Redesigning Front-End Retail Checkout

NCSU ISE Senior Design Spring 2018: Toshiba

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Executive Summary

Shopping for groceries and toiletries can often be a frustrating and time consuming process, and as a result, retailers are constantly trying to improve their stores to satisfy their customers. This frequently ties back to companies like Toshiba Commerce, the sponsor for this project, who manufactures and sells checkout equipment to retailers.

The primary goal of this project is to improve customer experience of shoppers and loss prevention methods, with a focus on club stores like BJ's and CostCo. Through Voice of Customer surveys and provided/collected data, the primary needs were identified. The project will improve customer experience, reallocate labor, increase customer throughput and improve loss prevention methods to create a solution that Toshiba can present to their retail customers. Main objectives include making the checkout process at club stores faster, easier and more relevant, to develop a more efficient system.

The solution consists of two phases. Phase I, the short term solution, matches shopper basket size distributions to the checkout machine ideal to handle that basket size. The optimal number of each machine that handles each basket size arrival rate determined a layout with three times as many Self Checkout (SCO) machines as Traditional Lanes, divided into two SCO and one Traditional Pod. The addition of entrance and exit gates, along with camera and monitor systems, address loss prevention risks due to the increased number of Self Checkout machines. Additionally, reallocated employees in the checkout area better assist shoppers during Self Checkout and with the checkout process in general, directing shoppers to the ideal machine for their basket size. A new role also exists to monitor exit gates at Self Checkout pods, where most theft occurs.

Phase II, the long term solution with more technological advancements, focuses on reducing theft, time to scan items and the number of employee interventions. Three technologies were recommended to Toshiba for future partnerships to address these needs and keep up with current retail market trends.

While the focus of Phase I and II is club stores, the solution also adapts to other retail stores, like grocery stores and Walmart. These adaptations include minor changes to the analyses that determines the number of machines, additions to the machines, and layout.

At the conclusion of this project, Toshiba received an improved layout, operating procedure, and simulation for the Phase I solution, which will be used to sell the solution to their customers. For Phase II, Toshiba received a technology matrix of the team's research on potential partnerships to pursue.

The team's solution not only assists Toshiba Commerce with modernizing the checkout process, but also improves the overall experience for shoppers and employees while saving club stores time and money in the long run.

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1. Overview

Purpose

The purpose of this project is to redo the front-end retail checkout process to keep up with technology and process improvements that are changing the customer experience. The goal is to accommodate to customer demographics according to their individual needs and behaviors through the group's alignment with the target market.

Problem Definition

The problem with the retail checkout process from the customer's perspective is that the whole experience is time consuming. Shoppers prefer not waiting in lines or waiting on employees to assist them. These problems attribute to the overall negative connotation attached to shopping in a brick-and-mortar retail store, and retailers want to change this perception, while reducing the occurrence of theft, particularly with Self Checkout systems.

Toshiba provided numerical data such as transaction times, tender times, checkout system used, and other various factors. Analysis of various trends on the current state of the club checkout system over a specific period of time provides a better understanding of the differences between Traditional Checkout Lanes and Self Checkout, i.e. the total time taken and their utilization.

Collected in-store data gives a benchmark for queue times/number in queue, lane management, staffing, and auditing procedures. The Voice of the Customer further defines where the users see inefficiencies in the system, which is wasted time for both shoppers and employees.

Scope

The scope of the project involves the proposal of a redesign of the retail checkout process, specifically focusing on club membership stores. Included in the scope of the project are:

1. Working within reasonable technology currently available or next generation technology.
2. Focusing on customer demographics and behaviors of the current club store markets and economies.
3. Adapting to or redesigning the layout of current club store checkout lines.

Data is split between data provided by Toshiba, collected by group members while visiting checkout sites, and through Voice of Customer (VOC) exercises with store shoppers and employees. Areas, such as retail consulting and pricing, are out of the scope of this project.

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Objectives and Success Criteria

A main focus of this project is to improve customer experience through a frictionless shopping experience. Members desire a faster, easier and more relevant shopping trip to lessen the burden of purchasing groceries in-store. Creating a more relevant shopping trip is done through improving customer experience in ways such as "knowing" your membership shoppers and treating them accordingly, or offering checkout methods to fit each demographic.

Another objective of retail stores is allocating labor efficiently to optimize customer experience. Thus, employees will be reassigned positions towards assisting shoppers only when needed and increasing targeted interaction based on need to ensure the best experience for the customer.

Improving loss prevention methods is another large focus of this project. Theft within retail is an ever-present issue that requires high priority when redesigning checkout systems. Toshiba specifically wants to eliminate the employee-driven audit step in the current club-membership store checkout process, so the redesigned checkout area uses alternate loss prevention methods to accommodate for the eliminated auditor position.
A successful front-end checkout solution combines the best mix of checkout technology and allocates employees to improve the efficiency and economy of current checkout technologies while incorporating loss prevention methods outside of those currently in place. Furthermore, it provides Toshiba with options for competing in future retail checkout markets, by catering their technology and business partnerships towards the recommended checkout solutions. *Figure 1.1* depicts a detailed breakdown of the objectives and how they align with the success criteria.

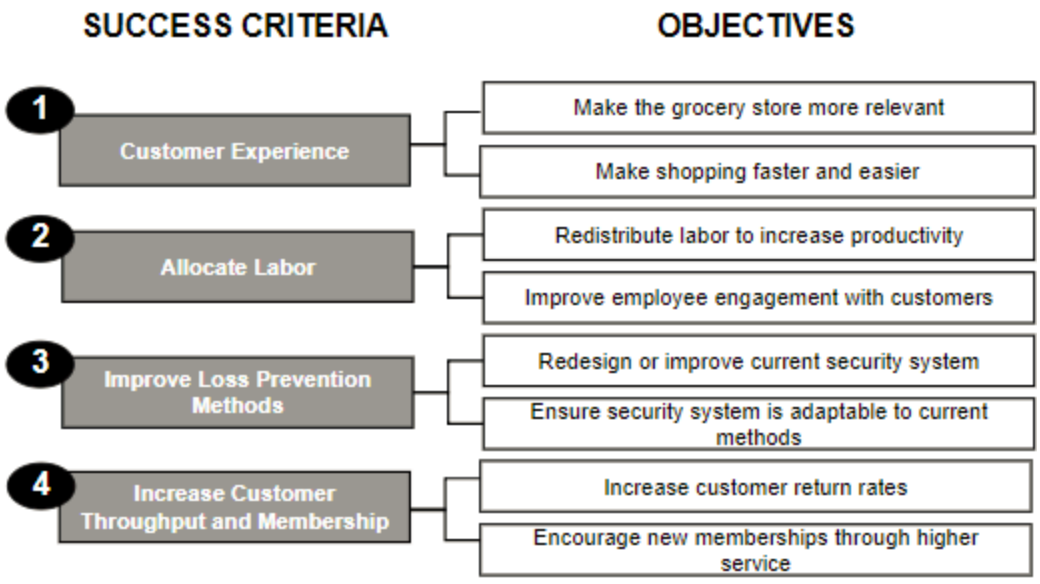

Figure 1.1: Project objectives

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Alignment with Business Needs

There are two business sectors addressed by the project: club stores utilizing the checkout process and Toshiba Commerce Solutions, who manufactures equipment and designs solutions for checkout processes. The business needs of retail stores pertain to managing costs and margins, reducing losses from theft, improving customer experience to drive larger baskets and increase membership, and planning for the future to anticipate consumer expectation and protect investment. While profit from the sale of checkout equipment is a benefit, Toshiba's main focus is customer buy-in. They seek proof of concept to serve as a selling point to retailers in discussions about meeting the needs of shoppers.The needs of all sectors are considered in the final solution.

Stakeholder Analysis

As mentioned above, both Toshiba Commerce and club stores are major stakeholders in the team's solution. Toshiba, as the project sponsor, has significant influence and their goals are of utmost importance. Toshiba seeks buy-in from club stores, as they want to sell not only checkout equipment but an improved checkout process. While the goals of club stores are important as well, communication with stores was outside the scope of the project. Additionally, both shopping customer and employee satisfactions are goals of Toshiba and club stores, so these opinions were significant in the development of a solution. *Figure 1.2* depicts an overview of the stakeholder analysis.

Figure 1.2: Stakeholder analysis

Project Deliverables

As the team's given and collected data is for a club membership store (such as BJ's, Costco, Sam's Club...etc), the final deliverables for Toshiba cater towards a club membership store. The Phase I solution, one that could be implemented within a 6-month time frame, consists of a final Phase I Value Stream Map (VSM), improved layout, Phase I operating procedure to manage lanes and designate staffing, and a Phase I simulation (via SIMIO) along with results to visualize

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the new process and obtain statistics to measure improvement. Ideas for the Phase II solution, an "out of the box" dream solution with a 2 to 3 year implementation schedule, is in the form of a comprehensive Phase II matrix of various existing and potential technologies and/or solutions that further improve specific characteristics of the Phase I model. The deliverables for Phase I and II prioritize on improving customer experience, designing loss prevention methods, and redistributing labor. The faster, low-theft club checkout process will attract more shoppers, thus increasing overall purchasing throughput in the long run.

Toshiba will utilize the four components of the Phase I solution in persuading their retail customers to modernize their checkout system to meet the demands of shoppers. The data collected through the Voice of Customer will serve as a selling point to retail stores, proving to Toshiba's clients that change is necessary to keep up with the growing market. Specifically, the final VSM details which parts of the checkout process show an improvement from the past, to help differentiate the two models. The new layout dictates where each current or new machine/technology would be located to promote an organized, more efficient checkout process. The operating procedure describes the overall store functionality and allocates the appropriate number of employees to each part of the checkout area, according to time and day, aligning staffing and the management of each checkout lane.

The Phase II solution, in the form of a matrix, highlights the most promising technologies and solutions to integrate into Phase I within the next 2 to 3 years. Toshiba plans to utilize the matrix of the team's research and recommendation as a tool to develop partnerships with companies that best meet the needs of their retail customers.

2. Project Roadmap

Our Approach

Our approach to tackling the presented problem develops a strong understanding of what consumers desire in comparison to what employees and the store itself can accommodate; it is outlined by following actions:

1. Processing and interpreting transaction data and identifying areas of inefficiency such as time wasted or lack of system availability.
2. Determining improvement priorities based on those contributing to the most time and cost savings.
3. Obtaining feedback from shoppers and employees through surveys and interviews to determine their concerns and suggestions. This information, alongside the results of the data given, guides which areas require improvements.
4. Performing research on current and next generation technologies, then analyzing and comparing the results of the various methods, implementations, and pilot tests.
5. Designing an optimal system that incorporates new technologies to improve customer experience and quicken the checkout process, while preventing loss to the retailer.

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This approach utilizes the data provided by Toshiba to visually and numerically see customer shopping trends, quantity of purchases and other areas of interest. Combining these trends with the Voice of Customer results reinforces or discovers areas that require improvement. Research on checkout technology/solutions is done simultaneously to give our group an idea of what is currently available or what could be available in the future, while providing the pros and cons of each solution. The final design combines the best mix of technologies an efficient system to meet set objectives.

Project Timeline

To create hard deadlines and an overview of the schedule of this project, a general timeline was created. This timeline in *Figure 2.1* organizes the milestones of the project, while the Gantt chart shown in *Figure A.2.1* in the Appendix shows a more comprehensive overview of the schedule.

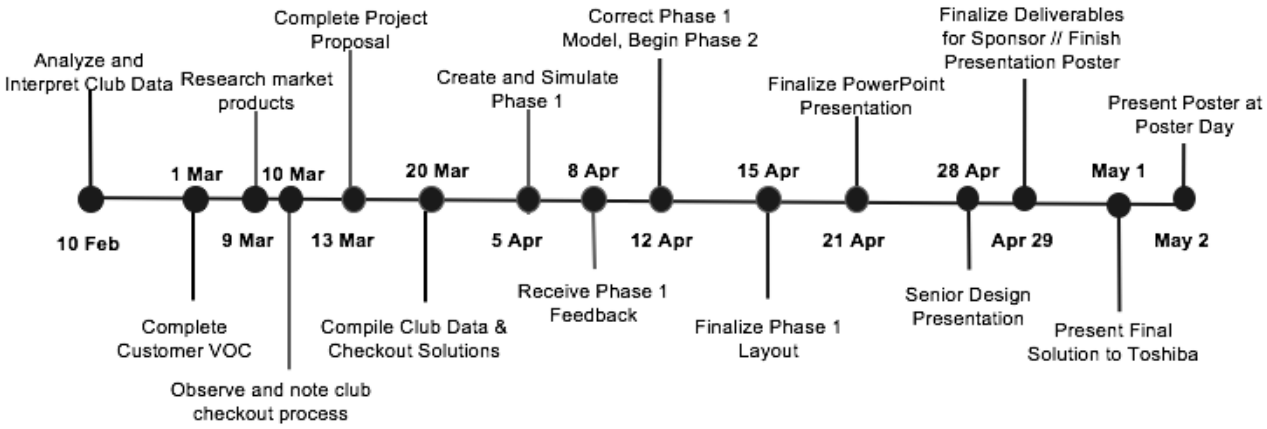

Figure 2.1: Project milestones

Voice of the Customer : The Grocery Store Shopper

The Voice of Customer (VOC) further defines where the users see inefficiencies in the system, which is wasted time for both shoppers and employees. Critical to Quality (CTQ) charts for traditional and SCO Lanes summarize the results of the Voice of the Customer surveys done prior to solution development. *Figure 2.2* and *Figure 2.3* display the CTQ charts. The faded charts depict customer complaints that are not relevant to a club store format, such as keyed items and a weighted bagging area, and the yellow boxes represent non-measurable characteristics that are considered in the final solution.

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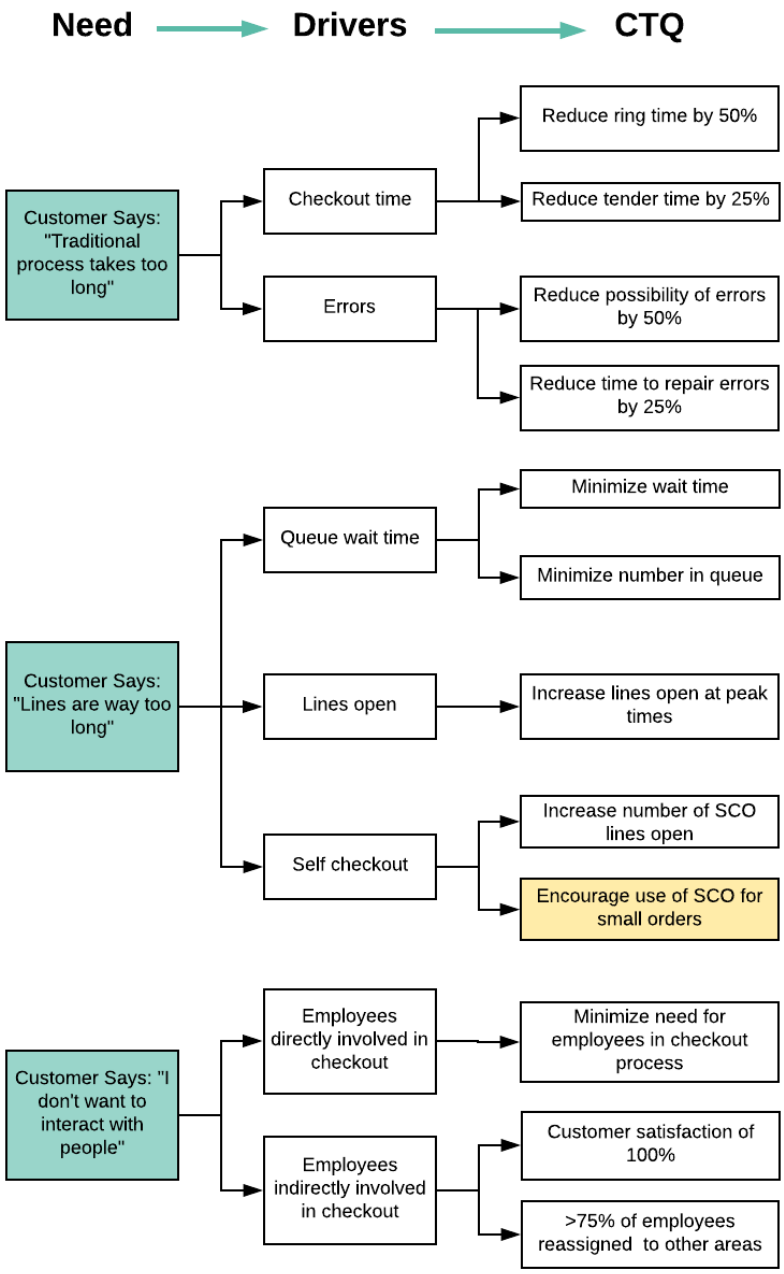

Figure 2.2: CTQ Chart summarizing customer concerns with Traditional Checkout Lane

