Vending Machine System Design for Webco Star Center Tube Division's Storeroom

Senior Design Project Report

Spring 2022

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Submitted in partial fulfillment of the requirements of the course, IEM 4913, Senior Design and the Baccalaureate degree requirements of the School of Industrial Engineering and Management at Oklahoma State University

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Executive Summary

Webco is one of North America's leading manufacturers of precision welded tubing, producing carbon, stainless and specialty steel, nickel, titanium, and other alloy tube products for a variety of applications. Webco's Star Center Tube facility was opened in Sand Springs, Oklahoma in May 2012. Built specially to accommodate Webco's machinery and tube manufacturing process, this facility has a unique, spread-out footprint. As such, travel times for employees traversing the facility are significant. Each position in the assembly line requires a specific set of exhaustible materials required for the manufacturing process. When employees leave their posts to retrieve those standard, everyday materials and equipment, production is hampered.

By exploring a custom vending machine system to dispense this equipment, our team hopes to eliminate much of the lost productivity that this facility is currently experiencing. Within Webco, the Mechanical, Repair, and Operations (MRO) unit is working towards an automated storeroom system. Manual cycle counts and 24/7 staffing requirements mean the current system is costly in terms of labor. Part of this Webco automation initiative involves placing vending machine kiosks throughout the plant floor to distribute inventory items as needed for production. The team has prepared an optimization model to generate several alternative solutions. They vary in location, number of machines, and the items stocked in each machine. The team conducted a cost-benefit analysis of these alternatives to make a final recommendation for the optimal storage solution.

The Senior Design Team (SDT) began by obtaining data from the facility through on-site discovery and given datasets. Afterward, SDT began identifying items within given data to conduct data analysis and pertinent calculations. This "cleaning" phase allowed SDT to stay within the scope of the project when beginning to build an optimization model. After this discovery phase, Pareto analysis was used to demonstrate the diminishing returns of including more items in the proposed kiosks.

After the discovery phase, SDT used OpenSolver optimization software to create and solve a model that assigned kiosks to locations, and parts to kiosks, based on savings potential data. The model then assigned the kiosk to different candidate locations inputted in the model. After analyzing the results of the model, the senior design team created 5 different alternatives to analyze: One kiosk solution, two kiosk solutions, three kiosk solutions, a "do-nothing" solution, and a low-security alternative. Each solution was evaluated against multiple criteria influenced by both Webco and IEM faculty.

After evaluation, SDT recommended Webco SCT implement the 2-kiosk solution to best accommodate their needs and vision for a best-in-class solution. This solution comes with a four-phase implementation plan. This plan outlines everything from procurement to final implementation and stocking. This solution provides SCT with a variety of benefits including operating efficiency, culture improvements, and a blueprint to reference for future expansion of this project in the event of an expanded facility. All in all, the SDT collected data to analyze the problem and used that data to provide solution alternatives to the client along with an official recommendation and implementation plan.

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1.0 Introduction

Oklahoma State University's Industrial Engineering and Management (IEM) Program offers a unique way to equip students with professional experience before graduation. By requiring all students to complete a Senior Design course, students are able to immerse themselves in the industry by virtue of small consulting projects. The objective of this endeavor is to take and apply principles taught in the classroom and apply those principles in innovative ways to a company's problems. In this case, the team applied their knowledge and skills to analyze the feasibility of implementing a vending machine system in a large Webco production facility. Throughout the spring semester, the team worked hand-in-hand with Webco management, IEM faculty, and IEM alumni to analyze the problem, generate solutions, and evaluate alternatives. The culmination of that work can be found in this report detailing the project's results and solutions.

1.1 Background Information

Webco is North America's premier provider of innovative tubing solutions, founded in 1969 by Bill Weber. Since then, Webco's footprint has expanded all the way from Texas to Pennsylvania. In May 2012, Weber opened the Star Center Tube Manufacturing facility in Sand Springs, OK, which is home to over 1000 employees, seven manufacturing plants, and two distribution centers. Star Center Tube (SCT) manufactures a plethora of different product types, including carbon, stainless steel, nickel, and other alloy products for a variety of applications. Products from SCT can be seen in the agriculture, automobile, oil, and gas industries across the country. In addition to the extensive supply of welded tubular products, Webco also offers cold drawn carbon and alloy seamless and welded products.

1.2 Current State Observations

Currently, SCT consists of various Work Stations that require a different set of exhaustible materials for maintenance repair and operations (MRO). These materials are vital for line functionality and faulty items must be replaced before production is continued. As it stands, these items are stored in a centralized storeroom at SCT which logs over 3,000 transactions a month. Specifically, these items range from small items (batteries, gloves, etc.) to larger items (grippers and blades). Due to the large footprint of the facility, some Work Stations are extremely far away from the storeroom. This translates to lost production time as a line worker must halt production to withdraw to the storeroom and acquire any necessary materials. Furthermore, due to the nature and frequency of visits, the storeroom must be constantly staffed to monitor transactions during operating hours, which is generally 24/7.

Webco MRO is moving toward an automated storeroom system. Cycle counts are completed manually, which is a very time-consuming process. MRO's vision is to develop fully automated storerooms that would not require a 24/7 attendant. The benefits of this would include, but are not limited to, cycle count and inventory accuracy benefits. As part of the automated storeroom vision, MRO plans to use kiosks in the plant to distribute inventory items needed for production.

The Senior Design Team (SDT) was engaged to develop a kiosks solution for the SCT Cold Draw Process that minimizes the cost of employees traveling to the storeroom to obtain the necessary items. This project is applicable to five Work Stations, made up of three "pointers" and two "drawbenches".

1.3 Problem Statement and Objective

Webco is concerned by the amount of wasted time and equipment down time at SCT. This is caused by a lack of readily available equipment and parts near work stations. The objective of this project is to

develop an efficient, best-in-class vending machine system to distribute items to employees. Consideration was given to type of kiosks, location, and items to be stocked in each kiosk.

SDT gauged solution effectiveness through consideration of economic metrics, along with a bevy of qualitative characteristics which are described further in section 4.1 “Evaluation Criteria”. The economic metrics were determined by considering line efficiency and savings through reduced downtime to determine overall money saved. These can be considered as a proxy measure of downtime.

2.0 Current State Analysis

2.1 Data Collection Methods

To determine the current state of the work stations in terms of item utilization data, two methods of data acquisition were utilized. The first method was contacting the SCT storeroom manager to procure raw transactional data (with appropriate permission from Webco). This data outlined a wide range of attributes and statistics for each item including transactional data, item classification, cost per item, and more. The second method of data acquisition came by virtue of site visits. SDT tabulated the physical sizes of each item in the store relevant to the work stations considered, as well as receiving downtime coefficients, activity rates, and more from SCT management. The combination of these methods gave our team all the data necessary to develop our solutions and alternatives.

2.1.1 Data Cleaning

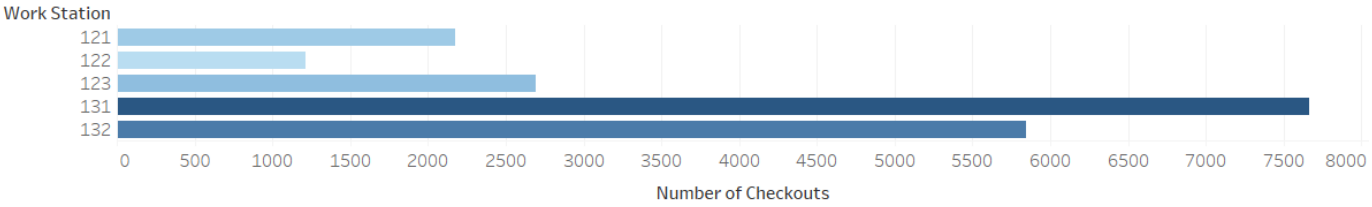
Once all data was collected, SDT "cleaned" the data by trimming the data from all storeroom SKUs to only those products needed by the relevant work stations (121,122,123,131,132). After making this cut, our team then cross-referenced the new data set with current workers and supervisors to make cuts based on a variety of reasons. The surveyed employees, using prior knowledge and experience, were able to judge the remaining items first by the feasibility of placement in a potential vending machine kiosk. For example, a "5-gallon drum of oil" was cut from the data set because it could not realistically be placed in a kiosk due to its enormous size. Another reason supervisors cut some SKUs was based on project scope. Because SDT was not tasked with strategically placing safety units in the kiosks, these items were cut from the list to ensure only MRO items were placed in the kiosks. In addition, irrelevant item characteristics, such as per unit price, were removed from the data set. This allowed for a clear, concise collection of data that all further analysis could reference.

2.1.2 Item Properties

While there were initially 267 distinct items included in our data, only 67 items were determined as eligible candidates for placement in kiosks outside the SCT storeroom after "cleaning". Specifically, these items have the appropriate sizes for storing in the kiosk and are checked out a significant number of times to possibly affect production efficiency. All SKUs are commercially purchased items that are regularly used by Webco's production staff. These items are also tagged by the storeroom in order to show which Work Station is checking out which item in the facility.

