus will be on Lab 1701, which is located within the Process Development department.

METHODOLOGY

The methodology for this project follows a Lean improvement approach. At the time of this investigation, no formal booking, scheduling, or visual monitoring system existed for the use of the Recipe Development Unit (RDU) or sample management activities in Lab 1701. Recognizing the potential risks associated with increased laboratory utilization, such as scheduling conflicts, lack of visibility, inefficient coordination, and excessive reliance on manual communication, this project was initiated as a proactive effort to establish standardized work and visual management before the routine use of the laboratory expands. This project follows a structured nine-step methodological framework, which is outlined in detail in the sections below.

Problem Definition and Stakeholder Identification

The first step of the methodology process involves starting to define the problem in detail and identifying the key stakeholders involved in laboratory operations. The stakeholders include the Senior Manager as the laboratory owner and accountable party, and laboratory users who request access to the laboratory. The needs and clear expectations of the stakeholder are going to be obtained through the Voice of the Customer, also known as the VOC. The information obtained from the VOC will help us to understand the challenges related to visibility, scheduling clarity, and administrative burden. We can clearly define roles, responsibilities, and customer requirements and expectations to provide an effective and aligned solution.

Current State Process Analysis Using Value Stream Mapping

In order to understand the workflow and provide a clear understanding of the current state that serves as a baseline for a future state design, a Value Stream Map, also known as VSM, was performed (Figure 1). This VSM was developed to document the existing workflow for requesting approval and scheduling. This analysis enables the clear identification of non-value-added activities and sources of inefficiency.

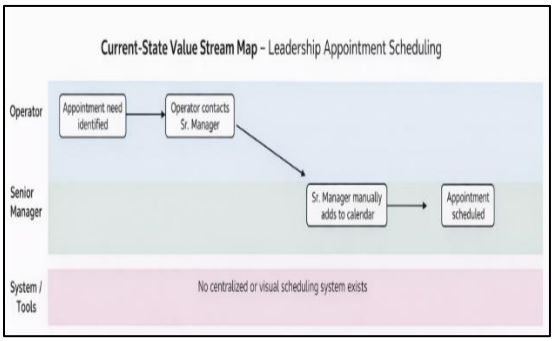

Figure 1
Current State Value Stream Map

Future-State Design Through Visual Management and Standardization

For this step, based on the VSM findings, a future state Value Stream Map process was designed to define an improved scheduling and coordination process (Figure 2). The future state VSM focused on eliminating identified waste by simplifying the request and approval flow, reducing manual

communication, and improving visibility of laboratory activities. This step defined the desired process behavior, information flow, and improved coordination prior to the development of the tools.

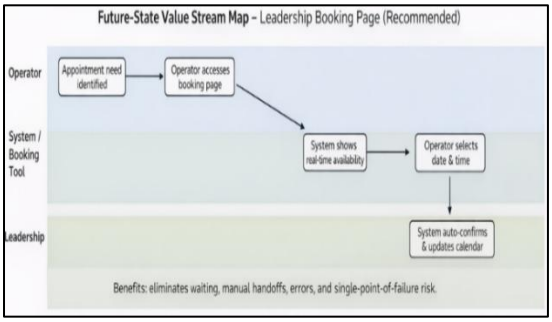

Figure 2

Future State Value Stream Map

Visual Management Solution Development

Following the definition of the future state process, a visual booking and scheduling dashboard was developed to support execution of the future state. The dashboard includes a clearly defined purpose, visibility of training requirements, a centralized calendar displaying availability, and direct links to supporting resources such as Standard Operating Procedures, training materials, and contact information. Due to company policy, the real dashboard cannot be shared as part of this Project; however, a mockup based on the original Smartsheet was created (Figure 3).

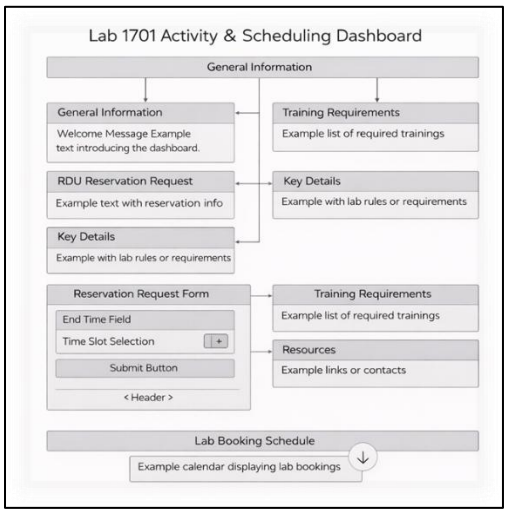

Figure 3

Visual Mockup Representing the Structure and Layout of the Original Smartsheet Dashboard

A key part of the Dashboard is the Reservation Request Form, which the operator must complete to submit a request through Smartsheet. The user is required to provide the following information: Requestor's name, Requestor's work email address, Type of Request, Start Time, End Time, and Time Slot Selection.

