WAREHOUSE REDESIGN OF FACILITY LAYOUT, RACKING SYSTEM AND ITEM CLASSIFICATION AT SUNRIZE TACKLE INC

by

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A Senior Project submitted

in partial fulfillment

of the requirements for the degree of

Bachelor of Science in Industrial Engineering

California Polytechnic State University

San Luis Obispo

Graded By:________________________ Date of Submission:________________________

Checked By:________________________ Approved By:________________________

Executive Summary

This report presents the warehouse redesign of Sunrize Tackle Inc's main facility. Located in Santa Barbara, California, Sunrize Tackle is a manufacturer of premium swimbaits and other fishing tackle. They currently face a problem as their product is undergoing an alteration in packaging, and will not fit into the current space available. The objective is to develop an alternative layout and plan for the facility that improves flow of product and employees, reduces inefficiencies in daily operations, and can adapt to fluctuations in demand and sales. The current layout and operations were reviewed, and three major components which affect the majority of processes were identified. The rack formation, rack and shelf type, and classification system were all identified as areas for potential improvement. Alternatives to the current were produced for each area, and then compared against the each other. The best of the options from each category were then used to create two comprehensive alternative layouts to the current situation. Alternative two with horizontal aisles with several cross aisles, customized racks, and an ABC classification system was determined to be the best. This alternative improved the efficiency of operations at a minimum implementation cost of $320, which was calculated to be recouped within a maximum of two years.

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Introduction

This project was conducted for Sunrize Tackle LLC., located in Santa Barbara, CA. Sunrize Tackle sells their signature line of Big Hammer premium swimbaits, as well as other fishing tackle, clothing and accessories. After speaking with the owner, it was determined that there was opportunity for applications of Industrial Engineering concepts in the facility. Their primary facility is a relatively small warehouse, usually staffed by two or three. Although Sunrize Tackle is currently a relatively small operation, their business has been experiencing consistent growth which is expected to continue. This expansion has, among other things, resulted in a need for a new type of packaging for the product. The new packaging takes up significantly more space compared to the current bulk packaging. The problem addressed with this project is how to accommodate the different packaged product in the existing space.

The project satisfies several objectives in order to improve the operations at Sunrize Tackle. These include:

- Continue current functions of warehousing and distribution in current space although packaging space requirements are altered.
- Improve flow of employees and product throughout the facility.
- Decrease efficiencies in the current methods, including putaway, order picking and replenishment.

This project does not include changes to the product packaging, as that is determined by the manufacturer's capabilities and marketing requirements. In addition, alterations to the current order quantities and methods are not made as they are outside the project scope agreed upon with the customer.

The solution to the problem was reached by using the DAMES engineering approach [8,13]. This utilizes a distinctive set of five steps, and is a widely accepted standard. First, the problem is defined, as is presented previously in the opening paragraph. The next step is to analyze, both the problem and the data collected. The third step in the approach is to make the search for alternatives. This includes developing several different alternatives which theoretically could be implemented. The following step is to evaluate the alternatives which were developed. The evaluation could be according to a variety of criteria, although quantitative metrics are preferred. A ranking or scoring system can be used to quantify other metrics that are originally qualitative in nature. The final step is to select an alternative, and includes both the optimal alternative as well as a plan for implementation. Deliverables for the project include a final report, with the following sections: background, literature review, design, methods, results, conclusion, and bibliography and appendices. Items included within this are the alternatives, analysis, economic justification, implementation plan and current layout.

Background

Sunrize Tackle currently receives the majority of their Big Hammer swimbaits in bulk packaging from the manufacturer. Due to a shift in their target customers, they are transitioning from the bulk packaging to a packaging which provides better presentation of the product. This new packaging takes up more space than the original per unit. The product undergoing the change in packaging is the Big Hammer line of premium swimbaits. Sunrize Tackle also sells perch grubs, jig heads, bass lures, scents and fishing apparel. Details on their products can be found at www.swimbait.com and www.sunrizetackle.com. The Sunrize Tackle facility functions primarily as a distribution center. They receive goods from the manufacturer, in less than truck load lots, from UPS, Fed Ex or USPS. The products are then placed in storage or on shelves for picking. A minority of the product requires a small amount of value-added work, such as the placement of eye stickers on jig heads. When an order is received, an employee takes the list and picks items included in the order. They then assemble the order, and pass it to the shipping area. Here the box is sealed, and shipping labels printed. The package is then shipped on the next visit of the specified carrier.

Although there are a large number of projects done on layouts of a facility and its racking systems and picking methods, this project is still relevant. This is due to the fact that it focuses on a smaller company, which is seldom done. The solution will be beneficial to the company, maintaining a relatively easy and low-cost implementation, as well as minimal disruption to normal day to day activities. Due to this minimal available capital, automated racking systems and other high cost methods will not be considered, unlike many of the cutting edge projects which have been published recently. The literature review contains a summary of many sources and their contribution to the various topics encompassed by this project.

Literature Review

There are several documents which provide insight to others' approaches to problems similar to that of Sunrize Tackle, as well as information on best practices in comparable warehouse environments. The relevant documentation is limited by the fact that a significant portion of the literature pertains only to high volume operations. The topics which are relevant to this project, and will be included in this review are the general definitions and activities of a warehouse, facility layout, item classification systems, shelving and storage methods, picking methods and economic considerations.

The mission of a warehouse in a simplified form is to effectively receive, store and ship product to the next step in the supply chain without damaging the product. The warehouse must complete these activities quickly, effectively and accurately in order to be successful [14]. The four aspects which need to be addressed to develop a correct warehouse are the characteristics of the goods, their source and how they are conveyed, what will happen to them in the warehouse, and details of their ultimate destination. Specifically, Sunrize Tackle falls under the wholesaler/merchant category as they receive bulk finished or nearly finished goods, then break it and distribute it primarily to retailers [16]. This is opposed to the processes of storage for manufacturers or retailers/department stores. In the case of Sunrize Tackle, the three main working phases of the warehouse are receipt and storage of product, selection and replenishment, and packaging and outbound shipping [15][16].

The overall layout and design of the facility is a key factor in determining the effectiveness of the operation. Six steps should be taken to ensure an effective, flexible and well-ordered warehouse layout. Begin with establishing the objectives, then gather the facts, conduct analysis, formulate a plan, implement the plan, and finally follow-up [7]. In order to develop an efficient warehouse the design must incorporate the necessary components and space for receipt and storage of product, selection and replenishment, and packaging and outbound shipping. As a general best practice, it is recommended that the flow within the facility follow a 'U' shape [2]. In addition, it is recommended to enclose building supports within racks, and use narrow aisles due to the manual put away system in place [3]. Another sign of an ineffective use of space are travel aisles located on the perimeter of the area; the aisle should be shifted inward for the best utilization. Additional layout considerations are the placement of the aisles. In addition to the traditional layout of vertical or horizontal aisles, sometimes with one or two cross aisles, new research has shown that fish-bone and 'flying V' formations can be more effective [5][6]. Although these arrangements are shown to reduce travel time for single unit picking, their benefits decrease as the number of picks per trip increase. Furthermore, their benefit is offset as the additional travel aisles decrease the space utilization of the warehouse. The overall layout also needs to ensure that the correct amount of space is allocated and available for storage. Calculations of cubic space needed should be made for each item or group of items [1]. Typical assumptions assume sixty percent of the overall space can be used for product storage, with a loss of twenty percent from that amount due to honeycombing. Three general guidelines are available to make the best use of cubic space in the warehouse. "The first is to increase stacking height, the second is to reduce aisle width, and the third is to reduce the number of aisles."[1] A different option to increase cubic utilization is the construction of a mezzanine, although this requires a significant capital expenditure and generally needs a large, high-use facility to be justified.

An important part of organizing the warehouse is selecting the best type of classification system. An organizational best practice is to arrange the warehouse according to storage zones.

