# ISYE 3104 Project

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**Part 1 - Size**

The total facility size is 467,500 square feet. We determined an average pallet density of 1 pallet per 25 square feet, considering the height of the pallet racks, 100 foot long sections of doubled up pallet racks, and the necessary aisles surrounding the pallet racks. Specifically, the racks are 8 feet wide, 12 feet of aisle on each side. The length is 100 feet of pallet rack plus 12 feet of isle. That gives 200 pallets / 2240 square feet.

We rounded up using the shared space equation $Vs = \sum \mu + z\sqrt{\Sigma\sigma i}$

We calculated Vs for each category class A, B and C, which gave us the number of pallets for each section.

For the fast pick area, there are roughly 6600 pallets required for class A in that area of the warehouse; one thousand of those pallets are designated for the fast pick area. An additional 3000 of those pallets are stored in the randomized available pallet rack space above the fast pick area. The remaining 2600 are stored in a dedicated randomized storage area.

We rounded up the square footage in multiple stages to account for space not associated with warehouse operations related to pallet storage, such as breakrooms, bathrooms, offices, managerial space, utilities space, equipment storage, etc..

**Part 2 - Classification**

**Pieces:**
**First-pick section (Class A):**

The first pick section would be a dedicated section for solely pieces.
Using the piece benefit equation $Benefit = (spi - crdi)/li$ with
$s = c2 - c1 = 3.35\, minutes - 0.35\, minutes = 3\, minutes$
$cr = 3\, minutes$ $di = piece\ demand\ in\ pallets$
$li = minimum\ pieces\ needed\ to\ be\ in\ forward$

Knowing that the first pick section capacity is 1000 pieces, we ranked the benefit of each SKU in the spreadsheet.
Since $\sum_{i=1}^{n} Min\ Pallet = 1000$ , we determine the highest benefit SKUs in the spreadsheet that will make up the first pick section. *The 485 SKUs that will be placed in first pick have SKU ID colored in yellow.*

**Class B:**
Excluding first-pick pieces, any *leftover pieces that have piece demand less than or equal to zero will not be stored in any of the classes. The SKU ID are colored in red.*
Using the activity ratio equation for pieces: $AR = pi/vi$
$with\ pi = piece\ picks,\ and\ vi = max\ pallets$

We ranked the leftover SKU pieces not in the first-pick section and are still in the warehouse (if demand $\geq 0$) in terms of activity ratio.

We decided to take the top half of the ranked SKU pieces population in terms of activity ratio to be in class B.

Specifically, for any SKU with ARi, the SKU is in class B if and only if
$ARi \geq 2.6,\ with\ demand \geq 0\ and\ not\ in\ first\ pick$

**Class C**
Similarly, class C can be separated by taking the latter 50% of the ranked SKU pieces population in terms of activity ratio to be in class C.

Specifically, for any SKU with ARi, the SKU is in class C if and only if
$ARi < 2.6,\ and\ demand \geq 0$

**Pallets:**
Similarly, pallets can be classified in the same method.
We first excluded all pallets that have pallet demand $\leq 0$, these items will not be stored in the warehouse.

Then, we ranked the pallets using the activity ratio, similar to pieces
$AR = pi/vi,\ with\ pi = pallet\ picks,\ vi = max\ pallet$

We classified the pallet population using ABC analysis and Pareto ratio of 20%, 30%, and 50%.