2.2 Analysis of item Utilization by Work Station

A closer look at the data indicates that some work stations use more items than others based on yearly usage. Based on the figure below, the team was able to determine which work stations need the most items. This information showcases where the "need" resides in the facility. This is another important



1. Checkouts by Work Station

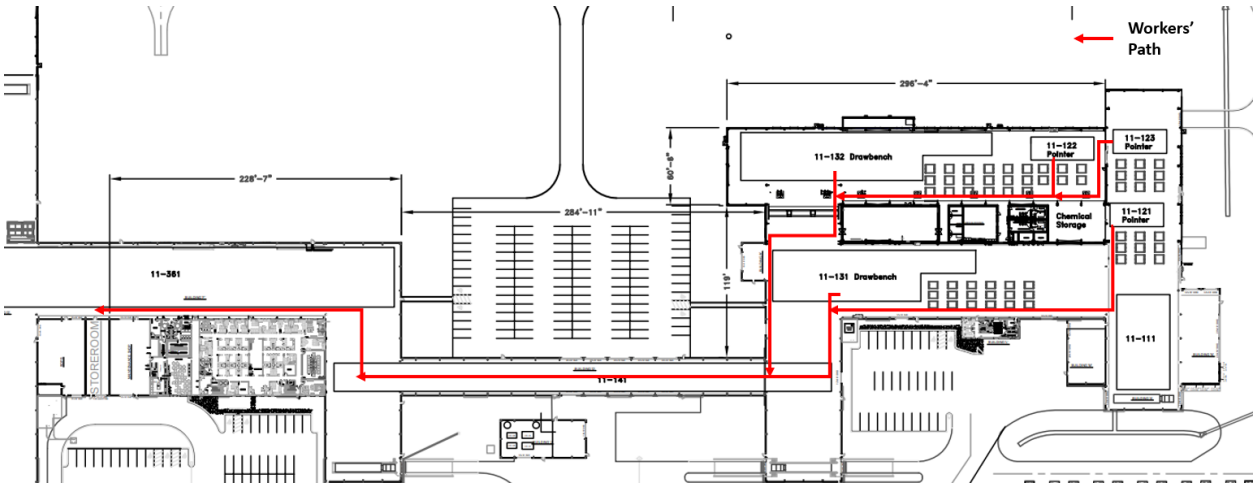
consideration in the analysis of possible locations for a kiosk. Work Station 131 checks out the most items on a yearly basis from the storeroom, while work station 122 checks out the least.

2.3 Problem Observations

After analyzing the problem further, SDT compiled a list of observations concerning the nature and side effects of the root problem. When a worker leaves his station to retrieve a part from a storeroom, problems arise that hinder efficiency and negatively affect inventory. A couple key attributes stood out as cause for concern.

2.3.1. Downtime

A variety of parts can cause downtime for any of the three pointers or drawbenches. These parts range from batteries to saw blades. Regardless of the individual item, an entire work station can be brought to a halt simply because a worker must traverse the expansive facility to procure an item from the storeroom. Figure *? below shows the routes that must be travelled to reach the storeroom from the relevant work stations.



2. Worker Path

This downtime is a major concern for Webco as the downtime begins to stack up over time, leading to wasted potential productivity time. SCT also believes there is an opportunity to expand production capacity by capitalizing on this reduced downtime.

2.3.2 Loss of Inventory

Another concern noted by SDT when observing the problem involved SCT's high prioritization of inventory management. Security is a major topic of concern as some items are of higher value than others. During interviews with the storeroom manger, it was noted that some products are checked out from the storeroom but are not logged as used in the line. This could be for a variety of reasons, but the main issue is that some items go missing from the storeroom without being logged. Webco emphasized that SDT account for security concerns when creating solution alternatives. By reducing the number of items that go missing, SCT can ensure that each inventory item is effectively used to provide value to the company.

3.0 Project Methodology

The general breakdown of our project methodology is shown below and discussed in further detail in subsequent sections.

- Phase 1: Discovery
  - Finalize Scope and Problem Statement
  - Clean Data
- Phase 2: Analysis/Optimization
  - Ranking
  - Model Creation
  - Determine Solutions
- Phase 3: Model Assessment
  - Feasibility Assessment
  - Update the Model with Additional Information
- Phase 4: Generate Alternatives
  - Determine Several Solutions
  - Develop Lists of Benefits and Drawbacks for Each Solution.
- Phase 5: Final Recommendation

3.1 Data Analysis

SDT began by identifying each of the relevant items within the given data. After sorting them in alphabetical order, SDT assigned item numbers in ascending order. There were 67 distinct items eligible to be placed in the kiosk, so these numbers ranged from 1 to 67. For example, the item ".255 Swage Pointing Die Shim, 4 each" was designated item number 1 because it came first alphabetically, and the item "Utility Knife, Self-Retracting" was designated item number 67 because it came last alphabetically.

Next, SDT tabulated the number of checkouts for each individual item number at each Work Station (excluding returns). The relevant work stations are 121, 122, and 123 (pointers) along with 131 and 132 (drawbenches). For illustration, a truncated table of the data at this stage is shown below.

Table 1 Example Checkouts by Work Station

Item Number	Total Checkouts	WS 121	WS 122	WS 123	WS 131	WS 132
1	3	0	0	2	0	1
2	4	0	0	0	1	3
3	1	0	0	0	0	1
4	4	0	0	0	1	3
5	1	0	0	0	0	1

3.1.1 Savings Potential

While this data allowed SDT to view high-checkout items both by total and work station, it did not capture the full picture. The client informed SDT that pointer Work Stations (121, 122, 123) cost about $175 to run hourly, while drawbench Work Stations (131, 132) cost about $725 hourly to operate. Therefore, down time on drawbenches is more costly to the client than down time on pointers. In addition, when some items are missing the Work Stations will immediately halt production. However, some less important items will only halt production in some cases. SDT sought to define a metric that could account for these discrepancies and rank items according to that metric before moving forward. Table (#*) shows an example of these calculations for Work Station 132.

Table 2 Savings Potential Table

Item #	WS 132 Checkouts	Downtime Coefficient	Trip Time (Hrs)	Operating Cost ($/Hr.)	Savings Potential ($/Yr.)
1	1	0.2	0.25	$725.00	**$36.25**
2	3	0.2	0.25	$725.00	**$108.75**
3	1	1	0.25	$725.00	**$181.25**
4	3	1	0.25	$725.00	**$543.75**
5	1	1	0.25	$725.00	**$181.25**

By deriving the following equations, SDT was able to calculate a general figure for potential annual savings for each item and Work Station, as shown below.

For a Work Station i belonging to the set {121,122,123,131,132} and an item j belonging to the set {1,2,3,....,267}:

$$(\text{Savings Potential})_{ij} = (\#\text{ of Checkouts})_{ij} * (\text{Downtime Coefficient})_{j} * (\text{Trip Time}) * (\text{Operating Cost})_{i}$$

(Equation 1)

For each item, j, $\sum_i (\text{Savings Potential})_{ij} = (\text{Total Savings Potential})_j$

(Equation 2)

Each term of the equations is explained in further detail below.

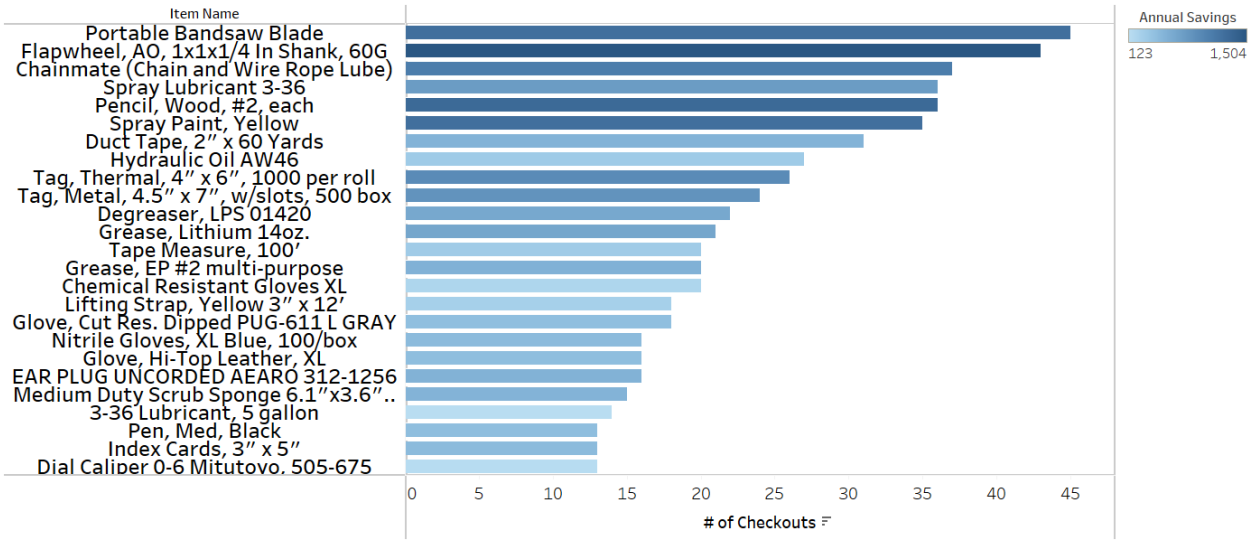
The number of checkouts term is the annualized number of times that an item was checked out from the storeroom in the data provided to SDT by the client.