There isn’t a need for traditional zones such as refrigerated goods, but instead the organization could be separated by product type, such as baits, hooks, and other fishing items. Although a classification based upon customer can be beneficial, the current sales are spread between many customers and do not justify this method [3]. An ideal classification method is to categorize products as 'fast' and 'slow' movers. This is based upon the items activity, defined as the number of storages and retrievals per unit time, not the quantity of materials moved [12]. Furthermore, it is beneficial to use part families; "items that are ordered together should be stored together"[4]. Stock location systems generally fall into one of two categories: fixed or floating. The floating system has the better space utilization, but is limited by the requirement that inventory records are updated on a real time basis [1]. If there are many stock keeping units (SKU's), a blend of dedicated and randomized storage may be ideal. In this case SKU's are assigned a class which has a designated area, but within the class placement of items is random. It is recommended that between three and five classes are defined [14]. According to Steven Bragg, author of *Inventory Best Practices*, the most commonly used and highly recommended best practices are the assignment of location codes to all inventory locations, and the configuration of the warehouse space according to ABC classification [3][9]. For location code assignments, aisles are frequently assigned a letter designation, with each rack having a numerical code and each level of the rack a third numerical code. Additional considerations for the labeling system are to label the racks sequentially from left to right to minimize travel time for pickers, to consider any potential expansion and plan accordingly, and label every location [11]. Another important technique is to reduce the number of location codes for a single item to the minimal possible.

Shelving and storage systems provide a wide range of opportunities to store goods, ranging from simple racks to fully-automated systems. There are two main categories of small part storage systems, static and dynamic. Static systems tend to be relatively simple and inexpensive, and are often best storage methods despite their lack of automation. They are particularly effective when there is low to moderate throughput and storage volumes and a large amount of product types [13]. Within static small parts storage there are two primary methods. The first is the traditional method of shelving, which can be customized in many ways to fit the process. The second is modular drawer storage, which yields higher space utilization, generally close to fifty percent, compared to shelving. This increased capacity comes with a higher cost though, and is generally better for very small, loose items. Dynamic storage is preferred for applications with a very high level of activity so that its initial cost can be recouped. Common dynamic systems include vertical and horizontal carousels, movable-aisle systems, and automated storage/retrieval systems [13].

Due to the lack of automation of the Sunrize Tackle warehouse and the relatively low weight of the products, only manual picking systems will be examined. Order picking, regardless of which method is chosen, is one of the most important warehouse operating responsibilities [1]. Incorrect picks are expensive, preventable mistakes. The methods for order picking vary greatly and the level of difficulty in choosing the best method depends on the type of operation. The characteristics of the product being handled, total number of transactions, total number of orders, picks per order, quantity per pick, picks per SKU, total number of SKUs, value-added processing such as private labeling, and whether you are handling piece pick, case pick, or full-pallet loads are all factors that will affect the choice of a method for order picking [9]. Piece picking is the method in which individual items are picked. This method is characterized by a small number of quantities per pick, short cycle times and large volumes of

SKU's. Batch or multi-order picking is a variation in which multiple orders are combined to a single pick list and all picked in one pass.

Design

The continued expansion of Sunrize Tackle products into mainstream markets has resulted in a need for a new type of packaging for the product. The new packaging takes up significantly more space compared to the current bulk packaging. With the current warehouse layout it will be very difficult to accommodate the different packaged product. The warehouse is required to be able to effectively manage shipping, receiving, picking and packaging processes. Furthermore, it needs to be flexible and able to adapt to increases in product volume, variations in product packaging, and evolving purchasing trends. The final solution must also demonstrate improved flow and decreased cost of operations as compared to the current state.

Several constraints are in place for the design of the solution, including those established by the customer. Due to the relatively small scale of the operations only a small amount of capital, approximately $3,000 (USD) is available for improvements. An additional constraint is that the operations continue within the same building, and encompass no more square footage used than currently used. The cubic space used can vary, provided it is within the current footprint and does not violate fire safety codes. The solution also must maintain the same suppliers as are currently contracted, as well as anticipate the use of the same order quantities and forecasting methods. In respect to the product itself, no solution may alter the product or the packaging, although flexibility to incorporate changes is recommended. The implementation of the solution must be of minimal interruption to the function of the operations, with complete cessation of operations lasting no more than one week.

The layout currently in place at Sunrize Tackle can be seen in Figure 1, page A2 of the appendix.

The operations at Sunrize Tackle currently fall into three main categories: receiving and putaway, order reception and picking, packaging and shipping. The first operation is receiving and putaway, which is initiated upon the arrival of a shipment of product from the manufacturer. The boxes are accepted, and then moved to a set of tables for unloading and placement into locations on the racks throughout the facility. Issues which are present with this process are the distance from the boxes to the locations on the shelves, and the potential for boxes to remain fully or partially unloaded for a considerable amount of time. The next major process is initiated when an order is received from a customer. It is printed out, with the item and quantity highlighted for easier reading by the order picker. A basket or box, depending on the size of the order, is then used by the employee to pick orders. There is no standardized route which they take during the picking process. Multiple orders are occasionally picked simultaneously, but there is no rule to determine when this takes place. Once the orders are picked the loose items are brought to the packaging area. At this point the packaging and shipping portion commences. Items are packaged depending on their type, size and quantity. Products ordered in full-box lots are left in the boxes, while loose swimbaits are bagged. They are then placed into a large box for shipping with the necessary padding. The shipping boxes are affixed with the appropriate labels, and then placed in the pickup location for the next arriving delivery person. This process is streamlined, but does not occur in an optimized location within the facility.

Industry best practices were examined and compared to current operations for areas which Sunrize Tackle could improve upon in order to determine the various options for alternatives. The first area is a reduction of travel distance and time. Relatively new research by Kevin Gue, professor at Auburn University, has revealed arrangement of racks in specific formations can reduce travel distance. The simplest technique is the inclusion of cross aisles in the warehouse. Although they reduce the capacity and utilization of the space, cross aisles allow more efficient movement for order picking and replenishment. An additional use of cross aisles, albeit in an unconventional fashion is the 'flying V' formation illustrated in Figure 2. This utilizes diagonal cross aisles to cut the time and distance required during operations. Another method is the arrangement of aisles into the 'fish-bone' formation, as seen in Figure 3. Both of these methods are proven to drastically reduce the expected travel for single pick (unit load) orders, by up to twenty percent. Despite the promise of these methods, their effectiveness has been shown to decrease as the number of picks per route increases. Furthermore, with their optimized form being in a warehouse of between 20 and 40 aisles in size, their improvement over the relatively small layout at Sunrize Tackle is notably reduced.

To increase the efficiency of operations, specifically by minimizing travel, a method for classification of items is recommended. The current classification is based upon product type, with the popularity of items only given secondary consideration. A proven system which would provide definite benefits is the ABC classification system. In this system products are categorized as either A, B or C depending on their level of activity. 'A' products have the greatest activity, and are therefore located in the areas with the easiest and best access and given fixed locations. 'B' products are medium in priority, and are located in areas less desirable that that of 'A' products. They may be stored in fixed or random locations depending on the circumstances. Class 'C' products have the lowest amount of activity and account for the smallest percentage of business. Therefore, they are placed in the least desirable locations, with random storage. This allows for the greatest space utilization at the expense of ease of access; a minimal detriment as 'C' items are seldom needed.

Choosing the correct type of racks is an important decision for a warehouse operation. Sunrize Tackle has several options which are feasible given their product characteristics. The current racks are a simple shelving design with cross braces located on the back. Another common manual racks which could be implemented is a binbox system. An alternative to manual systems are the automatic racks and warehouse management systems. While cost is prohibitive for an automated storage/retrieval system, both vertical and horizontal carousels are a valuable option. Generally ranging from five to ten thousand dollars, carousels provide much greater space utilization and less employee travel. Examples of vertical and horizontal carousels are shown in Figures 4 & 5 respectively.

The overall layout of the warehouse is an important factor in the optimization of operations. The flow throughout should generally move in either a line or a 'U' shape. In this facility there is a single door for both incoming shipments and outgoing orders, so the flow should be in a circular manner. Beginning with reception from the manufacturer, to putaway and replenishment, to order picking and fulfillment, and finally concluding with packaging and delivery to the outgoing shipper, each process should be in close proximity to those it relies upon.

Methods

In order to develop alternatives, options for the rack type, classification system and rack arrangement will be evaluated. The preferred choices of each category will then be used to develop two alternative layouts which will be compared to the current as well as each other. The following were selected as criteria to evaluate the options:

- Space Utilization – amount of product that can be stored in a given cubic space
- Ease of Access – ease of which employees can replenish product, pick for orders, and conduct inventory counts
- Cost of Implementation – total cost of implementation including equipment, installation labor and training
- Long-Term Viability – ability to adapt to changes in products and overall warehouse layout

These same guidelines will be used to evaluate all of the categories, with the exception of the substitution of a 'Travel Distance' section instead of 'Ease of Access' for the rack arrangement category.

