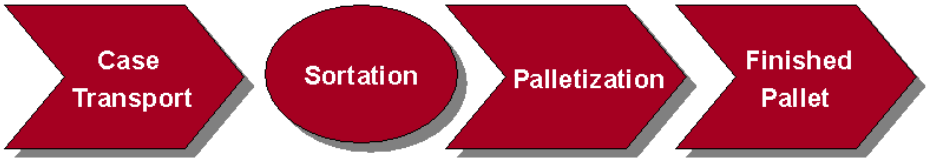
1. CENTRAL PALLETIZATION TECHNOLOGY EVALUATION

A central palletization solution consists of four key subsystems. They include:

- Case Transport
- Sortation
- Palletization
- Finished Pallet Handling



The Case Transport subsystem is responsible for the removal and delivery of finished goods cases from the manufacturing floor to the palletization area. Cases from various packaging lines are lifted off the production floor and merged into a case conveyor system for transportation. Lifting the products and transporting them overhead is necessary in order to free up production floor space and avoid a maze of conveyors on the production floor. Products from multiple production lines are merged together for the transportation, eliminating the need for dedicated conveyor lines from each line.

At the palletizing location, cases that have been merged by the Case Transport subsystem must be separated. This is accomplished by feeding the incoming cases into the Sortation subsystem.

Cases that are sorted are fed into the palletization subsystem where they are formed into finished pallets according to their designated pallet patterns.

In the Finished Pallet subsystem, finished pallets are wrapped and conveyed to a central discharge position for removal and staging.

These subsystems and the options that were considered are examined and analyzed in the following sections.

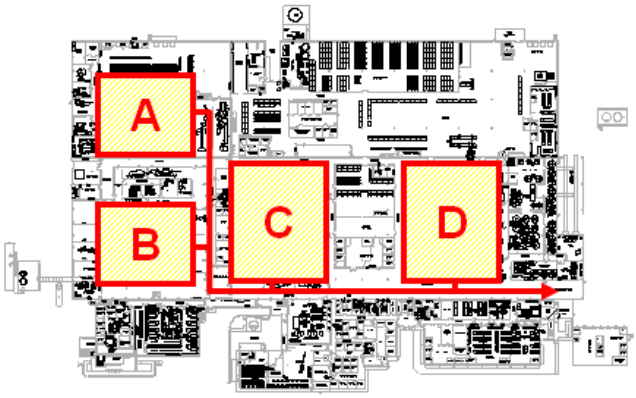
Note: all data and design criteria discussed in this document are provided as a reference example and are based on a specific case study.

1.1 Case Transport Subsystem

The case Transport subsystem is comprised of three key components:

- Lift
- Branch Conveyor
- Trunk Conveyor

This subsystem must be designed to accommodate the following maximum production rates:



Zone	Max CPM/TPM Current	Max CPM/TPM Future
Zone D	61	61
Zone C	18	57
Zone A	21	21
Zone B	14	14

1.1.1 Lifts

The design criteria for the lifts are as follows:

- Max Throughput 25 Cases / Min
- Max Case Dimensions 26”x17”x15”
- Max Case Weight 32 Lbs.
- Lift Height 15-20’

Various options for lifting cases from the end of the packaging line to the overhead transport level were considered. These options are summarized as follows:

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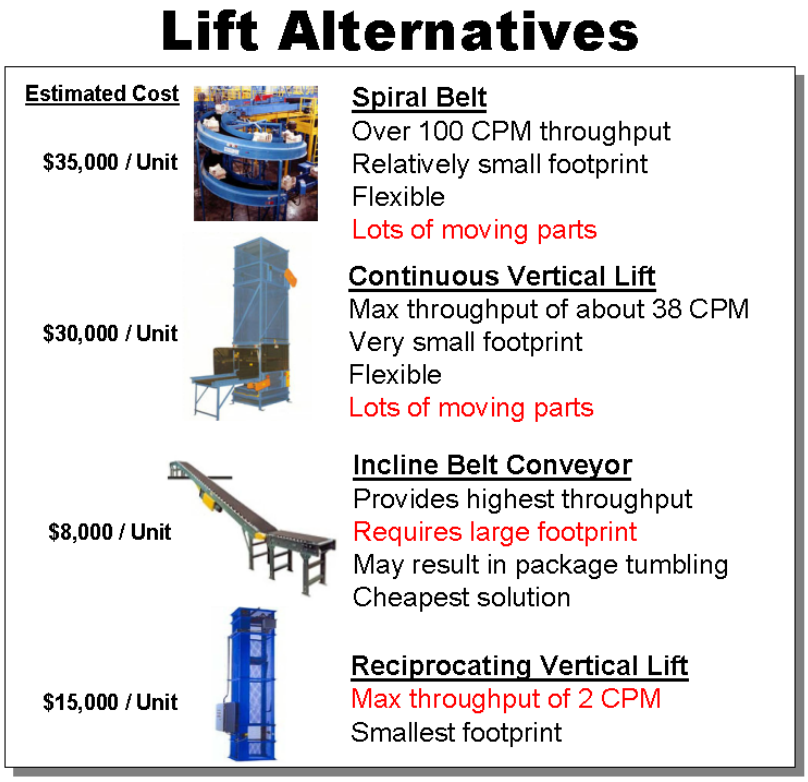