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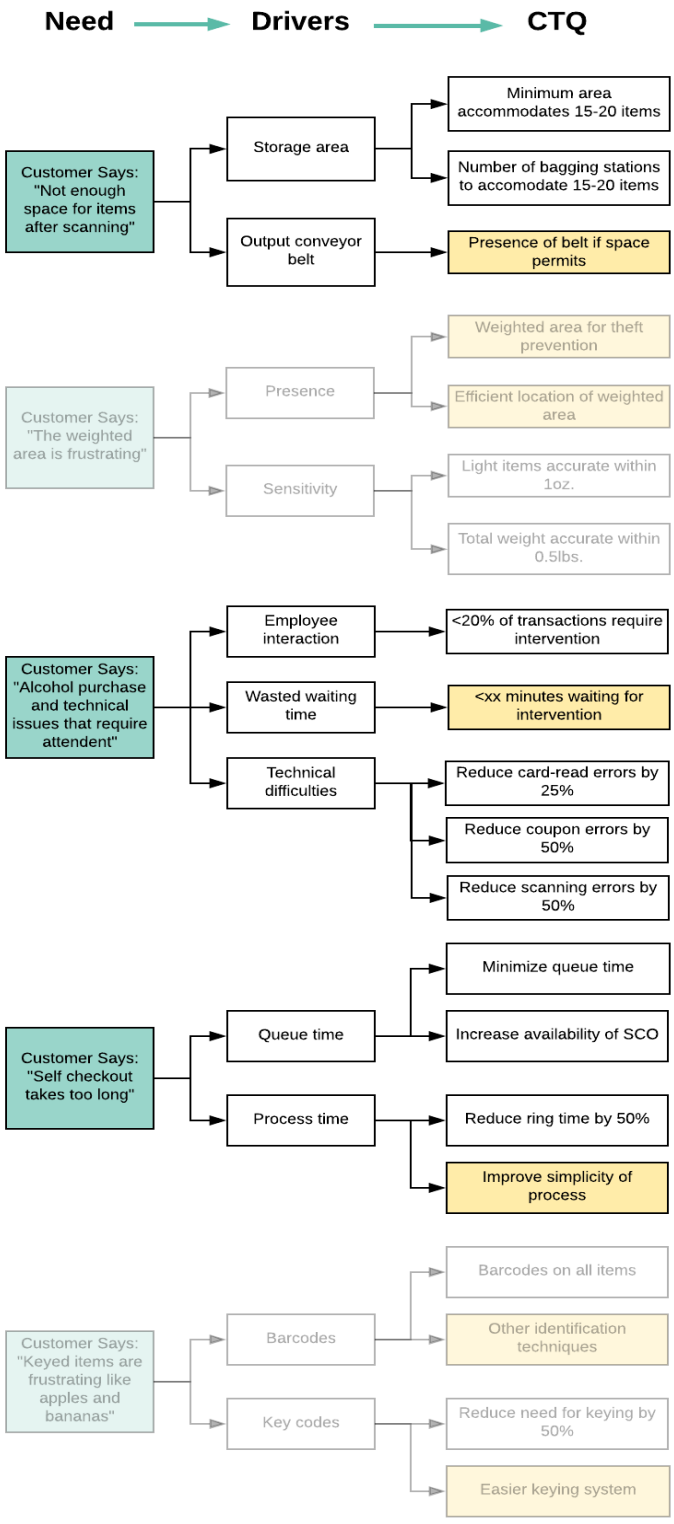

Figure 2.3: CTQ Chart summarizing customer concerns with Self Checkout Lane

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Shoppers voiced issues with the overall wait time within checkout as well as the wait in attendants for employee interventions. Overall, shoppers want a decrease in wait time and a decrease in interaction with employees. When asked specifically about Self Checkout systems, customers complain by the amount of space available, the number of employee interventions, and the time it takes to checkout.

Given Data

The sponsor provided data from 4 club stores in the form of transaction logs (T-logs), which record characteristics of each transaction made by the shopper. The name of the store from which this data pertains to, is kept confidential. One dataset, consisting of 15,012 transactions, is analyzed to provide an accurate overview of shopping trends. However, given additional time, all 4 data sets would have been analyzed. Since the focus of the project is the front-end checkout area, data from checkouts other than self-checkout and traditional systems, such as pharmacy counters, is excluded. Transactions spanned across 7 days: 11/04/16 (Fri) to 11/10/16 (Thurs) and occurred from the 8th to 22nd hour (8am to 10pm). Shown below in *Table 2.4* is a summary of performance measures important to a successful solution for all given data, what information is needed to obtain the performance measure, the source of data (where it is obtained), and how this measure is used.

Performance Measure	Information Needed	Source	Use
Flexibility to demand	Hours and days having high transaction rate	T-Log	Adapt to varying demand
Optimize system for the size of transaction	Basket size going through traditional checkout vs SCO	T-Log	Adjust checkout method based on basket size
Accommodate to varying transaction sizes	Frequency of basket sizes	T-Log	Characterize the customers entering checkout
Reduce ring time by 50%	Average ring time per basket size and checkout method	T-Log	Reduce non-value added actions that make up this time
Reduce tender time by 25%	Average tender time per tender and checkout method	T-Log	Reduce non-value added actions that make up this time
Accept frequently used payment methods	Tenders used and frequency of usage	T-Log	Have the resources to accept various tenders

Table 2.4: Summary of performance measure, information needed, source, and use of given data

Collected Data

In-person observations and manual data collection captured the characteristics of the current state that were not captured in the T-Log, and were required since our solution seeks to make improvements based on inadequacies of the current state. *Table 2.5* is a summary of measures important to a successful solution, data that must be obtained for the measure, the source of data (where it will be obtained), and why this measure is used for all collected data.

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Performance Measure	Information Needed	Source	Use
Address voiced needs of customers	Voice of the customer results	Survey	Adapt systems to varying demographics of customers who come to club stores
Address voiced needs of employees	Voice of the employee results	In-Person Interviews at club store(s)	Ensure employees are available and deployed when needed
Present optimal mix of products/tech	Comparisons of checkout technologies/solutions	Online sources and sponsor recommendations	Serve as a deliverable to record research
Reduce waiting in line	Current average number in queue, time in queue, and time in queue before leaving to another queue	Observations at club store(s)	Understand queuing system and how it contributes to total checkout time
<20% of all transactions will have interventions	Types of interventions	Observations at club store(s)	Reduce unnecessary/excessive employee interventions
Balance checkout method with demand	Which lanes open/how many open during a time period	Observations at club store(s)	Open/close checkout systems as dictated by demand
Allocate labor to meet demand	Current staffing methods	Observations at club store(s)	Ensure employees are available and deployed when needed
Improve loss prevention methods	Current audting procedures	Observations at club store(s)	Eliminate in-person audits
Reduce space needed to checkout	Current space requirements	Observations at club store(s)	Optimally utilize store area

Table 2.5: Summary of performance measure, information needed, source, & use of collected data

Assumptions

Since the project is broad and open ended, important considerations were made to ensure adequate data collection and analyses. Assumptions were made regarding customer and market behavior and significance of data. It is assumed that no queue forms when shoppers are audited by an employee, prior to exiting the store. According to the Toshiba, the probability of intervention occurrence is about 20 percent, and machine availability may be assumed to be 100% (machines assumed to not breakdown in calculations). Also, the market will remain constant to determine peak times and demand. Toshiba provided transaction data from club stores, so it is assumed that this data is a sufficient representation of the overall club retail market.

Constraints

The only constraint during data collection and the analyses is the time during which the project must be completed. Due to the breadth of the project and mid-way switch of focus from Kroger to club stores, a short, four-month completion time limits in-store observations to come from one nearby club store and to use one set of the given data to develop an understanding of the current state. Given more time, observations would be done on more club stores and all the given data would have been analyzed.

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Data Analysis

Current State Value Stream Maps

The current value stream maps (VSMs) shown below in *Figure 2.6* and *Figure 2.7* depict the current checkout process once a customer chooses a Traditional (Manned) Lane or Self-Checkout (SCO) machine. Metrics shown on the VSMs quantifies wait times, number in queue, time before jockeying, and auditing time since these were the measurable characteristics of the current system when in-store observations were done at a nearby club store. Non-value added factors during the scanning of items and payment of transaction are shown in the orange boxes, since these factors add extra time to the checkout process. At SCO, these non-value added factors may require an employee to assist the customer, an action known as an employee intervention. The most prevalent need for an intervention at club stores is assisting with coupons. At a Traditional Lane, the queue is observed for 14.97 minutes, and 8 shoppers' queuing behaviors were observed during this time period. At a SCO, the queue is observed for 41.33 minutes, and 20 shoppers' queuing behaviors were observed during this time period. Refer to *Table A.2.2 and A.2.3* in the Appendix for a summary of the calculations that gave current Traditional Lane queuing characteristics, and refer to *Table A.2.4 and A.2.5* in the Appendix for a summary of the calculations that gave current SCO queuing characteristics. Also refer to *Table A.2.6* in the Appendix for a summary of audit times observed (VSMs show the average audit time).

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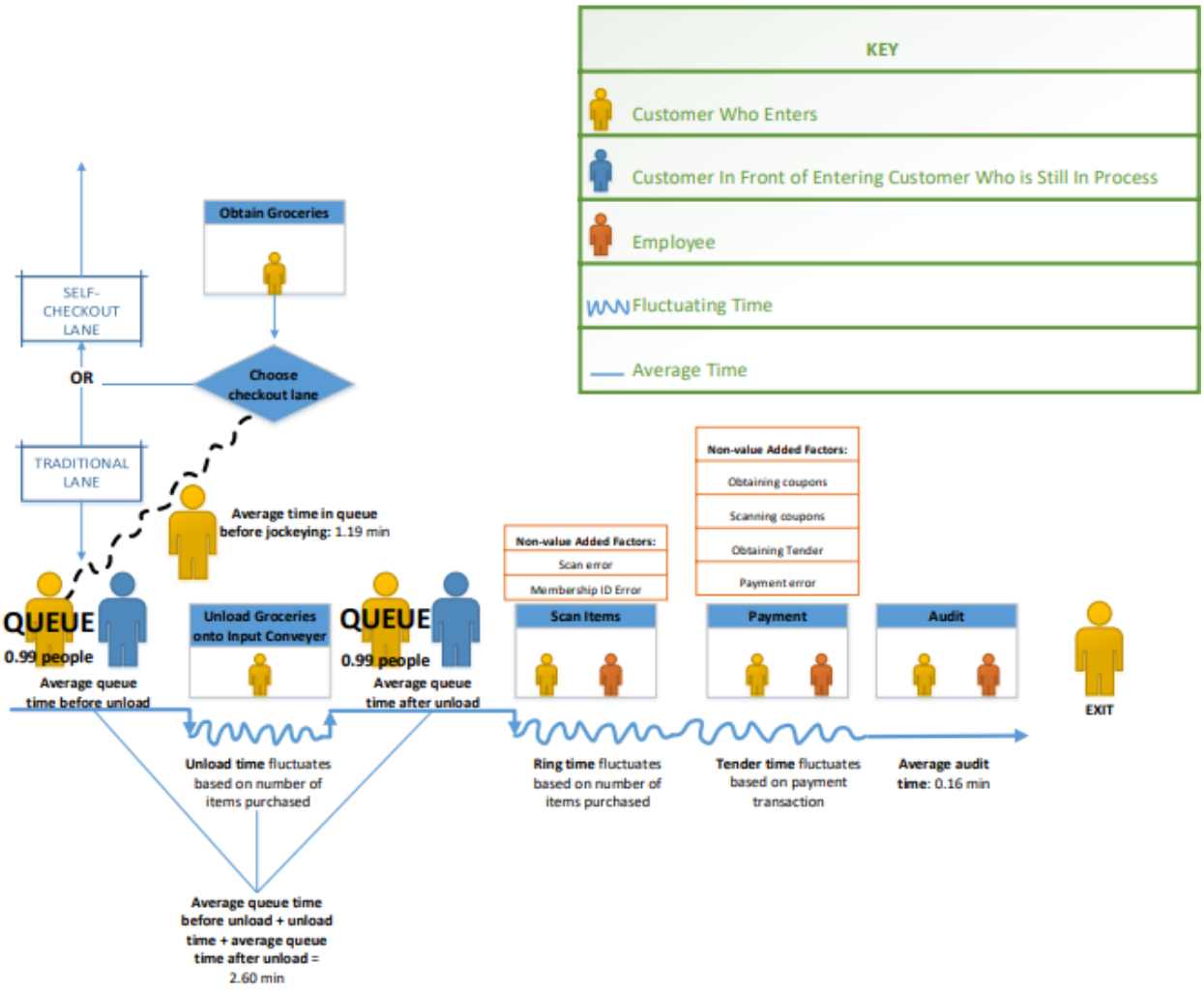

Figure 2.6: Current State Traditional Lane VSM

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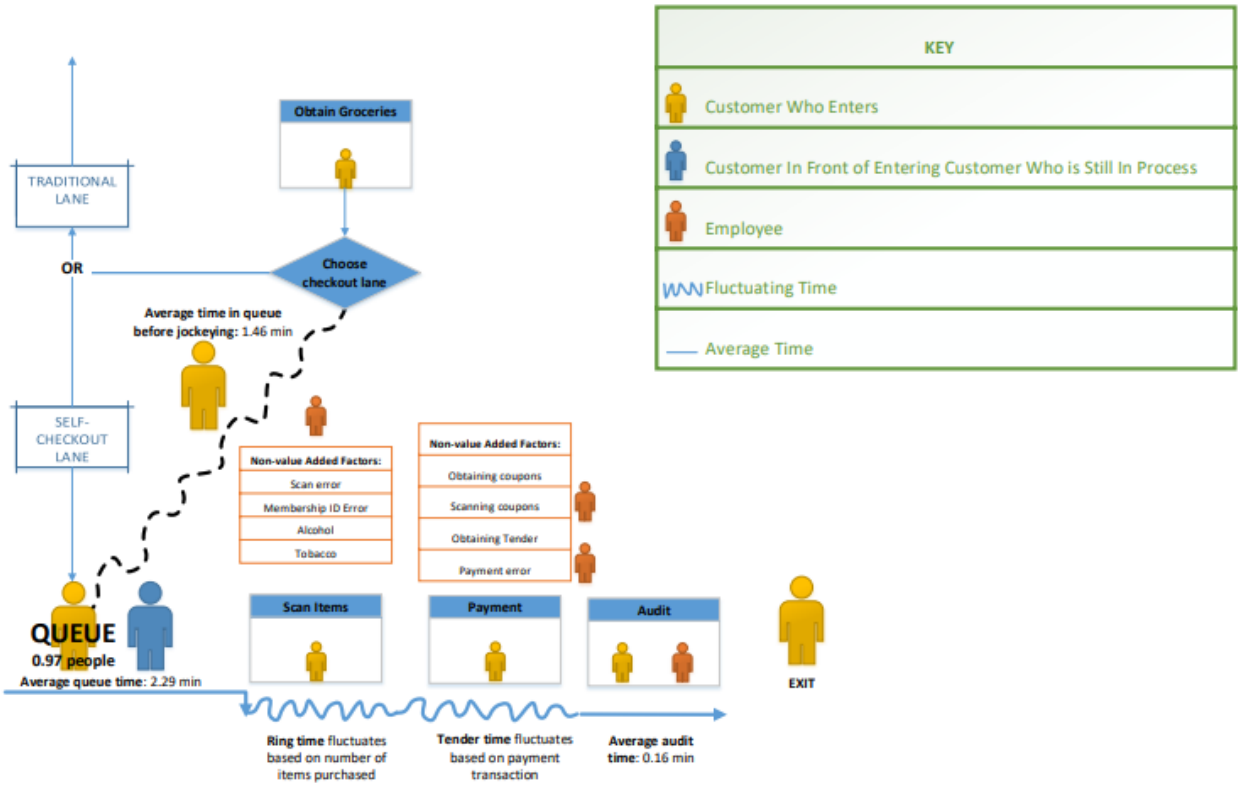

Figure 2.7: Current State SCO VSM

Shopper Profile

Analysis of the given T-logs builds a shopper profile, to tailor the proposed checkout solutions around the arrival, buying, and checkout habits of the shopper summarized below:

1. **Our solution must adjust to fluctuating shopper arrival times and days.** As shown in *Figure 2.8*, arrival rates are broken into 3 time periods: (1) 9-10am, (2) 10am-4pm, and (3) 4-9pm, which correspond to times the club store remains open to shoppers. The time periods are shown by hour of day, so for example, 4pm is the 16th hour of the day. Each weekday exhibits similar arrival patterns, but weekends exhibit different arrival patterns and have higher arrivals rates than weekdays. The peak arrival rate of 317 transactions/hr occurs on Sunday at 4pm. The new checkout system will have enough machines to handle this peak arrival rate, and have an appropriate lane management schedule to handle arrivals during other times of the day. Refer to *Table A.2.7* in the Appendix for the min and max arrival rates for each time period, comparing weekends to weekdays.