The first category which will be examined is that of the rack type which will be used throughout the warehouse. The racks need to provide safe and secure storage of the product, as well as allow for easy picking and replenishment. In addition, they must also utilize space well, and be able to adapt to changing product sizes and volumes. Given these requirements, three additional types of racks will be compared to the current. The current racks are simple shelves supported with cross pieces in back, set to the same dimensions throughout the warehouse and for all products. The first option is to take the current racks and modify the storage space heights and widths to better fit the product while maintaining the same outside structure as is currently in place. The two other options are vertical and horizontal carousels, which provide a more automated and space-effective approach to storage.

Rack Type	Space Utilization	Ease of Access	Cost of Implementation	Long-Term Viability
Current				
Current with Modifications				
Vertical Carousel				
Horizontal Carousel				

The next category to be evaluated is the type of classification system. This is important as it affects the ease at which employees can find product locations, as well as determining travel distances for all operations. The current system which will be compared with the alternatives is a systematic classification system in which there is a fixed location for all products, organized by size and color. An alternative to this is the random system, in which products are placed in any open location, maximizing the utilization of available space, although this tends to lead to difficulty finding items for picking and counting operations. A third choice is the ABC method of classification that is based upon the activity of item. The most active or accessed items are put in fixed locations in the best areas, while 'B' products are placed in less desirable locations, generally with fixed locations. The final category of 'C' items are stored with maximum space utilization in the least desirable locations. The final alternative system that will be evaluated is the customer zone in which inventory is organized by customer. This allows major customers to have dedicated zones in the warehouse, while another area remains to serve all smaller clients.

Classification System	Space Utilization	Ease of Access	Cost of Implementation	Long-Term Viability
Current/Systematic				
Random				
ABC Classification				
Customer Zone				

The overall rack arrangement and formation is currently a simple horizontal series of racks, and can be seen in Figure 1. In order to cut down on distance traveled during operations, three other formations will be evaluated. The first alternative is to add cross aisles to the current formation. The next option is to arrange the racks in a 'Flying V' formation, shown in Figure 3, as proposed by Dr. Kevin Gue. The third possibility, also published by Gue, is a 'Fishbone' formation, and can be seen in Figure 4.

Rack Formation	Space Utilization	Travel Distance	Cost of Implementation	Long-Term Viability
Current				
Current with Cross Aisles				
Flying V				
Fishbone				

The evaluation was conducted by using the previous tables to first rank then score the various options for each category. The alternatives, along with the current, were ranked from one to four, with one being the best rank and indicating superior performance to all other options in that segment. Each category was then assigned a weight based upon its importance to and impact on operations. The 'Ease of Access' and 'Travel Distance' categories are the most important, reflecting their weight of 45 percent. The ability for employees to efficiently complete their daily duties is of utmost importance, as the repetitious nature magnifies the adverse affects of any non-value added portion of the process. Due to the limited capital available, the 'Cost of Implementation' category was rated second highest. With the relatively small scale of the operations, a large capital expenditure will be difficult to recoup within an acceptable time. Therefore, a low capital cost is highly desirable, giving that category a weight of 25 percent. A weight of twenty percent has been assigned to the 'Long-Term Viability' section. This results from the intention of Sunrize Tackle to significantly expand operations within the next few years as their product is carried by large nationwide chain stores. The importance of ability for the warehouse to adapt is furthered by the fact that their product mix and characteristics are currently in transition. The least important category which was analyzed is that of 'Space Utilization'. Although this is important in optimizing the efficiency of operations, the transitioning product and surplus space in the warehouse minimize the need for the utmost use of the current racks. Using these weights and the previous ranking, scores were developed for each alternative for every category. The scores were found by taking the rank, subtracting it from five, then multiplying by the weight of the category. The scores were then totaled, and the best alternative was selected based upon the highest score. The best alternatives for rack type, classification system and rack formation were then used to create two alternative plans, including the overall layout, for the warehouse. The development of the layouts was also guided by the relationship between departments, given in Figure 11.

Each of the layouts were evaluated to find the which is optimal for Sunrize Tackle. There are four main criteria by which the layouts will be judged. First is the ability for the layout to adapt to changes in business, including in terms of volume, product mix, and product dimensions. This flexibility is created by effective utilization of space to allow for new racks to be added in case of expansion, while retaining good product flow and efficient operations at the current volumes. The next indicator is the travel distance for employees, measured for three different order types and the associated picking process. The first of the orders measured is for 3”, 4” and 5” swimbaits, and jig heads. The next typical order is for larger tackle, and is composed of 5”, 5 ½” and 6 ½” swimbaits as well as jigheads. The final order examined is for 3” and 4” swimbaits, perch grubs and apparel. These orders reflect the general demand for each product, and emphasize the best selling items such as the 3” and 4” swimbaits. The distance is measured from the order compilation tables to the average point for the product. In the alternatives, the ABC classification which places the product with higher demand in the more desirable positions is reflected by the fact that the employee travel distance is not to the middle of the rack but only approximately 1/3 of the way. This distance should cover the majority of the typical pick lengths. The time it takes for each type of order is found by assuming that the employee walks at a rate of four miles per hour. This is then used to calculate the annual cost of travel time during picking operations, assuming 8 sets of picks daily, a five day work week for eleven months annually, and a pay rate of 9.50 for the labor. The third category used to evaluate is that of cost of implementation. The cost is composed of the labor it will take to implement the new layout. The process of moving racks is assumed to take five minutes per rack, 3 minutes to unload and two to move it to the new location. Each rack also must be adjusted so the shelf heights are optimal for the various stock, which will take five minutes per rack. To move the stock to the newly placed racks it is expected to take ten minutes, including both the movement and actually restocking. The number of racks which fall into each category is determined for each layout, then used to find the time for each operation. The sum of these operations is combined with the time for the movement of other equipment, which allows the calculation of the time needed for the rearrangement of the warehouse. This time is then converted into the cost for each scenario based on a wage of $9.50 per hour for workers. The ease of use is the final category by which the layouts will be evaluated. Ease of use involves the relative ease or difficulty for an employee to complete four common tasks. These are finding items, receiving shipments and putaway of the bulk product, order picking and fulfillment, and replenishment. The alternatives and current layout were ranked in each task, and then the rankings were translated into scores by subtracting the sum of the rankings from 12.

Results

Analysis of the rack types found that the current racks with modifications of the shelves to better fit the product was the best option. The current racks with modifications were the best combination of space utilization, ease of access, cost of implementation and long-term viability as demonstrated by Table 1. The score given was 3.55, better than the current racks which scored 3.05. The vertical and horizontal carousel options scored 2 and 1.4 respectively.

The analysis of the classification system considered four alternatives. Following the analysis, the ABC classification system received a 3.4, the highest score. Some of the characteristics which led to its resulting as the best option include a high degree of ease of use for employees conducting tasks such as order picking and inventory counts and flexibility as the business evolves. The second highest rated classification system, with a 3.15, was systematic classification, the method currently applied in the majority of the facility. In this situation product is organized by name or type, allowing for an organized warehouse and minimal difficulties for employees looking for products. The random classification allows for the maximum space utilization, but is highly inefficient for all activities involving the product leading to a score of 2.25. The worst score of 1.2 was given to the customer zone system. Although it is highly effective in certain situations, the lack of a few large customers that make up a large part of the business at Sunrize Tackle makes it wholly unsuitable technique. Table 2 provides the full data from the analysis.

The four rack formations which were considered as possible options for the facility were the current long aisle formation, the current with added cross aisles, a "Flying V" formation, and a fishbone arrangement. The current with cross aisles layout was deemed as the best of the four, receiving a score of 3.65. This reflected its minimal cost to implement, ability to expand to future changes in sales volumes, and shortest travel distance for employees on multiple product picking trips. The second best option was the current formation, due to its high space utilization and lack of implementation cost. The Flying V and fishbone formations were ranked third and fourth respectively. Their low scores resulted from the cost to implement combined with minimum benefits for multiple load unit picking. The ranking and scores of all the rack formation options can be seen in Table 3.

Using the outcomes for the various categories, two alternatives to the current layout were developed. Both alternative layouts used the best from each category; the current racks with adjusted shelving dimensions, an ABC classification system and cross aisle formations. The current layout can be seen in Figure 1, while Alternative 1 and 2 can be seen in Figures 6 and 7 respectively.

