Design and Justification of an Automated Palletizing Line

by

Rebecca Anderson

A Research Paper
Submitted in Partial Fulfillment of the
Requirements for the
Master of Science Degree
in

Technology Management

Approved: 3 Semester Credits

David Fly

The Graduate School

University of Wisconsin-Stout

May, 2008

The Graduate School
University of Wisconsin-Stout
Menomonie, WI

Author: **Anderson, Rebecca A.**

Title: ***Design and Justification of an Automated Palletizing Line***

Graduate Degree/ Major: MS Technology Management

Research Adviser: **Fly, David, P.E**

Month/Year: **May, 2008**

Number of Pages: **28**

Style Manual Used: **American Psychological Association, 5th edition**

ABSTRACT

This project is a cost justification for replacing manual case stacking onto pallets with an automated system. Three automated case stacking (palletizing) systems were designed. The challenges of implementing the automated systems include the cost justification, allowing for future flexibility, and the increased space utilization that the equipment requires over a manual operation. This paper analyzes the three different layouts and reviews which is the most cost effective based on the space required to install, the flexibility to add additional lines, and the ergonomic improvement it will contribute. The final result is a recommendation to the company studied for the layout that best meets their needs with the least amount of total cost.

The Graduate School

University of Wisconsin Stout

Menomonie, WI

Acknowledgments

Thank you to Professor David Fly for his support as an advisor, and providing needed guidance for the completion of this project.

A special thank you to my husband, Aaron, for providing the time and support needed to complete my degree.

TABLE OF CONTENTS

Chapter I: Introduction

A key objective for all manufacturing facilities is to reduce the number of work related injuries incurred by their employees. The company this project was completed for is no different. This company is a local manufacturer of food products that are distributed primarily in the United States and Canada. Although installing an automated palletizing system needs to meet the payback criteria for implementation to be feasible, one facet of the justification is to reduce the risk of ergonomic related injuries that could potentially occur due to employees manually palletizing cases.

Statement of the Problem

The purpose of designing three different automated palletizing systems, and completing a comparison analysis was to determine the most cost effective way to eliminate the manually palletizing of inspection cases. The most effective option must provide flexibility to handle future products, the best use of warehouse space for the installation, and have the best cost justification for its entire installation. An additional factor considered is the reduction or elimination of the potential for ergonomic injury due to the current practice of manually stacking these cases. Since there have not been any lost time accidents due to this manual operation to date, the project will need to meet the cost justification requirements of the company.

Currently this company produces multiple products into three can sizes, each having their own case size; each case is palletized by size and batch (specific lot kept separated during manufacturing and shipping for traceability purposes). The three case sizes (one case size per can size) are produced on two dedicated packaging lines. One line runs only the 8 ounce case size, and one line runs either the 13 ounce or 32 ounce

case size. All three of these lines produce a liquid filled can, which is seamed, labeled, cased, and then transported by a dedicated conveyor per line to the palletizing area of the factory. Immediately prior to the cases reaching the palletizers, every tenth case is diverted to a gravity conveyor that delivers the case to an operator for manual stacking onto a pallet. The remaining cases travel past the diverter gate and are palletized using an automated palletizer.

Any solution would need to be able to palletize the current products, plus have the capacity to add another 8 ounce line in the future due to possible plant expansions.

The three options analyzed were a robotic palletizer, refurbishing and installing two existing inline palletizers, purchasing and installing a single inline palletizer. The robotic palletizer utilizes two robotic arms in a fenced in area that will stack cases as they enter the infeed to the palletizer. There would be two dedicated conveyors, each feeding product to one of the two robotic arms. One lane would carry only 8 ounce products, the other lane would carry either 13 ounce or 32 ounce product. Once a pallet is complete it moves forward onto a transfer conveyor that will move the pallet to the correct location to transfer to the automated stretch wrapper. Once each pallet is stretch wrapped it will be removed by an operator using a forklift and transported to the incubation area.

Installing two existing inline palletizers involves equipment the company already owns. These palletizers are referred to as Currie palletizers, in reference to the company that manufactured them. There are two Currie palletizers, one in storage due to upgrades on a past project, and one currently in use for the non-inspection product palletizing. Due to the age of these machines it would be necessary for them to have all of their controls upgraded, all drive motors converted from direct current to alternating current motors,

and a maintenance overhaul of the machine. Each palletizer would have one dedicated conveyor feeding product. One palletizer would handle only 8 ounce product, the other would palletize either 13 ounce or 32 ounce product depending on which is currently being produced.

The single inline palletizer considered was an Alvey brand palletizer. Due to the higher capacity this machine has over the Currie palletizers proposed in option two, only one palletizer would need to be installed. The cases will still travel on dedicated lanes, and the ten percent to be palletized would be diverted onto dedicated accumulation conveyors. Each accumulation conveyor would need to hold enough cases to allow the palletizer to finish an entire pallet of a different product size while the other product is queued. For example while the palletizer is palletizing 13 ounce product, the 8 ounce product will need to be accumulating, and cannot begin palletizing until the 13 ounce pallet exits the palletizer. This requires more floor space.

Purpose of the Project

The goal of this project is to design functional layouts for three options of palletizing, and determine which provides the best installation regarding flexibility, space utilization and ergonomics and meets the return on investment requirements. The most effective option must provide flexibility to handle future products, the best use of warehouse space for the installation, and have the best cost justification for its entire installation. It is important to note that the best option may not necessarily be the lowest initial cost. The option that provides better for the future may not be the lowest cost to install at this time, but may provide the overall lowest cost to the company in the long term.

Assumptions of the Project

The current line configurations will not change. The 8 ounce product is only produced on one line, and has a single dedicated conveyor. Also, the production of 13 ounce and 32 ounce products will not occur simultaneously. These products currently have dedicated fillers and seamers, but share a labeler, caser and conveyor, so the facility is only capable of producing either 13 ounce products or 32 ounce products at one time.

The costs developed for this project only include the incremental installation costs that will be incurred by each option. It is assumed that no matter what project is undertaken each will have the same base project costs for engineering, maintenance systems updates, and similar items. The millwright costs that will vary with the installations have been included in the cost estimates.

Space utilization is determined for each option. The critical aspect of space utilization for this project is not the cost of building additional warehouse, but rather since this manufacturing location is land locked; it is which option uses the least amount of space.