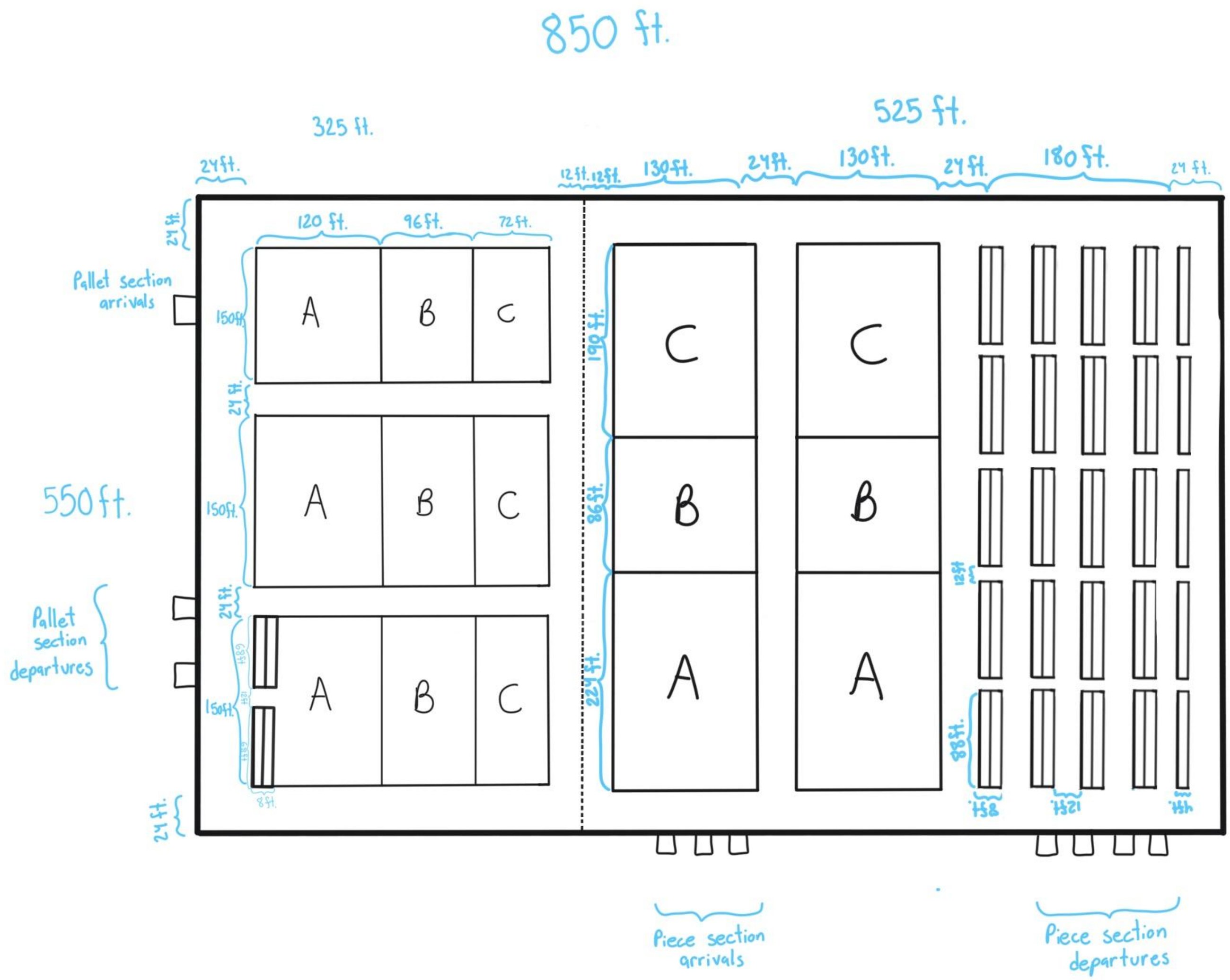
The pallets can be classified into the three different sections. When ranked according to activity ratio, the top 20% of the pallets will be ranked in class A, the middle 30% of the pallets ranked in class B, and the bottom 50% in class C.

The specific breakdown of the classes are as follows:

$if\ AR \geq 0.217,\ class\ A$
$0.217 > AR \geq 0.125,\quad class\ B$
$0.125 > AR,\quad class\ C$

The last 1000 pallets are not considered due to 0 pallet demand.

**Part 3 and 4 - Design and Fast Pick Layout**




The dotted line represents the splitting of warehouse operations into tire pallet and tire piece operations. Both sections function effectively as separate warehouses, each having separate receiving and shipping docks proportional to the average flow through each section.