The initial layout has several aspects which cause the operations to be significantly less efficient than is possible. A flaw readily seen in the drawing of the layout in Figure 1 is the lack of consistent organization throughout the facility. In several locations empty racks are interspersed with active racks containing product, and certain product groups are spread around in various locations throughout. This makes it difficult to find specific products, especially for new workers, and is a necessary component for nearly every process. The wasted time equates to a consistent and unnecessary funds spent for workers to complete tasks which could take less time. A comparison of the ease of use for the current layout and the two alternatives is shown in Table 4c. The current situation received the lowest score of the three, a result of the difficulties it causes for employees in most operations. Another part of the arrangement which forces inefficient work is the long uninterrupted aisles. Although large product groups can be condensed into a single aisle, it significantly adds to the travel time for each order. This is especially relevant as order picks are not single unit load, but rather multiple products in each trip. The paths taken by an employee for three typical orders can be seen in Figure 8. The combined distance for the orders is 509.95 feet, or a total of 170 miles annually. This equates to a cost of $403.71 each year for employees simply walking to pick orders (Table 4a). A lack of customization of the shelving and racks leads to a less than ideal space utilization. Another disadvantage of the current layout is its inability to expand or adapt to changes in the demand. Open space could be created by discarding unnecessary items, but the space would in large part be scattered throughout the facility, lessening its usefulness. The benefits of the current layout lie in the fact that it is of minimal cost. Due to the requirements of the customer for a solution with small capital expenditure this is a highly important factor.

Alternative 1 involves a reorganization of the layout, including altering rack positioning and product grouping. The new layout can be seen in Figure 6, and utilizes vertical racks for increased space utilization. The positioning of the current racks allows for the addition of ten extra racks if required. This provides flexibility for expansion if needed, while minimizing capital expenditure by not installing the additional racks at this time. The arrangement of Alternative 1 also decreases the travel distance for typical orders. The distance for the three typical orders is 242.53 feet in travel for this arrangement. This is a significant improvement over the current layout which 509.95 feet for the same orders. When this average is extrapolated to the number of orders for a typical year, and a walking speed of 4 miles per hour assumed, a total of 20 hours will be spent by employees walking to pick the orders. As shown in Table 4a, this translates into a cost $192 for employee wages. The current situation has a cost of $404 for the travel the equivalent orders. This decrease is due in part to shorter, more accessible aisles, as well as the ABC classification improving the location for the highest activity products. The layout showing the paths traveled for the order picks can be seen in Figure 9. The new layout we accomplished by the various manipulations of the racks and shelves. All 111 of the racks were moved which took 888 minutes, assuming each rack took 3 minutes to unload and another two to physically move it. The next step was to adjust the shelf dimensions to suit the product, which takes eight minutes per rack. This resulted in 600 minutes of work for the adjustment of 75 racks. The bulk stock and product must then be moved to its new location and placed back on the shelves, taking 990 min for the 99 racks worth of product. This calculation excluded twelve racks as they are currently empty and therefore would not contribute to this process. The above operations totaled 41.3 hours of work, and were combined with the five hours it was assumed to take to move all other equipment such as desks and packaging equipment. At a labor cost of $9.50 per hour, the redesign would cost $440 (Table 4b). This cost is offset by the predicted savings of 192 dollars annually for streamlined travel distance and time for order picking. The alternative 1 layout received a score of four in the ease of use category, better than the current but worse than alternative two (Table 4). Its benefit over the current, although not quantified, should further reduce the time it takes for employees to complete various actions, lowering labor costs. Combined with the travel distance savings, this alternative is expected to have a payback period of far less than two years.

The layout which performed the best overall is Alternative 2. As seen in Figure 7, it retained the horizontal aisles of the current facility, but added cross aisles to improve travel for employees. The new arrangement drastically improves the flexibility of the facility, especially pertaining to expansion. A total of 27 new racks can be implemented while maintaining its functionality and flow, nearly a 25 percent increase from the original capacity. Figure 10 shows the paths for the three orders for the layout of alternative two. The travel distance is the least in this design, totaling a mere 231 feet for the orders. This equates to an annual cost of $182, similar to that of alternative 1 at $192, but far less than the original which is $404. The cost of this alternative is mediated by the fact that several racks stay in their current position. Only 38 racks are required to be moved, resulting in 304 minutes of work. The height adjustment and movement of stock are performed on the same number of racks as the first alternative, and result in 600 and 990 minutes respectively. The total time for the movement of the racks becomes 31.57 hours, with an added to hours for the movement of other equipment. This is less than the five additional hours needed in Alternative 2 as the main station which receives orders and is used for packaging remains in nearly the same location as it is currently. The sum of the above time results in a labor cost of $318.88 for the implementation of the layout. The preceding calculations can be seen in Table 4a and b. The ease of use of this layout for the employees is the best of the three layouts. The ABC classification system organizes the warehouse, placing items of high activity in easily accessed locations. Compared to the other layouts it was deemed the best in terms of finding items, receiving shipments and bulk putaway, and order picking. This resulted in a score of seven, clearly bettering the other options. The payback period is approximately one and half years, based off of the savings from travel distance and the cost of implementation. The payback period is would likely be far less as savings in areas such as reduced labor costs due to optimized operations and fewer defects from increased organization are benefits which have not been quantifiably measured.

Conclusion

The current facility at Sunrize Tackle Inc is able to satisfactorily complete all of the necessary operations, although many are inefficient. Furthermore, the current layout is unable to effectively cope with fluctuation in the business, such as sales volume and product size. The results indicated that the implementation of a layout as proposed in Alternative 2 would provide extensive and enduring benefits at a minimal initial cost. Rearrangement of the rack formation, customization of the shelves, and new classification system for item placement are all key improvements, saving time and money for the company. The implementation of an alternative such as the proposed would allow the company freedom to pursue significant expansion of their sales while remaining in the same facility.

The topic of warehouse redesign is minimally explored in the case of small operations. With limited resources, many of the methods recommended for large-scale operations are not feasible or cost effective. Solutions for smaller operations require innovative ideas and sound management rather than a focus on automation and the newest technologies. Many of the most significant improvements can be made by implementing proven best practices such as organization via the 5 S's and a item classification system tailored to the specific needs of the company and facility.

The project accomplished the objectives stated in the introduction and formulated in conjunction with the customer. An alternative was created that streamlined the employee and product flow, as well as identified and resolved inefficiencies in the current methods. The processes improved including reception of bulk product and putaway, order picking, replenishment, and packaging and shipping. Furthermore, the facility was altered to be able to accommodate alterations in product size, as well as changes in demand and volume of orders.

All of these improvements were obtained with minimum interruption, less than a two business days with three employees working, and at a low cost which will be recouped within two years by the company.

If this projected were to be attempted again, it would be beneficial to analyze the ordering policy of the company. It is possible that they did not need the space they currently have if inventory could be reduced by implementing better ordering policies. Analysis of this process would have made the project more complete and the result a more comprehensive solution.