All options are dependant upon a separate project currently in consideration for centralizing all of the palletizing in the factory. The second option considered in the project of relocating two existing Currie palletizers includes the cost to purchase an additional palletizer to replace one of the Currie palletizers currently in use, and expected to be used by the centralized palletizing project.

Definition of Terms

Alvey. Refers to the brand name of one palletizer being proposed. This palletizer is manufactured by FKI Logistex.

Currie. Brand name of an inline palletizer.

Limitations of the Project

The project is limited by the information known today. While the project will examine which line is most flexible to additional products or conveyor lines being added, there are numerous factors that can not be taken into account without knowing what are these products and their packaging requirements. These include can size and shape, can materials, case size, case materials, case configurations, case weight and pallet patterns.

Methodology

Literature was reviewed that takes into consideration the factors impacting the recommendations of this project. These include cost justification, automated palletizing, ergonomics and space utilization. The project was conducted by first developing layouts that were feasible with existing equipment. The area required for each installation was calculated. Ergonomic implications for operator access to the new installations were determined. The flexibility to change to other product sizes, or add additional product lines and the cost implications of these changes were detailed.

Chapter II: Literature Review

Cost Justification

Cost justification comparison was one of the two major components of this project. While every company wants to first and foremost protect the safety of its employees, there is still a need to justify the cost of the equipment against the potential risk for injury. Injury risk is evaluated by industrial hygiene studies based on the weights lifted and the amount of twisting and turning necessary to complete the task within a certain time frame. As detailed later in this report, the manual stacking of these pallets has a minimal ergonomic risk due to the precautions previously taken to reduce the chance of injury.

The company considering this new automation has a requirement for capital projects to have a two year return on investment. This standard is set by the company itself, many companies use two, three or four year payback. (Dossenbach, 2005) This company also takes into consideration if projects are safety related, compliance related (either government or the company's standards), or due to a new product line being introduced. If the project relates to one of these items the two year return on investment requirement is relaxed. It is necessary when justifying any capital investment to show its impact to the bottom line of the company. This equipment will be justified both with the savings from a reduction in labor and the avoidance of cost by removing the potential risk for injury. Reduction in the risk for injury can have long term results in lower insurance premiums and reduce the costs that are paid to treat the injury. (Ayral, 2007)

Cost justification needs to take into consideration that the capital investment aligns with the master plan for the company and the individual factory implementing the

investment. The investment needs to show that it is beneficial to the company, not just new equipment for the sake of implementing new equipment. However, constantly repairing existing equipment instead of making the investment in new can be more costly than an investment in new equipment. (Dossenbach) This project has been considered as part of the master plan for this factory for the past five years. The benefits to the company come in reduction in injury risk, and labor cost reductions. In this project the justification of new equipment and rebuilding existing equipment is compared.

Another important part of the cost justification is to write to an audience that does not have a technical background. Presentations of capital investments need to be geared towards the audience. For example, when presenting to the finance group the rate of return and the annual spending on the investment are key. When presenting to a marketing group the speed of implementation is a critical component. (Hynes, 2007)

Ergonomics

Risk of injury to employees was evaluated. By analyzing Liberty Mutual tables provided in the research article the risk for this movement is acceptable because it accommodates more than 75 percent of the population (Dempsey and Maynard, 2005). The tables are included for reference in Appendix F. The activity is actually at 81 percent based on the table interpretation provided. This puts the possibility of injury at a low risk for occurrence. This is why the project will need to be justified primarily by labor savings with the ergonomic factor being an added benefit, not necessarily definable cost avoidance.

An ergonomic lifting calculator has been created by the National Safety Council based on the NIOSH (National Institute for Occupational Safety and Health) for

calculating the recommended lifting weight based on the lifting height, angle of rotation, and the required reach to lift the object. This calculator, using the measurements of the previously mentioned items, determined that the recommended lifting weight is 9.5 pounds. (National Safety Council [NSC], n.d.) The case weights for the products that are part of this project range from 10.9 pounds to 14.1 pounds per case. This re-affirms that even though there have not been injuries related to this operation yet, the potential exists according to both the Liberty Mutual tables and the above calculator.

Automated Palletizing

Automated palletizing was the third aspect of the project. There were three options desired by the company to be studied that involved two different types of technology. These were robotic palletizing, and dedicated palletizers, also referred to as inline palletizing.

Robotic palletizers will typically pick several cases at a time either with a mechanical or vacuum gripper. They are capable of building multiple pallets at a time, which is one of their significant advantages over inline palletizers. Inline palletizers build a layer of the pallet at a time. Once the layer is built it is usually swept onto the pallet by a mechanized arm. The advantage of inline palletizers is their speed capabilities. (Maloney, 2001)

Chapter III: Methodology

The goal of the project was to find the least cost solution to automating the palletizing, which best meets the company's requirements for return on capital investment, flexibility and minimizing space utilization. The basis for these evaluations started with creating layouts for each type of palletizing: A robotic cell, two existing dedicated palletizers (referred to as Currie), and the installation of one dedicated palletizer with the flexibility to changeover between products automatically (referred to as Alvey). Once the layouts were completed, the costs were estimated by using quotations from the vendors for the palletizers, past cost estimates developed by the company for the refurbishing of the Curries, and the estimated conveyor installation cost. Only one quotation was obtained for each of the major pieces of equipment. This was due to the requirement to keep standard equipment for any option installed. All three options that were considered consist of equipment that is common to this company. This is an overall efficiency and cost savings for the company since the amount of training required for mechanics and operators will be significantly less if the equipment is familiar, and the amount of additional spare parts that will need to be stocked is greatly reduced if the new equipment is similar to existing equipment.

The cost estimates are based on the items that differ for each option. No matter which option is chosen there will be the same basic costs. These basic costs include: design costs, bid package preparation, main electrical feeds to the palletizers, conveyor electrical installations, updating factory systems with the new equipment, purchasing spare parts, and equipment tagging. The costs that will be different depending on the option are: equipment costs, conveyor costs, millwright costs for installation of

equipment and conveyors and equipment relocation. The final cost that will be specific to each option is the fabrication and installation of operator access platforms. The equipment costs are the initial investment cost for the automated palletizers. For the robotic cell and the Alvey palletizer this is the equipment purchase cost. For the Currie palletizers this is the cost to rebuild and refurbish the existing palletizers the company owns. Overall length of conveyor, and the number of turns for each conveyor layout determine conveyor costs. Millwright costs include the cost of installation of the equipment, and additionally relocation of the Currie palletizers from their existing locations. Also under this cost element there is the cost to install the conveyors. This cost is derived again by the length of conveyor needed which determines the number of supports needed to hang the conveyor from the ceiling, or support from the floor. Finally there will be the cost to install operator access platforms for the Alvey palletizer, and the Currie palletizers. This is due to the main operations of these machines being elevated. The robotic cell is all at the floor level and will not require any access platforms.

