Improvement of Receiving and Handoff Service Times at a Car Dealership

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Abstract

The focus of this work is the problem-solving procedure by a team of engineering students in their Design Project course to achieve reductions in the waiting time of a car dealership service area. The objectives were, (1) reduce by 20% the receiving process time and (2) reduce by 30% of the handoff process time. A Waste walk found wastes in motion, waiting, overproduction, over-processing, defects, and skills that represented a 13.34% loss in process time. Four main areas of opportunity identified are:

- The waiting time of clients per inspection is different between associates.
- Wastes of motion and waiting.
- The difficulty of finding the car keys.
- Reparation Orders do not have a prioritization system.

Design alternatives were considered for these areas of opportunity, which resulted in a time reduction of 5 minutes in the receiving process and 4.16 minutes in the handoff, achieving a 20% reduction in the receiving process and 33% on the handoff process times. The recommendations can be completed in 12 weeks and result in an average Return of Investment of 861%.

Keywords
Engineering Education, Capstone Project, Service Industry, Process Improvement

1. Introduction

With more than thirty years of experience in the automotive industry, a dealership is committed to offering customers quality services and a unique experience during the purchase and servicing of their car. The problem statement is that service times in the dealership takes more than expected and processes are not standardized. The process includes several manual stages such as the registration documentation and physical handoff of a car key. Operations impacted by this project are Receiving, which registers customers and routes them in the dealer, and Handoff, the return of the car to the customer once the vehicle is serviced. Reducing process times is necessary to achieve proposed objectives and increase customer satisfaction. The research question supports our claim that improvements to the receiving and handoff activities reduces the mean process times.

Receiving:

- Ho: mean process time for Receiving is equal before and after improvement: $\mu_{Rinitial}=\mu_{Rfinal}$
- H1: mean process time for Receiving is not equal before and after improvement: $\mu_{Rinitial}\neq\mu_{Rfinal}$

Handoff:

- Ho: mean process time for Handoff is equal before and after improvement: $\mu_{Hinitial}=\mu_{Hfinal}$
- H1: mean process time for Handoff is not equal before and after improvement: $\mu_{Hinitial}\neq\mu_{Hfinal}$

1.1 Objectives

The team, along with stakeholders proposed two business objectives: reduce receiving service time by at least 20% and handoff service time by at least 30%. An additional objective is producing statistically significant changes of the average process times for Receiving, and Handoff.

2. Literature Review

The literature review will focus on defining DMAIC and its proven results in service industries. Another section references of the process improvement tool used through this paper. These tried-and-true techniques are widely supported by practitioners and academics as seen in the literature. A comprehensive process improvement structure is effective in any productive industry. The last section shows that academia is currently using problem solving tools both for continuous improvement and in collaborative efforts with industry. Collaborative projects, such as Capstone Design experiences, mutually benefit industries, with positive impacts to their bottom lines, and students, that gain lifelong proficiencies in technical and soft skills.

2.1 Service industries and the need for process improvement

Service industries have seen a significant growth in the last two decades. Musharavati (2013) defines two types of services: service operations and service systems. For this paper, we focused on service systems, as the car dealership is part of organization designed to deliver services. Customer satisfaction is an important variable in service industries, and low indexes require improvements to retain and attract additional services. Li et al. (2017) shows an application at Purdue university and how their focus was on the customer. Their specific methodology, similarly, to this project, wants to ensure customer satisfaction indexes are sustained and increased.

Using a problem-solving structure with several tools to improve operations, has been proven to have a significant impact. George (2005) states that DMAIC is an organized methodology for problem solving and serves practitioners as a roadmap for process improvement. If a project is logically analyzed from problem definition to end, we should expect the largest impact. Ali et al. (2019) shares the results of a successful application of DMAIC in a service industry in Libya, including several tools also used in this paper. Even with a large variation in service types, these process improvement tools are applicable in diverse service industries. For the automotive industry, Cunha and Dominguez (2015) present a case study for the warranty billings operations, where improving the process resulted in changing the process metrics, redefining the way the process was measured. This resulted in not just seeing the impact on the bottom line, but how the metrics affect specific aspects of the operation.