Leadership Review and Approval

The proposed solution was presented to the leadership for review and approval to ensure alignment with operational objectives. Leadership approval confirmed readiness for pilot implementation.

Pilot Implementation

A formal project kickoff was conducted to communicate the objectives, roles, and usage guidelines. A pilot implementation was executed with a total of 40 selected laboratory users for 14 days to validate the system functionality and usability. During this phase, users received training on submitting booking requests, interpreting calendar information, and following the general approval workflow.

Feedback Collection and Analysis

User feedback was gathered through structured surveys and informal observations during the pilot phase. The same survey was given before and after implementation to enable direct comparison of user perceptions regarding visibility, organization, planning ability, and delays. The survey results were analyzed to identify areas of improvement opportunities.

Table 1

Survey Statement and Response Scale for Feedback Collection (Before and After Implementation)

No.	Survey Statement	Response Scale
1	I clearly understand how to book a time slot to perform activities in the laboratory.	Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree
2	It is easy to know when the laboratory is available for different activities.	Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree
3	The process for booking time in the laboratory is well organized.	Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree
4	I can plan my laboratory activities effectively using the current scheduling process.	Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree
5	I experience delays or waiting time when trying to book a laboratory time slot.	Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree
6	I need to interrupt others to obtain scheduling or availability information.	Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree

Refinement and Full Deployment

Based on the findings from the pilot exercise, a minor change was made to the booking system. An issue with a Smartsheet formula was detected, addressed, and corrected. After thoroughly validating these corrections to ensure their effectiveness, we officially launched the booking system as a standardized tool for submitting laboratory 1701 requests.

Time Performance Before and After Booking System Implementation

A time-performance analysis was conducted to evaluate process efficiency. For this step, administrative processing times were measured using timestamp data from actual booking requests, both before and after the implementation of the booking tool (Table 2). For this analysis, processing time will be defined as the interval between receiving the initial request and receiving final approval. This analysis aims to assess the tool's effectiveness (Figure 4).

Table 2
Time Comparison: Pre- and Post-Tool Implementation

Before Implementation				
Request Initiation Date	Request Initiation Time	Request Completion Date	Request Completion Time	Processing Time (hrs.)
March 12,2025	09:14 am	March 12,2025	01:36am	4.37
March 17,2025	3:11pm	March 17,2025	4:48pm	1.61
April 3, 2025	1:54pm	April 4,2025	8:09am	18.25
June 26,2025	11:07am	June 28 2025	10:13am	47.11
July 10 ,2025	03:08 pm	July 11, 2025	05:34pm	26.43
After Implementation				
Request Initiation Date	Request Initiation Time	Request Completion Date	Request Completion Time	Processing Time (hrs.)
December15, 2025	2:45 pm	December15, 2025	04:13pm	1.47
December18, 2025	11:39am	December 18, 2025	03:26pm	3.78
January 03, 2026	08:54am	January 04, 2026	10:30am	25.60
January 8,2026	12:15pm	January 8, 2026,	03:44pm	3.48
January 20,2026	09:03am	January 20, 2026	01:24pm	4.35

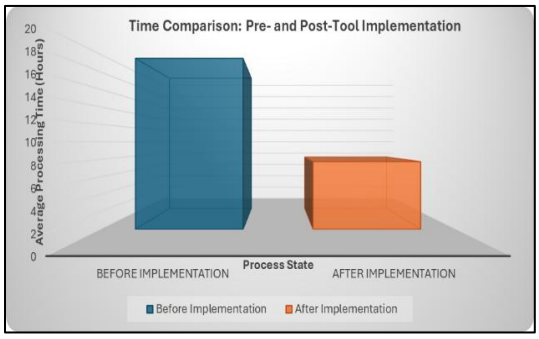

Figure 4
Time Comparison Analysis Pre and Post-Implementation

RESULTS AND DISCUSSION

The sample for this study includes 40 laboratory users who utilize the new scheduling platform to reserve time slots for performing laboratory activities in Lab 1701. These participants represent the primary users affected by the current scheduling process. The same group of participants were invited to complete the survey both before and after implementation to allow direct comparison of user perceptions, satisfaction, and scheduling experience. A sample size of 40 is appropriate for this project, as it reflects the available population of laboratory users and provides sufficient data to evaluate changes in the Voice of the Customer resulting from the Lean initiative.

Survey Results Interpretation

Prior to the implementation of the visual booking initiative, survey results revealed that 70% of participants were not completely satisfied with the existing laboratory scheduling process (Table 3).

Table 3
Survey Percentage Results Before and After Implementation

Survey Phase	Satisfaction Level	Percentage of Participants	Number of Participants
Before Implementation	Not completely satisfied	70%	28
Before Implementation	Generally satisfied	30%	12
After Implementation	Satisfied	85%	34
After Implementation	Neutral	15%	6

These users reported challenges related to limited visibility of laboratory availability, reliance on manual coordination, and delays caused by the approval process. The remaining 30% of participants indicated general satisfaction, primarily due to familiarity with informal scheduling practices rather than the effectiveness of the process itself.