Data Collection Procedures

Quotations were requested from both a vendor that supplies robotic palletizers, and one that manufactures automated fixed palletizers. An existing cost estimate provided by the company for refurbishing two of their existing palletizers was used in determining the cost for that option. The company also provided capacity requirements for each case size produced.

Chapter IV: Results

This project evaluated possible options for automating the palletizing of inspection cases. The most effective option must provide flexibility to handle future products, the best use of warehouse space for the installation, and have the best cost justification for its entire installation. In this section the costs for each option are presented, as well as the amount of space required for each installation and other factors for each option that relate to its viability to be the best choice for the company to install.

Option 1 – Robotic Cell

The first option analyzed was the installation of a robotic cell for palletizing cases. The cell would require a dedicated lane conveyor for each case size, but these lanes are able to be as short as is needed to reach the robot elevation, and deliver the cases to the appropriate lane in the cell. The shorter conveyors reduce the space needs for the installation. The robotic cell is able to have shorter infeed conveyors because of its ability to palletize on demand. Each case will be palletized as it reaches the robotic cell and there will be minimal time in the queue. Since there are two robotic arms, each line will be palletized independently. To increase the capacity of this cell, another dedicated conveyor lane will be required, a third robotic arm will have to be added, and additional pallet conveyor is needed to reach the stretch wrapper.

Option 2 – Currie Palletizer

The second option studied was refurbishing two existing Currie palletizers. These are low speed palletizers that the company already owns. Each lane of conveyor would have a dedicated palletizer. One of these palletizers was removed from operation last year, and is immediately available. The second of these palletizers is still being used, and

would only be available if a new palletizer was purchased to replace the palletizer currently in use. It is preferable to use the existing palletizer in this project because of the low capacities of this project, and use the new palletizer on the main line. This option shares a benefit with the robot cell in that the lanes are dedicated, and the amount of conveyor needed is less, subsequently the entire installation requires less space. In order for this option to be feasible for a future line addition a third palletizer and the corresponding case and pallet conveyor would need to be purchased.

Option 3 – Alvey Palletizer

The final option studied was installing a new Alvey palletizer. This is a high speed palletizer that could palletize both lines with one palletizer. This option requires more conveyor installation since the palletizer can only palletize one lane at a time, and the other lane needs enough conveyor to accumulate a full pallets worth of cases while the first lane finishes palletizing. This option requires the most amount of space because of the length of conveyor required to accumulate cases. This installation will only require a third lane of conveyor in order t handle a future lane of cases. The palletizer has enough capacity to palletize all three lanes in succession.

Installation Cost Analysis

Each option of the automated palletizer was reviewed for total conveyor length, and either the equipment purchase cost, or refurbish cost to arrive at a baseline cost for each installation. These baseline costs are a key component of the overall cost justification.

Table 1

Cost Estimate Summary – Current Needs

Option	Total Cost
1 – Robotic Cell	$314,350
2 – Existing Curries	$351,940
3 – Alvey	$378,969

The robotic cell has installation requires the least amount of capital expenditure. The rebuild of the existing palletizers and the installation of the Alvey palletizer are next in order listed for the cost evaluation.

The next factor reviewed was the space utilization required by each layout. These are noted on each of the layouts included in Appendix A. The table below provides a summary of the space requirements for each option.

Table 2

Space Utilization Comparison – Current Needs

Option	Total Space Required (square feet)
1 – Robotic Cell	2476
2 – Existing Curries	2470
3 – Alvey	3731

The values in the above table show that options one and two require the smallest footprint for their installations. The difference between the two options is negligible.

The third option, installing the Alvey palletizer requires over 1000 additional square feet; this is a significant increase over the other two options.

After examination of the costs and space utilization of the installations needed to palletize the cases as the factory operates today, a second analysis was completed to determine what additional costs and space requirements would be needed to palletize an additional line of 8 ounce cases.

Below are the costs associated with changing each option so it can also palletize and additional lane of 8 ounce cases. This product will be on its own dedicated line, and can not be co-mingled with the existing 8 ounce case size. For the robot and the Currie options this means adding an additional lane of conveyor, plus one more palletizing station (robot) or palletizer (Currie). For the Alvey option one additional lane of conveyor capable of accumulating a pallets worth of cases will be required. The costs are based on the additional conveyor, equipment and installation costs due to the additions.

Table 3

Cost Estimate Summary – Future Needs

Option	Total Cost
1 – Robotic Cell	$496,925
2 – Existing Curries	$577,740
3 – Alvey	$440,569

As seen from the capital investment estimates above, the Currie costs for the future improvements are significantly more than the robotic cell or the Alvey.

Following are the space utilization requirements to add an additional lane.

Table 4

Space Utilization Comparison – Future Needs

Option	Total Space Required (square feet)
1 – Robotic Cell	2967
2 – Existing Curries	3297
3 – Alvey	3731

It is evident from these numbers that the robotic cell and Currie palletizers still use less space than the Alvey palletizer.

The next area of comparison between the options is the ergonomic considerations. All three options remove the need for manual palletizing of these cases, thus eliminating ergonomic concerns for repetitive, turning and twisting injuries. There is however one safety consideration for the automated layouts. The robotic cell is the only option that palletizes the cases at floor level. Both the Currie and Alvey options require the operators to climb a set of stairs to clear jams and access the palletizer controls. Although these controls could also be located on the floor level, this would be at an additional cost, and would not eliminate the need for operators to climb the stairs to attend to jams or issues with the palletizer.

Chapter V: Discussion

This project proposed to find an automated palletizing solution for the manual palletizing currently being performed on the 10 percent inspection product line. This project explored three different options to provide an automated solution. These options included a robotic cell, multiple dedicated inline palletizers with lower speeds, and a single inline palletizer with enough speed to palletize all lines in this project.