The downtime coefficient is a number provided to SDT by the client that captures the portion of time that a Work Station is down when workers are retrieving a particular item. For a critical item, such as batteries, this value is 1. This means that when an employee needs batteries and checks them out from the storeroom, their Work Station is down for the entirety of the trip. For a less important item, such as duct tape, the downtime coefficient is 0.2. This means that when employees are retrieving duct tape their Work Station is down about 20% of the time, on average.

The trip time is an estimate of how long it takes for an employee to travel to the storeroom, retrieve an item, and walk back. It has units of hours. SDT used a constant value of 0.25 hours for this term. While there is some variability in travel time based on employee, item, and Work Station, SDT determined the effects to be negligible in the long run. In addition, it would be a very tedious process to account for these variations.

Finally, the operating cost is the hourly cost of operating each Work Station. As mentioned earlier, this value is significantly higher for drawbenches than pointers.

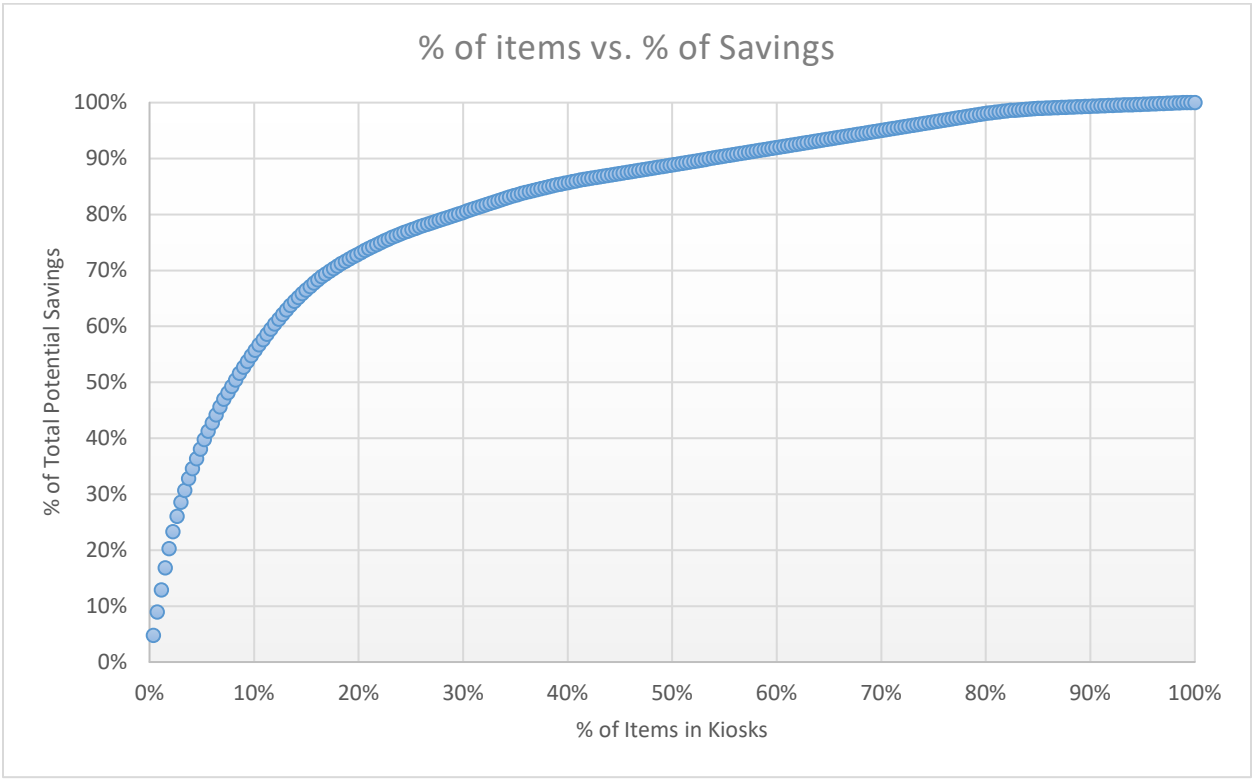
Multiplying all of these terms together gave SDT an estimate of an item's savings potential on an annual basis. While this model neglects the new travel time associated with the kiosk, it shows the potential savings for each item, which SDT will seek to capture as much of as possible. This provided SDT with a baseline for potential savings, and an understanding of the importance of placing each item in a vending machine near a Work Station. Using this data along with checkout number, SDT created a bar chart showing the number of checkouts for high value items with color density depicting increasing savings potential.



3. Savings Potential of Frequently Used Items

3.1.2 Pareto Analysis

SDT also took the cumulative values of each item and used Pareto analysis to communicate the importance of items graphically as shown below.

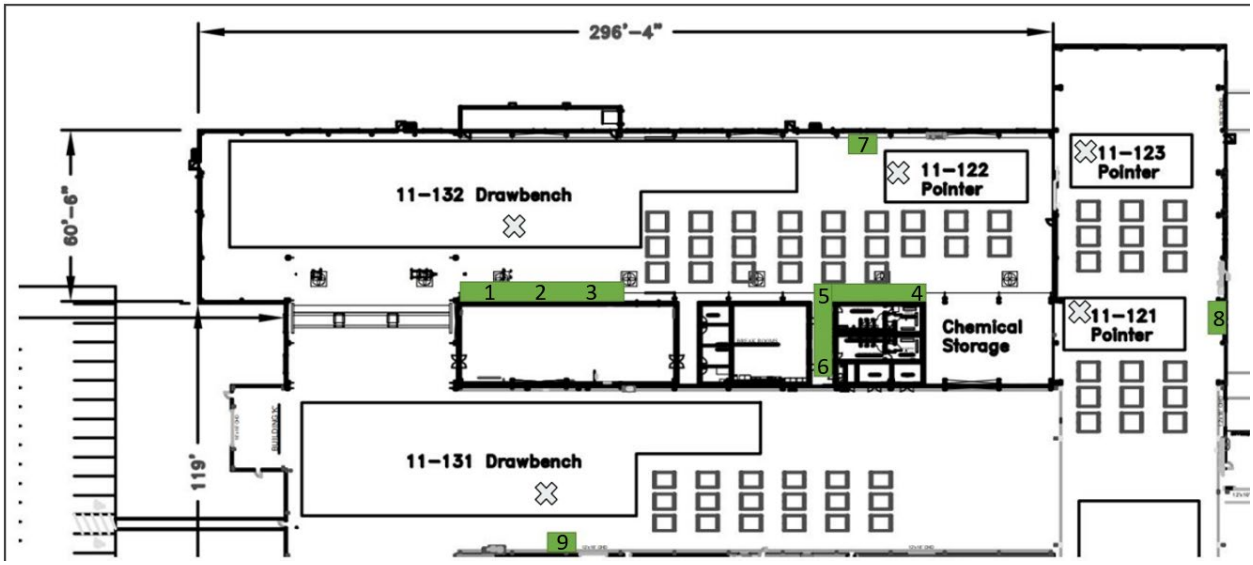


4. Pareto Chart of Items vs Savings Potential

This clearly demonstrates the diminishing returns of including more items in the kiosks.

3.1.3 Narrowing Scope

After analyzing the facility and talking with SCT management, SDT compiled a list of candidate locations (CL's) to potentially place a kiosk. The rationale for this decision came from the fact that each kiosk must be placed against a wall. This restriction was given so that each kiosk has access to power and does not impede workers or machinery moving through the facility. Therefore, the locations in FIGURE WHATEVER were chosen based on their access to power and location adjacent to a wall. Additionally, some locations were not chosen despite access to power because other machinery, storage, or other item was positioned in that location. For contiguous available areas, such as CL's 1-3 and 4-6, locations were placed 20 feet apart.



5. Candidate Locations

3.2 Vending Machine Selection

Upon request, SDT was provided with a product catalogue from Webco's preferred vendor, CribMaster. The catalogue contained many different options. SDT knew that an optimization model that chooses a vending machine from the dozens of options would not be feasible. SDT consulted with Webco about their needs and narrowed the possible vending machine options to two alternatives, which could be mixed and matched as needed. The ToolBox family of products was selected as it only vends one of each item per interaction, making it easier to keep track of which items are going where and control inventory. The ProLock with scales was also considered as it has individualized doors for each product and a scale on each shelf to keep track of the weight of product and sends an alert when it drops below a certain threshold.

Table 3 Example Item Attributes

Item Number	Item Name	Annual Savings Potential	Length (in)	Width (in)	Height (in)	Rectangular Volume (in^3)
60	Tag, Metal, 4.5" x 7", w/slots, 500 box	$ 870.00	5	6	8	240.00
61	Tag, Thermal, 4" x 6", 1000 per roll	$ 942.50	8	8	6	384.00
62	Tags, Thermal 6"X8" w/Sensors & Punch	$ 97.50	7.25	7.25	6.5	341.66
63	Tape Measure, 100'	$ 312.50	1	5	5	25.00
64	Tape Measure, 100', 3:1 gear ratio	$ 216.25	2	8	9	144.00
65	Thermal Transfer Ribbon, 102mm x 360m	$ 362.50	2.75	2.75	4	30.25

This dimension information allowed SDT to determine which items could fit in which type of machine. For the ToolBox option, SDT determined if each item could fit in single, double, or large helixes, or if the item could not fit in any of these options. For ProLock kiosks, SDT determined if the items would require one, two, or three lockers, or if the item could not fit at all. Further discussion of how this affected our optimization will follow in the 3.3.3 “Constraints”.