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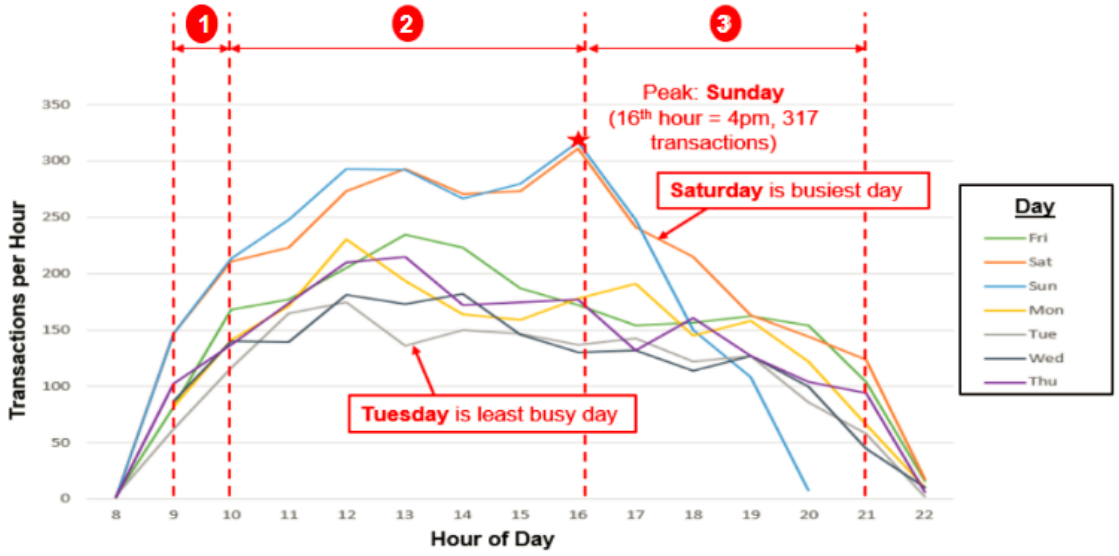

Figure 2.8: Arrival rates for all seven days of week

2. **Currently, approximately 50% of all shoppers going to Traditional Lanes had 11 items or less in their cart (basket size), revealing that Traditional Lanes often pick up the demand that SCO machines cannot handle**. Most clubs only have 5 SCO machines and around 16 Traditional Lanes, with a layout similar to the one shown below in *Figure 2.9*. SCO machines are wedged between Traditional Lanes, further preventing people from easily accessing the SCO machines when needed.

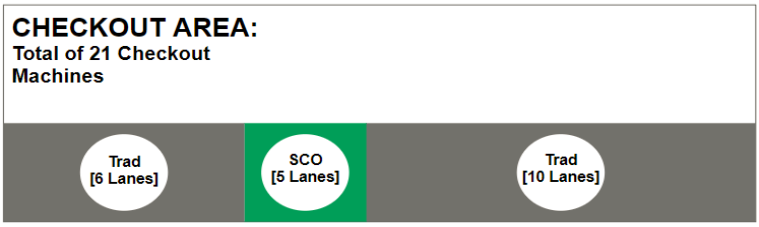

Figure 2.9: Layout of checkout area

3. **Out of the ~15,000 transactions from the given club data, around 50% of all the transactions had basket sizes that were 10 items or less, 30% had 11-20 items, and only 20% had basket sizes that were >20 items.** *Figure 2.10* shows which machines best handle these basket sizes, based on feedback from Toshiba. Machine descriptions will be provided in "Section 3 Recommendations." The majority of shoppers, 80%, are bringing basket sizes suited towards SCO. Refer to *Table A.2.8* in the Appendix for the full distribution of shopper basket sizes.

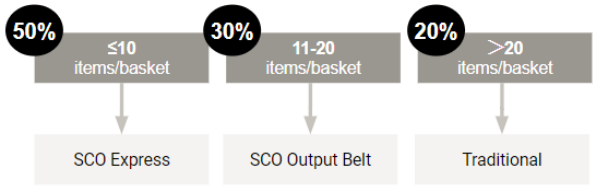

Figure 2.10: Basket size breakdown by machine

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4. **Lastly, it is important that the solution accommodates for a mix of tender types** used for payment. Refer to *Table A.2.9* in the Appendix for a summary of all tender types used, their frequency of usage, and average time to process the tender type (called tender time).

Current Lane Management and Staffing

Discussions with the HR Manager at the club store from which in-observations were made, give how many lanes remain open and the current checkout staffing schedule for each time period and day. Weekends require the most amount of open lanes and employees.

Traditional Lanes fluctuate throughout each day, but all SCO machines remain open irrespective of the time of day. Refer to *Table 2.11* and *Table 2.12* to see which lanes remain open for each time period for weekends and weekdays respectively. For Monday to Saturday, the store opens to shoppers at 9am and closes at 9pm. On Sundays, the store opens to shoppers at 9am and closes at 7pm.

CURRENT WEEKEND LANE MANAGEMENT: SAT-SUN				
	Traditional Min	Traditional Max	SCO Output Belt	SCO Express
9-10am	3	4	3	2
10am-4pm	4	9	3	2
4pm-7pm OR 4pm-9pm	4	12	3	2

Table 2.11: Current number of open lanes on weekends

CURRENT WEEKDAY LANE MANAGEMENT: MON-FRI				
	Traditional Min	Traditional Max	SCO Output Belt	SCO Express
9-10am	1	1	3	2
10am-4pm	2	3	3	2
4pm-7pm OR 4pm-9pm	3	4	3	2

Table 2.12: Current number of open lanes on weekdays

Employee roles include cashiers (C) who man Traditional Lanes, attendants (A) who oversee the SCO machines, supervisors (S) who usually stay at a help desk or at the back of the checkout area to observe shoppers, and the auditor (Ad) who checks each shopper's receipt before leaving the store. Refer to *Table 2.13* and *Table 2.14* to see how the number of each role fluctuates per time period for weekends and weekdays respectively. A minimum and maximum number of employees required for a period indicates a range: the required number of employees for the role varies over the course of the time period, depending on the number of open traditional, SCO

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output belt lanes, and SCO express lanes. Currently, due to a large number of Traditional Lanes, cashiers (the employees who man Traditional Lanes) dominate and there are only a few attendants to assist shoppers at SCO.

CURRENT WEEKEND STAFFING: SAT-SUN								
	SCO Machines			Traditional Lanes		Audit	TOTAL CHECKOUT STAFF (MIN)	TOTAL CHECKOUT STAFF (MAX)
	S	A		C		Ad		
	Constant	Min	Max	Min	Max	Constant		
9-10am	2	1	1	3	4	1	7	8
10am-4pm	2	1	2	4	9	1	8	14
4-7pm OR 4-9pm	2	1	2	4	12	1	8	17

Table 2.13: Current staffing patterns for weekends

CURRENT WEEKDAY STAFFING: MON-FRI							
	SCO Machines		Traditional Lanes		Audit	TOTAL CHECKOUT STAFF (MIN)	TOTAL CHECKOUT STAFF (MAX)
	S	A	C		Ad		
	Constant	Constant	Min	Max	Constant		
9-10am	2	1	1	1	1	5	5
10am-4pm	2	1	2	3	1	6	7
4-7pm OR 4-9pm	2	1	3	4	1	7	8

Table 2.14: Current staffing patterns for weekdays

Ring Time Regression Model

Based on given T-log data, *Equation 2.15* is the regression model that predicts the ring time in seconds, which is the time to scan items for a transaction, based on the number of items per transaction and the checkout method used: Traditional or SCO. SCO_{Bin} is a binary variable that takes on a value of 1 if the shopper is using a SCO machine, which includes SCO Output Belt machines and SCO Express machines, or a value of 0 if using a Traditional Lane. The model also includes an interaction effect between the number of items in the transaction and the checkout method used, shown by the (Number of Items)*(SCO_{Bin}) term. Refer to *Code A.2.10* and the corresponding SAS output table, *Table A.2.11*, in the Appendix to see how SAS is used to develop the ring time regression model.

Equation 2.15: Regression model that estimates ring time in seconds

Optimal Number of Machines for Shopper Basket Size

Since the current checkout system lacks an adequate number of machines to match the basket sizes that shoppers bring, the redesigned checkout area will contain the optimal number of machines, for each "m" type of machine, for a system where people go to the correct machine for their basket size. *Equation 2.16* calculates the optimal number of each type of checkout machine

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and is shown below, along with each type of "m" machine for which the calculation is done. This equation combines the arrival rate during peak demand, r_a , for each type of checkout system and the process time, t_e , per transaction.

$$\#\ \text{of m machines} = \left[\ r_a * t_e + 1\ \right]$$

MACHINE TYPE (m) | SCO Express | SCO Output Belt | Traditional

Equation 2.16: Model that calculates the optimal number of machines for each machine type "m"

First, the peak arrival rate (demand), r_a, is categorized by basket size to determine how much should ideally go to the checkout machine that may best handle this basket size, as shown below in *Figure 2.17.* SCO Express receives the highest arrival rate of 158.5 arrivals/hr, and Traditional Lanes receive the lowest arrival rate of 63.4 arrivals/hr.

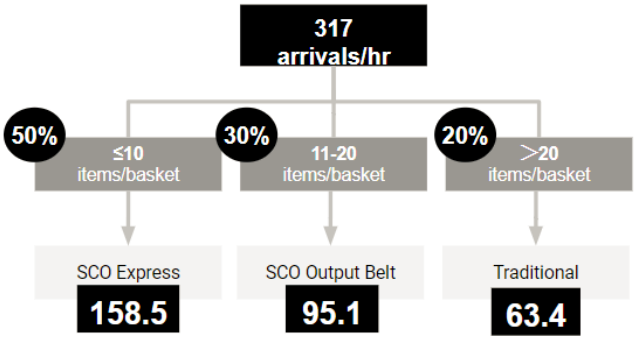

Figure 2.17: Arrival rates per basket size

Then, the sum of the ring time from the ring time regression model and the average tender time (time from the end of scan to payment acceptance) gives the process time, t_e, per transaction. The number of items used in the regression model, corresponds to the basket size that goes with each machine.

Three separate optimal machine calculations determine the number of SCO Express machines, SCO Output Belt machines, and Traditional Lanes that would be needed for the ideal checkout area that accommodates to shoppers' basket sizes. The resulting required number of each type of machine is as follows: 8 SCO Express machines, 7 SCO Output Belt machines, and 5 Traditional Lanes. Even though the min and max number of machines were calculated (corresponding to the min and max values in each basket size range), the max is chosen as the optimal since the system should be able to handle the majority of the basket sizes within the range. The detailed calculations for each machine are shown in *Table A.2.12*, *A.2.13,* and *A.2.14* in the Appendix; calculations treat transactions/hr and arrivals/hr as equivalent rates.

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Future State Value Stream Maps

Through the analyses and VOC data, the projected future state of the club store checkout will have reduced queue times and eliminates the audit step for loss prevention. The Phase I solution addresses these. In-store observations indicate that ring time and tender time are difficult to reduce due to their variability and/or require more technology based changes, so the projected 50 and 25 percent reductions respectively for these times and 20 percent intervention reduction at SCO is addressed through the longer term, Phase II solution. *Figure 2.18* and *2.19* depict the future state for Traditional Lanes and Self Checkout Lanes respectively, with areas for improvement identified in the starbursts.

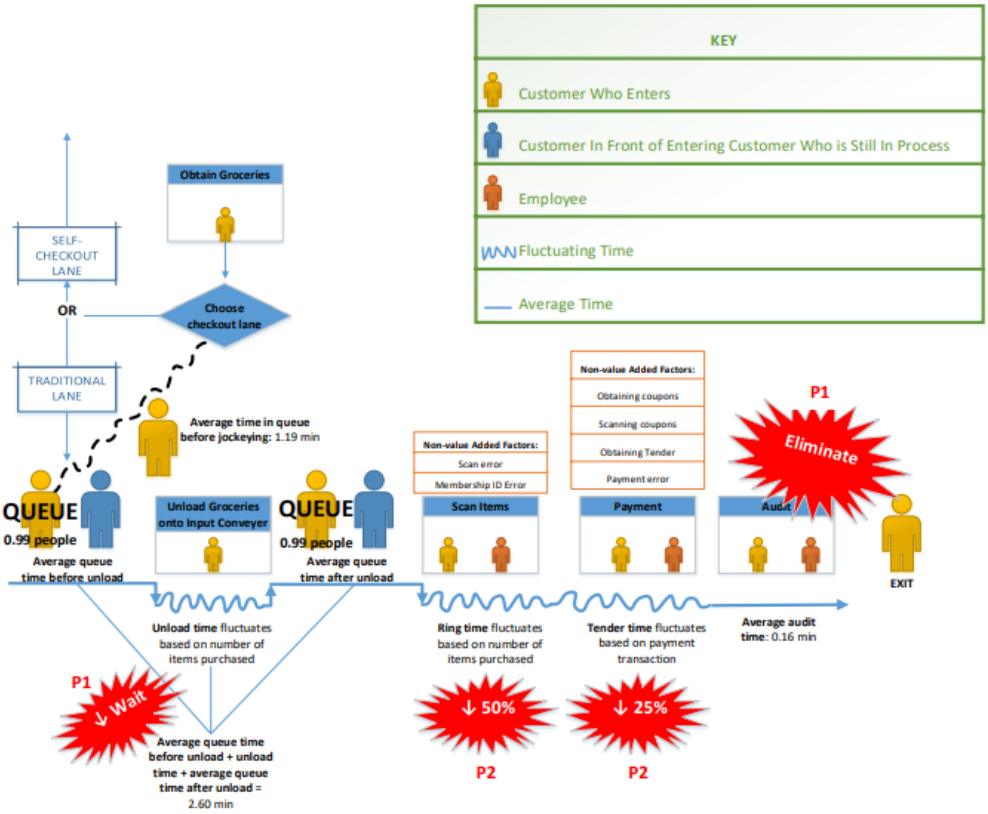

Figure 2.18: Future State Traditional Lane VSM

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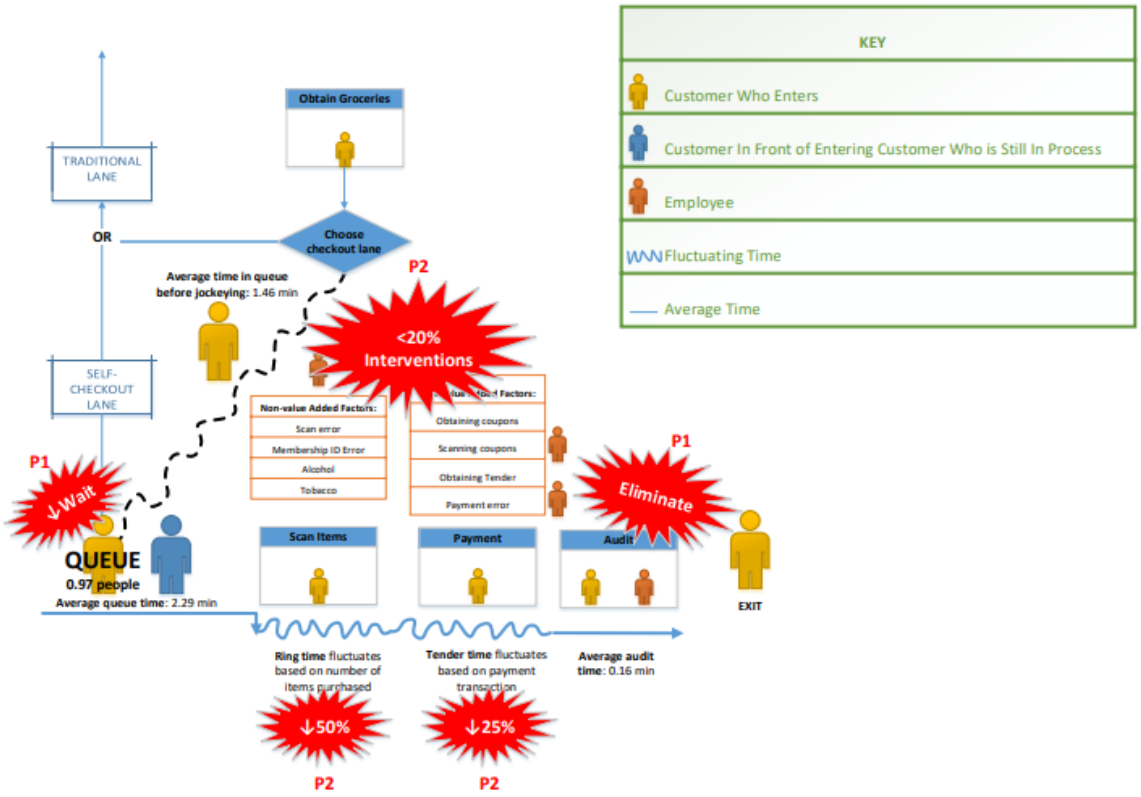

Figure 2.19: Future State SCO VSM

3. Recommendations

The analyses, described in "Section 2: Data Analysis," assists in the development of an improved layout and checkout procedure. The optimal number of checkout machines based on shopper basket size, customer feedback, and wait times were utilized to determine the most efficient flow throughout the store.

All data was incorporated into the final solution, which is divided into two phases. Phase I is a quick implementation phase, with a predicted timeline of six months. It involves few changes to the overall store process, but focuses on reducing wait times and theft, and improving customer experience. Phase II is a longer term solution with a slower implementation of two to three years, requiring more drastic technological changes to further reduce theft and reduce ring times.