Limitations

This project is only related to the information as it known today. If the case sizes change this could impact the results of this project.

Conclusions

Overall the robotic cell provides the best value for current and future expansion. The capital investment for current needs is the lowest and the space utilization is also the smallest. When analyzing the data for a possible future expansion the robotic cell is the second highest in capital investment by thirteen percent. This equates to fifty six thousand dollars. Although it is not the least costly it still has the lowest space utilization, requiring only two thirds of the space of the lowest cost option for future needs, the Alvey palletizer. Another positive factor for the robotic cell is that it is floor level, and does not require the operators to climb stairs in order to operate the equipment.

Recommendations

Currently this project is only considered viable if the centralized palletizing project is implemented. With the low space utilization that the robotic cell requires it may be beneficial to consider installing this option in the current location for the manual

palletizing. If the company decides to pursue the centralized palletizing in the future the cell could be relocated to that location.

References

Ayral, T., & Moran, M. (2007). Quantifying the ROI of an Asset Performance Management Program. *Hydrocarbon Processing, 86*(5), 63-68.

Dempsey, P.G., & Maynard, W.S. (2005). Manual Materials Handling. *Professional Safety, 50*(5), 20-25.

Dossenbach, T. (2005). Equipment Justification Getting What You Need, Not What You Want. *Wood & Wood Products, 110*(8), 35-36.

Hynes, J. (2007). Selling Capital Projects to Management. *Power Engineering, 111*(6), 74-84.

Maloney, D. (2001) Palletizers: man vs. machine. *Modern Materials Handling, 56*(7), 65-69.

National Safety Council, (n.d.) Ergonomic Lifting Calculator.

Appendix A: Product Information

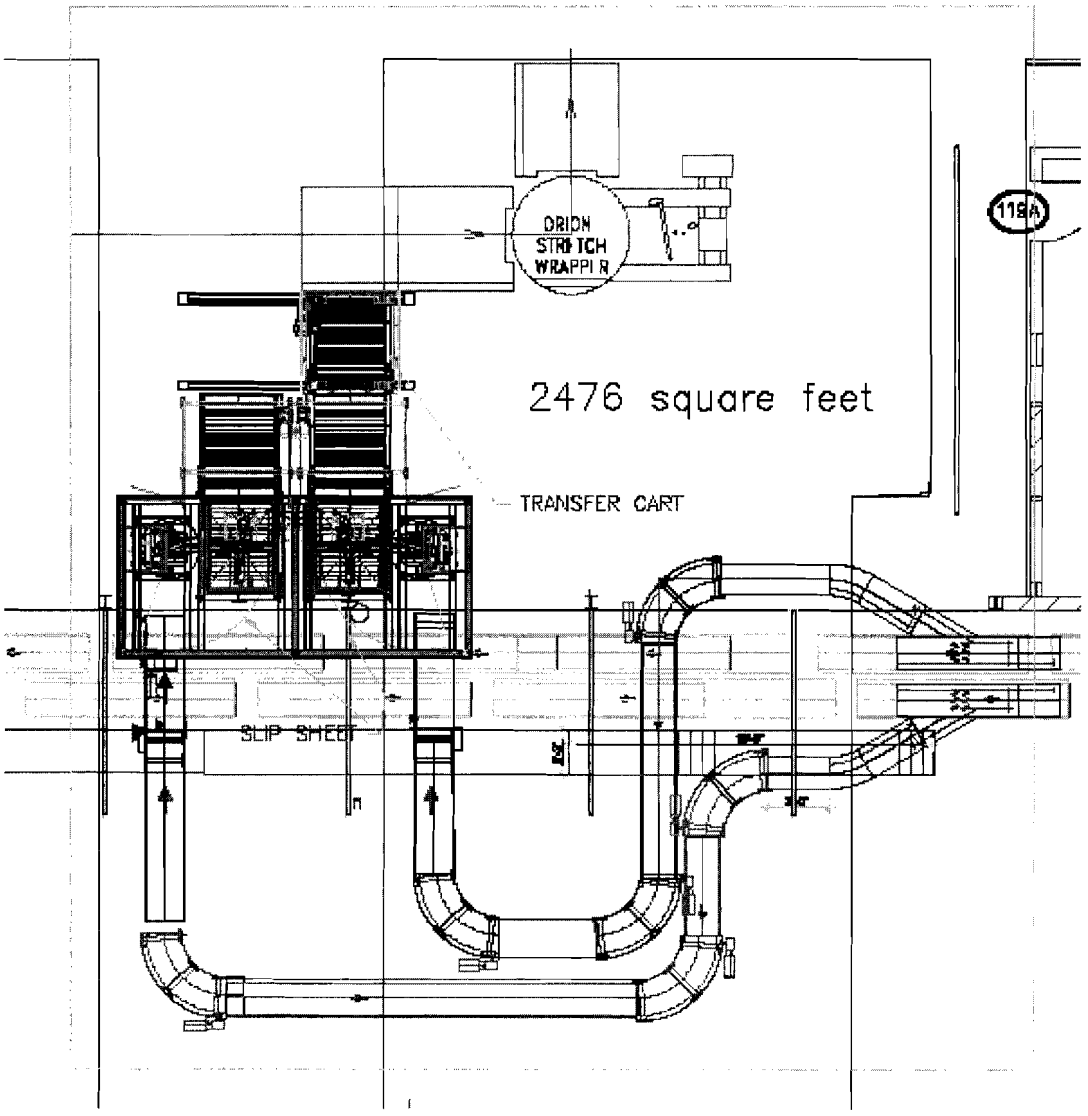
PRODUCT	CASE DIMENSION	WEIGHT
8 oz	16.38"L x 11.00"W x 4.00"H	14.1 lbs
13 oz	10.5"L x 7.125"W x 8"H	10.9 lbs
32 oz	12"L x 9.25"W x 4.5"H	12.9 lbs

PRODUCT	SPEED OF SUPPLYING LINE	CAPACITY NEEDED
		10% for this line
8 oz	18.75 cs/min	1.9 cs/min
13 oz	31.25 cs/min	3.1 cs/min
32 oz	31.7 cs/min	3.2 cs/min