3.3 Optimization Model

Using this data in conjunction with our previous analysis allowed SDT to begin formulating a capacitated facility location optimization model. Optimizing the model several times with minor adjustments, SDT developed a set of solution alternatives. This set of solutions was then analyzed further and ranked in order of preference based on analysis of a variety of qualitative and quantitative considerations. Finally, SDT provided the client with our proposed solutions with appropriate documentation of our methodology.

3.3.1 Open Solver

Before the construction of the optimization model, the senior design team consulted with SCT to decide which optimization software to use that would best suit the needs of Webco. Currently, Webco exclusively uses Open Solver to handle any optimization problems at the facility. Because of this, SCT explicitly asked SDT to use Open Solver to generate alternatives. Open Solver is an open-source Excel add-in that allows excel users to solve linear or integer programming models using the COIN-OR CBC solver. While the default solver in Excel is not able to handle more than 100 constraints, Open Solver has no such limitations and thus can solve larger models. Open Solver is free to use and download. SDT then undertook the design in Open Solver in accordance with the requests from SCT.

3.3.1 Objective

To begin formulating the optimization model, SDT began by creating the objective function. As stated earlier, the objective of the created model was to minimize the total cost across all work stations. SCT explicitly dictated to SDT not to factor in opportunity costs within the model due to the uncertainty of figures in this regard. Each of the 67 items used in the model possesses a unique cost savings attribute based on if it were placed in one of ten candidate locations. For instance, one item (say a battery) may have more savings potential if it were placed closer to a work station that uses more of that item. The combined savings potential of all items based on candidate locations was then combined into a single table.

Table 4 Savings Potential by Candidate Location on a per Item Basis

Item #	CL1	CL2	CL3	CL4	CL5	CL6	CL7	CL8	CL9
1	$ 55.98	$ 56.22	$ 56.15	$ 55.41	$ 55.48	$ 55.14	$ 55.61	$ 54.73	$ 51.05
2	$ 135.51	$ 136.03	$ 135.62	$ 131.02	$ 131.81	$ 131.36	$ 130.60	$ 129.48	$ 125.75
3	$ 159.34	$ 159.81	$ 158.87	$ 149.26	$ 150.19	$ 149.26	$ 149.26	$ 147.38	$ 138.23
4	$ 616.76	$ 619.11	$ 617.23	$ 596.16	$ 599.87	$ 597.96	$ 594.27	$ 589.12	$ 574.22
5	$ 159.34	$ 159.81	$ 158.87	$ 149.26	$ 150.19	$ 149.26	$ 149.26	$ 147.38	$ 138.23
6	$ 138.74	$ 139.67	$ 140.61	$ 148.39	$ 149.29	$ 150.19	$ 146.50	$ 146.98	$ 159.52
7	$ 277.47	$ 279.35	$ 281.22	$ 296.77	$ 298.58	$ 300.39	$ 293.00	$ 293.96	$ 319.04
8	$ 318.68	$ 319.62	$ 317.75	$ 298.51	$ 300.39	$ 298.51	$ 298.51	$ 294.76	$ 276.47
9	$ 457.42	$ 459.29	$ 458.36	$ 446.90	$ 449.68	$ 448.71	$ 445.01	$ 441.74	$ 435.99
10	$ 138.74	$ 139.67	$ 140.61	$ 148.39	$ 149.29	$ 150.19	$ 146.50	$ 146.98	$ 159.52

The objective function was then formulated in excel by taking the sum of the savings potential of items chosen by the model. For instance, if the model chose candidate location 1 with all items, it would add all the numbers in the “CL1” column of the above table. This sum is negative in the objective function as savings potential can be thought of as negative costs. The model built was given the objective of minimizing costs by choosing the candidate locations, kiosks, and items that would extract the highest savings potential from items based on a set of constraints discussed in the next section.

3.3.2 Layout of the Model

The model layout was created by creating a matrix of binary variables with item on the y axis and candidate location on the x axis.

Table 5 Optimization Matrix

CL1	CL2	CL3	CL4	CL5	CL6	CL7	CL8	CL9
0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

In this case, a "0" would represent an item not included in a candidate location and a "1" would represent an item placed in a candidate location. The objective function was placed in a cell (using cell referencing) and used an equation that takes the sum product of the binary matrix and the savings matrix in table 5. Another matrix of binary variables was also inserted into the model that would show the type of kiosks selected. For instance, if a "1" was shown for the ProLock kiosk, the ProLock is the chosen machine type (per the model). Thus, the solution can be interpreting by selecting the all the items with a value of "1" and putting them in the type of kiosks dictated at the location in which column they reside.

3.3.3 Constraints

The objective function was then restricted based on the following constraints. First, the model considers first the number of kiosks inputted by the user. Using this information, the model will choose which items for the given number of kiosks. The next constraint is inserted into the model to ensure that the model picks only the number of kiosks inserted by the user. For instance, if the input was 1 kiosk, the model would not have "1" values in more than one column.

Table 6 Single Assignment Constraint

CL10	Kiosk Decision Variables		
0	ProLock		
0	ToolBox	Single Assignment Const	
0	1		0
0	2		0
0	3		0
0	4		0
0	5		0
0	6		0
0	7		0
0	8		0
0	9		0
0	10		0

Then, a capacity constraint was inserted into the model that dictated the max capacity for the machines. The ProLock has a max capacity of 24 lockers and the ToolBox has a capacity of 70 helixes. The model was tasked with determining which type of kiosk and how many of them should be placed in the facility based on the inputs from the user. If an item was chosen, it would then be multiplied by its size value and then added up. The total summation of all items size was then to fit within the size constrains shown below.

Table 7 Capacity Check

0	0	0	0	0	24	0	0	0	0	ProLock Capacity Check (<= 24)
0	0	0	0	0	40	0	0	0	0	ToolBox Capacity Check (<=70)

Another constraint was added to ensure that items were not placed in more than 1 candidate location. Lastly, a constraint was added to ensure that if the ToolBox kiosk was chosen, the items would fit correctly based on size constraints. The ToolBox kiosks consists of stacked rows of helixes. These helixes can either have a size of "2" or "1". Items of size 1 and items of size 2 must be consistent across each of the seven rows available in the ToolBox model. Ergo, the model must ensure items, based on their size, are chosen to fit on the same row. Furthermore, only 5 items of size 2 can make up a row where ten items of size 2 can fit on a row.

3.3.4 Inputs and Assumptions

Within the model, SDT imbedded several assumptions. Kiosk costs, walking speed of employees, checkout time for kiosks, hourly labor costs, and distances between WS's and CLs are all values that can be adjusted in our model. The results and recommendations in the following sections are based on these values from figure 6 and table 8.

Annualized ToolBox Cost	Annualized ProLock Cost
$ 12,000.00	$ 12,000.00
Walk Speed (MPH)	**Kiosk Interaction Time (min.)**
3	2
Labor Cost ($/Hr.)	
$ 18.00	

6 Inputs and Assumptions

Distance (Ft.)	CL1	CL2	CL3	CL4	CL5	CL6	CL7	CL8	CL9	CL 10
121	245	225	205	10	20	30	60	40	280	3920
122	240	220	200	85	65	85	45	125	285	3920
123	290	270	250	45	65	85	15	85	335	3920
131	480	460	440	275	255	235	315	305	25	3920
132	35	25	45	250	230	250	250	290	485	3920
Time (minutes)	CL1	CL2	CL3	CL4	CL5	CL6	CL7	CL8	CL9	CL10
121	2.9280	2.8523	2.7765	2.0379	2.0758	2.1136	2.2273	2.1515	3.0606	15.0000
122	2.9091	2.8333	2.7576	2.3220	2.2462	2.3220	2.1705	2.4735	3.0795	15.0000
123	3.0985	3.0227	2.9470	2.1705	2.2462	2.3220	2.0568	2.3220	3.2689	15.0000
131	3.8182	3.7424	3.6667	3.0417	2.9659	2.8902	3.1932	3.1553	2.0947	15.0000
132	2.1326	2.0947	2.1705	2.9470	2.8712	2.9470	2.9470	3.0985	3.8371	15.0000
Time Saved	CL1	CL2	CL3	CL4	CL5	CL6	CL7	CL8	CL9	CL10
121	12.0720	12.1477	12.2235	12.9621	12.9242	12.8864	12.7727	12.8485	11.9394	0.0000
122	12.0909	12.1667	12.2424	12.6780	12.7538	12.6780	12.8295	12.5265	11.9205	0.0000
123	11.9015	11.9773	12.0530	12.8295	12.7538	12.6780	12.9432	12.6780	11.7311	0.0000
131	11.1818	11.2576	11.3333	11.9583	12.0341	12.1098	11.8068	11.8447	12.9053	0.0000
132	12.8674	12.9053	12.8295	12.0530	12.1288	12.0530	12.0530	11.9015	11.1629	0.0000

Table 8 Parameters

However, SDT has provided the client with the flexibility to adjust these parameters as they see fit. All relevant values are calculated based on cell references, so any change in these assumptions will allow the client to produce alternate solutions that better match their assumptions.