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Phase I

Phase I, the quick to implement solution, comprises the optimal mix of existing and next-generation checkout technology integrated into a new layout with additional loss prevention methods and lane/staffing management for the redesigned checkout area.

Layout

The entrance and checkout areas have been reconfigured to improve loss prevention and accommodate peak demand. *Figure 3.1* shows the overall store layout. A more detailed layout with dimensions of spacing and machines can be found in *Figure A.2.15* in the Appendix.

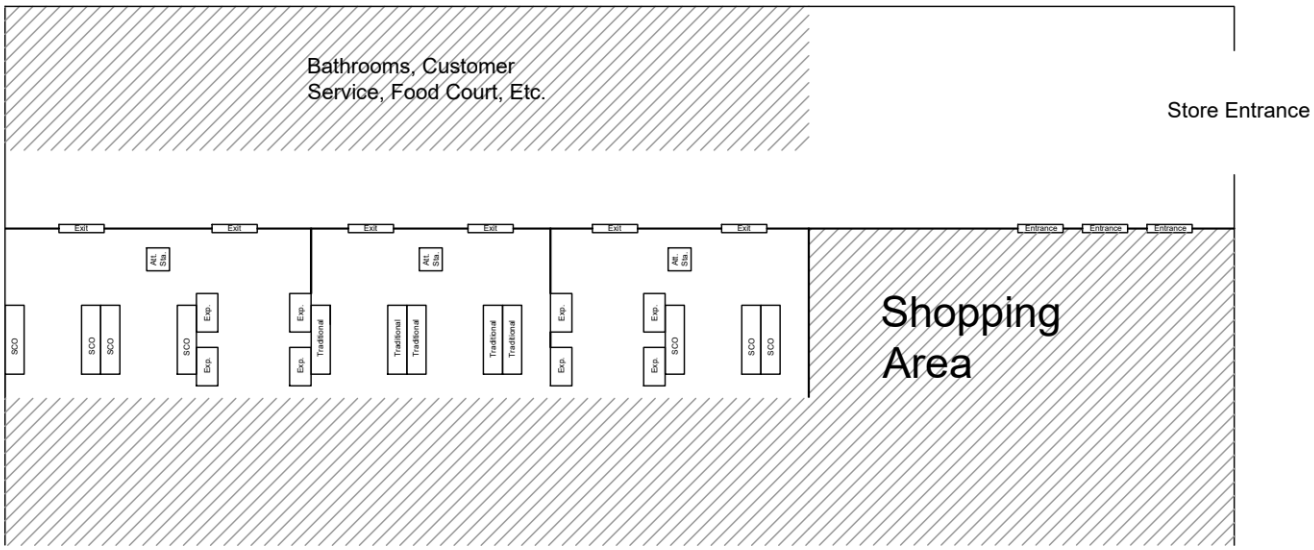

Figure 3.1: Overall store layout with store entrance, shopping area, checkout area, and services outside enclosed area

The area is divided into three pods, two dedicated to Self Checkout and one for traditional, manned checkout. Most basket sizes at peak demand are less than 20 items, which is ideal for Self Checkout, so the Self Checkout pods receive the most traffic and are seen first in the new layout. The traditional pod is located between the two Self Checkout pods, so shoppers are deterred from using Traditional Lanes unless they have large baskets or require extra assistance. *Figure 3.2* shows the checkout pods.

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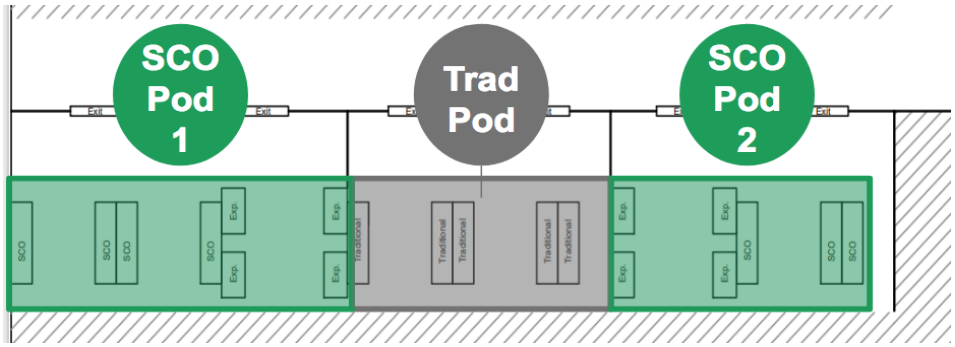

Figure 3.2: Three checkout pods

The two SCO pods include four Express SCO Lanes restricted to 10 or fewer items and either three or four SCO Lanes with output belts. All baskets of under 20 items can be accommodated by the two SCO pods (having a total of 15 SCOs) at peak demand. The traditional pod contains five Traditional Lanes with input belts, the same machines currently used in club stores. Based on the team's analysis, five Traditional Lanes are sufficient for all basket sizes of greater than 20 items. *Table 3.3* provides a detailed breakdown of the machines used in the new layout.

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CHECKOUT MACHINES		
Express Self-Checkout System (1 to 10 items purchased)	**Self-Checkout System with Output Belt (11 to 20 items purchased)**	**Traditional Checkout Lane (>20 items purchased)**
		
Characteristics		
Enhanced, flexible, modular, next-gen model - More appealing and versatile design - Shortened reach distance to screen - Tilting and adjusting the display to minimize glare **Better user experience** - Flat platen: for order with many items, warehouse or specialty stores (encourages orders up to 10 items to use Express) - Customer guidance lights to assist in navigating between scanning, payment and grabbing receipt	**Enhanced, flexible, modular, next-gen model** - More appealing and versatile design - Shortened reach distance to screen - Tilting and adjusting the display to minimize glare **Better user experience** - Hand scanner: for processing large or heavy items - Transaction awareness light **Output belt** - 15-20% reduced footprint - Smaller dimensions; utilizing less space - Customer guidance lights to assist in navigating between scanning, payment and grabbing receipt	**Previous Generation Model** - Appealing and versatile design - Ease of transaction for customer with fully cashier-manned system - Places employee and customer on same side of POS system for ease of maneuverability for cashier when working with large items - Contains input belt to accommodate large transactions - Contains platform following input belt to provide space for items to collect prior to collecting items for exit

Table 3.3: Detailed description of checkout machine technology

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All checkout lanes will be labeled with basket size requirements. Each machine will also have an awareness lighting system that indicates availability/intervention: Light on=open, Light flashing=intervention required. The spacing between each lane is based on the turn radius of carts and carts/people moving through.

Each of the three pods includes an unmanned attendant station for use as needed. This may include errors with coupons that cannot be addressed at the checkout lanes, or membership ID issues that require the attendant to look up the customer's information.

Each checkout lane will have an surveillance camera with artificial intelligence capabilities installed within, or directly below, the awareness lighting system. The camera's image will be projected onto a 10" monitor that is attached to the point of sale system, displaying the customer's actions while checking out. The system will serve as a deterrent of theft and extra form of security.

At the front of the store, the shopping floor containing all products will be blocked with guard railings. One-way, motion-detecting entry gates will allow one-way flow of shoppers into the shopping area. Each checkout pod will be enclosed by guard railings to contain the flow of shoppers. There will be two automatic, motion-detecting exit gates at the back of each pod behind the attendant station, which shoppers will be required to pass through in order to exit the checkout area. All gates will be wide enough for large carts and wheelchairs. Employees will be able to trip the entry and exit gates if needed to allow two-way flow. In the case of emergencies, the gates will open and two-way flow will be possible. *Table 3.4* explains the gate, camera and monitor technologies.

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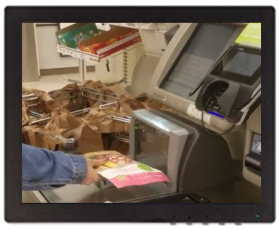
ADDITIONS TO CHECKOUT AREA			
Security Camera	**Security Camera Monitor**	**Entrance Gate**	**Exit Gates and Guard Railing**
			
Benefits of Implementation			
Smart Technology - Implement AI security camera into transaction awareness light **Reinforced Security** - Camera acts as a form of security by monitoring the shoppers actions from an above angle **Full Vigilance** - The camera will be able to see all customer movements, from removing items from cart, to scanning, to output area *Phase 1 purpose of camera is solely for customer awareness of surveillance*	**Easy Implementation** - Monitors will be attached to existing POS systems, externally **Reinforced Security** - Monitors will display the security camera feedback throughout the checkout process - Creates customer awareness of security system in place *Phase 1 purpose of monitor is solely for customer awareness of surveillance*	**Loss Prevention** - Entrance gate forces one-directional flow of shoppers for anti-theft purposes **High Traffic Location** - Entrance gate will be located prior to entering the grocer/retail portion of store in efforts of encouraging all shoppers to exit through the checkout system - Prevents need for auditor to monitor customer flow near entrance	**Loss Prevention** - Exit gates and guard railings are security modifications to the checkout area of the store **Reinforce Customer Flow** - The guard railings force shoppers to exit through the exit gates located conveniently within their gated area - Exit gates discourage theft and act as a second form of security if employees are vigilant of customer activities

Table 3.4: Detailed description and benefits of additions to checkout area

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Located outside the enclosed checkout and shopping areas are the services that do not require a regular checkout process. These include bathrooms, customer service, optics center like at BJ's, food court, etc. Some shoppers come to club stores only for these reasons, so the team wanted to ensure that these shoppers would not have to deal with checkout traffic in order to leave the store. *Figure 3.5* shows this area.

Figure 3.5: Close up of area designated to services separate from and outside checkout area

Process

The overall customer flow throughout the store is similar to the original model, with a few changes regarding entry and exit. Shoppers enter the store through the main entrance, and utilize the one-way entry gates to enter the shopping floor, where they can purchase their items. Carts and baskets are located at the entrance, outside the entry gates.

Following shopping for items, shoppers approach the checkout area where they are directed to choose a checkout line based on their basket size. The lanes are clearly labelled with these basket sizes. *Figure 3.6* depicts this process.

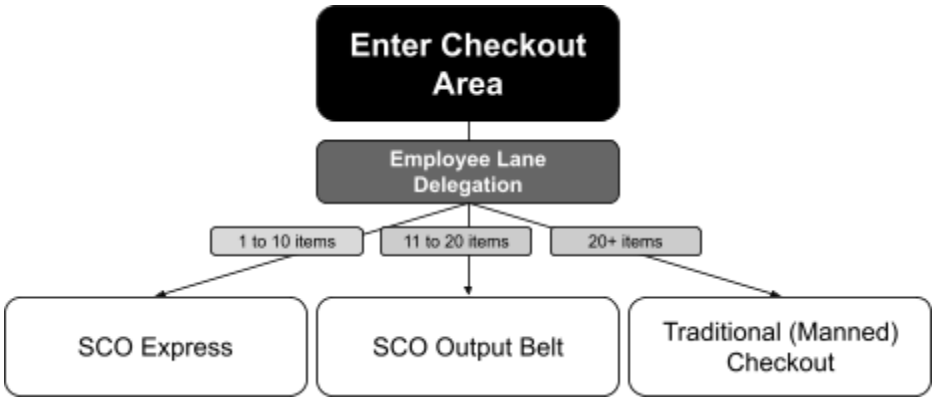

Figure 3.6: Shoppers choose checkout method based on basket size

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The customer enters the correct pod and chooses the shortest lane. The actual checkout process with each machine remains unchanged. Attendants and cashiers (for Traditional Lanes) are available for assistance. Upon payment, the customer collects their purchase and exits the pod through an automated exit gate. They are then free to exit the store the way they entered. There is no longer an employee audit at the exit, as the controlled flow of shoppers through the entrance and exit eliminates the need for this loss prevention method.

Lane Management and Staffing

For the Phase I model, the required number of lanes to be open during each time period and day depends on the expected arrival rate per time period and day. Thus, the same optimal number of machines calculation that determined the overall layout (max number of machines) determines how many Traditional Lanes should remain open to accommodate demand. The min and max arrival rates corresponding to each time period and day now become the arrival rate used in the calculation. Once again, refer to *Table A.2.7* in the Appendix for these min and max arrival rates. The following *Table 3.7* and *3.8* show the required number of machines to be open; just like the current checkout area, the Phase I model only has Traditional Lanes that fluctuate and SCO machines remain open throughout the day.

PHASE I WEEKEND LANE MANAGEMENT: SAT-SUN					
	Traditional Min	Traditional Max	Traditional Management	SCO Output Belt	SCO Express
9-10am	3	3	Keep 3 open	7	8
10am-4pm	4	5	Increase to 4 open by 10am, increase to 5 open by 12pm	7	8
4pm-7pm OR 4pm-9pm	1	5	Keep 5 open until 6pm, then decrease by one lane every 30 minutes to close	7	8

Table 3.7: Optimal number of lanes open on weekends

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	PHASE I WEEKDAY LANE MANAGEMENT: MON-FRI				
	Traditional Min	Traditional Max	Traditional Management	SCO Output Belt	SCO Express
9-10am	1	2	Increase to 2 open by 10am	7	8
10am-4pm	2	4	Increase to 3 open by 11am, increase to 4 open by 12pm	7	8
4pm-7pm OR 4pm-9pm	1	3	Decrease to 3 open by 4pm, keep 3 open until 6pm, then decrease by one lane every 30 minutes to close	7	8

Table 3.8: Optimal number of lanes open on weekdays

As the new layout has eliminated a large quantity of cashier-manned lanes, the redistribution of staffing within the checkout system is meant to redelegate the roles of employees and corresponds to how many checkout lanes remain open for each time period and day. The new distribution of employee is designed to:

1. Optimize customer flow
2. Ensure security throughout the 3 checkout pods
3. Provide quick assistance to shoppers to boost customer experience

Four different types of employees staff the checkout area: cashiers, attendants, exit guards, and traffic monitors. Descriptions of each role are listed below, and abbreviations of each role name are in parentheses.

Cashier (C): A cashier stays at a traditional checkout lane to scan membership card and items, initiate transaction payment, and resolve any errors that arise during checkout; each open Traditional Lane requires a cashier.

Attendant (A): An attendant assists with interventions at SCO or traditional checkout lanes.

Exit Guard (EG): An exit guard stands close to SCO pod exit gates and monitors whether each customer who exits with items, actually went through checkout.

Traffic Monitor (TM): A traffic monitor stands in front of each checkout pod (SCO Pod 1, Traditional Pod, or SCO Pod 2) to direct entering shoppers to the appropriate checkout machine

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Employee allocation per role varies by the following characteristics:

1. **Day of Week**: Weekends (Saturday-Sunday) and Weekdays (Monday-Friday)
2. **Area of Checkout**: SCO Pod 1, Traditional Pod, or SCO Pod 2
3. **Time of Day**: 9-10am, 10am-4pm, 4-7pm (only Sundays close at 7pm) or 4-9pm

The required number of employees for weekends is summarized in *Table 3.9* and for weekdays in *Table 3.10*. All staffing levels fluctuate by daily and hourly shopper arrival rates. The minimum staffing levels are used during early mornings, late evenings, and slow weekdays. The maximum staffing levels are used during all peak times, particularly weekends. The number of required attendants, traffic monitors, and cashiers primarily tend to fluctuate the most throughout the day. In particular, the number of cashiers match the number of Traditional Lanes that will be open during that particular time period and day. More attendants float around SCO pods than in the Traditional pod, since SCO's tend to have more interventions. The number of exit guards remains constant for both weekends and weekdays and all periods of the day.

PHASE I WEEKEND STAFFING: SAT-SUN																
	SCO Pod 1				Traditional Pod						SCO Pod 2				TOTAL CHECKOUT STAFF (MIN)	TOTAL CHECKOUT STAFF (MAX)
	EG	A		TM	A		TM		C		EG	A		TM		
	Constant	Min	Max	Constant	Min	Max	Min	Max	Min	Max	Constant	Min	Max	Constant		
9-10am	1	1	2	1	0	1	0	1	3	3	1	1	2	1	9	13
10am-4pm	1	2	3	1	1	1	1	1	4	5	1	2	3	1	14	17
4-7pm OR 4-9pm	1	2	3	1	1	1	1	1	1	5	1	2	3	1	11	17

Table 3.9: Optimal staffing patterns for weekends

PHASE I WEEKDAY STAFFING: MON-FRI																
	SCO Pod 1				Traditional Pod						SCO Pod 2				TOTAL CHECKOUT STAFF (MIN)	TOTAL CHECKOUT STAFF (MAX)
	EG	A		TM	A		TM		C		EG	A		TM		
	Constant	Min	Max	Constant	Min	Max	Min	Max	Min	Max	Constant	Min	Max	Constant		
9-10am	1	1	1	1	0	1	0	1	1	2	1	1	1	1	7	10
10am-4pm	1	2	3	1	1	1	1	1	2	4	1	2	3	1	12	16
4-9pm	1	2	3	1	1	1	1	1	1	3	1	2	3	1	11	15

Table 3.10: Optimal staffing patterns for weekdays

Simulating Phase I

To prove that the proposed optimal mix of checkout machines and layout changes reduces average wait time and average number of shoppers in queue, a simulation was created in SIMIO utilizing the data provided by Toshiba and the data the team collected in-person. Current customer arrival rates feed into the redesigned Phase I checkout area, to accurately model how the new system behaves with current shopper demand patterns.