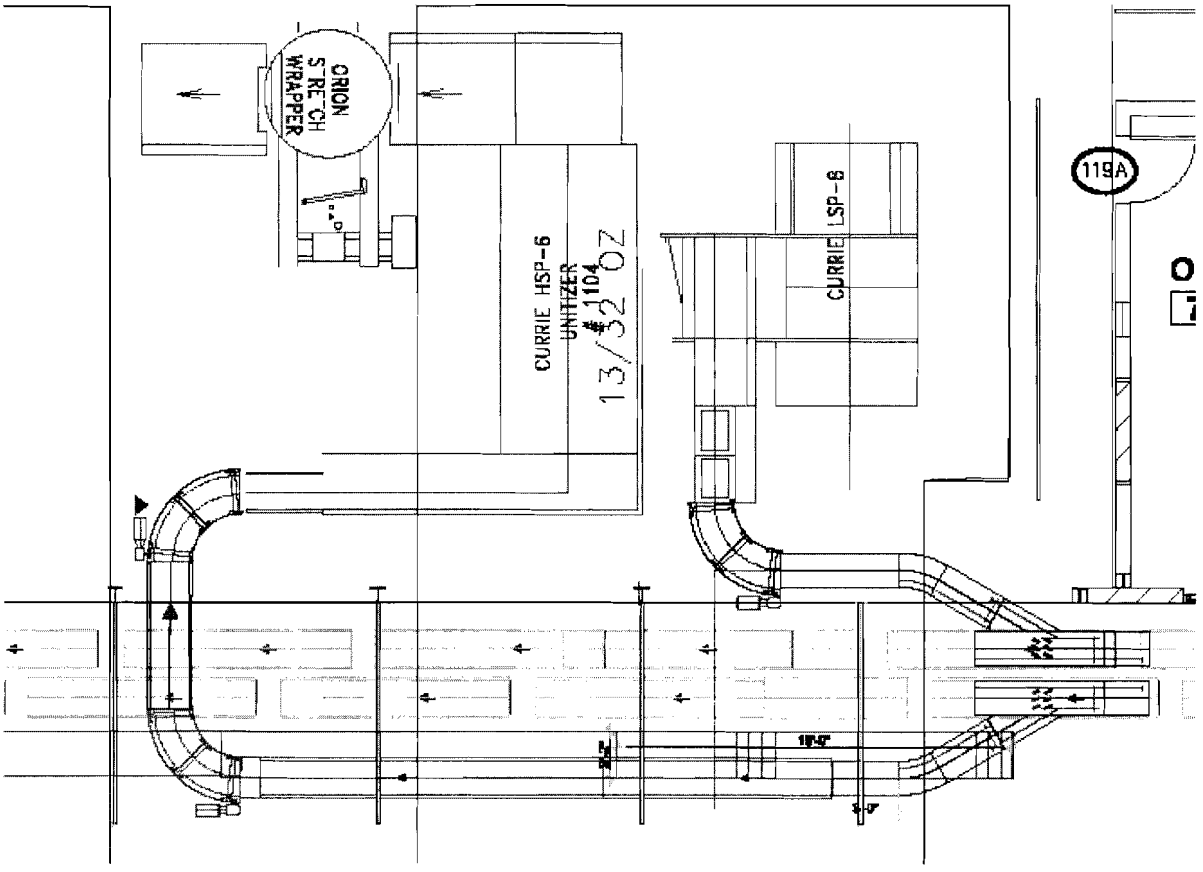
Capacity Needed for Palletizer [illegible] 5 cs/min