2.2 Historical data analysis, root cause and analysis and improvement tools

An improvement project in a service industry will usually require practitioners to determine the duration of one or more activities and the calculation of standard time. Two methods for time studies are the stopwatch method and work sampling, Niebel and Freivalds (2014). Another deliverable in the evaluation of the standard times is the direct observation of labor and identification of non-value-added activities. In service industries, customers usually must wait in line and go to a queue. Equations from queuing theory, discussed on Hillier and Lieberman (2004) model the service system and numerically determine the optimal headcount and queue parameters for the operation. Once the process baseline is determined; the next step is finding the relationship between the key process variables (X) and the response variables (Y). In this development, the response variables are service times. The relationships and causality can be recognized using root cause analysis tools such as fishbone diagram and 5 Whys', part of the seven quality tools discussed by Montgomery (2008). The goal in every improvement project is validating the results, requiring the research question is successfully answered. This is proved applying statistical inferences tests, such as Analysis of Variance (ANOVA) and non-parametric statistics, reviewed in Montgomery and Runger (2010) and Minitab (2019). The validation of results indicates a solution was found, and the economic impact of the alternatives can be computed using models presented by Blank and Tarquin (2012).

2.3 Teaching problem solving in academia

Johnson (2017) asserts that capstone projects increase confidence, self-reliance as well as professional lifelong skills in students. These proficiencies facilitate the entrance of students to the engineering field after graduation. The capstone experience at Northeastern University as detailed by Jaeger-Helton et al. (2019) challenges students with open ended projects and limited information. Under these constraints, students must develop skills in time management and problem-solving criteria, while setting a problem-solving mindset useful in their career activities after graduation. Our current project approach to analyzing and improving process times in a car dealership is aligned with the four main core pedagogical strategies described by Martinez-Leon (2018): "flipped classroom, guided student project interventions, project mentoring and constructive feedback". These principles are represented in our Senior Design Project where students have the role of consultants while, faculty and company leaders act as subject matter experts by providing necessary mentoring and constructive feedback. In our course, guided interventions were performed during the weekly class, as progress was tracked, while students also benefiting from benchmarking with other project teams.

Service industries can benefit from the use of DMAIC, and can expect, when using the methodology correctly, a significant impact in their operations. Similarly, there is a variety of lean six sigma tools at the practitioner's disposal. When using those included in the DMAIC methodology, the process of data collection, root cause analysis, proposal of alternatives and validation of results is straightforward. These lessons can be applied at any level of professional expertise, including during the performance of a capstone project.

3. Methods

The methods used include tools for historical data analysis such as stopwatch and work sampling studies to determine the current standard times while identifying non-value-added activities. A process capability sixpack analysis was performed to compute the baseline process variation and centralization. Queueing theory analysis was performed to compute queuing metrics while evaluating different headcount scenarios. Tools such as fishbone and 5 whys were completed to find the root causes to the problems identified. The root cause analysis facilitates the suggestion of alternatives to eliminate problem causes. Once alternatives are proposed, a decision matrix with a scale from 0 to 100 facilitated selecting the best alternatives. To check if objectives are met, the baseline and proposed results were compared using inferential analyses such as ANOVA and non-parametric tests. The economic impact was measured using the return of investment (ROI). Lastly, a Gantt Chart was used to show the duration of the proposed processes and its reduction in process time.

4. Data Collection

For the historical data analysis, a work sampling study considering 144 samples for the receiving process and 369 samples for the handoff process was performed. The current standard time for the receiving process is 25.1 minutes and for the handoff process 6.24 minutes. In parallel to the work sampling, a Waste Walk to identify non-value-added activities was also performed, with results shown in Table 1.

Table 1: Summary of Waste Walk (TIM WOODS) Observations

Waste	Observed example
Motion	Form distributed between greeter to advisor, technician and returns to an advisor
Waiting	Clients wait while information is confirmed by the advisor when the greeter already confirmed this information at the entrance.
	The advisor does not find the vehicle's keys.
Overproduction	The technician performs inspection and diagnostic of the unit and suggests possible opportunities causing changes in the already created invoice
Over Processing	Validate client's information 3 times
Defects	The system has defects in portraying appointments in the calendar
Skills	The advisor needs to perform greeter plus advisor activities

Observations estimating headcount showed that with only one available advisor the service times increase significantly. Furthermore, when one greeter and two advisors are available, which is the desired scenario, service time decreased. Some opportunities identified are:

- Differences in time to perform operations from personnel in a similar role.
- Headcount requirements / capacity analysis not optimized.
- Several non-value-added activities.