4.0 Solution Alternatives

After ensuring the model ran according to the parameters while appropriately conforming to the constraints, SDT ran the model, and it generated the following solutions:

4.0.1 One Kiosk Solution

This solution suggests putting one ProLock vending machine at candidate location 9, near Work Station 131. The following 24 items in the table below would be stocked in the vending machine.

- Battery, AA Size
- Chainmate (Chain and Wire Rope Lube)
- Degreaser, LPS 01420
- Duct Tape, 2" x 60 Yards
- EAR PLUG UNCORDED AEARO 312-1256
- Flapwheel, AO, 1x1x1/4 In Shank, 60G
- Glove, Cut Res. Dipped PUG-611 L GRAY
- Glove, Hi-Top Leather, XL
- Grease, EP #2 multi-purpose
- Grease, Lithium 14oz.
- Index Cards, 3" x 5"
- Medium Duty Scrub Sponge 6.1"x3.6"x0.7"
- Nitrile Gloves, XL Blue, 100/box
- Paint marker, White
- Pen, Med, Black
- Pencil, Wood, #2, each

- Pipe Wrench, 18", Cast Iron
- Portable Bandsaw Blade
- Spray Lubricant 3-36
- Spray Paint, Yellow
- Tag, Metal, 4.5" x 7", w/slots, 500 box
- Tag, Thermal, 4" x 6", 1000 per roll
- Tape Measure, 100'
- Thermal Transfer Ribbon, 102mm x 360m

This solution would save $16,456.40 annually and save an opportunity cost of 23.721 hours of production per year.

Objective function value: -$4,456.10

4.0.2 Two Kiosk Solution

This solution suggests placing a ToolBox kiosk at candidate location 5 near the restrooms and a ProLock kiosk at candidate location 9. The following 35 items in the table below would be placed in the ToolBox kiosk.

- .255 Swage Pointing Die Shim, 4 each
- 1" x 4" Full Thread Stud
- Battery, 3 Volt, CR2032
- Chainmate (Chain and Wire Rope Lube)
- Chemical Resistant Gloves XL

- Contact Cleaner, CRC 2000, 13oz
- Disposable Wipes, Q-Fold, Case of 18
- Duct Tape, 2" x 60 Yards
- Flapwheel, AO, 1x1x1/4 In Shank, 60G
- Gen Use Disposable Mask - ea box has 50
- Glove, Cut Res. Dipped PUG-611 M GRAY
- Glove, Cut Res. Dipped PUG-611 XXL GRAY
- Glove, Hi-Top Leather, Large
- Glove, Hi-Top Leather, Small
- Glove, Hi-Top Leather, XL
- Glove, Hi-Top, 2XL
- Gloves, Chemical Resistant, Large
- Hitch Pin Clip, Light Wall Tubing
- Index Cards, 3" x 5"
- Leather Glove XL Memphis 1716 Big Jake
- Nitrile Gloves, XL Blue, 100/box

- Oil Analysis Kit
- Paint marker, White
- Pencil, Wood, #2, each
- RELUBE Tags
- Safety Glasses, Over-the-Glasses style
- Scrap Tag
- Spray Lubricant 3-36
- Swage Dies 1.250/.595
- Swage Dies 2.250/1.450
- Tag, Metal, 4.5" x 7", w/slots, 500 box
- Tape Measure, 100'
- Thermal Transfer Ribbon, 102mm x 360m
- Thermal Transfer Ribbon, 152mm x 600m
- Utility Knife, Self-Retracting

The following 21 items would be placed in the ProLock kiosk.

- Battery, AA Size

- Bucket, Gray, 10QT
- Cleaner, Lysol Foaming Disinfectant 24oz
- Clip, Heavy Wall Tubing, Plain
- Copy Paper 8-1/2 X 11 (CASE)
- Degreaser, LPS 01420
- EAR PLUG UNCORDED AEARO 312-1256
- Glove, Cut Res. Dipped PUG-611 L GRAY
- Glove, Cut Res. Dipped PUG-611 XL GRAY
- Grease, EP #2 multi-purpose
- Grease, Lithium 14oz.
- HAMMER BLOCK ROLL PIN A-11A-8-A
- Insect Repellent, 6 oz.
- Medium Duty Scrub Sponge 6.1"x3.6"x0.7"
- Pen, Med, Black
- Pipe Wrench, 18", Cast Iron

- Portable Bandsaw Blade
- Spray Paint, Yellow
- Tag, Thermal, 4" x 6", 1000 per roll
- Tags, Thermal 6"X8" w/Sensors & Punch
- Tape Measure, 100', 3:1 gear ratio

This solution would save $20,540.90 annually and generate an additional 31.53 hours of production per year across all work stations.

Objective function value: $3,459.10

4.0.3 Three Kiosk Solution

This solution suggests placing a ToolBox at candidate location 5 and a ProLock kiosk at candidate locations 2 and 9.

The 12 items in the following table would be placed in the ToolBox at candidate location 5.

- Chainmate (Chain and Wire Rope Lube)
- Chemical Resistant Gloves XL
- Contact Cleaner, CRC 2000, 13oz
- Disposable Wipes, Q-Fold, Case of 18
- Duct Tape, 2" x 60 Yards
- Glove, Hi-Top Leather, Large
- Gloves, Chemical Resistant, Large

- Spray Lubricant 3-36
- Swage Dies 1.250/.595
- Tape Measure, 100'
- Thermal Transfer Ribbon, 102mm x 360m
- Utility Knife, Self-Retracting

The 21 items in the next table would be placed in the ProLock kiosk at candidate location 2.

- .255 Swage Pointing Die Shim, 4 each
- 1" x 4" Full Thread Stud
- Battery, 3 Volt, CR2032
- Bucket, Gray, 10QT
- Clip, Heavy Wall Tubing, Plain
- Copy Paper 8-1/2 X 11 (CASE)
- EAR PLUG UNCORDED AEARO 312-1256
- Flapwheel, AO, 1x1x1/4 In Shank, 60G
- Glove, Cut Res. Dipped PUG-611 XXL GRAY
- Grease, Lithium 14oz.

- HAMMER BLOCK ROLL PIN A-11A-8-A
- Hitch Pin Clip, Light Wall Tubing
- Index Cards, 3" x 5"
- Leather Glove XL Memphis 1716 Big Jake
- Oil Analysis Kit
- Paint marker, White
- Pencil, Wood, #2, each
- Pipe Wrench, 18", Cast Iron
- RELUBE Tags
- Tag, Metal, 4.5" x 7", w/slots, 500 box
- Tag, Thermal, 4" x 6", 1000 per roll

The 23 items in the final table would be placed in the ProLock kiosk at candidate location 9.

- Battery, AA Size
- Cleaner, Lysol Foaming Disinfectant 24oz
- Degreaser, LPS 01420

- Gen Use Disposable Mask - ea box has 50
- Glove, Cut Res. Dipped PUG-611 L GRAY
- Glove, Cut Res. Dipped PUG-611 M GRAY
- Glove, Cut Res. Dipped PUG-611 XL GRAY
- Glove, Hi-Top Leather, Small
- Glove, Hi-Top Leather, XL
- Glove, Hi-Top, 2XL
- Grease, EP #2 multi-purpose
- Insect Repellent, 6 oz.
- Medium Duty Scrub Sponge 6.1"x3.6"x0.7"
- Nitrile Gloves, XL Blue, 100/box
- Pen, Med, Black
- Portable Bandsaw Blade
- Safety Glasses, Over-the-Glasses style
- Scrap Tag
- Spray Paint, Yellow

- Swage Dies 2.250/1.450
- Tags, Thermal 6"X8" w/Sensors & Punch
- Tape Measure, 100', 3:1 gear ratio
- Thermal Transfer Ribbon, 152mm x 600m

This solution would save $20,746.34 annually and save an opportunity cost of 31.723 hours of production per year.

Objective function value: $15,253.66

4.0.4 “Do Nothing” Alternative

This solution suggests making no changes to the system as it currently stands. It provides no savings potential and generates no opportunity cost.

Objective function value: $0

4.0.5 Low Security Alternative

This solution suggests implementing a series of shelves throughout the facility where various items would be stocked and readily available for workers to pick them up as needed.

4.1 Evaluation Criteria

The alternatives will be evaluated on several factors laid forth by the client. These include total savings potential, potential opportunity cost, degree of control of inventory, feasibility, economic justification, potential for growth, and conformity to company culture and goals. The criteria given the most weight will be total savings potential, potential opportunity cost, degree of control of inventory, and potential for growth as these metrics have been repeatedly stated to be of the utmost importance to the client. SDT will be looking for solutions that:

- Maximize total savings while minimizing work center cost
- Provide a high potential opportunity cost for more savings
- Allow the MRO department to maintain a high level of control of the inventory
- Can be easily implemented into the given candidate location
- Present potential for long time returns on investment
- Can be modified and expanded upon to other locations within the facility as well as to additional locations
- Compliments Webco’s commitment to safety, quality, and continuous improvement

4.2 Evaluating Alternatives against Criteria

With the given criteria in mind, SDT then evaluated each alternative against the criteria.