**Part 4 - Fast Pick Layout**

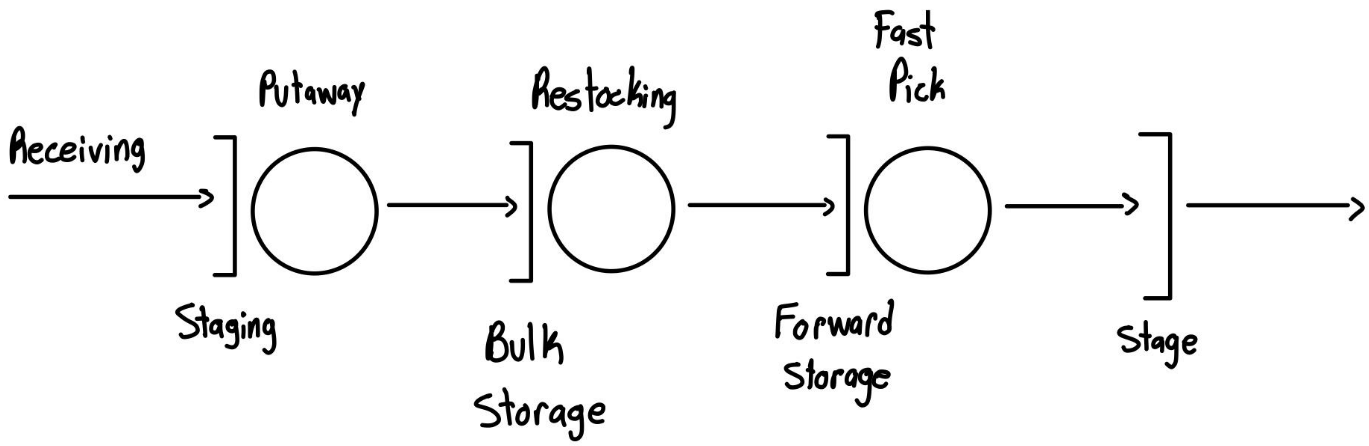
**Part 5 - Fast Pick Classification:**

*(This is copied from the start of part 2, since we already calculated the different classes)*

The first pick section would be a dedicated section for solely pieces.
Using the piece benefit equation $Benefit = (spi - crdi)/li$ with
$s = c2 - c1 = 3.35\, minutes - 0.35\, minutes = 3\, minutes$
$cr = 3\, minutes$ $\qquad di = piece\ demand\ in\ pallets$
$li = minimum\ pieces\ needed\ to\ be\ in\ forward$

Knowing that the first pick section capacity is 1000 pieces, we ranked the benefit of each SKU in the spreadsheet. Since $\sum_{i=1}^{n} Min\ Pallet\ =\ 1000$ , we determine the highest benefit SKUs in the spreadsheet that will make up the first pick section. *The 485 SKUs that will be placed in first pick have SKU ID colored in yellow.*

**Part 6 - Estimated number of pickers given interruptions**




To determine the optimal number of pickers in the warehouse. We have to calculate the effective picking rate given interruptions. Using the equation for effective processing time given interruptions:

$te\ =\ to/A$ and $A\ =\ mf/mr\ +\ mf$

Given: $te\ =\ 21\ seconds\ per\ piece,\quad cp\ =\ 0.6,\ mf\ =\ 30\ *\ 60\ =\ 1800\ seconds$
$mr\ =\ 5\ *\ 60\ =\ 300\ seconds$
$A\ =\ 1800/2100\ =\ 0.8571 \qquad te\ =\ 21/0.8571\ =\ 24.5\ seconds$
$re\ =\ 1/24.50\ =\ 0.040816\ /\ seconds$

$After\ converting,\ re\ \approx\ 23510\ pieces/\ month$

When summing the pieces picks per month, the pieces pick per month for the fast pick section sums to around $34150\ pieces/month$

$ra\ =\ 34150\ pieces/month,\ re\ =\ 23510\ pieces/month$
Given $U\ =\ ra/mre$, the utilization of the system can be assumed to be around 0.80, then
$0.80\ =\ 34150/(23510\times m) \qquad m\ =\ 1.816,\ m\approx\ 2$

$Therefore,\ the\ optimal\ picker\ number\ is\ 2\ pickers,\ assuming\ U\ =\ 0.8$