5. Results and Discussion

The purpose of this section is understanding the current state of the system and how the process variables (X) affect the service times (Y). As part of the root cause analysis, we can model the relationships between Y and process X's. To understand the process issues, these analyses were performed:

1. Service times total and per operator
2. Analysis of queues: L and Lq, W, Wq, duration and headcount system and in queue, respectively.
3. 5S Audit

4. Capacity and utilization analysis

After the root cause analysis is completed, various alternatives are proposed and evaluated using decision analysis. The development of these alternatives for the Receiving area is shown in detail in the next sections as well as the results from some deliverables. The section closes with the validation of the results, answering the research question with the application of statical inference methods as seen in Montgomery and Runger (2010.

5.1 Numerical Results

A process capability sixpack, as seen in Figure 1, was completed, showing samples are out of the control limits in the "Moving Range Chart", showing an Out-of-Control process with assignable causes. The process capability has high variability, and the mean is not centralized. Since index es <1.33, and Cpk ≠ Cp, the process is not centralized.

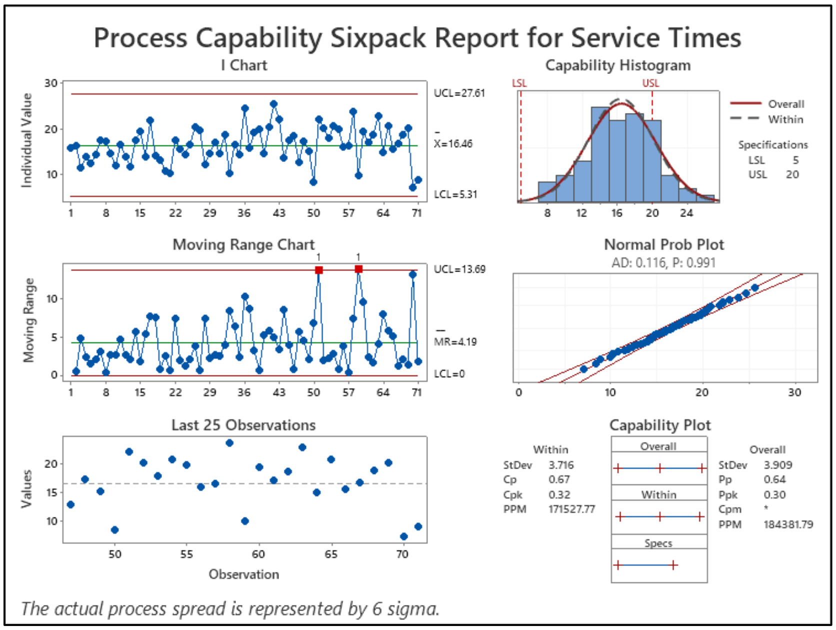


Figure 1. Process Capability Analysis for service times

A statistical test was performed to compare the inspection times performed by different operators. The hypothesis formulated is:

- Ho: mean inspection time equal for all operators: $\mu_{i}=\mu_{j}=\mu_{k}$
- H1: mean inspection time is different for at least one operator: $\mu_{i}\neq\mu_{k}$

As seen in Figure 2, the difference in letters in the Tukey pairwise test, shows a statistically significant difference in these times. One potential reason for these differences is a lack of standardization in the task.

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Who performs Inspection?	N	Mean	Grouping	
2	34	268.71	A	
3	11	178.7		B
1	37	160.08		B

Figure 2. Comparisons of inspections time (receiving)

A queueing analysis considering one and two servers for the receiving process, with the configuration's M/M/1 and M/M/2 as presented by Hillier and Lieberman (2004) is shown in Table 2 and repeated for the handoff process in Table 3. For receiving the M/M/1 best reduces queues and for the handoff M/M/2 would work the best by reducing queues.

Table 2. Receiving queuing analysis, initial and proposed.

Stage	System	L	Lq	W	Wq
Initial	M/M/1	10.59	1.59	3.53	0.53
	M/M/2	12.38	0.13	3.54	0.04
Proposed	M/M/1	8.3	1.01	3.07	0.37
	M/M/2	9.05	0.05	3.02	0.02

Table 3. Handoff queuing analysis, initial and proposed.