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Modeling Customer and Machine Behavior in the Checkout Area

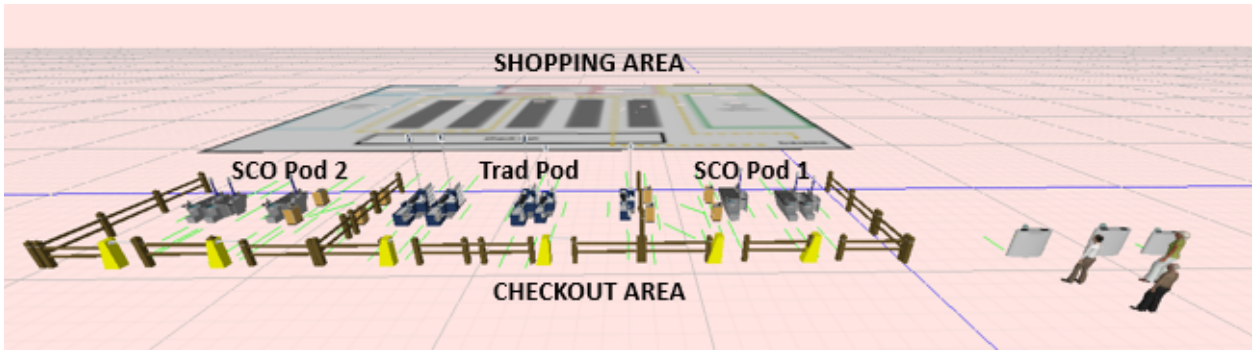

Figure 3.11: Front view of simulation layout

Above, in *Figure 3.11*, is the simulation layout, which precisely models the Phase I layout. Shoppers enter through the three entry gates on the right, then shop in the shopping area. As the shoppers approach checkout, the simulation categorizes them by their basket size, according to the basket size distributions described in "Section 2: Data Analysis, Shopper Profile." Then, the shopper goes toward the appropriate checkout machine for their basket size. Once directed to an appropriate checkout machine, shoppers pick the machine with the shortest queue, selecting the machine with the fewest shoppers in the queue. Queues are laid out behind each machine, except for SCO Express machines, where shoppers stand in one queue for all four SCO Express machines; this is shown below in *Figure 3.12*.

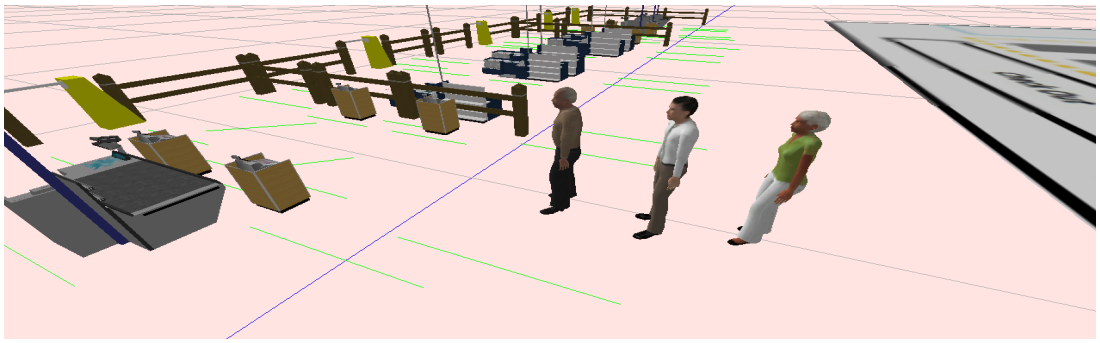

Figure 3.12: Queue placement for SCO Express machines

Next, shoppers were programed to jockey, which is when some shoppers leave the queue they are currently standing in to find a shorter line. Since only Traditional Lanes open and close throughout the day, a work schedule varies the opening and closing of Traditional Lanes. Machine capacity equals one when the machine needs to be open, and zero when the machine needs to be closed. The required number of lanes depends on the minimum number of machines calculations based on collected observations, employee feedback and given data. The model was run from 8am-8pm to encompass the provided data, with twenty replications for accuracy. This

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provided the most reliable averages and reduced the effect of outliers. Visit https://www.youtube.com/watch?v=6uo1KxRwj-Q to see a video of the simulation running.

Data Inputs

As mentioned in "Section 3: Phase I, Layout", both the data given by Toshiba and the collected data contributed to the three major inputs: jockeying, arrival rates, and processing times.

The team went to club stores to collect data on current jockeying behavior. For Traditional Lanes, eight people jockeyed per hour and with an average wait time of 1.19 minutes before jockeying. These results were incorporated into Simio by adding a reneging trigger with a 28.6% probabilistic condition and a uniform distribution of 1.1 to 1.3 minutes. The probabilistic condition models how not every customer jockeys after waiting that long. For SCO Output Belt machines, ten people jockeyed per hour with an average wait time of 1.46 minutes before jockeying. A probabilistic condition of 35% and uniform distribution of 1.4-1.5 minutes models jockeying at SCO with output belt lane queues. Finally, for SCO Express machines, since there is only one queue per four kiosks, no jockeying occurs. Shoppers simply wait for the next kiosk to open.

The arrival rates and processing times were averaged by sorting the transaction data, given by Toshiba and were broken down to each hour of operation within the store. The type of transaction coming through the system was sorted by the number of items in the transaction:

1. Self Checkout Express lanes limited shoppers to 1 to 10 items
2. Self Checkout with output belts limited shoppers to 11 to 20 items
3. Traditional cashier-manned lanes handled transactions of 21 or more items

The arrival rate was calculated by using the full throughput of shoppers for each hour and creating an exponential distribution to replicate real life throughput levels. An exponential distribution models these arrival rates.

The processing times were calculated by adding together the ring time and tender time, a combination of the time taken to scan all items and the time taken to pay for the transaction. An average processing time was found for each hour of the day and placed into another exponential distribution within the simulation.

Phase I Impacts

Layout Features, Lane Management, and Staffing

The new Phase I layout has three times more Self Checkout machines than Traditional Lanes, to accommodate to the majority of basket sizes that shoppers bring to checkout. However, due to the increased number of SCO machines in the new Phase I layout, loss prevention is a priority. The implementation of entrance and exit gates forces shoppers to go through the monitored

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checkout area, through the exit gates, and pass the exit gate attendants before leaving the store. Also, the added cameras to all checkout lanes and monitors to SCOs further address loss prevention. Additionally, the recommended management of checkout lanes and corresponding redelegation of staffing improves customer experience by increasing the number of available attendants to assist shoppers with interventions and creating the new traffic monitor role to direct shoppers to the machine best suited towards their basket size.

Voice of Customer: Feedback on Proposed Phase I Changes

Since many of the changes in the redesigned Phase I layout directly impact customer experience, a survey was conducted to receive feedback from shoppers on their willingness to comply with these adjustments. The results of the survey of 50 people were primarily positive.

- **55%** - shoppers willing to enter the store through entrance gates
- **73%** - shoppers willing to leave the checkout area through exit gates
- **90%** - shoppers willing to only use Traditional Lanes for transactions of more than 20 items
- **80%** - shoppers willing to always use self-checkout systems for transactions of 20 items or less
- **52%** - shoppers appreciate employee to direct them to ideal checkout lane
- **78%** - shoppers appreciate more employee assistance at Self Checkout

Based on this feedback, the team determined the Phase I solution's layout and process changes would be accepted by the public in club stores.

Simulation Results

To compare the Phase I solution to the current model, three major statistics were analyzed: queue time, number of shoppers in the queue, and machine utilization. Results of the simulation are depicted in the following graphs.

Average Waiting Time

As expected, due to the majority of basket sizes being ten or less items, SCO Express machines were primarily used in the morning, which remained applicable throughout the day. Traditional Lane wait time peaks at 12pm, which verifies the reasoning for all five Traditional Lanes to be open during this time. Overall, SCO Output Belt machines have a significantly higher wait time, though when compared to the current model, great improvements are still seen. *Figure 3.13* shows the average wait time results of the simulation.

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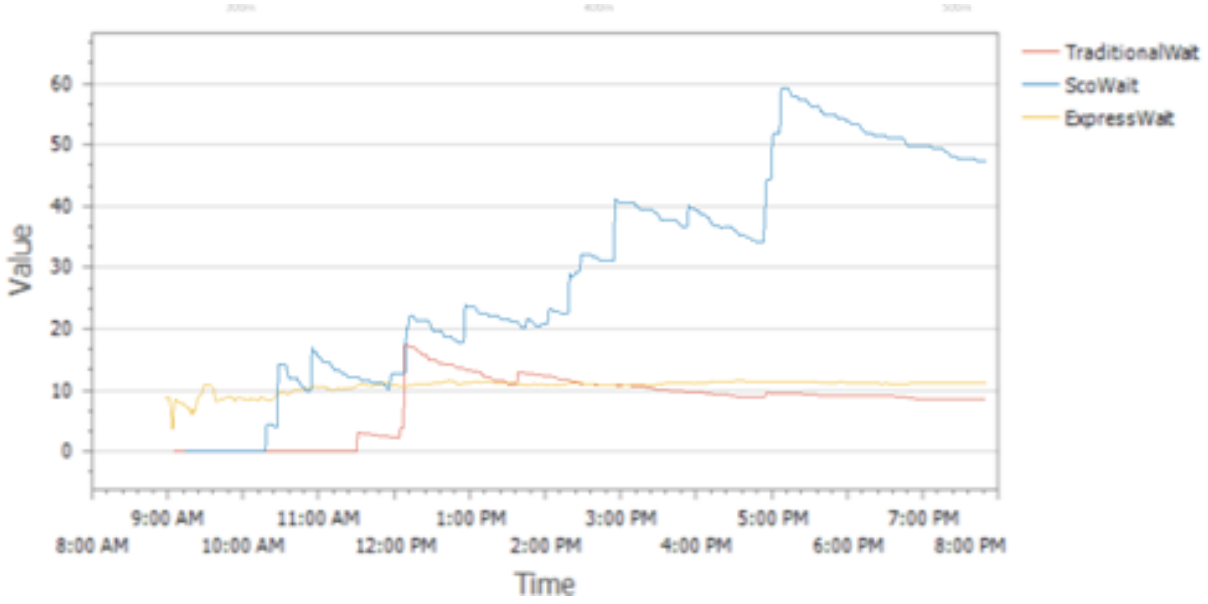

Figure 3.13: Average wait time

Average Number in Queue

SCO Output Belt machines and Traditional Lanes have significantly fewer people waiting in line at any given time. More shoppers wait in line for SCO Express machines, though this is due to the single queue that feeds each set of four SCO Express machines. *Figure 3.14* depicts the average number of shoppers in the queue.

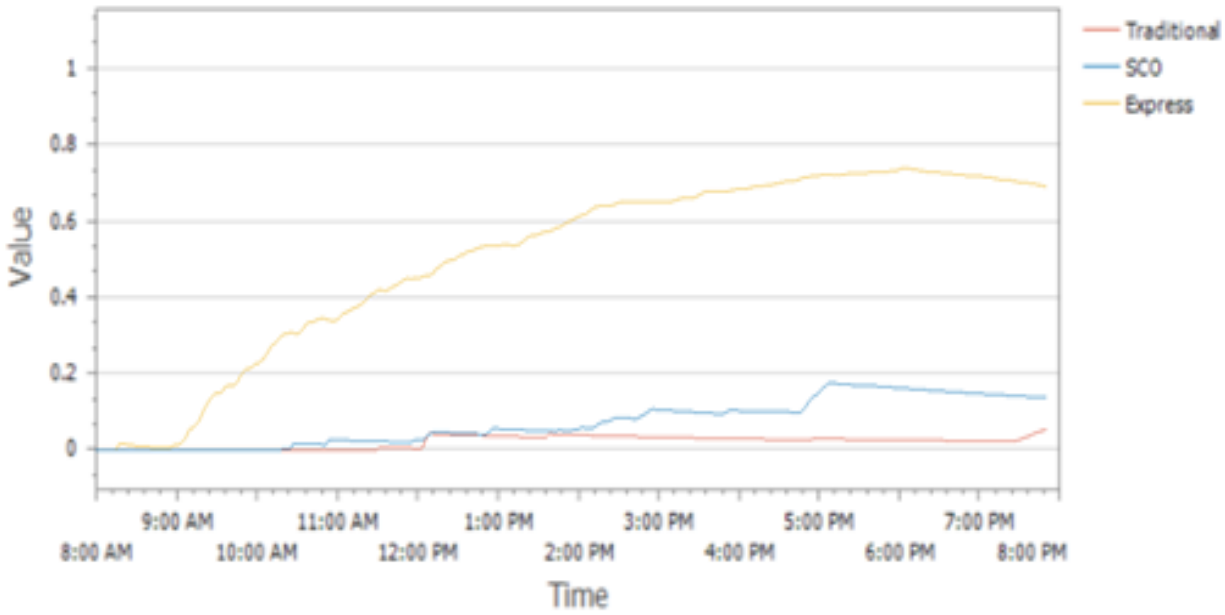

Figure 3.14 : Average number in queue

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Average Machine Utilization

All machines were sufficiently utilized. Given utilization rates for all machines remained under 50% at any given time, the number of each machine is adequate to handle peak demand. The Traditional Lane utilization schedule, determines the number of Traditional Lanes to open during different time periods. *Figure 3.15* shows the average utilization of machines.

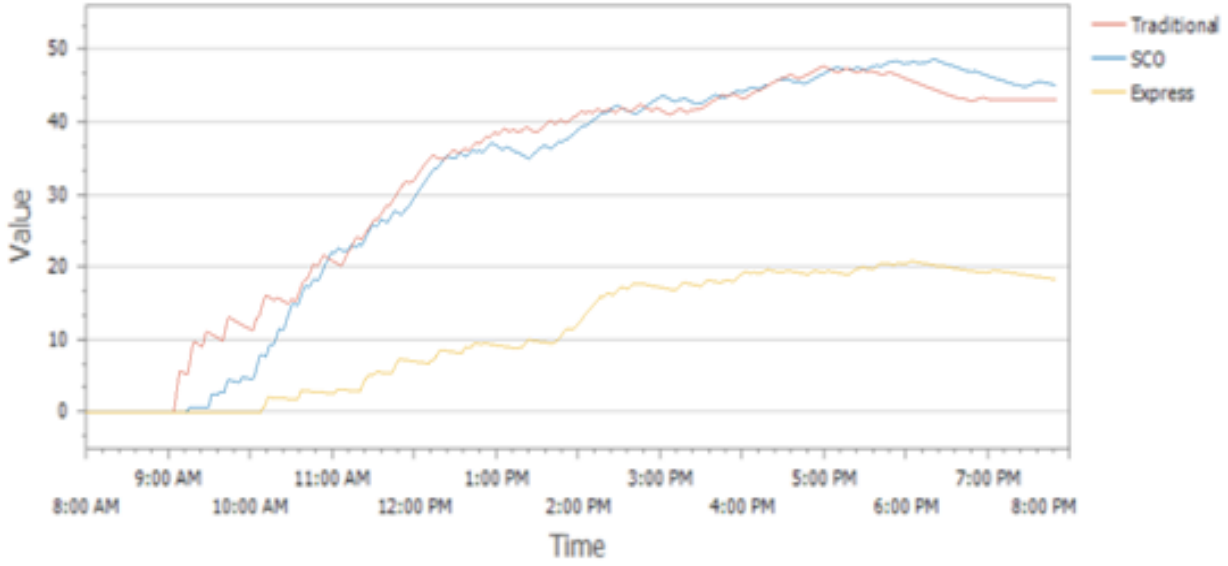

Figure 3.15 : Average machine utilization

When comparing the Phase I model to the current store layout, significant improvements are evident. Both the average wait times for Traditional Lanes and SCO Output Belt machines dropped significantly, as well as the average number of shoppers in the queue. The number in the queue for Traditional Lanes and SCO Output Belt machines changed from about one person in the queue to almost zero at any given time. No data was available for the current wait time and number in the queue for SCO Express machines, so only the simulation results are provided. *Table 3.16* and *Table 3.17* display the current model values and results of the simulation for wait time and shoppers in queue. *Figure 3.18* displays the percent reductions between the current and proposed models.