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Appendix A

Figure 1: Current Layout

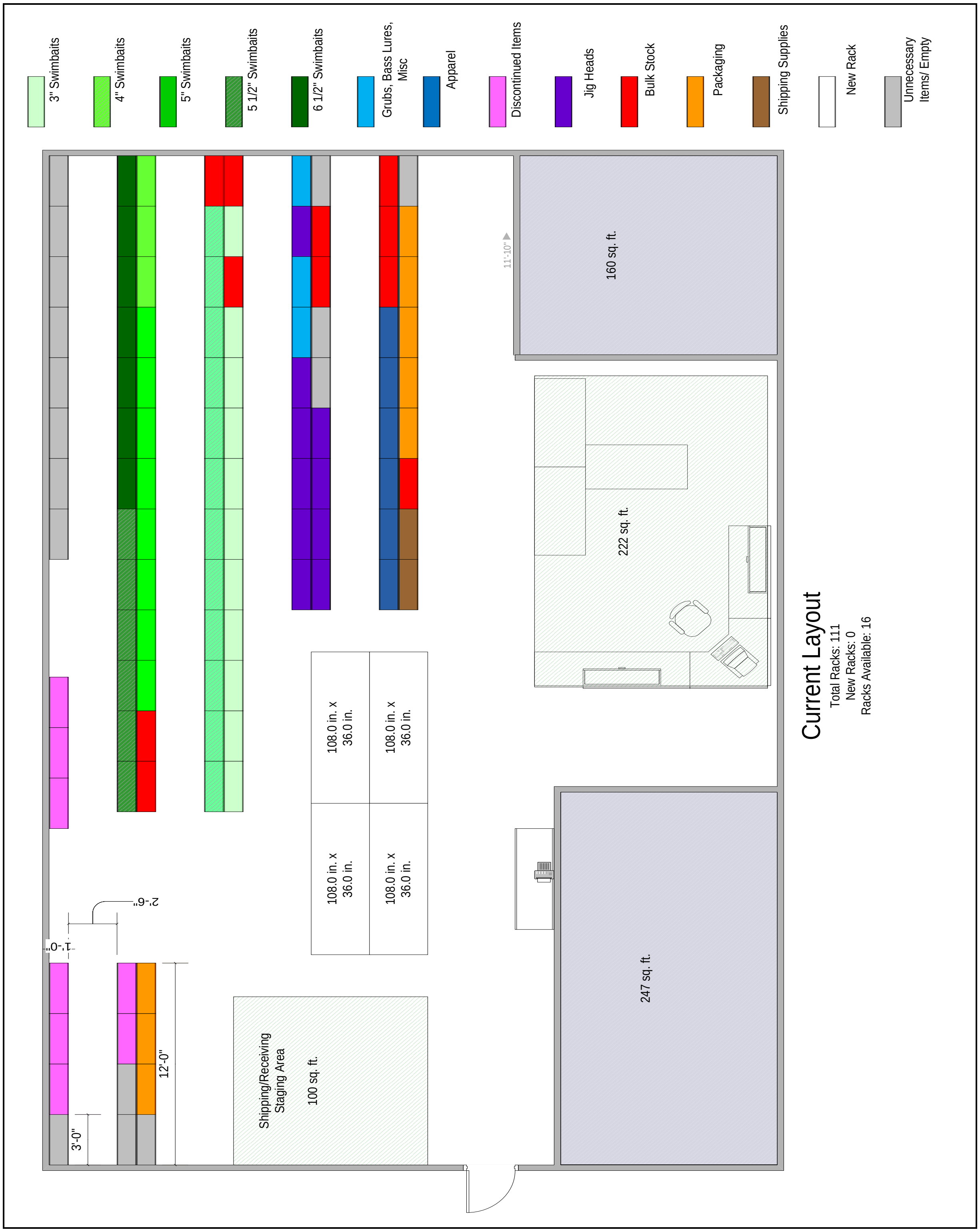

Figure 1: Current Layout

Figure 2: Flying V Rack Formation

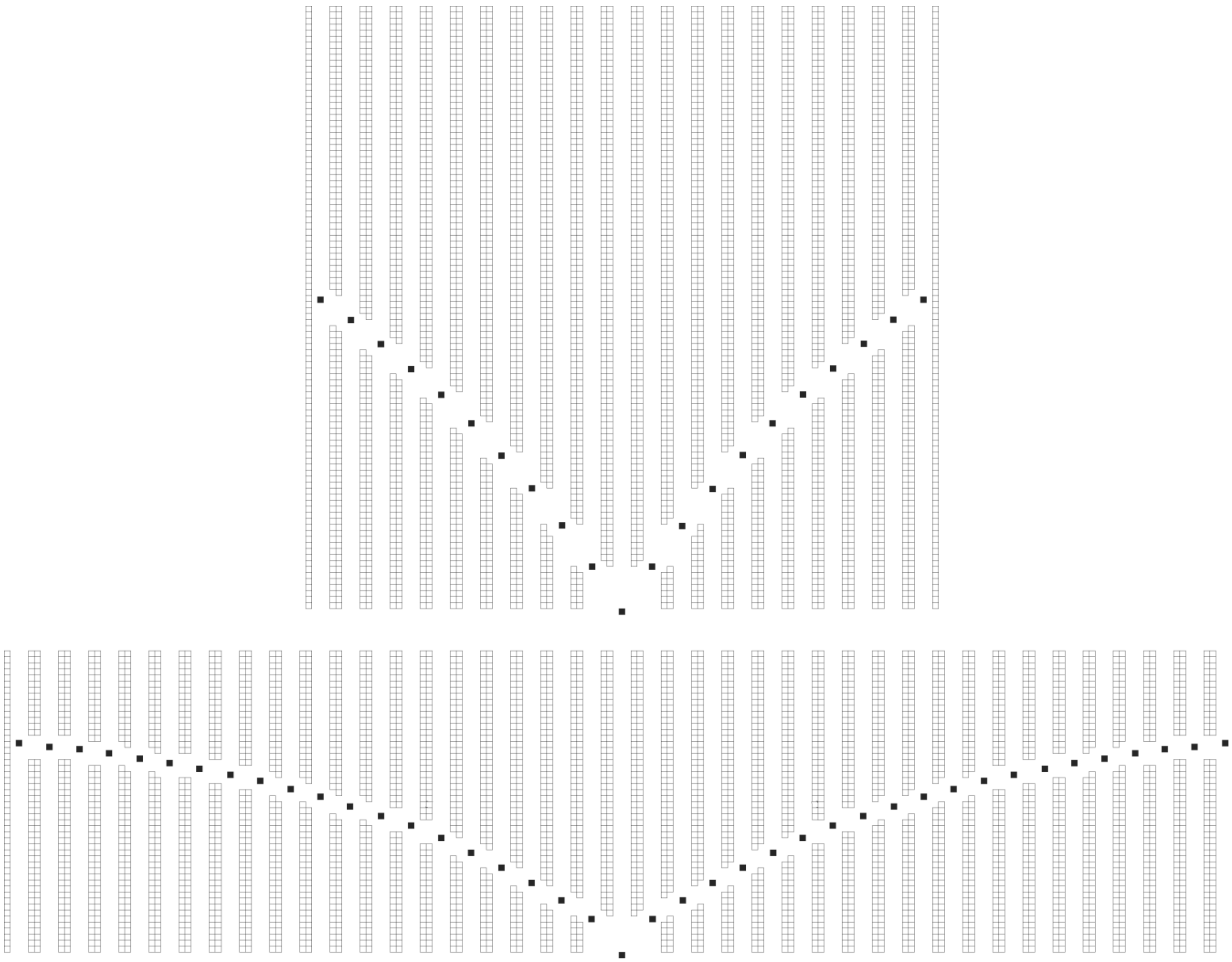

Figure 2: Flying V Rack Formation

[6] Gue, Kevin R. and Meller, Russell D.(2009)'Aisle configurations for unit-load warehouses',IIE Transactions,41:3,171 — 182