Stage	System	L	Lq	W	Wq
Initial	M/M/1	21.82	5.82	5.45	1.45
	M/M/2	16.29	0.29	4.07	0.07
Proposed	M/M/1	15.39	3.14	4.40	0.09
	M/M/2	12.38	0.13	3.54	0.04

5.2 Graphical Results

A root cause analysis was performed to locate the underlying issues in each of the four problems identified.
The two most significant problems for the receiving process are:

- Problem 1 (see Figure 3): Waiting time of clients during the inspection task is different between associates.
  - Root cause: no standardization and no checklist or procedure in place.
- Problem 2 (see Figure 4): Waste of motion of the service evaluation form between technicians and advisors.
  - Root cause: no direct channel of communication between technicians and advisors.

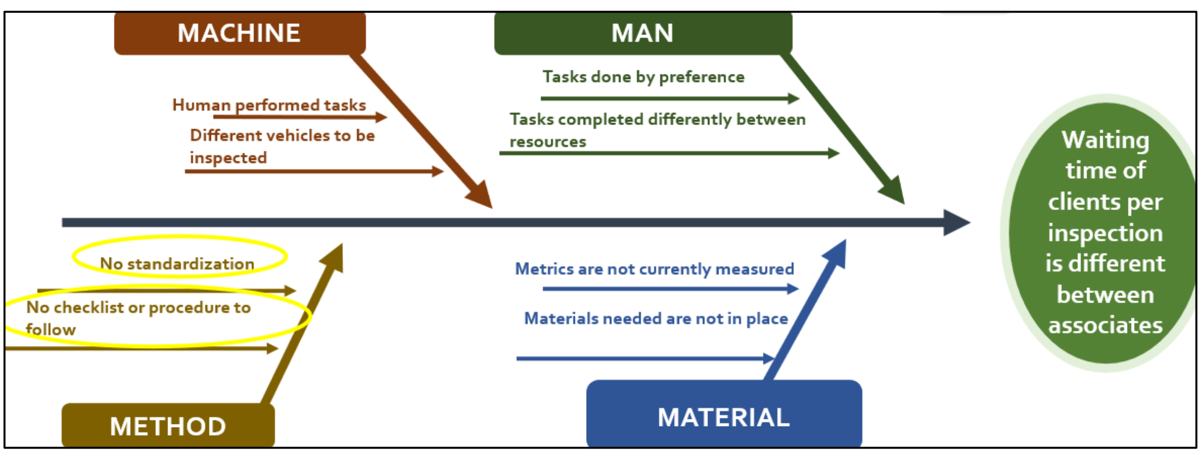


Figure 3. Cause and effect receiving problem #1 (Different waiting time per associates)

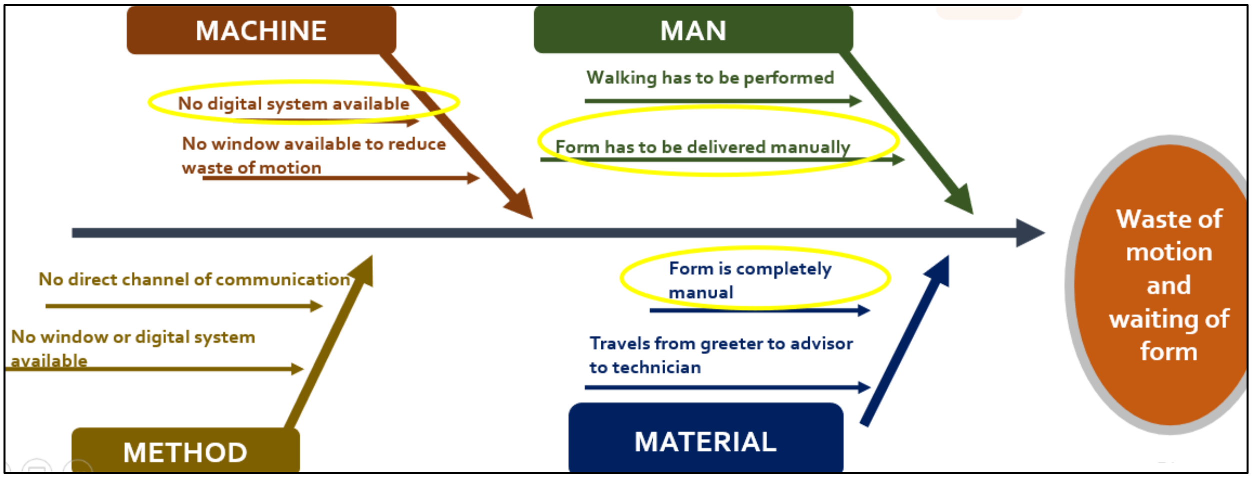


Figure 4. Cause and effect receiving problem #2 (Waste of motion)