	Average Wait (seconds)	**Average Number in Queue**
Traditional Lane	156	.9912
SCO Output Belt	137	.9689
SCO Express		

Table 3.16: Current layout values

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	Average Wait (seconds)	Average Number in Queue	Average Machine Utilization
Traditional Lane	13.75	.054	46.3%
SCO Output Belt	30.55	.11	44.6%
SCO Express	13.86	.68	37.4%

Table 3.17: Results of Phase I simulation

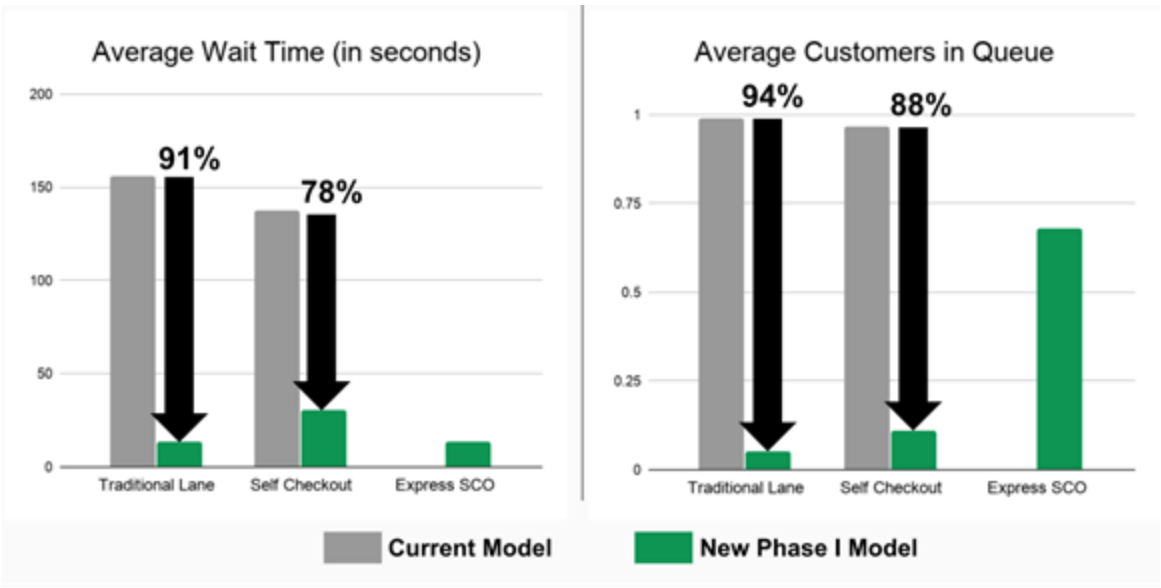

Figure 3.18 : Percent reductions comparing Current and New Phase I Model

Cost Analysis

The purpose of the cost analysis is for Toshiba to be able to present metrics to market retailers displaying the cost of implementation for their specific store. The costs defined in this model are specific to the Phase I solution.

Implementation Quantities and Costs

The implementation of Phase I requires new equipment to accommodate the change in number of checkout machines as well as the new security measures added to the checkout area. 4 SCO Output Belt and 6 SCO Express machines need to be purchased; the rest of the machines in the layout will be reused from what is currently in the store.

For the new security measures, cameras will be purchased for each machine and monitors will be purchased for each SCO system, totaling to 20 cameras and 15 monitors. For exit and entrance gate systems, 9 entrance and exit gates will be purchased. The railing that structures the pods is sold in 8 foot lengths, totalling 22 railing lengths to encompass the checkout area.

Table 3.19 below is a comprehensive list of the costs of implementation. Refer to *Table A.2.16* in the Appendix for sources for these products.

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Phase I Implementation Cost to Retailer				
Machines	**Quantity**	**Cost / Unit**	**Total Cost**	**Note**
SCO Express	6	$12,000	$72,000	-
SCO	4	$15,000	$60,000	-
Traditional	0	$0	$0	-
			$132,000	
Gates and Railing	**Quantity**	**Cost / Unit**	**Total Cost**	**Note**
Entrance Gate	3	$15,000	$45,000	-
Exit Gates	6	$15,000	$90,000	-
Railing	21.375	$95	$2,031	Quantity in 8' lengths
			$137,031	
Visual Security	**Quantity**	**Cost / Unit**	**Total Cost**	**Note**
Cameras	20	$300	$6,000	-
Monitors	15	$90	$1,350	-
			$7,350	
			GRAND TOTAL	
			$276,381	

Table 3.19 : Comprehensive Cost Analysis

Profit to Toshiba

The Self Checkout machines used in the final solution are sold through Toshiba, therefore, the profit to Toshiba is the increase in Self Checkout systems. Toshiba would profit $132,000 in the cost of this implementation. In Phase II, Toshiba would benefit from partnering with a new company as their system proves successful and the partnering company saw profit. As far as redeployment of resources, this would fall in the hands of the stores.

Cost Avoidance

Cost avoidance was a large consideration in making the final design. The focus on loss prevention is a large selling point to retailers, making it a key component of the solution for Toshiba. According to a study performed by Everseen Technologies, 1.76% of all customer transactions have errors, where 96% of those errors were caused by non-scanned items. For every 1000 customer transactions that are processed, retailers lose an average of $197 at Self Checkout machines and $21 at Traditional Lanes. By investing in a better security system with the Phase I and Phase II solutions, retail stores will improve loss prevention thereby reducing overall shrinkage costs.

Risks of Implementation

Based on the positive results of the VOC conducted for feedback on the proposed Phase I changes, there are no risks to implementation from shoppers. The primary risks stem from Toshiba's retail customers, club stores, as the monetary benefits of implementation cannot be quantified. The assumed increase in arrival rate post-implementation cannot be predicted, therefore future throughput and profit values cannot be predicted either.

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Final Value Stream Maps

The following Traditional Lane and SCO machine VSMs, *Figure 3.20* and *3.21*, capture the final state of the checkout area if Phase I were to be implemented. These VSMs highlight the reduced queue times and number waiting, and they also show where a shopper would interact with employees and the entrance/exit gate technology.

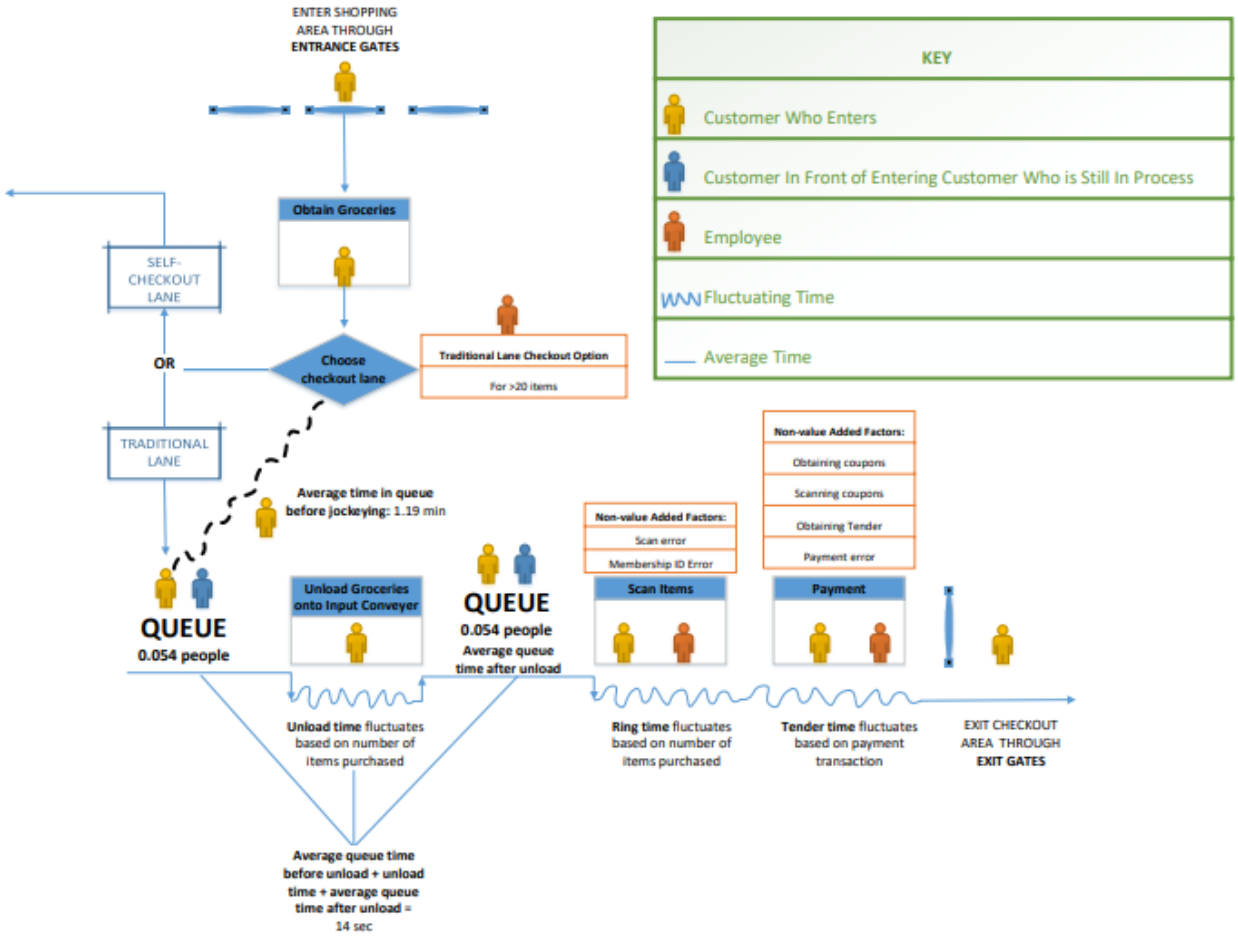

Figure 3.20: Final State Traditional Lane VSM

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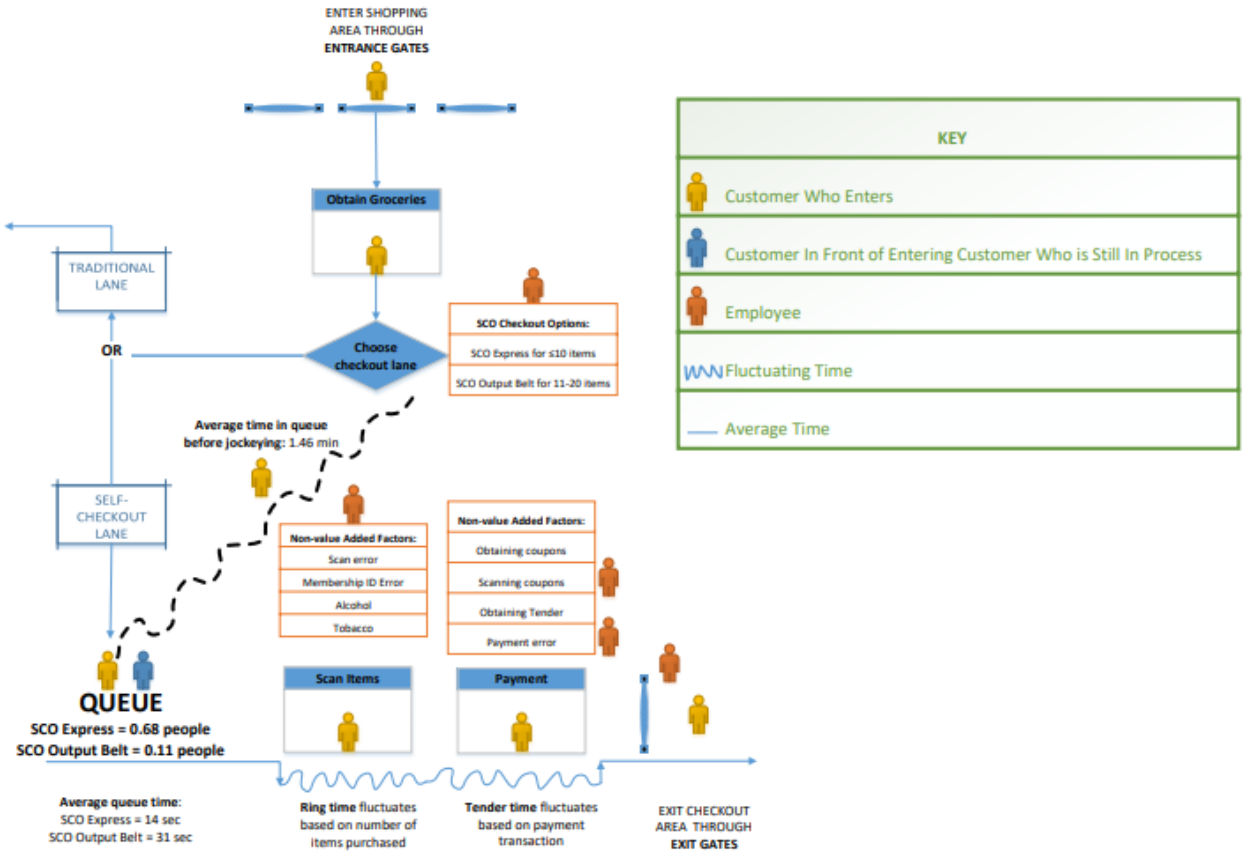

Figure 3.21: Final State SCO VSM

Phase II

Phase II is an extension of the Phase I solution that explores various technologies and provides recommendations to Toshiba for company partnerships. This solution requires more time to develop and gather the needed data for implementation, so it is defined by a two to three year implementation period. Phase II focuses on increasing accuracy for loss prevention methods, improved ease of checkout, and reducing employee interventions.

Research Summary

Through recommendations from Toshiba, nine different technologies were analyzed as potential solutions for the Phase II solution. Details on these technologies may be seen in the technology matrix shown in *Tables A.2.17* and *A.2.18* in the Appendix.

Partnership Recommendations

Based on the research summarized in the matrix and a close comparison of the different alternatives, three were chosen. These products were selected because they best improve loss

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prevention, reduce ring time (scan time), and reduce the number of employee interventions and could be integrated with the proposed Phase I solution.

The first proposed partnership is with Everseen that markets an artificial intelligence surveillance system. Everseen's solution involves surveillance cameras that monitor customers behaviors and automatically detects any type of irregular activity at the checkout process in real time then alerts store employees via their smart mobile device. Employees can address the issue immediately. Everseen's system can be integrated into the Phase I solution through the artificially intelligent cameras already in the layout.

The second proposed partnership is with Digimarc. Their product wraps an invisible ink version of the product's standard UPC barcode around the entire product, keeping the barcode invisible to the human eye. This allows for scanning items in any orientation, regardless of surface geometry. For weighted items, barcodes can be printed in stores. Digimarc products can be scanned 5 times faster than the current barcoding system and eliminates issues with misprints or damaged barcodes. Furthermore, implementing Digimarc's solution requires no Phase I layout changes, since their solution only applies to products within the store.

Lastly, integrating a mobile coupon app within the club store will eliminate coupon errors and inform shoppers of weekly specials prior to shopping. This will reduce the need for employee interventions due to coupon errors, decreasing the time it takes to complete checkout by reducing the overall tender time. Multiple club stores currently have apps for this purpose and could be integrated into the Phase I solution.

Phase II Projected Impacts

Since the goal of the Phase II solution is to ensure that Toshiba is fully aware of their partnership options for competing in future retail markets, the efficiency and economy of current and potential checkout technologies were compared to produce the final recommendations. Overall, our hopes is that the addition of these products will reduce overall shrinkage costs through improved loss prevention and improve customer experience through decreased ring (scan) and tender processing times per transaction.

Risks of Implementation

Due to the nature of Everseen's technology, customers will not be aware of the use of AI to monitor their actions. This leads to no implementation risks, as customer concerns will not be an issue. However, Digimarc has major risks, as many sectors are involved in its implementation. The invisible ink barcodes must be applied at the manufacturer, not in-store, so Toshiba would be required to convince the entire back end of the retail supply chain to also partner with Digimarc. It would no longer be a club store decision, but an entire market decision. Finally, risks of the coupon app would stem from pushback from older generations not comfortable with the use of smartphones in shopping.

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Final Assumptions

Assumptions regarding customer and market behavior, significance of data, and store focus still hold for the final solution. Shoppers are expected to remain loyal and return to the store, so they should be supportive of any implemented solution. The market will remain constant to determine peak times and demand. Toshiba agrees that the given and collected data is a sufficient representation of the overall market.

Additional assumptions for the final solution apply to the Phase I simulation and cost projections. In the simulation, it is assumed that queues will line up in front of each machine, except for SCO Express machines. For SCO Express machines, one queue will form in front of each set of four machines. Next, since our solution is designed for peak demand, which occurs at 4pm on Sundays, results from the simulation are assumed to accurately represent the standard demand for an entire Sunday. According to Toshiba, the probability of intervention occurrence is about 20 percent and is accounted for in the tender time for Phase I, and since Toshiba also said to assume machines do not break down, all machines have 100% availability when open. Lastly, the cost estimates were for general reference since Toshiba gave no budget to develop a solution off of and might vary depending on Toshiba's partnerships and special pricing in bulk purchases.

Final Constraints

The constraints to our final solution concern technology, patent laws, ADA regulations, and the limited time frame to complete the project:

1. **Technology:** Our main model is limited to technology that is within the means of currently available technology or is feasible to implement in the next generation.
2. **Patent Laws:** Any chosen technology or solution cannot violate patent laws. A verification with Toshiba's legal team and our own team's research will ensure that this is achieved.
3. **ADA Regulations:** The solution must meet all ADA requirements for shoppers with disabilities.
4. **Time:** Due to the breadth of the project and mid-way switch of focus from Kroger to club stores, a short, four-month completion time limits us to a solution proposal rather than full implementation of a final solution.