Figure 3: Fishbone Rack Formation

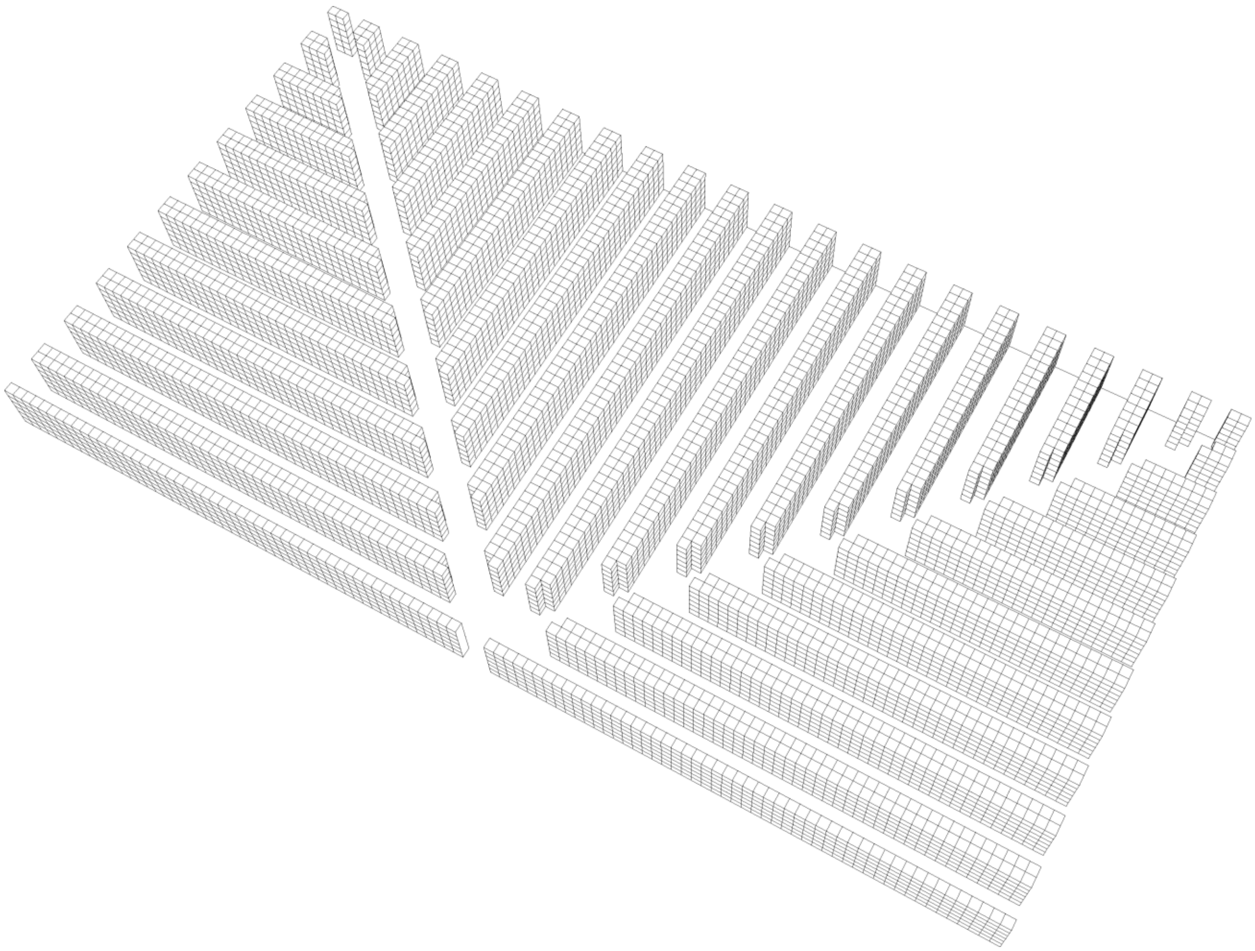

Figure 3: Fishbone Rack Formation

[6] Gue, Kevin R. and Meller, Russell D.(2009)'Aisle configurations for unit-load warehouses',IIE Transactions,41:3,171 — 182