The root cause analysis was also performed for the handoff process, where the two most significant problems are:

- Problem 3: finding vehicle keys is difficult
  - Root cause: no lean tool has not been established to place keys in an orderly way and the keys are placed in one place without organization,
- Problem 4: Orders, (RO) waiting at the desk not being prioritized
  - Root cause: RO's are all mixed in one pile, and they are placed without prioritization.

At least three alternatives were proposed for each of these problems. These are discussed later in the paper.

5.3 Proposed Improvements

The proposed alternatives resolve these four problems are revealed in Table 4 and Table 5. These evaluate operation and financial information, such as payback period and return of investment (ROI) and support the decision analysis.

Table 4. Receiving Problem 1: Waiting time of clients per inspection is different between associates.

Receiving Problem 1: Waiting time of clients per inspection is different between associates							
Short Name	Alternative	Implementation Time	Advantages	Disadvantages	% Objective Improvement	Payback Period	Return of Investment
A1	Create Standard Operating Procedure	2 weeks	Standardized procedure	Implementation could be challenging	40%	3.16 months	1223%
A2	Standard Operating Procedure + Checklist	1 month	Quick implementation of visual aid	Place for checklist not available	70%	3.69 months	1033%
A3	Train personnel	3 weeks	Personnel may perform tasks the same way	Does not ensure task standardization	16%	11.73 months	691%
A4	All the above	2 months	Implement all alternatives	Several tasks to be completed	86%	16.56 months	1532%

Table 5. Receiving Problem 2: Motion of form between advisor and technicians.

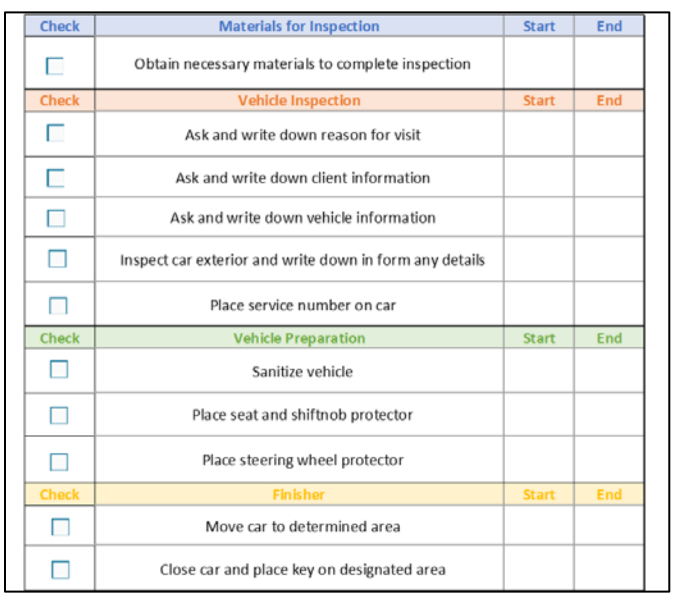
Receiving Problem 2: Motion of form between advisor and technicians							
Short Name	Alternative	Implementation Time	Advantages	Disadvantages	% Objective Improvement	Payback Period	Return of Investment
A1	Intercom	5.5 months	No PC / software required	Lack of privacy	26%	9.61 months	335%
A2	Glass Door	3 months	Motion is reduced	Advisor needs to approach window. Motion still exists.	20%	8.46 months	394%
A3	Tablet	1 month	No waste of motion	Process will be 100% digital.	40%	4.07 months	928%

The alternatives selected using the decision analysis for the receiving and handoff problems are summarized in table 6, including the return of investment (ROI) and payback period. All alternatives have quite large ROI, due to extremely low investments in alternatives, only spending on minor purchases, in-house labor costs and no construction activities.