In the Phase I and Phase II solution, ADA regulations are met and no patent laws are violated by the implementation of machines and systems that are currently implemented in retail markets.

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4. Next Steps

Adaptation

To expand the market reach of the proposed Phase I and Phase II solutions, adaptations to the current solutions will accommodate to retail stores outside of club stores. These adaptations will concern the following:

1. The optimal number of machines
2. The inclusion of bagging areas to all machines
3. Accommodating for transactions that occur behind the entrance gates

Optimal Number of Machines

The data that determined the optimal number of machines for Phase I came from a single club store. To adapt to other club stores or retail stores, similar data would need to be gathered and analyzed to determine arrival rates and tender times. The same analysis methods would be used to determine the ideal number of machines for peak demand, and the same categorization by basket size would be implemented. As long as shoppers to each new store purchase similar basket sizes as at the wholesale store investigated for Phase I, which the sponsor claims is true, then there will be a similar 3:1 proportion of Self Checkout machines to Traditional Lanes regardless of store type.

Bagging Area Additions

Unlike wholesale stores, where shoppers purchase bulk items, grocery and other retail stores require machines with bagging areas. Since all of Toshiba's SCO systems offer a bagging area, machines identified in the Phase I solution would be quick to implement in a grocery store with the addition of bagging areas to each machine. Additionally, the quantity of items purchased at club stores is similar to that of grocery stores, which reinforces the recommendation of having more SCO machines than Traditional.

Entrance and Exit Gates

Since some stores, like grocery and retail stores, have other services (i.e. pharmacy, restaurant, etc.) located throughout the store that do not require a traditional checkout, the use of entrance and exit gates could potentially force shoppers to participate in multiple checkout processes. To address this concern, a fourth pod with an attendant and exit gate would be included beside the three checkout pods to allow shoppers not purchasing items to exit. This gate would be continuously manned to ensure shoppers are, in fact, not purchasing additional items. Shoppers could then bypass the checkout system and avoid its traffic. This fourth "exit-only" pod would allow entrance gates to operate as intended in the original Phase I solution.

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Toshiba: Moving Forward

The project sponsor's objective involves obtaining customer buy-in from wholesale and retail stores, and building partnerships with next-generation technology companies. Therefore, all analyses methods, VOC results, research and recommendations has been provided to Toshiba. The data analysis and VOC information is used to convince stores to increase the number of Self Checkout machines as well as improve the way employees interact with shoppers through the checkout process. The research and recommendations advises Toshiba on which technologies to pursue and how to change the flow of shoppers and employees in retail stores.

Following the defined Phase I and II timelines, the change to the number and types of machines in the checkout area, entrance/exit gate security system, and camera/monitor additions for Phase I could potentially be implemented in the next six months. Phase II partnership discussions would begin within a year, encouraging implementation in the next 2 to 3 years. The greatest advice to Toshiba is to slowly implement major changes to maintain positive customer experience throughout the process.

5. Conclusion

The final solution improves the club store checkout process through two phases. Phase I ensures shoppers have shorter wait times as compared to prior checkout systems. Reallocated employees assist shoppers in choosing the correct checkout method, focus on extra help for shoppers using SCOs, and target the monitoring of SCO areas. The surveillance cameras and monitors paired with the entrance and exit gate system provides security measures during and after checkout.

Phase II provides retailers with the next step in implementation following Phase I to further address loss prevention and to reduce the time to checkout. The compatibility of Phase I to II provides ease in implementation while slowly adapting shoppers to the changing systems.

Since improving customer experience is a key aspect of this project, addressing customer concerns and changing the current checkout model to implement changes is a priority. Customer throughput and volume of club memberships is expected to increase over time with the Phase I implementation. In conclusion, the newly developed design of the club store checkout system is a cost effective and easily adaptable implementation plan to the current checkout model while remaining versatile and adaptable to most retail settings.

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Appendices

1. Definitions and Acronyms

Audit: When an employee compares receipt and products for product security prior to customer exit.

Basket Size: Volume or number of items that can fit into given cart or basket.

Intervention: Situation where employee must assist with transaction in some way (ie. alcohol, coupons, etc.).

Item Losses/Shrinkage: Loss of store inventory that is unpaid for.

Jockeying: When a customer leaves a queue to go to a perceived shorter queue.

Loss Prevention: Security system that prevents any loss of inventory or theft in the store.

Self Checkout Express Machine: Self Checkout lane for shoppers with small basket sizes.

Self Checkout with Output Belt Machine: Self Checkout lane with a weighted conveyor belt. to place products onto after scanning and paying for items.

Ring Time: The time it takes from the first item scanned to last item scanned.

Tender Time: The time it takes when cashier hits “total” or customer hits “finish and pay” to when the payment is accepted.

Traditional/Manned Lane: Employee scans product off a conveyor belt. The employee prompts customer for payment, coupons, membership card.

Transaction Log (T-Log): A logged history of store transactions that include data such as transaction times, items purchased, tender type used, checkout system used, and various other checkout components.

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2. Additional Tables and Figures

Figure A.2.1: Project Gantt Chart

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TRADITIONAL: 1 Queue Feeds 1 Trad				
Person Waiting	From (min)	To (min)	Total Time in Queue (min)	Left to be Processed (P) or Switch to Another Queue (S) or Never Processed (N)
1	2.21	3.98	1.77	P
2	4.23	5.15	0.92	S
3	5.67	5.68	0.02	P
4	6.87	8.39	1.52	P
5	9.05	12.05	3.00	P
6	10.51	17.18	6.67	P
7	10.97	12.42	1.45	S
8	16.78	-	-	N

# of People Processed/min	0.33	count of P's /total time queue was observed
# of People Processed/hour	20.04	multiplied # of people processed per minute by 60 min/hr
# of People Who Jockeyed/min	0.13	count of S's/total time queue was observed
# of People Who Jockeyed/hour	8.02	multiplied # of people jockeyed per minute by 60 min/hr
Average Time in Queue for Those Who Were Processed (min)	2.60	average of total time in queue for P's
Average Time in Queue Before Jockeying (min)	1.19	average of total time in queue for S's

Table A.2.2: Process rate, frequency of jockeying and time before jockeying, and average queue time during 14.97 min queue observation time period for current Traditional Lanes

TRADITIONAL: 1 Queue Feeds 1 Trad			
Number Waiting	From (min)	To (min)	Total Time in Queue (min)
1	2.21	3.98	1.774333333
0	3.98	4.23	0
0	4.23	5.15	0
0	5.15	5.67	0
1	5.67	5.68	0.01666666667
0	5.68	6.87	0
1	6.87	8.39	1.521333333
0	8.39	9.05	0
1	9.05	10.51	1.456
2	10.51	10.97	0.9303333333
3	10.97	12.05	3.248
2	12.05	12.42	0.735
1	12.42	16.78	4.358666667
2	16.78	17.18	0.7966666667

Total Waiting Time (min)	14.837	sum of waiting time from 2.21 min to 17.18 min
Average Number in Queue (people)	0.991270071	total waiting time/total time queue was observed

Table A.2.3: Average number in queue during 14.97 min queue observation time period for current Traditional Lanes

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SELF-CHECKOUT (SCO): This Queue Fed into 1 SCO with Output Belt				
Person Waiting	From (min)	To (min)	Total Time in Queue (min)	Left to be Processed (P) or Switch to Another Queue (S) or Never Processed (N)
1	0.00	0.00	0.00	P
2	0.70	2.00	1.30	P
3	1.97	4.80	2.83	S
4	3.67	6.00	2.33	S
5	6.98	7.03	0.05	P
6	9.15	9.18	0.03	P
7	12.05	12.30	0.25	S
8	13.47	13.53	0.07	P
9	14.42	15.08	0.67	P
10	16.80	17.60	0.80	P
11	17.90	20.08	2.18	P
12	18.65	21.25	2.60	P
13	21.38	21.57	0.18	S
14	21.67	22.30	0.63	S
15	21.78	23.70	1.92	P
16	22.53	24.38	1.85	S
17	23.73	33.57	9.83	P
18	25.47	27.63	2.17	S
19	31.12	38.47	7.35	P
20	38.33	41.33	3.00	P

# of People Processed/min	0.31	count of P's /total time queue was observed
# of People Processed/hour	18.87	multiplied # of people processed per minute by 60 min/hr
# of People Who Jockeyed/min	0.17	count of S's/total time queue was observed
# of People Who Jockeyed/hour	10.16	multiplied # of people jockeyed per minute by 60 min/hr
Average Time in Queue for Those Who Were Processed (min)	2.29	average of total time in queue for P's
Average Time in Queue Before Jockeying (min)	1.46	average of total time in queue for S's

Table A.2.4: Process rate, frequency of jockeying and time before jockeying, and average queue time during 41.33 min queue observation time period for current SCO machines

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SELF-CHECKOUT (SCO): This Queue Fed into 1 SCO with Output Belt			
Number Waiting	From (min)	To (min)	Total Time in Queue (min)
1	0.00	0.00	0
0	0.00	0.70	0
1	0.70	1.97	1.266666667
2	1.97	2.00	0.06666666667
1	2.00	3.67	1.666666667
2	3.67	4.80	2.266666667
1	4.80	6.00	1.2
0	6.00	6.98	0
1	6.98	7.03	0.05
0	7.03	9.15	0
1	9.15	9.18	0.03333333333
0	9.18	12.05	0
1	12.05	12.30	0.25
0	12.30	13.47	0
1	13.47	13.53	0.06666666667
0	13.53	14.42	0
1	14.42	15.08	0.6666666667
0	15.08	16.80	0
1	16.80	17.60	0.8
0	17.60	17.90	0
1	17.90	18.65	0.75
2	18.65	20.08	2.866666667
1	20.08	21.25	1.166666667
0	21.25	21.38	0
1	21.38	21.57	0.1833333333
0	21.57	21.67	0
1	21.67	21.78	0.1166666667
2	21.78	22.30	1.033333333
1	22.30	22.53	0.2333333333
2	22.53	23.70	2.333333333
1	23.70	23.73	0.03333333333
2	23.73	24.38	1.3
1	24.38	25.47	1.083333333
2	25.47	27.63	4.333333333
1	27.63	31.12	3.483333333
2	31.12	33.57	4.9
1	33.57	38.33	4.766666667
2	38.33	38.47	0.2666666667
1	38.47	41.33	2.866666667
Total Waiting Time (min)	40.05		sum of waiting time from 0.00 min to 41.33 min
Average Number in Queue (people)	0.9689516129		total waiting time/total time queue was observed

Table A.2.5: Average number in queue during 41.33 min queue observation time period for current SCO machines

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OBSERVED AUDITS		
Audit No.	**Time (s)**	**Note**
1	6.58	
2	7.42	
3	10.1	
4	17.05	chatted excessively with shopper
5	17.88	chatted excessively with shopper
6	7.51	
7	7.42	
8	7.4	
9	8.12	
10	14.36	chatted excessively with shopper
11	10.45	
12	9.9	
13	8.67	
14	7.49	
15	5.2	
AVERAGE (s)	9.703333333	-
AVERAGE (min)	0.1617222222	-

Table A.2.6: Current audit times at observed club store

		Weekend Min		Weekend Max		Weekday Min					Weekday Max				
Period	**Time**	**Sat**	**Sun**	**Sat**	**Sun**	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
1	**9:00 AM**	147		147		62					102				
2	**10:00 AM**	211		293		116					235				
	11:00 AM														
	12:00 PM														
	1:00 PM														
	2:00 PM														
	3:00 PM														
3	**4:00 PM**	8		317		45					191				
	5:00 PM														
	6:00 PM														
	7:00 PM														
	8:00 PM														
	9:00 PM														

Table A.2.7: Min and max number of transactions for weekends and weekdays per time period

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Basket Size (No. of Items/Transaction)	% of Total Transactions with the Basket Size	Basket Size (No. of Items/Transaction)	% of Total Transactions with the Basket Size	Basket Size (No. of Items/Transaction)	% of Total Transactions with the Basket Size
1	7.01%	44	0.17%	102	0.01%
2	6.79%	45	0.17%	103	0.01%
3	6.15%	46	0.15%	105	0.01%
4	5.82%	47	0.16%	108	0.01%
5	5.35%	48	0.13%	113	0.01%
6	4.75%	49	0.11%	116	0.01%
8	4.73%	50	0.12%	153	0.01%
7	4.73%	51	0.14%		
9	4.24%	52	0.13%		
10	4.02%	53	0.09%		
11	3.74%	55	0.07%		
12	3.54%	56	0.09%		
13	3.34%	57	0.06%		
14	2.98%	58	0.06%		
15	2.92%	59	0.09%		
16	2.62%	60	0.04%		
17	2.35%	61	0.05%		
18	2.30%	62	0.05%		
19	1.79%	63	0.03%		
20	1.72%	64	0.04%		
21	1.71%	65	0.03%		
22	1.46%	66	0.02%		
23	1.30%	67	0.03%		
24	1.27%	68	0.01%		
25	1.26%	69	0.03%		
26	1.03%	71	0.02%		
27	0.97%	72	0.01%		
28	0.88%	73	0.02%		
29	0.75%	74	0.01%		
30	0.76%	75	0.01%		
31	0.73%	76	0.01%		
32	0.56%	77	0.01%		
33	0.55%	78	0.03%		
34	0.47%	81	0.01%		
35	0.43%	82	0.01%		
36	0.43%	83	0.01%		
37	0.41%	84	0.01%		
38	0.37%	85	0.03%		
39	0.28%	86	0.01%		
41	0.41%	88	0.01%		
42	0.17%	91	0.01%		
43	0.22%	100	0.01%		

Table A.2.8: Distribution of basket size out of 15,012 transactions from given data

Tender Type	% of Total Transactions Used	AVG SCO Tender Time (s)	AVG Traditional Tender Time (s)
Credit Cards	36.05%	73.53	56.41
Debit	23.34%	72.73	59.40
Other	18.27%	166.19	110.45
Cash	17.04%	61.55	40.83
Food Stamps	4.26%	80.39	64.99
Check	0.97%	55.00	78.96
EBTCash	0.05%	50.67	46.20
EWIC, online wic	0.01%	0.00	55.00

Table A.2.9: Distribution and time to process various tender types during checkout

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```
*Read in data;
DATA club101REG;
infile 'C:\Users\Anjali\Documents\NCSU\Fifth Year\Spring 2018\Senior Design\File Backups\CLUB_101_REGDATA.csv' dlm=',' firstobs=2;
        input TransactionNO CheckoutType $  RingTime TotalNumberofItems SCO_Bin;
RUN;

*View data;
PROC print data=club101REG;
RUN;