Figure 4: Vertical Carousel

www.sjf.com/carousel.htm

Figure 4: Vertical Carousel

Figure 5: Horizontal Carousel

Figure 5: Horizontal Carousel

www.sjf.com/carousel.htm

Figure 6: Alternative 1

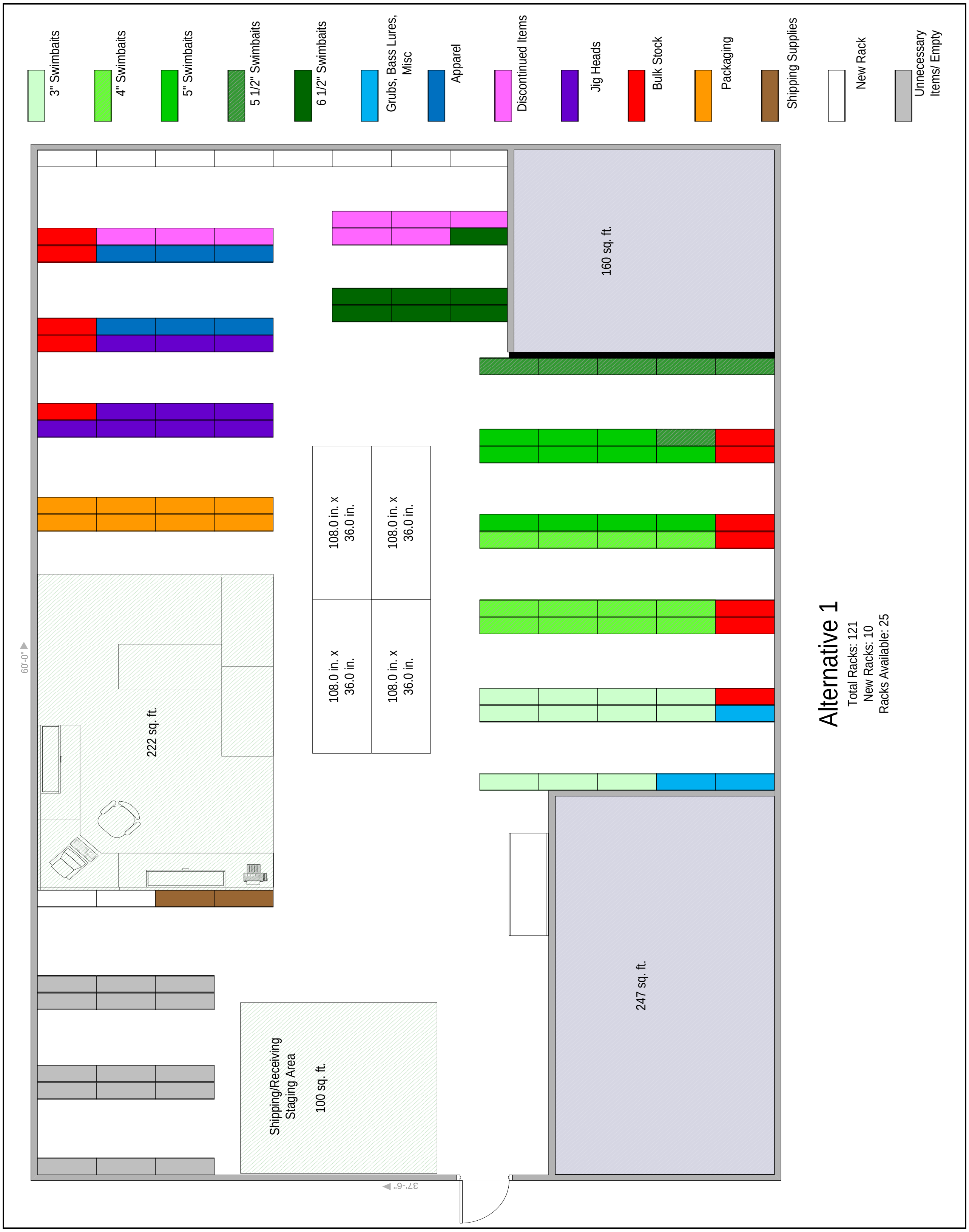

Figure 6: Alternative 1

Figure 7: Alternative 2

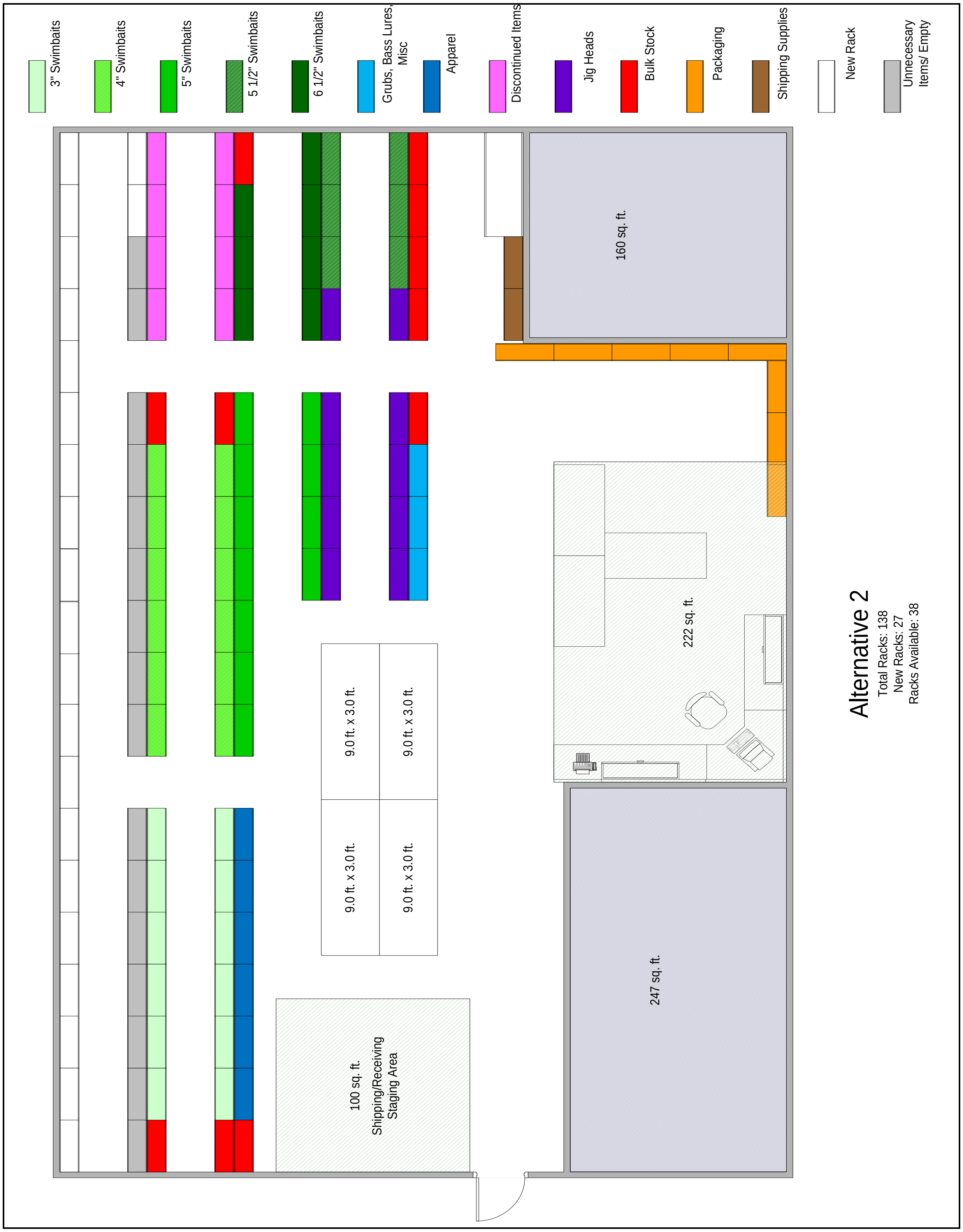

Figure 7: Alternative 2

Figure 8: Current Layout With Order-Picking Paths

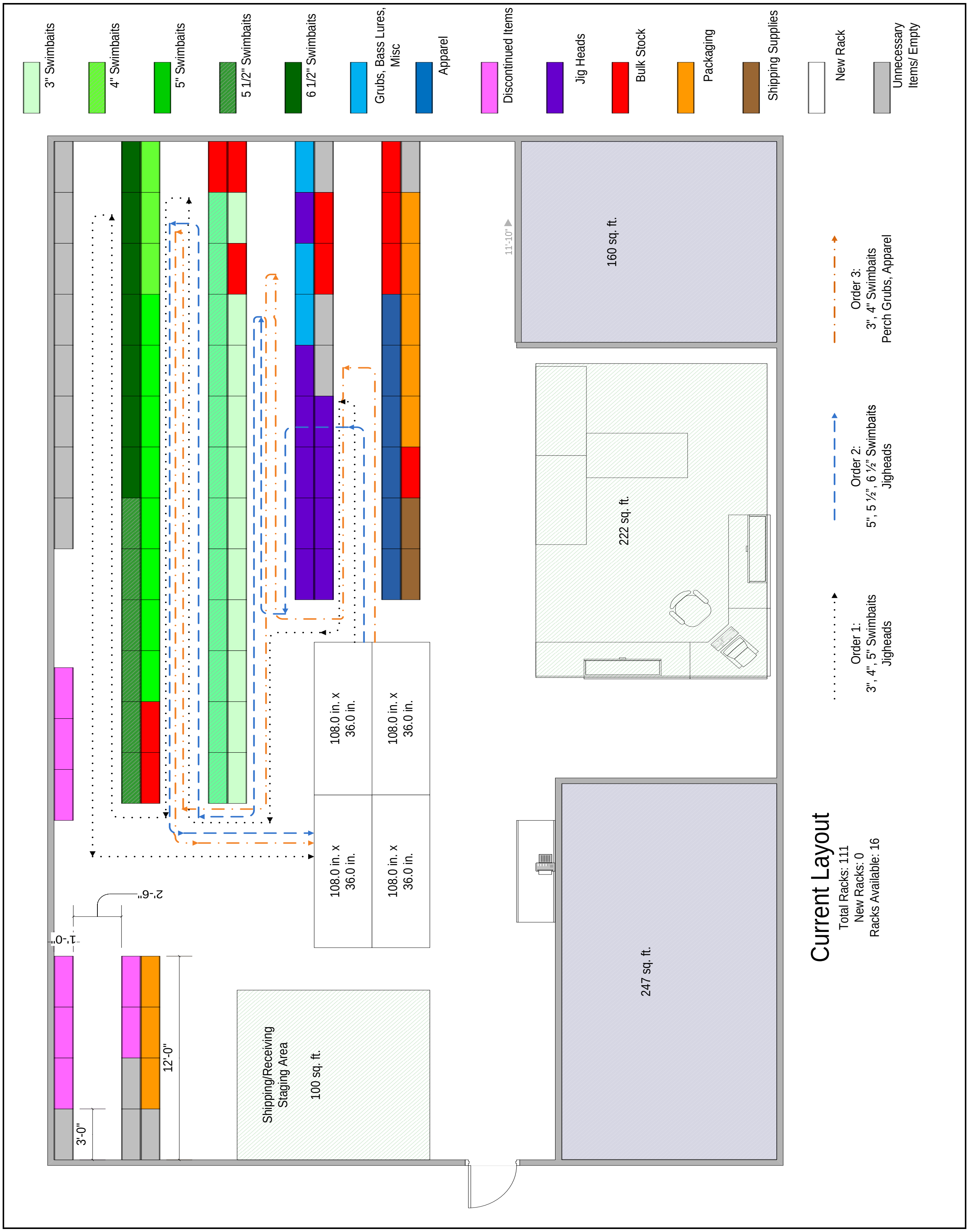

Figure 8: Current Layout with Order-Picking Paths

Figure 9: Alternative 1 With Order-Picking Paths

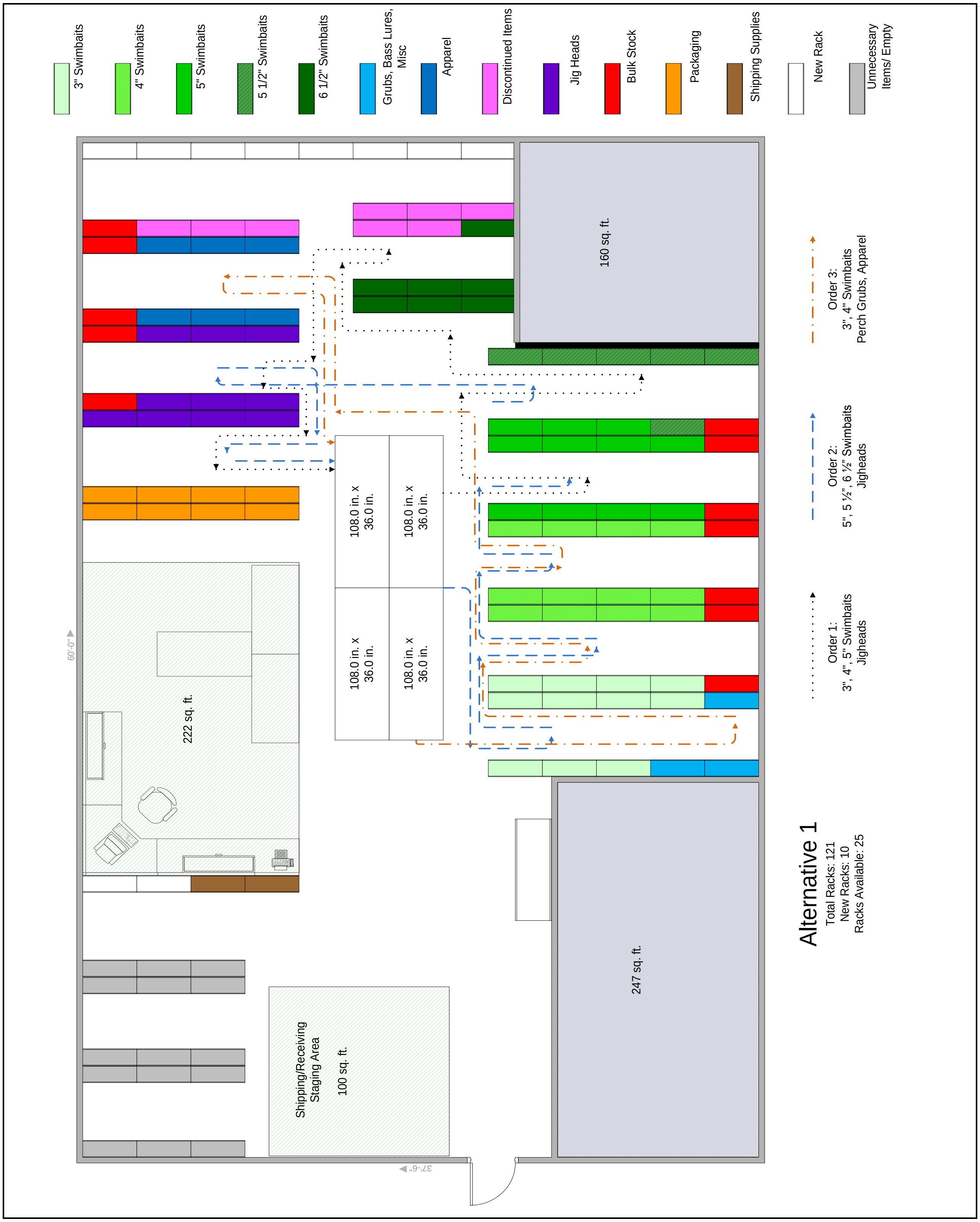

Figure 9: Alternative 1 with Order-Picking Paths

Figure 10: Alternative 2 With Order-Picking Paths

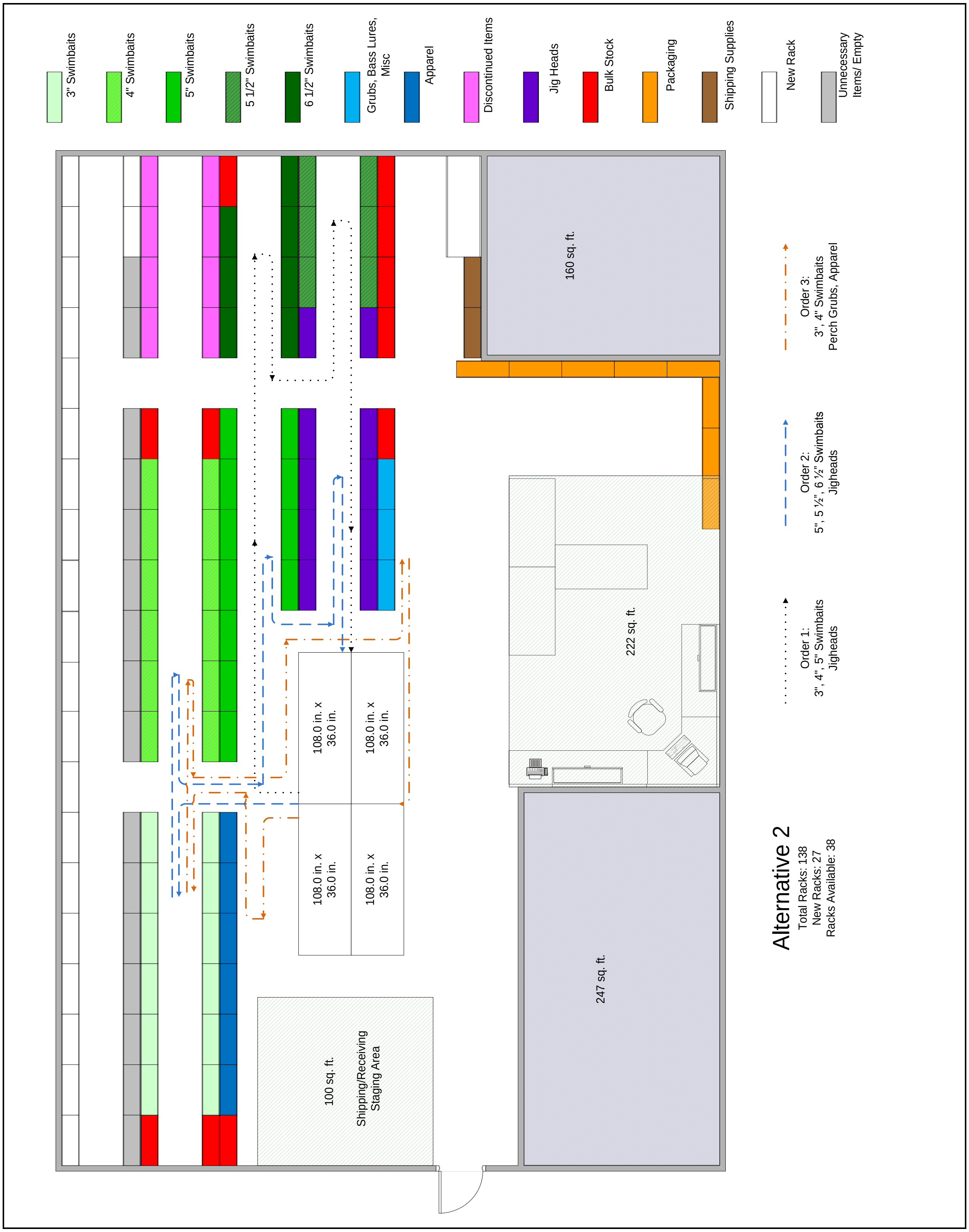

Figure 10: Alternative 2 with Order-Picking Paths

Figure 11: Relationships between Departments

Relationships between Departments

	swimbaits	other product	bulk product	order compilation	packaging	packaging mat'l	shipping	receiving
swimbaits	--							
other product	I	--						
bulk product	E	E	--					
order compilation	A	A	X	--				
packaging	X	X	X	A	--			
packaging mat'l	X	X	X	X	A	--		
shipping	X	X	X	X	A	X	--	
receiving	I	I	I	O	X	X	X	--

A	absolutely necessary closeness
E	especially important closeness
I	important relationship
O	ordinary closeness
X	no relationship

Figure 11: Relationship Between Departments

Table 1: Rack Type

Rack Type

	Space Utilization	Ease of Access	Cost of Implementation	Long-Term Viability
Current	4	2	1	2
Current with Modifications	3	1	2	1
Vertical Carousel	1	3	3	4
Horizontal Carousel	2	4	4	3

-	Space Utilization	Ease of Access	Cost of Implementation	Long-Term Viability	
weight	*10%*	*45%*	*25%*	*20%*	**Total**
Current	0.1	1.35	1	0.6	3.05
Current with Modifications	0.2	1.8	0.75	0.8	**3.55**
Vertical Carousel	0.4	0.9	0.5	0.2	2
Horizontal Carousel	0.3	0.45	0.25	0.4	1.4

Table 1: Rack Type

Table 2: Classification System

Classification System

	Space Utilization	Ease of Access	Cost of Implementation	Long-Term Viability
Current/Systematic	3	2	1	2
Random	1	3	2	4