4.2.1 One Kiosk Solution Evaluation

The one kiosk solution meets several of the evaluation criteria, but not to the fullest extent. The kiosk does create significant potential savings and opportunity cost, but not as much as solutions generated with more kiosks. MRO has a high level of control as the ProLock only allows access to one locker at a time and has integrated scales that send a restock notice when a specified weight threshold is crossed. It can be easily implemented at the candidate location and does provide a small framework for expansion. Of the kiosk-oriented solutions, it has the lowest initial investment and does generate a positive short-term return on investment. While other kiosk solutions have a higher startup cost, they also provide greater savings potential, greater convenience for workers, and offer a more robust solution to the problem.

4.2.2 Two Kiosk Solution Evaluation

The two-kiosk solution meets many of the outlined evaluation criteria. With two kiosks, a high savings potential and opportunity cost is generated as outlined in the previous section. It also gives the MRO department a high level of control of the inventory. The ToolBox kiosk at location 5 has an integrated computer system that keeps track of the number of checkouts. Only one item can be dispensed per interaction with the kiosk, meaning MRO should always be able to tell how many items remain. As for the ProLock at location 9, only one locker is opened at a time meaning only one type of item is available per interaction. The lockers also utilize integrated scales that will send a notification to restock when it drops below a certain weight. Based on the item recommendation generated in the model, the kiosks are not completely full. This provides an opportunity to double stock some high frequency items within the machine allowing greater savings and more time between restocks. Another benefit of this solution is the placement of kiosk 5 near the employee restroom. This would make it easy for employees to quickly grab an item while on the way to the restroom or vice versa, potentially yielding even less downtime on the line.

4.4.3 Three Kiosk Solution Evaluation

The three-kiosk solution meets the outlined criteria but has some drawbacks. It does generate a slightly higher savings potential and opportunity cost, but the difference in improvement from two to three kiosks is a couple orders of magnitude smaller than the improvement from one to two kiosks. With the most kiosks involved, this alternative also has the highest initial investment with a smaller opportunity for short-term return. It has many of the advantages of the earlier solutions, but the additional benefits it provides do not compensate for the drawbacks. This alternative is only marginally better than the previous one, but much more costly to implement.

4.4.4 “Do Nothing” Alternative Evaluation

The “Do Nothing” Alternative does not hold up under evaluation with the criteria. It creates no savings potential and has no effect on the cost of operating work centers. Additionally, no opportunity cost is generated by this alternative. It does give the MRO the same amount of control over the inventory they currently have, but also means they must keep the same number of staff in the storeroom at all hours, directly contradicting Webco’s culture of continuous improvement and MRO’s long-term vision of automation. Making no changes to the system provides no opportunity for return on investment. The current state of the system is what is concerning Webco, and they are hoping to avoid the current

problems as they expand the facility. Ultimately, SDT cannot recommend the “Do Nothing” alternative, as it fails to solve the problem or meet Webco’s company goals at a fundamental level.

4.4.5 Low Security Alternative Evaluation

The Low Security Alternative has some merits when evaluated but fails to meet some of the company’s objectives. Of the solutions that involve changing operations, this solution is the cheapest to implement with shelves being much more cost effective than kiosks. It is also fairly simple to implement as no electrical hookup is required. It would also be easily implemented into other areas of the facility. Where this solution falls apart is in MRO’s control of the inventory. This solution gives the department incredibly limited control over the inventory. There is no indication of when to restock unless it is reported by a worker, or a visual inspection is made. This all makes the long-term savings potential nebulous as items can be taken from the shelves with no record of who took them or where they ended up. These significant drawbacks mean that SDT cannot recommend this alternative.

5.0 Recommendations

Based on SDT's evaluation, the two-kiosk solution, detailed in section 4.0.2., would be the optimal solution to best fit the needs of SCT. As enumerated in the previous section, the two kiosks solution performed well against all evaluation criteria.

By implementing two kiosks, MRO can effectively monitor and secure inventories while still dispersing the necessary materials through the kiosks. The kiosks can be configured to track inventory while ensuring operators only take what they have checked out per their input into the machine. One of the main issues outlined in section 1 was security. Some operators marked that they only checked out an item when they took more items without documenting their retrieval. The two-kiosk solution implements two different types of kiosks, ProLock and ToolBox. Both kiosks are rated highly for security and will ensure that operators document all items they retrieve from the kiosks. This solution will be easy to implement and ensure returns in the long term. By implementing two different types of kiosks, Webco can use this as a litmus test to determine the feasibility of the expansion of the kiosk system. SCT can decide if one or both Kiosks work in this portion of the facility and then determine which solution to implement in future expansion of the facility.

Ergonomically speaking, this solution is easy to use and accounts for human factors. The kiosks are intuitive and are easily understandable to the average operator. Lastly, this solution perfectly aligns with Webco's commitment to a "Best-in-Class" working environment. With this solution implemented, no unnecessary stress is placed on operators to traverse the facility to retrieve parts from a distant storeroom. Instead, this solution brings the necessary materials closer to the operators creating a healthy work environment that encourages productivity while ensuring operator satisfaction.

5.1 Recommended Solution

In conjunction with the client, each alternative was shown and reviewed. All benefits were discussed, and it was ensured that the two-kiosk solution maximizes benefits and realistically rectifies many of the issues currently experienced by SCT. The recommended solution is the two-kiosk solution which places a ToolBox at Candidate location 5 and a ProLock at candidate location 9, which can be seen in figure 5 with specifications for each machine located in appendix B and C respectively.

The items that should be placed in the Toolbox are as follows:

- .255 Swage Pointing Die Shim, 4 each
- 1" x 4" Full Thread Stud
- Battery, 3 Volt, CR2032
- Chainmate (Chain and Wire Rope Lube)
- Chemical Resistant Gloves XL
- Contact Cleaner, CRC 2000, 13oz
- Disposable Wipes, Q-Fold, Case of 18

- Duct Tape, 2" x 60 Yards
- Flapwheel, AO, 1x1x1/4 In Shank, 60G
- Gen Use Disposable Mask - ea box has 50
- Glove, Cut Res. Dipped PUG-611 M GRAY
- Glove, Cut Res. Dipped PUG-611 XXL GRAY
- Glove, Hi-Top Leather, Large
- Glove, Hi-Top Leather, Small
- Glove, Hi-Top Leather, XL
- Glove, Hi-Top, 2XL
- Gloves, Chemical Resistant, Large
- Hitch Pin Clip, Light Wall Tubing
- Index Cards, 3" x 5"
- Leather Glove XL Memphis 1716 Big Jake
- Nitrile Gloves, XL Blue, 100/box
- Oil Analysis Kit
- Paint marker, White
- Pencil, Wood, #2, each
- RELUBE Tags
- Safety Glasses, Over-the-Glasses style
- Scrap Tag
- Spray Lubricant 3-36
- Swage Dies 1.250/.595
- Swage Dies 2.250/1.450
- Tag, Metal, 4.5" x 7", w/slots, 500 box

- Tape Measure, 100'
- Thermal Transfer Ribbon, 102mm x 360m
- Thermal Transfer Ribbon, 152mm x 600m
- Utility Knife, Self-Retracting

The items that should be placed in the ProLock at candidate location 9 are as follows:

- Battery, AA Size
- Bucket, Gray, 10QT
- Cleaner, Lysol Foaming Disinfectant 24oz
- Clip, Heavy Wall Tubing, Plain
- Copy Paper 8-1/2 X 11 (CASE)
- Degreaser, LPS 01420
- EAR PLUG UNCORDED AEARO 312-1256
- Glove, Cut Res. Dipped PUG-611 L GRAY
- Glove, Cut Res. Dipped PUG-611 XL GRAY
- Grease, EP #2 multi-purpose
- Grease, Lithium 14oz.
- HAMMER BLOCK ROLL PIN A-11A-8-A
- Insect Repellent, 6 oz.
- Medium Duty Scrub Sponge 6.1"x3.6"x0.7"
- Pen, Med, Black
- Pipe Wrench, 18", Cast Iron
- Portable Bandsaw Blade
- Spray Paint, Yellow
- Tag, Thermal, 4" x 6", 1000 per roll

- Tags, Thermal 6"X8" w/Sensors & Punch
- Tape Measure, 100', 3:1 gear ratio

Once stocked with the above items, the kiosk should be placed at their location and placed flush against the wall while connected to a power source.

5.2 Implementation Plan

The implementation plan for this solution will occur in the four distinct sequential phases. The first of the three phases will be the procurement phase which will cover everything from catalog to delivery. The second phase will be an installation phase that will also include certain trial phases to ensure the product's success. The third stage will be the stocking phase and "grand opening" phase which will see the kiosks fully operational and available for use by the operators. The final stage will examine the system holistically to monitor performance and make practical changes as needed in the stock count. An advantage to using this implementation plan is that it can be done one kiosk at a time or two kiosks all at once. SCT can decide which way would be most beneficial, but SDT would recommend placing both Kiosks at once to award immediate benefits.