*Do reg model with interaction;
PROC glm data=club101REG;
        model RingTime=TotalNumberofItems SCO_Bin TotalNumberofItems*SCO_Bin  ;
RUN;
```

Code A.2.10: SAS Code that creates ring time regression model

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	67189377.1	22396459.0	9299.15	<.0001
Error	15008	36145889.3	2408.4		
Corrected Total	15011	103335266.4			

R-Square	Coeff Var	Root MSE	RingTime Mean
0.650208	55.86793	49.07587	87.84266

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TotalNumberofItems	1	61645210.77	61645210.77	25595.5	<.0001
SCO_Bin	1	3442007.40	3442007.40	1429.14	<.0001
TotalNumbero*SCO_Bin	1	2102158.91	2102158.91	872.83	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TotalNumberofItems	1	42339188.40	42339188.40	17579.5	<.0001
SCO_Bin	1	65311.90	65311.90	27.12	<.0001
TotalNumbero*SCO_Bin	1	2102158.91	2102158.91	872.83	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	11.69375170	0.73714834	15.86	<.0001
TotalNumberofItems	5.21337123	0.03932017	132.59	<.0001
SCO_Bin	6.59637465	1.26670998	5.21	<.0001
TotalNumbero*SCO_Bin	2.54360942	0.08609654	29.54	<.0001

Table A.2.11: SAS Output for ring time regression model (parameter coefficients in red box)

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SCO EXPRESS MACHINES (for 10 or less item basket sizes)				
Parameters	**Description**	**Units**	**Value**	**Comment**
Traditional (0) or SCO (1)			1	value of SCO_Bin in regression model
r_a_total	total arrival rate	total transactions/hour	317	Peak @ 16th hour, Sunday
r_a_SCOEx	arrival rate going to SCO Express machines	SCO Express machine transactions/hour	158.5	transactions going to SCO Express checkout based on ideal basket size of 10 or less items = 50% of total transactions
min basket size		items/transaction	1	
max basket size		items/transaction	10	
basket size frequency		%	0.5	
t_e_min	effective process time min	hour	0.02668199998	
t_e_max	effective process time max	hour	0.04607449998	
t_0_min	natural process time min	hour	0.02668199998	regression model for ring time + average of tender time across all tender types
t_0_max	natural process time max	hour	0.04607449998	regression model for ring time + average of tender time across all tender types
A	availability		1	
MTTF	mean time to failure	hour	0	
MTTR	mean time to repair	hour	0	

# of Machines			
m_min			5
m_max			8

Table A.2.12: Optimal number of SCO Express machines for 10 or less item basket sizes

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SCO OUTPUT BELT MACHINES (for 11-20 item basket sizes)				
Parameters	**Description**	**Units**	**Value**	**Comment**
Traditional (0) or SCO (1)			1	value of SCO_Bin in regression model
r_a_total	total arrival rate	total transactions/hour	317	Peak @ 16th hour, Sunday
r_a_SCO	arrival rate going to SCO Output Belt machines	SCO Output Belt machine transactions/hour	95.1	transactions going to SCO checkout based on ideal basket size 11-20 items = 30% of total transactions
min basket size		items/transaction	11	
max basket size		items/transaction	20	
basket size frequency		%	0.3	
t_e_min	effective process time min	hour	0.04822922221	
t_e_max	effective process time max	hour	0.06762172221	
t_0_min	natural process time min	hour	0.04822922221	regression model for ring time + average of tender time across all tender types
t_0_max	natural process time max	hour	0.06762172221	regression model for ring time + average of tender time across all tender types
A	availability		1	
MTTF	mean time to failure	hour	0	
MTTR	mean time to repair	hour	0	

# of Machines			
m_min		machines	5
m_max		machines	7

Table A.2.13: Optimal number of SCO Output Belt machines for basket sizes of 11-20 items

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TRADITIONAL (for >20 item basket sizes)				
Parameters	**Description**	**Units**	**Value**	**Comment**
Traditional (0) or SCO (1)			0	value of SCO_Bin in regression model
r_a_total	total arrival rate	total transactions/hour	317	Peak @ 16th hour, Sunday
r_a_Trad	arrival rate going to Traditional	traditional transactions/hour	63.4	transactions going to traditional checkout based on ideal basket size= 20% of total transactions
min basket size		items/transaction	21	
max basket size		items/transaction	37	max for 80% of the transactions having >20 items
basket size frequency		%	0.2	
t_e_min	effective process time min	hour	0.05144349543	
t_e_max	effective process time max	hour	0.07461238432	
t_0_min	natural process time min	hour	0.05144349543	regression model for ring time + average of tender time across all tender types
t_0_max	natural process time max	hour	0.07461238432	regression model for ring time + average of tender time across all tender types
A	availability		1	
MTTF	mean time to failure	hour	0	
MTTR	mean time to repair	hour	0	

# of Machines				
m_min		machines	4	
m_max		machines	5	

Table A.2.14: Optimal number of Traditional Lanes for basket sizes greater than 20 items

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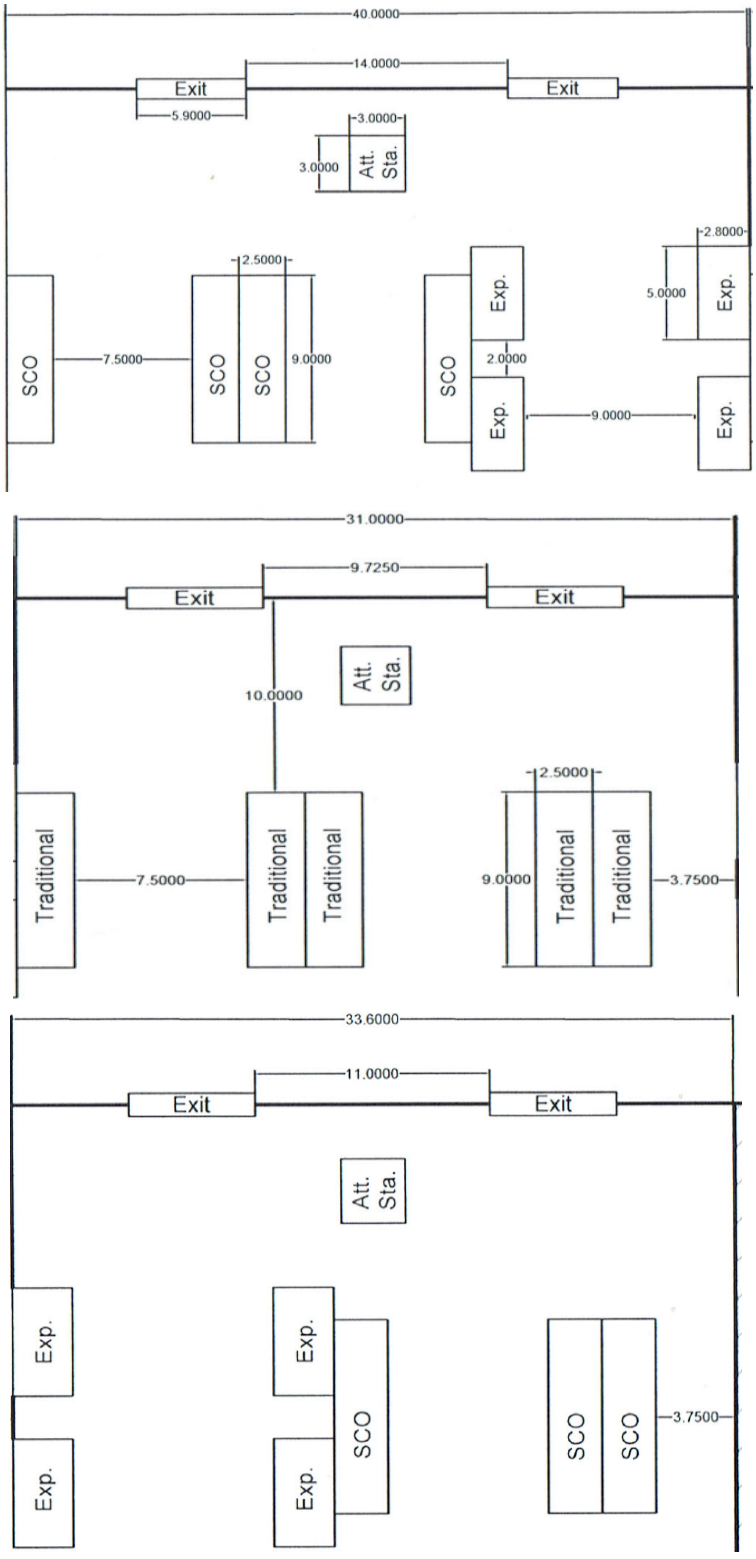

Figure A.2.15: Phase I layout with dimensions (in ft) by pod: SCO Pod 1 on top, then Traditional Pod, and SCO Pod 2 on the bottom

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Surveillance cameras	https://shop.light.house/product/lighthouse/
Display Monitors	https://www.amazon.com/TPEKKA-1024x768-Monitor-Computer-Security/dp/B01N35R5XD/ref=sr_1_12?s=electronics&ie=UTF8&qid=1523976286&sr=1-12&keywords=security+monitor+screen
Entrance and Exit Gates	https://www.wanzl.com/en_DE/industries/retail-dealers/products/turnstiles-and-swing-gates/egateR/
Railing	https://www.uline.com/Product/Detail/H-4978/Safety-Guards-Barriers/Safety-Railing-Steel-8?pricode=WA9792&gadtype=pla&id=H-4978&gclid=EAIaIQobChMI-JiF7OjM2gIVB8DICh2oIQ4FEAkYASABEgLVifD_BwE&gclsrc=aw.ds

Table A.2.16: Cost analysis product sources

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	Standard Cognition	ITAB EasyFlow	ITAB HyperFlow	ITAB Sesame Systems
Website	https://www.standardcognition.com/	https://itab.com/en/itab/checkout/self-checkouts/	https://itab.com/en/itab/checkout/self-checkouts/	https://itab.com/en/itab/checkout/self-checkouts/
Technology Focus	Autonomous Checkout	Item-identifying self-checkout system	Self-checkout systems for bulk/high inventory stores	Exit gate/Loss prevention system
Image				
Video Links	https://youtu.be/veS8TJwBAEs	https://www.youtube.com/watch?v=HF53HM3s1IA	https://www.youtube.com/watch?v=zB2I3ShAcQY	https://www.youtube.com/watch?v=HXGLFOu5xPI
How it Works	It detects item removal and what each item is. When a customer leaves the store, Standard Cognition automatically charges them and updates inventory. There are two apps provided in the service: one for shoppers, and one for store staff. Shopper App: enables customers to check into a store simply by opening the app. Then they just shop and leave. Store App: enables staff to know who's in the store, where they are and what they are buying. It also automatically detects shoppers, matches them to their basket, and processes payment.	Self-learning: builds a database for quicker/easier item identification; identified for what they are, not by barcodes; items loaded through input conveyor, go through enclosed scanning area then leave on exit conveyor before allowing for traditional payment methods	For "hypermarkets" with over 100,000 unique items; Self-learning: builds a database for quicker/easier item identification; identified for what they are, not by barcodes; items loaded through input conveyor, go through enclosed scanning area then leave on exit conveyor before allowing for traditional payment methods	Exit gate system integrated with EasyFlow/HyperFlow checkout; whole checkout area is gated so customers forced to leave through exit gate; ceiling sensor, motion-tracking system differentiates between employees and customers; customer is detected when entering checkout area, tracked as they walk to SCO, identified as "approved to exit" after completing transaction, and exit gate opens when they approach if IDed as "approved"
Specific Part of Checkout Process Involved	Scan and pay time	Self checkout hardware	Self checkout hardware	Exit/audit
Pros	• Eliminates the need for any checkout system as long as the customer is a member. • Re-enforces the need for membership • Would work best in a bulk purchasing setting, due to dispersed product and larger area consumed by each item	• Self learning • Scanning area is short so items don't "disappear" • No need to key or scan items • 24/7 availability	• Self learning; good for stores with bulk items • No need to key or scan item • 24/7 availability • Stores with up to 100,000 items	• Don't need to scan barcode receipt to exit (no audit) • All motion inside checkout area is "invisibly supervised" • alarms if people exit at same time or enter while someone exits • No limit for employees assisting customers • Supports up to 8 SCOs, ceiling sensor monitors up to 200 people and can have multiple exit gates in an area
Cons	• Currently only 98% accurate, according to Brandon Ogle (co-founder and engineer). • Still have not fully developed payment method, could be automatic payment through app if the designers choose. • Would have to manually edit the items overcharged or undercharged if the selection is incorrect, shrinkage.	• Must differentiate between similar items (i.e. different kinds of green apples) • Cannot accommodate large stores	• larger scanning area causes items to "disappear," which customers don't like	• Only one person can exit at a time (tough for parents with children or groups checking out together) • Works best when integrated with other ITAB systems (must purchase those as well)
Inefficiencies Addressed	Checkout Time	Ease of checkout; shrinkage	Ease of checkout; shrinkage	Shrinkage; audit
Impact to Customer Experience	Completely new experience	New experience; easier SCO process	New experience; easier SCO process	No need for audit; easy exit process
Impact to Loss Prevention	Only 98% accurate, but with potential to improve with artifical intelligence.	Minimizes shrinkage; identifies items with more than 99% certainty	Minimizes shrinkage; identifies items with more than 99% certainty	Backflow prevented; ensures payment
Barriers to Implementation (if applicable)	Need a lot of cameras	Entirely new system requiring all new machines, though it does look and feel like a normal checkout	Entirely new system requiring all new machines, though it does look and feel like a normal checkout	
Results Post Implementation (if applicable)	Monitor Accuracy	Reduces staffing by >50%; one staffer serves 2-8 machines	Reduces staffing by >50%; one staffer serves 2-3 machines	
Operational Definitions		MatchX technology: self learning system with 6 sensors & 9 classifiers with unique algorithms for identifying items	MatchX technology: self learning system with 6 sensors & 9 classifiers with unique algorithms for identifying items	Sesame: ceiling mounted tracking system allowing for barcode-free exit

Table A.2.17: Phase II Technology Matrix

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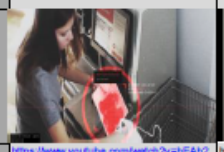
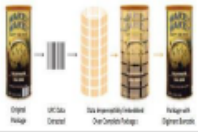
	Everseen	Aipoly	Digimarc	NCR	Club Membership Coupon App
Website	https://www.everseen.com/index.html	https://www.aipoly.com/	https://www.digimarc.com/products/digimarc-barcode	https://www.ncr.com/retail/food-drug-mass-merchandise/ncr-self-checkout	http://play.cpathelp.com/app/answers/detail/a_id/7386/kw/Add%20to%20Card
Technology Focus	Shrinkage, autonomous checkout	Autonomous checkout	Barcode reading software, reduce ring time, intervention during ring time (error during scan)	Self-Checkout Stations	Scanning Coupons
Image					
Video Links	https://www.youtube.com/watch?v=hEAb2Y0dAbo	https://www.youtube.com/watch?v=LGUp2bePrwE	https://www.youtube.com/watch?v=XoJFXEUI-s8	https://www.youtube.com/watch?v=D7Ad4_nX1uw	https://www.youtube.com/watch?v=14XxPQ0hI
How it Works	Integrates with security cameras that are overlat traditional lane registers/self checkout machines to automatically detect any type of irregular activity at the checkout process in real time then alerts store employees via their mobile device to address the issue immediately by sending a picture of the item that underwent an irregular activity.	Uses artificial intelligence to track in real time the movement of products and customers. In addition it provides updates on stock outs, sales and other data. It is an "Autonomous Store Platform". This means that you can simply pick up and item and leave the store. In addition it uses augmented reality and learns the preferences of the user. It uses cameras and "machine learning models" to track customers and products. These cameras can identify humans as separate entities by their clothing, body movements, faces, and hair color.	Takes standard UPC barcode and puts it all over product in ink invisible to the human eye. This allows for you to scan in checkout at any orientation and regardless of surface geometry. It also allows for easier mobile scanning and barcodes can be printed in store for weighted items.	NCR has three major areas of focus. First, it does SCO kiosks very similar to that of toshiba. With varying models depending of the space needed and hardware wanted. Second it has a software called ScanWatch, which will be detailed below and is what the video is on. Third, it has scan portal, which detailed below and is what the image is of.	The BJ's app allows you to search upcomming deals and add coupons directly onto your membership card. Allowing for a faster frictionless checkout.
Specific Part of Checkout Process Involved	Security Scanning	Paying and Scanning	Scanning	Security, Scanning, and Paying	
Pros	• Reduces shrinkage • Improves on-shelf availability • Optimizes inventory replacement: often disrupted by non-scans, fraud, errors • Improves customer service • Allows employee to intervene when customer unknowingly makes a mistake • Reduces stress on customers who struggle with self checkout systemsImproves overall store ops • Since retailers have access to POS data that's paired with information about loss incidents, they're able to determine all the various sources of loss and how they affect their operations as a whole	• Easy to Install, IOS • Proven it can be used effectively as Aipoly Vision (helps blind or color blind shop and interact) • Just point and you can gain information on the product • Can track people's movements and products in real time for product accountability • Can train the AI to recognize not stored products • AI adapts to your liking	• Scan any orientation. • Eliminates miss prints, damaged, or wrinkled UPC barcodes. • Can be printed in store for keyed items	• ScanWatch:Software that will visual verify keyed items. Helps solve problems like banana code • Scan Portal: Any orientation self scan, which is much faster. Also allows for next customer to start scanning as initial customer pays.	• Saves paper. • Saves time, coupons uploaded at once. • Can save, print, and share coupons. • No limit to the number of coupons. • Coupons are updated every week. • Coupons disappear when expire, so don't have to check all of them.
Cons	• Requires high volumes of in-store retail data for deep learning • Getting access to the data may be an issue: access to publicly available data • Is there a way for alerts to be filtered based on importance? • Difficult to assess similar looking items from each other via video: honeycrisp apple>>red delicious apple • Barcode switching: place barcode of cheap item on top of a more expensive item	• Aipoly is not ready for download yet, • Aipoly Vision is the only app out • Some people may feel that they have no privacy • Requires people to use their phones while shopping • Uses a lot of storage space (Aipoly Vision) • Not very accurate yet, can only recognize about 1000 objects (Aipoly Vision)	• Not specific to checkout process. • Needs work on manufacturer's end to print barcodes	• ScanPortal: Takes up a lot of floor space. Number and size of items limited.	• Cannot share coupons if multiple people use one membership. • Takes ten minutes to update so you cant do it right before checkout.
Inefficiencies Addressed	Shrinkage	Checkout time	Barcode scan problems	Keyed Items Theft	Tender time and number of interventions
Impact to Customer Experience	Little Impact	Revolutionizes Experience	Positive	Positive impact as easier to find key number and faster checkout	Positive impact as faster checkout
Impact to Loss Prevention	Positive Impact	Not currently accurate enough	Neutral	Positive impact	Neutral. Less loss of coupons
Barriers to Implementation (if applicable)	Cameras and Software	Store wide cameras. Need app	Manufacturer Printing	Floor space	Software
Results Post Implementation (if applicable)			Digimarc 2014 online video showed 51.91sec for 50 items. Whereas the current model takes 272.34 sec		
Operational Definitions		OWL: Underside of Shelf Eagle: up high camera			

Table A.2.18: Phase II Technology Matrix continued

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3. Sources

Please refer to *Table A.2.16* for sources used to estimate the cost of Phase I and to *Table A.2.17*, and *A.2.18* for sources on each researched technology for Phase II. All other sources of information for this project came from the team's own analyses or data provided by the sponsor, Toshiba.

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