ABC Classification	2	1	3	1
Customer Zone	4	4	4	3

-	Space Utilization	Ease of Access	Cost of Implementation	Long-Term Viability	
weight	*10%*	*45%*	*25%*	*20%*	**Total**
Current/Systematic	0.2	1.35	1	0.6	3.15
Random	0.4	0.9	0.75	0.2	2.25
ABC Classification	0.3	1.8	0.5	0.8	**3.4**
Customer Zone	0.1	0.45	0.25	0.4	1.2

Table 2: Classfication System

Table 3: Rack Formation

Rack Formation

	Space Utilization	Travel Distance	Cost of Implementation	Long-Term Viability
Current	1	4	1	3
Current with Cross Aisles	2	1	2	1
Flying V	3	4	3	2
Fishbone	4	3	4	4

-	Space Utilization	Travel Distance	Cost of Implementation	Long-Term Viability	
weight	*10%*	*45%*	*25%*	*20%*	**Total**
Current	0.4	0.45	1	0.4	2.25
Current with Cross Aisles	0.3	1.8	0.75	0.8	**3.65**
Flying V	0.2	0.45	0.5	0.6	1.75
Fishbone	0.1	0.9	0.25	0.2	1.45

Table 3: Rack Formation

Table 4: Alternative Analysis

	Current	Alternative 1	Alternative 2
Total Racks	111	121	138

Table 4a

Average Order Travel Distance	Current	Alternative 1	Alternative 2
1) 3", 4", 5", Jig heads	149.09	89.84	83.75
2) 5", 5.5", 6.5", Jigheads	197.71	74.18	75.77
3) Perch Grubs, apparel, 3", 4"	163.15	78.51	71.41
Total Distance (ft)	509.95	242.53	230.925
Total Distance (miles)	0.096581439	0.045933712	0.043735795
Annual Miles	169.9833333	80.84333333	76.975
Travel Time (hrs)	42.49583333	20.21083333	19.24375
Annual Cost ($)	**$403.71**	**$192.00**	**$182.82**

Table 4b

Cost		Current	Alternative 1	Alternative 2
Moving Racks	3 min to unload each rack, 2 min move	0	888	304
Customizing Racks Adjustments	8 min	0	600	600
Moving Stock	10 min per rack to move and restock	0	990	990
Total Time	(hrs)	0	41.3	31.57
Moving Other Equipment	Desk, tables, packaging equipment	0	5	2
Cost	**(labor @ $9.50/hr)**	**$0.00**	**$439.85**	**$318.88**

Table 4c

Ease of Use	Current	Alternative 1	Alternative 2
Finding Items	2	3	1
Receiving Shipments and Putaway	3	2	1
Restocking	3	1	2
Order Picking and Fulfillment	3	2	1
Total	**1**	**4**	**7**
Payback Period	**N/A**	**2.077630693**	**1.443598244**

Table 4: Alternative Analysis