5.2.1 Phase 1

The first stage of the implementation plan is the procurement phase. While, at first glance, this phase might seem like the easiest of the four, there are more steps than meets the eye. SCT has already established good relations with a CribMaster salesman. For phase 1, SCT should communicate to the salesman their wishes to purchase a ProLock and ToolBox kiosk to be used at their facility. From there, the salesman can handle most of the specifics of delivery to the actual facility.

5.2.2 Phase 2

The second stage of the implementation plan is the installation and trial phase. After the reception of the physical kiosks, SCT should immediately install the kiosks at their given candidate locations. After the kiosks are implemented, SCT should familiarize themselves with the operating manuals to fully understand the inner workings of the machines. After this, SCT should conduct a series of "mock" checkouts and trial runs to ensure they understand the capabilities of the kiosks while ensuring it meets their security and inventory standards. During these trials, SCT should also ensure each item can be tracked in accordance with the expectations given by CribMaster. Any and all issues should be sorted out during this short phase to ensure full implementation success. Once SCT is sure they can track all items, all items can be checked out by operators, and security measures are added, they can move on to the next phase.

5.2.3 Phase 3

A "grand opening" is the third phase of the implementation plan. In this phase, the kiosks will be fully available for operators to access during their work time. An important aspect of this phase is making the operators aware of their new expectation to gather materials at the kiosks instead of the storeroom. SDT team recommends an in-service, briefing, or team training meeting to ensure operators know the expected procedure to get necessary items from the kiosks. Expectations should be made abundantly clear to ensure a smooth transition from storeroom to kiosk.

5.2.4 Phase 4

The last phase of implementation is primarily concerned with future updates. Management should keep a close eye on operations to ensure good habits are created and the kiosks are being used correctly and to their full potential. Webco's primary aim is to ensure a "best-in-class" working environment for all employees and this phase allows Webco to continuously improve its kiosks system following the methodology outlined in section 2.

6.0 Benefits

In the short-term, our solution will increase operating efficiency of the affected work stations. In the long-term, our solution has the potential to provide a wide variety of benefits to Webco which are detailed in this section.

6.1 Operating Efficiency

Having our proposed kiosks and items available at candidate locations 5 and 9 will allow SCT employees to avoid many long, unproductive trips to the storeroom. SDT estimates over $20,000 in activity and labor savings will result from our solution annually. In addition, over 30 hours of machine downtime will be avoided, with no additional cost to SCT. The exact figures SDT calculated for these savings at each relevant work center are shown below in table 9.

Table 9 Estimated Savings

	WS 121	**WS 122**	**WS 123**	**WS 131**	**WS 132**	**Total**
Activity and Labor Savings ($/Yr.)	$714.99	$449.39	$1,206.94	$10,598.59	$7,570.99	**$20,540.90**
Production Savings (Hrs./Yr.)	2.698	1.696	4.661	13.118	9.357	**31.53**

6.2 Company Culture and Vision

Webco's company culture prioritizes safety and quality. They often refer to themselves as a "forever company", meaning they do not prioritize short-term profits over the long-term value of their operations. SDT's proposed solution fits within this paradigm. SDT prioritized the quality of life of the employees, as our solution will result in a large reduction in long walks across the facility.

In addition, SDT's recommendation ties into MRO's long-term vision of full automation. A handout provided to SDT by SCT states, "MRO's vision is to develop fully automated storerooms. An automated storeroom would not require a 24/7 attendant. An automated storeroom would also have cycle count and inventory accuracy benefits. As a part of the automated storeroom, MRO plans to use kiosks in the plant to distribute inventory items needed for production." This project and recommendation are the first step towards realization of this goal and its stated benefits.

6.3 Expansion and Iteration

While this project is limited in scope to five work stations and 67 items, there is potential for broad application of these methods throughout SCT and other Webco locations.

First, there are many other work stations within SCT that use exhaustible materials and could increase efficiency through similar methods. Second, there are other functions within SCT that use many other

materials. Specifically, the maintenance function at this location could benefit greatly from a similar material dispensing system. Next, there is the distinct possibility of northward expansion at SCT. In such a scenario, the additional work stations would be even farther from the storeroom. Therefore, the potential savings and efficiency gains for these work stations would be even more significant. In addition, Webco has a variety of other facilities across the United States that could benefit from a similar program to varying degrees.

Finally, there will be room for iteration. Our proposed solution will not be perfect. Invariably, real-world experience with the kiosks at these work stations will provide ideas for further improvement. With this project being centered on a small sliver of Webco's overall operations, the level of commitment by the company to this solution is minimal. There will be plenty of opportunity for improvement and iteration as Webco's next generation of material dispensing systems roll out.

As the expansion and iteration trends progress, SDT believes these trends will complement each other to provide Webco with a best-in-class system for dispensing materials to employees. SDT firmly believes that we have built a strong framework for such a scenario to occur.

References:

Bonjour, B. (2022). *Senior Design Spring 2022*. Sand Springs, Oklahoma; Webco.

Cribmaster (Ed.). (2022). *Cribmaster*. CribMaster. Retrieved April 4, 2022, from https://www.cribmaster.com/

Webco (Ed.). (2021, May 19). *Webco tubing: Steel tubing supplier: Tubing manufacturer*. Webco Industries. Retrieved February 8, 2022, from https://www.webcotube.com/

WordPress (Ed.). (2022). OpenSolver for Excel. Retrieved March 30, 2022, from https://opensolver.org/

Appendices:

Appendix A: Project Proposal

PROJECT PROPOSAL 1/31/2022

Webco Industries Vending Machine System Design

An Oklahoma State University
School of Industrial Engineering and Management
Senior Design Project
Spring 2022

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WEBCO INDUSTRIES VENDING MACHINE SYSTEM DESIGN

We are grateful and excited for the opportunity to partner with Webco for this project. Our team is thankful for the facility tour and hospitable welcome. We enjoyed meeting some of Webco's team members, and we appreciate their willingness to answer questions. The tour of the facility was very insightful, and we enjoyed hearing more about the company. We are eager to get to work improving efficiency and reducing downtime with the implementation of our solution.

This proposal is organized in the following sections:

1. Background
2. Objectives and Scope
3. Anticipated Methodology
4. Anticipated Schedule
5. Anticipated Deliverables
6. Anticipated Benefits
7. Risks and Mitigation Strategy
8. Works Cited

1. Background

Webco is one of North America's leading manufacturers of precision welded tubing, producing carbon, stainless and specialty steel, nickel, titanium, and other alloy tube products for a variety of applications. Webco's Star Center Tube facility was opened in Sand Springs, Oklahoma in May 2012. Built specially to accommodate Webco's machinery and tube manufacturing process, this facility has a unique, spread-out footprint. As such, travel times for employees traversing the facility are significant. Each position in the assembly line requires a specific set of exhaustible materials required for the manufacturing process. When employees leave their posts to retrieve those standard, everyday materials and equipment, production is hampered. By exploring a custom vending machine system to dispense this equipment, we hope to eliminate much of the lost productivity that this facility is currently experiencing.

Within Webco, the Mechanical, Repair, and Operations (MRO) unit is working towards an automated storeroom system. Manual cycle counts and 24/7 staffing requirements mean the current system is costly in terms of labor. Part of this Webco automation initiative involves vending machine kiosks being placed throughout the plant floor to distribute inventory items as needed for production.

2. Objectives and Scope

The objective of this project is to develop an efficient, state-of-the-art vending machine system to distribute items to employees. Per specific requests by Webco, kiosks will be the primary distribution mechanism; ergo, we will consider the type of kiosks, the physical location of these kiosks, and which items will be stocked in each kiosk.

The type of kiosk will be selected from those currently offered by Cribmaster. This project scope is restricted to work centers located in the "A-Bay" and "B-Bay" of the facility. We will

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also give secondary consideration to the inventory and restock systems necessary to maintain the use of these kiosks.

3. Anticipated Methodology

Discovery Phase

1. Finalize Scope and Problem Statement
2. "Clean" data
   a. Remove items that are outside project scope
   b. Remove other instances of unreliable data
   c. Apply necessary filters for ease-of-use

Analysis and Optimization

3. Rank items by highest use in each work center to identify general areas of focus
4. Build an optimization model with the given inventory and cost data
5. Determine several potential near-optimal solutions

Assess Model/Iterate

6. Assess feasibility
   a. Measure items
   b. Analyze inventory-tracking capabilities of the kiosks
   c. Ensure locations are realistic
   d. Brainstorm possible unintended consequences
   e. Identify relevant engineering standards and ensure they are adhered to
7. Update the model with additional information as needed

Generate Alternatives

8. Determine several alternative solutions
9. Develop comprehensive lists of benefits and drawbacks for each solution
10. Rank solutions

Provide final recommendation

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4. Anticipated Schedule

The expected timeline is as follows.