Appendix B: Layout Options – Current Needs

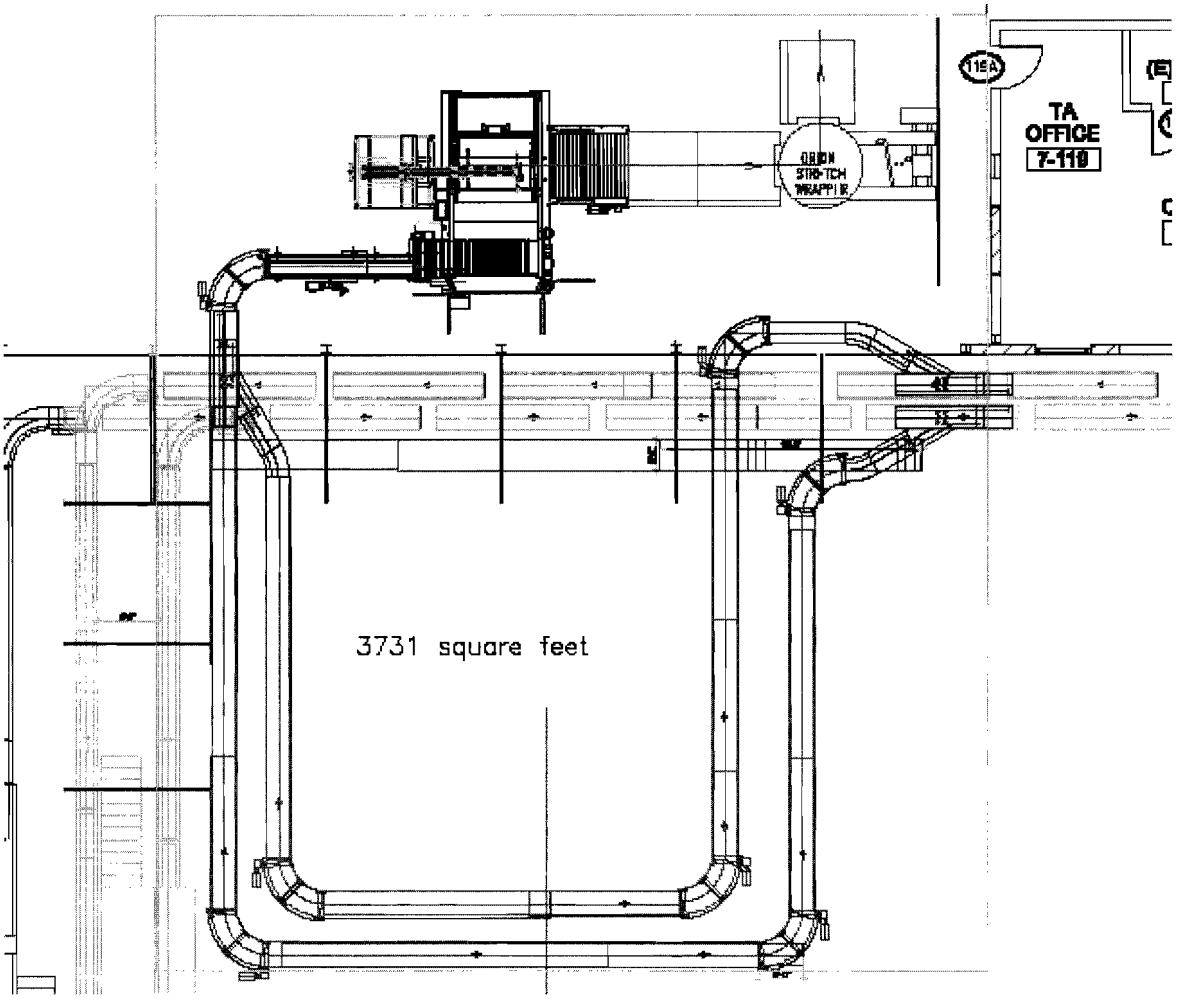
Option 1: Robotic Cell



Option 2: Currie Palletizers



Option 3: Alvey Palletizer



Appendix C: *Cost Estimates – Current Needs*

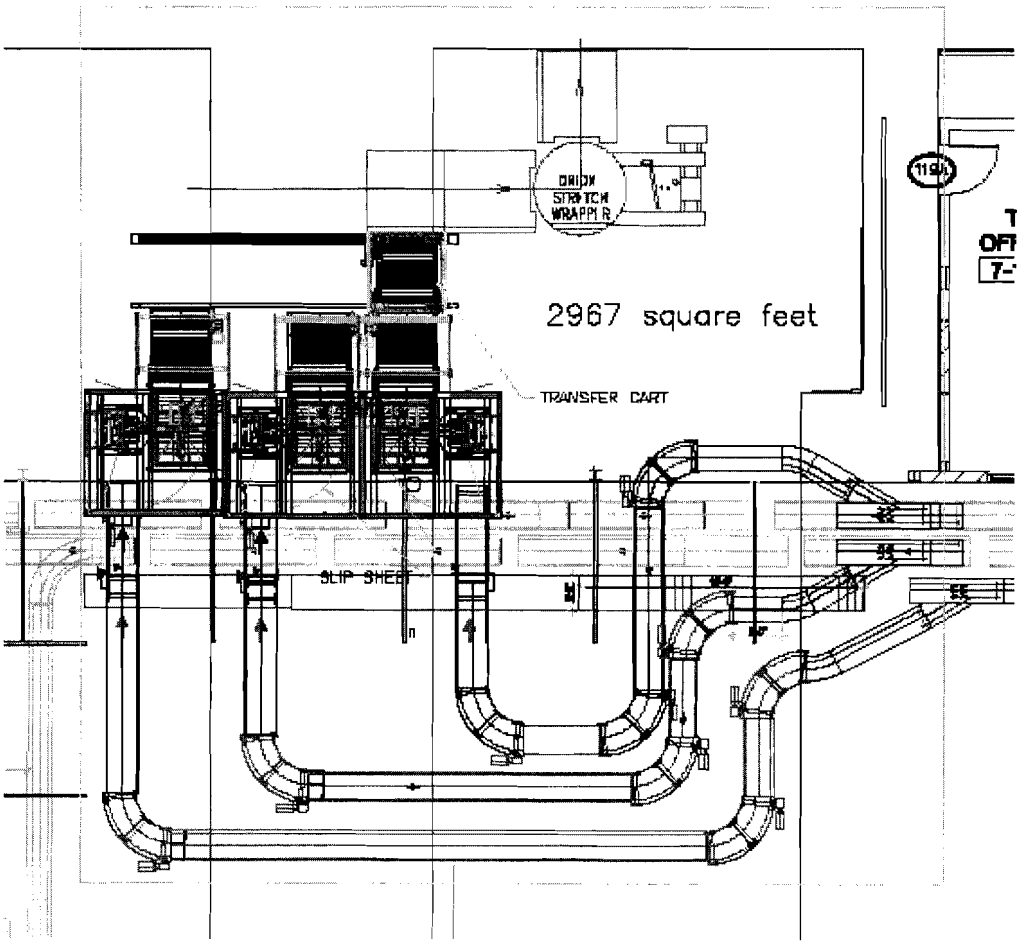
Option 1 - Robotic Cell	
Conveyor - Lane 1	$ 18,400
Conveyor - Lane 2	$ 23,200
Robot Cell	$ 272,750
Total Cost	$ 314,350

Option 2 - Currie Palletizers	
Conveyor - Lane 1	$ 6,800
Conveyor - Lane 2	$ 22,800
Rebuild Existing Currie	$ 97,740
Move Curries from Existing Locations	$ 19,600
New Palletizer	$ 180,000
Operator Platform	$ 25,000
Total Cost	$ 351,940