After implementation, survey results showed a positive shift in user perception, with 85% of participants reporting satisfaction with the new scheduling system. Users indicated that the visual booking page improved clarity, reduced uncertainty, and enabled better planning of laboratory activities. Lastly 15% of the participants showed neutral overall satisfaction since they required time to adapt to this

new process. These results demonstrate a clear improvement in the Voice of the Customer and validate the effectiveness of the Lean-based solution.

Pilot Findings and System Modification

During the pilot implementation, time-slot conflicts were identified within the booking page. Further analysis revealed that these conflicts were caused by incorrect Smartsheet formulas used to calculate availability. The formulas were reviewed, corrected, and validated to ensure accurate time-slot allocation. Once corrected, no additional conflicts were observed. This finding highlights the importance of pilot testing and supports the Lean principle of identifying and addressing issues early before full-scale deployment.

Time Comparison: Pre and Post Implementation

A time analysis assessed changes in the administrative processing time for the Senior Manager reviewing and approving laboratory booking requests, comparing periods before and after the implementation of a standardized booking system.

Processing time was measured from receipt of the initial request to final approval, using actual request timestamps (Table 2). The results in Table 2 show variation in processing times. This is because not all requests arrive with the same information. Before the implementation, requests were received via email, and the Senior Manager often had to request clarification before being able to approve them, which made the process take longer. The "before" analysis corresponds to the process before using the tool, while the "after" analysis corresponds to the process after the tool was implemented. With the tool, the Senior Manager receives all the necessary information from the start, reducing the need for clarification and shortening the process time. The process is basically the same before and after.

Using the information obtained, a comparison of the average processing times was performed. Figure 4 shows a comparison of the average processing times: before implementation, 5 sample timestamps; after implementation, 5 sample timestamps. Requests took about 19.6 hours on average, whereas after, the time decreased to approximately 7.7 hours, an estimated 60% reduction.

This suggests a gain in administrative efficiency from the Senior Manager's perspective. The standardized request process reduced the need for follow-up, clarification, and multi-channel coordination, enabling faster decision-making with fewer disruptions. Importantly, this improvement did not eliminate approval waiting times or managerial decision-making but removed non-value-added delays and enhanced workflow consistency.

Process Change Statistical Validation

The statistical analysis comparing process performance before and after the improvement shows no sufficient evidence to confirm that the reduction in processing time is statistically significant at a 95% confidence level. Although the average processing time is lower after the change, the mean hypothesis test's p-value of 0.1275 exceeds 0.05, indicating no significant difference. Similarly, the variance test's p-value of 0.133 suggests variability remains statistically unchanged (Figure 5).

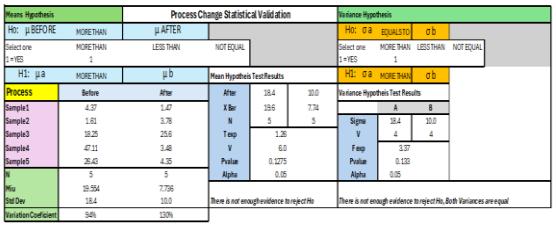

Figure 5
Process Change Statistical Validation

A key factor influencing these results is the small sample size (n = 5 for each condition), coupled with high process variability, as shown by the large standard deviations and variation coefficients in both datasets.

Therefore, it is highly advisable to increase the sample size in future data collection efforts. Doing so will allow for a more accurate representation of the process behavior and will significantly enhance the reliability of statistical validation, leading to more robust and trustworthy results.

CONCLUSION

This project demonstrated that challenges related to scheduling, coordination, and visibility in shared laboratory environments are primarily organizational in nature and can be effectively addressed through Lean principles. In Lab 1701, the absence of a standardized and visual scheduling process resulted in inefficiencies such as waiting, excessive communication, motion, and scheduling conflicts, all of which negatively affected both laboratory users and management.

By applying Lean Methodology, including Voice of the Customer analysis and Value Stream Mapping, a future-state solution was designed and implemented in the form of a visual scheduling and booking system. The system introduced standardized work and visual management, enabling clearer visibility of laboratory availability, improved coordination, and more proactive decision-making by laboratory leadership. The use of Smartsheet as a visual management tool supported real-time access to scheduling information while maintaining flexibility within a regulated environment.

Although the hypothesis test results indicated there was insufficient statistical evidence to confirm a significant change, I have learned that in a biopharmaceutical company, even the smallest improvements can make a difference. Every process and system, no matter how well it functions, can always be refined. Over time, I've seen firsthand how small changes, whether in workflow, communication, or laboratory procedures, can add up to create significant progress.

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