Activity	Start Date	End Date
Phase 1: Discovery		
Finalize Scope and Problem Statement	1/24	1/29
Clean Data	1/24	2/5
Phase 2: Analysis and Optimization		
Ranking	2/8	2/12
Model Creation	2/8	3/5
Determine Initial Solutions	2/15	3/12
Phase 3: Model Assessment		
Feasibility Assessment	3/8	3/26
Update Model	3/15	4/2
Phase 4: Generate Alternatives		
Determine Candidate Solutions	4/5	4/16
Develop Lists of Benefits and Drawbacks	4/12	4/16
Rank solutions	4/12	4/23
Phase 5: Final Recommendation	4/26	4/30

5. Anticipated Deliverables

1. A formal report including detailed methodology and models for future use by the facility
2. A final design report and presentation addressing the following:
   a. Number of kiosks to optimize the cost of employee travel
   b. Optimal kiosk location(s)
   c. Items stored in each kiosk
   d. Type of kiosk best for each location
   e. Potential inventory replenishment process (if time allows)
3. An optimization model used for developing the recommended solution

6. Anticipated Benefits

The benefits of this project to the client include, but are not limited to, the following:

1. Increased productivity
   a. Fewer stops in production
   b. Less time walking for employees
2. Reduced operating costs
   a. Reducing occurrences of paying to run a work center without an employee
3. Less strain on the storeroom attendant
4. Draws the MRO department closer to full automation
   a. Increases cycle count accuracy
   b. Further reduces operating costs

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5. Provides a blueprint for expansion to more work centers
    a. Our methodology can be improved on further with hindsight
    b. Will be applicable to more work centers in the event of this plant expanding
    c. May be implemented in some of Webco's other locations

7. Risks and Mitigation Strategy

Risks	Mitigation Strategy
Inaccurate inventory in kiosks	Careful selection of kiosk type based on inventory security
Inefficient/suboptimal solution	Formulate a holistic model and make design decisions prudently.

8. Works Cited

About Webco. Webco Industries. (2019, February 5). Retrieved January 26, 2022, from https://www.webcotube.com/tubing-products/product-types/

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Endorsements – Endorsement below acknowledges receipt and acceptance of the proposal of a Senior Design Team from Oklahoma State University's School of Industrial Engineering and Management. Project will be executed on a 'best effort' basis and no warranty is stated or implied. All modifications to this proposal shall be provided, in writing, to all signatories for approval and acceptance.

On Behalf of Webco

Bailey Bonjour

On Behalf of Senior Design Team

Ben Burchard

Ben Burchard

Chris Chesnut

Chris Chesnut

Jay Eischen

Jay Eischen

2/1/2022

Date of Last Signature

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Appendix B: ProLock Specifications

ProLock™

High-Security Storage for Durable Items

This access-controlled locker solution is ideal for securely storing and distributing valuable durable items, like returnable hand and power tools.

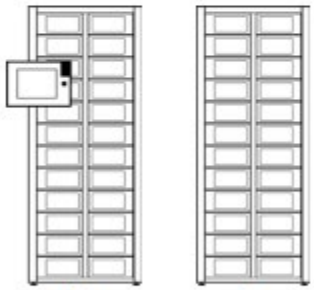
The ProLock features individual lockers with configurable shelves, making it easy to customize on site. Available with different combinations of locker sizes, and the ability to link lockers together for added space, it can easily accommodate durable items of all sizes.

The ProLock is designed to manage serial IDs, kits and expendables and monitor calibrated items and schedules, all while improving operational efficiencies.

Configuration Options

All ProLock units are available as a main or auxiliary unit. The standard ProLock is available in a 12, 24, or compact 20 door model, and the ProLock with Scales is available with 24 doors.

Link locker doors together & remove the shelves to create a larger locker ideal for housing bigger items.



Suggested Inventory

The ProLock is ideal for secure storage of durable items of all sizes.

- Hand tools like wrenches, screwdrivers, pliers, or hammers
- Power tools like nail guns, drills, power saws, or sanders
- High-volume consumables like fasteners, drill bits, cutting tools, nuts & bolts, and various types of PPE
- Aerosols that need to be vended from an upright position

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ProLock™ Solution Line Specs

The specs and the exterior & interior dimensions for both the ProLock and the ProLock with Scales are the same—the only difference is the ability to utilize scales within the locker compartments.

Standard Main Exterior Dimensions		
Height	83 in.	210.82 cm.
Width	35 in.	88.9 cm.
Depth	37 in.	93.98 cm.
Weight	515 lbs.	234 kg.
Standard Auxiliary Exterior Dimensions		
Height	83 in.	210.82 cm.
Width	30.5 in.	77.47 cm.
Depth	32 in.	81.28 cm.
Weight	465 lbs.	211 kg.
Compact Main Exterior Dimensions		
Height	70 in.	177.8 cm.
Width	35 in.	88.9 cm.
Depth	37 in.	93.98 cm.
Weight	498 lbs.	226 kg.
Compact Auxiliary Exterior Dimensions		
Height	70 in.	177.8 cm.
Width	30.5 in.	77.47 cm.
Depth	32 in.	81.28 cm.
Weight	448 lbs.	203 kg.
Power Requirements		
Amps	3	1.5 (EU)
Voltage	120	230 (EU)
Operating Environment		
Temperature	32°F to 95°F	0°C to 35°C
Humidity	20% to 85%	
Technical Information		
CE Compliant		
Windows OS		

Lockers

Number of Lockers	1	2	3
Height (in)	5.06	11.19	17.31
Height (cm)	12.86	28.42	43.97

Each locker width is 11 in / 27.94 cm and depth is 28.25 in / 71.76 cm. Optional locker combinations are available. Maximum locker capacity 70 lbs / 31.75 kg.

Scale plates are a good sensor for items that may not fit in the bins

ProLock™ with Scales Bins

Bin Sizes		
Small	12 in. x 9 in.	30.48 cm. x 22.86 cm.
Medium	18 in. x 9 in.	45.72 cm. x 22.86 cm.
Large	24 in. x 6 in.	60.96 cm. x 15.24 cm.
Plate Size		
Scale Plate	10 in. x 24 in.	25.4 cm. x 60.96 cm.

STANLEY

CribMaster—a division of STANLEY*—is the global leader in inventory and asset management solutions for a broad range of industrial and manufacturing applications. Our industry-leading, software-enabled products simplify how our customers work. Backed by a team of knowledgeable and dedicated problem-solvers, CribMaster makes progress easier to manage.

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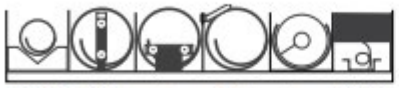
Appendix C: ToolBox Specifications

Available Accessories**

- 7" interactive display screen
- Vertical inner partition to vend narrow items
- Riser platform to vend short items
- V-channel mini helix to vend small, narrow items
- Spray Can Dispensing Kit to vend up to 12 spray cans
- Auger helix for vending small items (available in 30 coil pitch with 0.5 in / 1.27 cm slot depth)



V-channel & Mini Helix | Vertical Partition | Riser Platform | Flip Bar Pusher | Auger | Spray Can Dispenser

Each single helix shelf can hold 10 SKUs. Each large and dual helix shelf can hold 5 SKUs. Shelf height is 6 to 8 in / 15.24 to 20.32 cm. Single coil maximum capacity is 10 lbs / 4.54 kg. Maximum shelf capacity is 100 lbs / 45.36 kg.

Suggested Inventory Items

The Express ToolBox is tailored to dispense small PPE items and cutting tools such as:

- Inserts
- Batteries
- Safety glasses
- Filters
- Tape
- Fasteners
- Cutting tool inserts
- Welding tips

Express ToolBox Specs

Main Exterior Dimensions		
Height	72 in	182.88 cm
Width	39 in	99.06 cm
Depth	36 in	91.44 cm
Weight		
Main - 6 Shelf	544 lbs	247 kg
Power Requirements		
Amps	3	1.5 (EU)
Voltage	120	230 (EU)
Operating Environment		
Temperature	35°F to 110°F	1°C to 43°C
Humidity	20% to 85% (no condensation)	
Technical Info		
CE Compliant		
Linux OS		

Helix Info			
Helix Count	10	20	32
Slot Depth (in)*	1.87	0.96	0.53
Slot Depth (cm)*	4.75	2.44	1.35

* Not the actual size of opening. Slot depth is measured from the peak of one spiral pitch to the next.

**Sold separately

Express ToolBox Configurations

Single Helix Configuration (2.5 in / 6.35 cm diameter)										
Helix Count	5	7	8	9	10	12	15	18	24	32
Slot Depth (in)*	4.04	2.9	2.51	2.25	2.02	1.66	1.3	1.05	0.75	0.53
Slot Depth (cm)*	10.26	7.37	6.38	5.72	5.13	4.22	3.3	2.67	1.91	1.35
Large Helix Configuration (3.75 in / 9.53 cm diameter)										
Helix Count	4	5	7	9	10	12	15			
Slot Depth (in)*	4.1	3.45	2.58	2.06	2.01	1.55	1.24			
Slot Depth (cm)*	10.41	8.76	6.55	5.21	5.11	3.94	3.15			
Dual Helix Configuration (5 in / 12.7 cm diameter)										
Helix Count	5	7	9	10	12	15	18	24		
Slot Depth (in)*	4.04	2.9	2.25	2.02	1.66	1.3	1.05	0.75		
Slot Depth (cm)*	10.26	7.37	5.72	5.13	4.22	3.3	2.67	1.91		

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