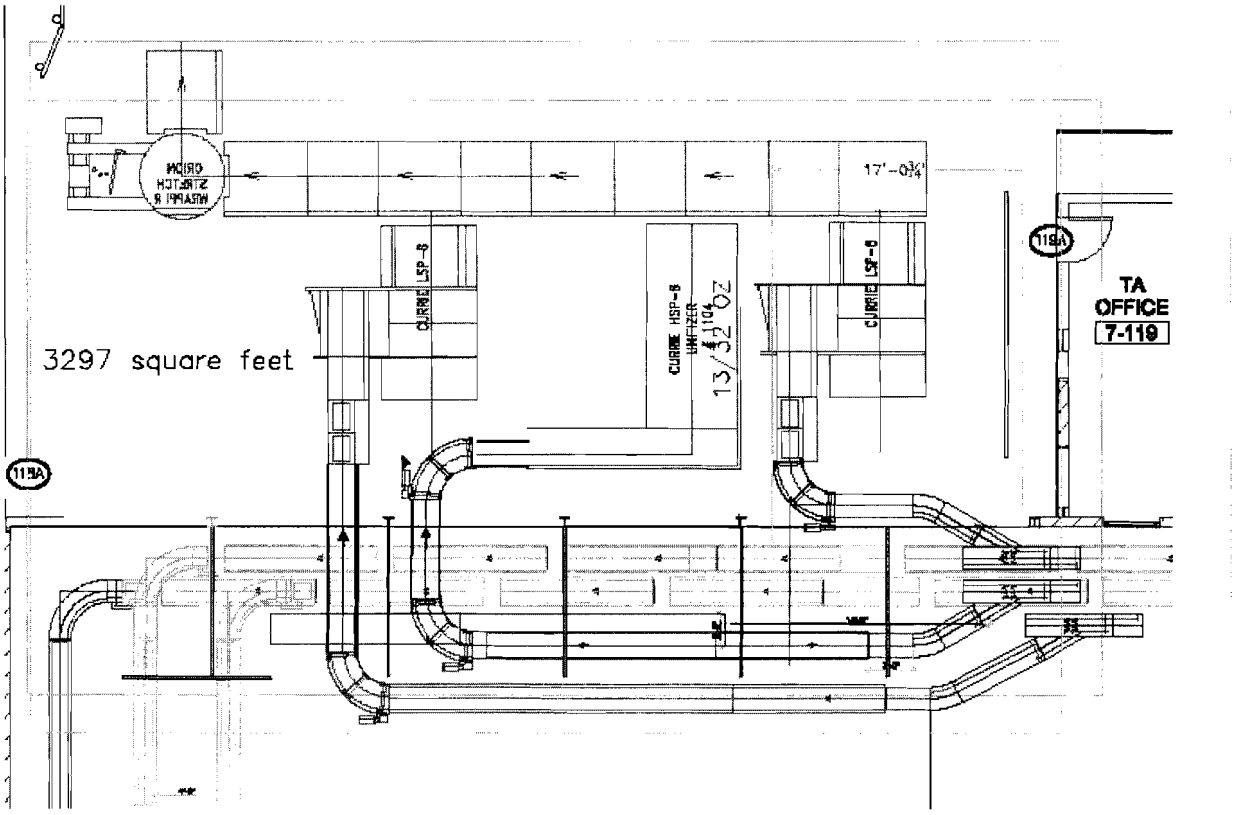
Option 3 - Alvey Palletizer	
Conveyor - Lane 1	$ 45,600
Conveyor - Lane 2	$ 42,400
Palletizer	$ 265,969
Operator Platform	$ 25,000
Total Cost	$ 378,969

Appendix D: Layout Options – Future Needs

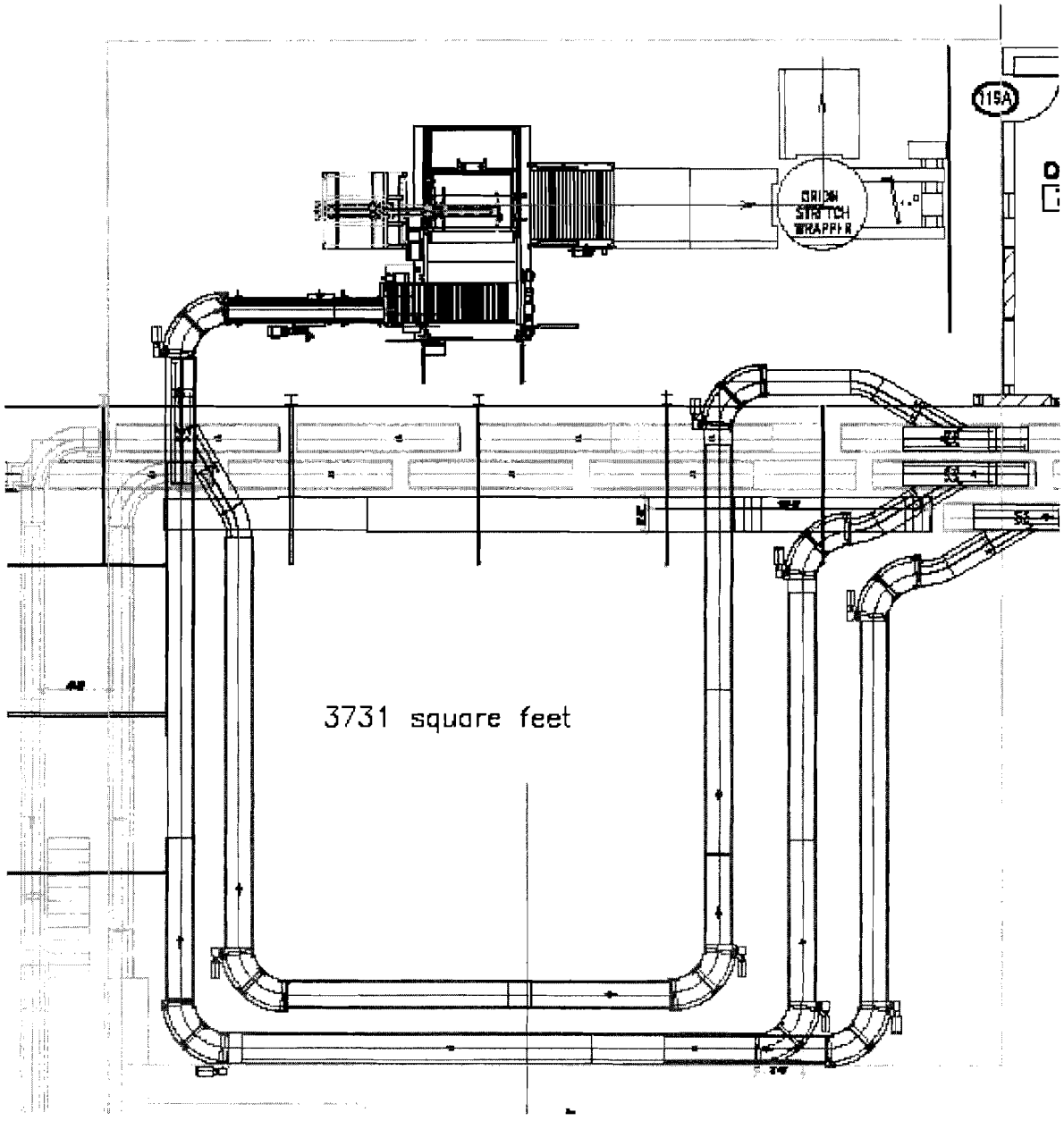
Option 1: Robotic Cell – Future Expansion