Table 6. Selected alternatives for each of the main problems

Area	Problem	Alternative selected	**Payback Period**	**Return of Investment**
Receiving	1	All (A1 thru A4)	17 months (max)	621% (min)
Receiving	2	A3	4.07 months	928%
Handoff	1	A1 (Cabinet Safe)	0.34 months	512%
Handoff	2	A1 (5S implementation)	0.51 months	877%

Examples of project deliverables, including an inspection task checklist in Figure 5, facilitate standardization and use visual aids, and a training matrix in Figure 6 to track the training and skill development of employees.



Check	Materials for Inspection	Start	End
☐	Obtain necessary materials to complete inspection		
Check	Vehicle Inspection	Start	End
☐	Ask and write down reason for visit		
☐	Ask and write down client information		
☐	Ask and write down vehicle information		
☐	Inspect car exterior and write down in form any details		
☐	Place service number on car		
Check	Vehicle Preparation	Start	End
☐	Sanitize vehicle		
☐	Place seat and shiftnob protector		
☐	Place steering wheel protector		
Check	Finisher	Start	End
☐	Move car to determined area		
☐	Close car and place key on designated area		

Figure 5: Checklist draft for the Inspection task

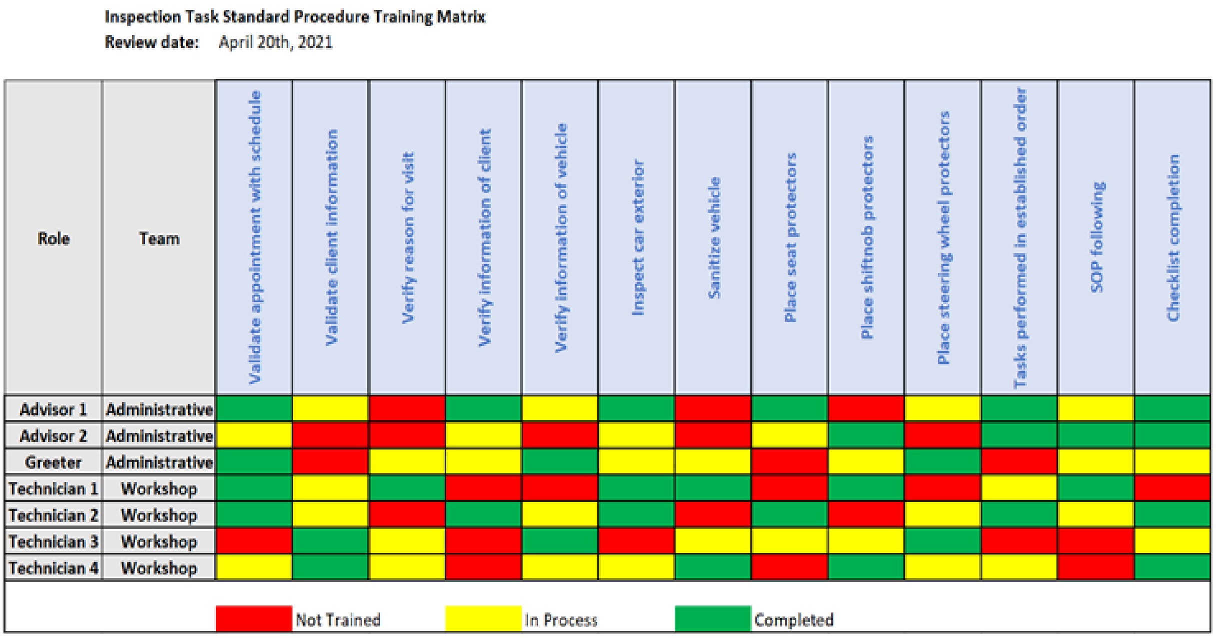


Figure 6: Training Matrix

5.4 Validation

The baseline standard time for the receiving process is 25 minutes, the Gantt chart in Figure 7 shows a reduction to 20 minutes if all alternatives are implemented. With a 5-minute reduction, objective of this project to reduce 20% of the receiving process is achieved.