Option 2: Currie Palletizers – Future Expansion



Option 3: Alvey Palletizer – Future Expansion



Appendix E: *Cost Estimates – Future Needs*

Robotic Cell	
Conveyor - Lane 1	$ 18,400
Conveyor - Lane 2	$ 23,200
Conveyor - Lane 3	$ 31,200
Robot Cell	$ 272,750
Third Cell	$ 136,375
Pallet Conveyor	$ 15,000
Total Cost	$ 496,925

Currie Palletizers	
Conveyor - Lane 1	$ 6,800
Conveyor - Lane 2	$ 22,800
Conveyor - Lane 3	$ 30,800
Third Palletizer	$ 180,000
Pallet conveyor	$ 15,000
Rebuild Existing Currie	$ 97,740
Move Curries from Existing Locations	$ 19,600
New Palletizer	$ 180,000
Operator Platform	$ 25,000
Total Cost	$ 577,740

Alvey Palletizer	
Conveyor - Lane 1	$ 45,600
Conveyor - Lane 2	$ 42,400
Conveyor - Lane 3	$ 61,600
Palletizer	$ 265,969
Operator Platform	$ 25,000
Total Cost	$ 440,569

Appendix F: *Liberty Mutual Table*

Liberty Mutual Manual Materials Handling Guidelines

TABLE 2M - MALE POPULATION PERCENTAGES FOR LIFTING TASKS

ENDING BETWEEN KNUCKLE AND SHOULDER HEIGHT (≥31" AND ≤57")

OBJECT WEIGHT (POUNDS)	LIFTING DISTANCE (INCHES)	HAND DISTANCE	7 INCHES					10 INCHES					15 INCHES				
		FREQUENCY ONE LIFT EVERY	15s	30s	1m	5m	8h	15s	30s	1m	5m	8h	15s	30s	1m	5m	8h
96	30		-	-	-	-	12	-	-	-	-	-	-	-	-	-	-
	20		-	-	-	-	25	-	-	-	-	12	-	-	-	-	-
	10		-	-	16	21	46	-	-	-	-	30	-	-	-	-	-
92	30		-	-	-	-	16	-	-	-	-	-	-	-	-	-	-
	20		-	-	-	-	30	-	-	-	-	16	-	-	-	-	-
	10		-	-	20	25	52	-	-	-	13	36	-	-	-	-	-
88	30		-	-	-	-	21	-	-	-	-	-	-	-	-	-	-
	20		-	-	-	13	36	-	-	-	-	21	-	-	-	-	-
	10		-	11	25	32	57	-	-	12	17	42	-	-	-	-	13
84	30		-	-	-	-	27	-	-	-	-	13	-	-	-	-	-
	20		-	-	12	17	42	-	-	-	-	26	-	-	-	-	-
	10		-	15	31	38	63	-	-	17	22	48	-	-	-	-	17
80	30		-	-	-	11	33	-	-	-	-	18	-	-	-	-	-
	20		-	-	17	23	49	-	-	-	11	32	-	-	-	-	-
	10		12	20	38	44	68	-	-	22	28	54	-	-	-	-	23
76	30		-	-	11	16	40	-	-	-	-	24	-	-	-	-	-
	20		-	-	23	29	55	-	-	11	15	39	-	-	-	-	11
	10		17	26	45	51	72	-	13	29	35	60	-	-	-	-	29
72	30		-	-	16	21	47	-	-	-	-	31	-	-	-	-	-
	20		-	14	30	36	61	-	-	16	21	47	-	-	-	-	16
	10		23	33	52	58	77	11	19	36	42	66	-	-	-	13	36
68	30		-	11	22	28	54	-	-	-	15	39	-	-	-	-	11
	20		12	20	37	44	67	-	-	22	28	54	-	-	-	-	23
	10		30	41	59	64	81	16	26	43	50	72	-	-	14	19	44
64	30		12	17	30	36	61	-	-	16	21	47	-	-	-	-	16
	20		18	27	45	52	73	-	14	29	36	61	-	-	-	-	30
	10		39	49	65	70	84	25	33	51	57	77	-	-	20	26	52
60	30		18	25	39	45	68	-	12	23	29	55	-	-	-	-	34
	20		25	35	54	60	78	13	20	36	44	68	-	-	-	15	39
	10		47	57	72	76	87	21	42	59	64	81	-	13	29	34	60
56	30		26	33	48	54	74	13	19	32	38	63	-	-	-	-	32
	20		34	45	62	67	83	20	29	47	53	74	-	-	17	22	48
	10		56	65	77	91	+	41	51	67	71	85	13	20	37	44	67
52	30		35	43	57	63	80	21	28	41	48	70	-	-	13	17	42
	20		44	54	69	74	86	28	39	56	62	80	-	11	26	31	57
	10		64	72	82	85	+	50	60	73	77	89	20	29	47	53	74
48	30		46	54	66	71	86	31	38	52	58	77	-	11	21	27	53
	20		54	63	76	80	+	39	49	66	70	84	12	19	36	42	66
	10		72	78	86	89	+	60	68	80	83	+	30	40	57	63	80
44	30		57	64	74	78	88	42	50	62	67	83	14	19	32	38	63
	20		64	72	82	85	+	51	60	74	77	88	20	29	47	53	74
	10		79	84	+	+	+	69	76	86	87	+	42	51	67	71	86
40	30		68	73	81	84	+	55	61	72	76	87	24	31	44	51	72
	20		73	79	87	89	+	62	70	81	84	+	32	42	59	64	81
	10		86	88	+	+	+	77	82	89	+	+	54	63	75	79	89
36	30		77	81	87	89	+	66	72	80	83	+	39	46	58	63	80
	20		81	85	+	+	+	72	78	86	88	+	46	56	70	74	87
	10		89	+	+	+	+	84	88	+	+	+	66	73	82	85	+
32	30		84	87	+	+	+	77	81	86	88	+	53	60	70	74	87
	20		87	+	+	+	+	81	85	+	+	+	61	69	79	83	+
	10		+	+	+	+	+	89	+	+	+	+	76	82	88	+	+
28	30		+	+	+	+	+	85	88	+	+	+	68	73	81	84	+
	20		+	+	+	+	+	88	+	+	+	+	74	79	87	89	+
	10		+	+	+	+	+	+	+	+	+	+	85	88	+	+	+

+ = GREATER THAN 50% - = LESS THAN 10%

4