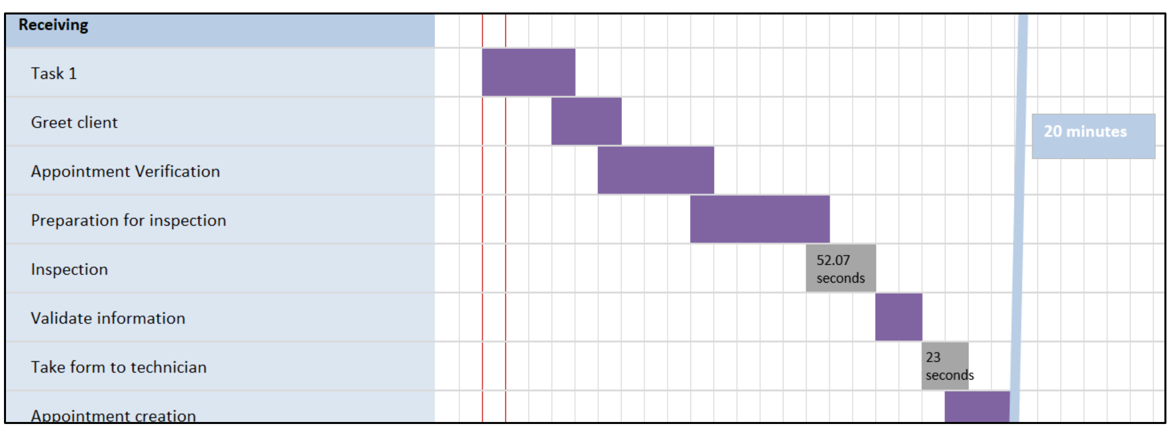


Figure 7: Proposed Gantt Chart for Receiving Process

Similarly, the baseline standard time of the handoff process is 6.28 minutes, when reduced to 4.16 minutes as seen in Figure 8 the standard time of the receiving process can be reduced by 33%, achieving the initial objective.

Figure 8: Proposed Gantt Chart for Handoff Process

A research question for the mean process time of receiving and one for the mean process time at handoff was established in the Introduction. A statistical inference analysis, for non-normally distribute variables, using the Mann Whitney non-parametrical test was performed. The results for the receiving process show the P-value, seen in Figure 9, is less than the 0.05 significance level (α), therefore we reject the null hypothesis and conclude that there is a significant difference between the data median times. For the handoff process, the P-value is less than α, which in this case we can conclude that there is a significant difference between the median by rejecting the null hypothesis. With these results, we can conclude the central tendency variable is different after implementation. By inspecting the values, a significant numerical difference is observed.

Receiving

Method

η_1: median of Current Process Time R
η_2: median of Proposed Process Time R
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
Current Process Time R	55	33
Proposed Process Time R	55	18

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
15	(13, 17)	95.01%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	4530.00	0.000
Adjusted for ties	4530.00	0.000

Handoff

Method

η_1: median of Current Process Time H
η_2: median of Proposed Process Time H
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
Current Process Time H	55	14
Proposed Process Time H	55	4

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
10	(9, 11)	95.01%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	4380.50	0.000
Adjusted for ties	4380.50	0.000

Figure 9. Statistical test to show differences in receiving and handoff time after project completion.

In both cases, the alternate hypothesis, H1 was proven, showing process time for both operations indeed changed. The conclusions for the tests, reflecting the non-parametric test used are:

- H1: median process time for Receiving is not equal before and after improvement:

- H1: median process time for Handoff is not equal before and after improvement:

6. Conclusion

This paper presents the successful completion of a capstone project, which using problem solving tools, reduced service times at a car dealership. The objectives of reducing process time for the Receiving and Handoff operations were met, with results summarized in Table 7. At this moment, some of the recommendations are in process of completion and should be ready by the end of 2021. The success of this project lies in the ability of management to sustain changes over time.

Table 7. Summary of project achievements

Problem	Baseline (minutes)	Improved(minutes)	Objective	Achieved
Receiving	25	20	20%	20%
Handoff	6.18	4.16	30%	33%

Additional opportunities for improvement were identified during the study such as development and calendarization workforce tasks development of virtual systems, and 5S implementation to organize the work area and the process of attending clients. These are all discussed in table 8.

Table 8: Summary of additional problems identified.

Opportunities Identified	Possible Solutions
Flow impacted when the employee is on vacation	Calendarize vacation in outlook to align everyone on vacations' period
Appointments not completely online	Implement 100% online appointments plus, allow appointments to be made via social media
5S – Waiting area not identified and clients get lost	Use visual controls to better communicate advisors and clients.
5S – Materials are not in place for inspection	Perform and implement 5S Methodology in inspection workstation
Ensure walk-ins can have realistic expectations of service time	Evaluate with queuing theory and capacity how many additional clients can be attended

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Biographies

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