Based on this analysis, the continuous vertical lift was identified as the recommended solution. These lifts meet the 25 CPM per line maximum throughput requirement, handle the maximum case dimension/weight, are cost effective, reliable and take up a relatively small footprint.

1.1.2 Transport Conveyors

The design criteria for the branch conveyors include:

- Overhead / Out-of-the-way
- Low noise level
- Aesthetically pleasing
- Reliable
- Accessible for maintenance

The main conveyor trunks must be able to support maximum capacity as outlined in the following table:

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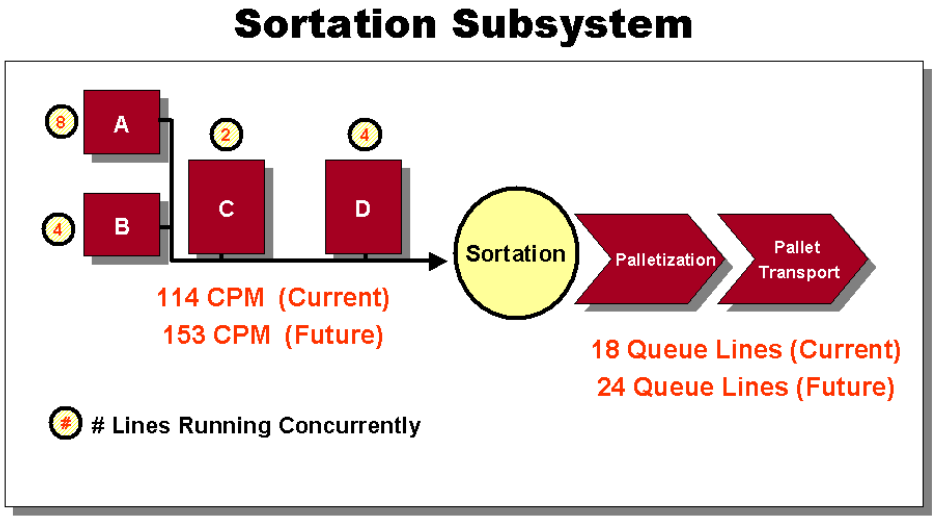
Zone	Max CPM/TPM Future	Max Required Capacity (case feet per minute)
Zone D	61	100
Zone C	57	125
Zone A	21	31
Zone B	14	22

Typical case conveyors transport product at about 300 feet per minute. A minimum of one conveyor trunk is required in order to transport the maximum production from all lines. Additional trunk lines should be considered for redundancy purposes.

1.2 Sortation Subsystem

The sortation subsystem consists of a sorting device that is responsible for the correct separation of cases that were merged together during transport to the palletizing area.

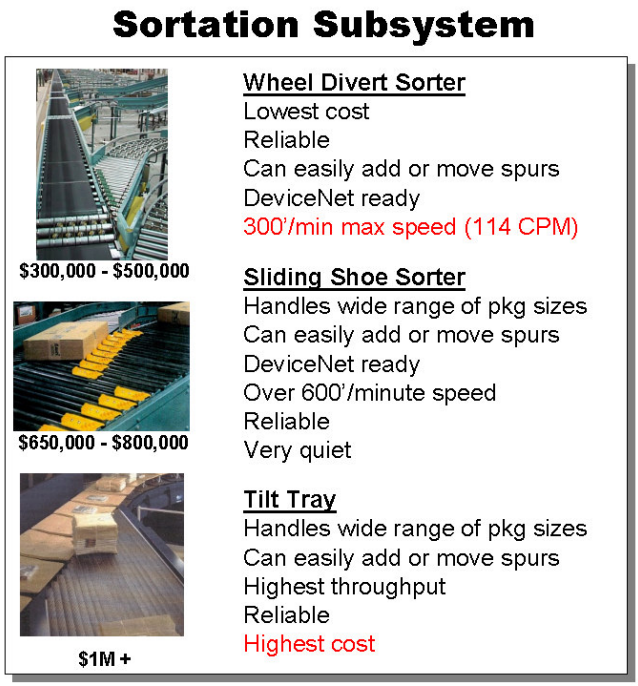


The sorter must meet the following criteria:

- Sort up to 153 CPM
- Max Package Size 26”x17”x15”
- Max Package Weight 32 Lbs.
- Sort into 18 spurs (current), 24 spurs (future)
- Provide reject spur for no-read or misdiverted cases for manual resolution

A number of case sortation options were considered. These options are summarized as shown:

Based on this analysis a sliding shoe sorter is required in order to meet the maximum throughput requirements.



1.3 Palletizing Subsystem

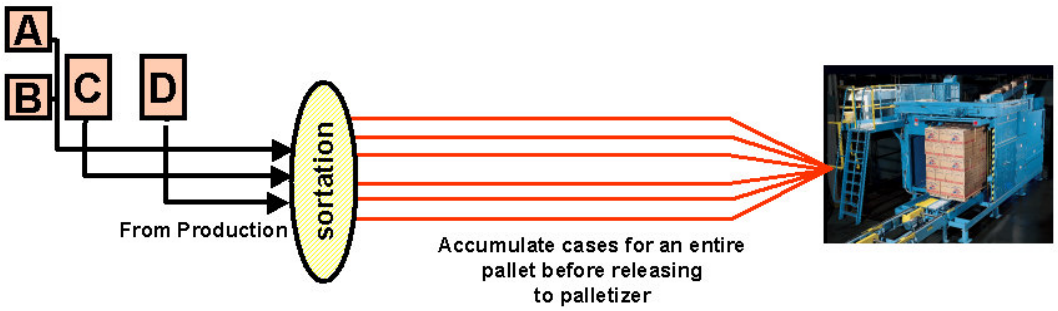
The palletizing subsystem is comprised of two key components:

- Accumulation conveyor
- Palletizing Device

1.3.1 Accumulation Conveyor

Following the sorter, cases of finished goods must be accumulated in some manner. Two approaches are available. One approach is to immediately palletize the cases onto a wooden pallet as they exit the sorter. In this case, the wooden pallet acts as the only accumulation device. With this approach, each production line must have a dedicated palletizer, which is costly and requires significant floor space (13 palletizers). Another approach is to share a palletizer across multiple production lines. To achieve this goal, cases of product must first be queued up until such time when a sufficient number of cases have been accumulated for release to the palletizing device. Accumulation case conveyors are used for this queuing purpose. The length of the accumulation conveyor (i.e. number of cases accumulated) is a direct result of the type of palletizing method and the dimensions of the finished cases.

A conventional palletizer can palletize product from multiple production lines, however, cases from each line must be sorted and accumulated in a dedicated conveyor section until a full pallet's worth of cases have been gathered. This train of cases can then be released to the conventional palletizer for processing. Once the pallet is built and discharged, the next product in the queue can be released for palletization. Long sections of accumulation conveyors are costly and require adequate space. Conventional palletizers, therefore, should only be considered for relatively high throughput applications.



Pedestal-mounted robotic palletizers, on the other hand, are capable of palletizing up to four different incoming products onto four different pallets at the same time. Furthermore, a gantry-mounted robotic system overcomes this limitation and can palletize cases from multiple input points to multiple pallet positions. Given this flexibility, robotic palletizers

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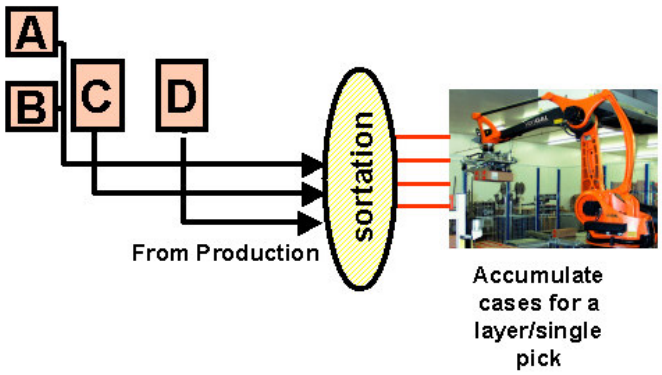
require a relatively short section of accumulation conveyor (typically less than a layer's worth of cases) in order to present the robot with a few cases at any given time. Short accumulation conveyors make robots very attractive, however, robotic palletizers are more costly and are only suited for slow/low volume operations.

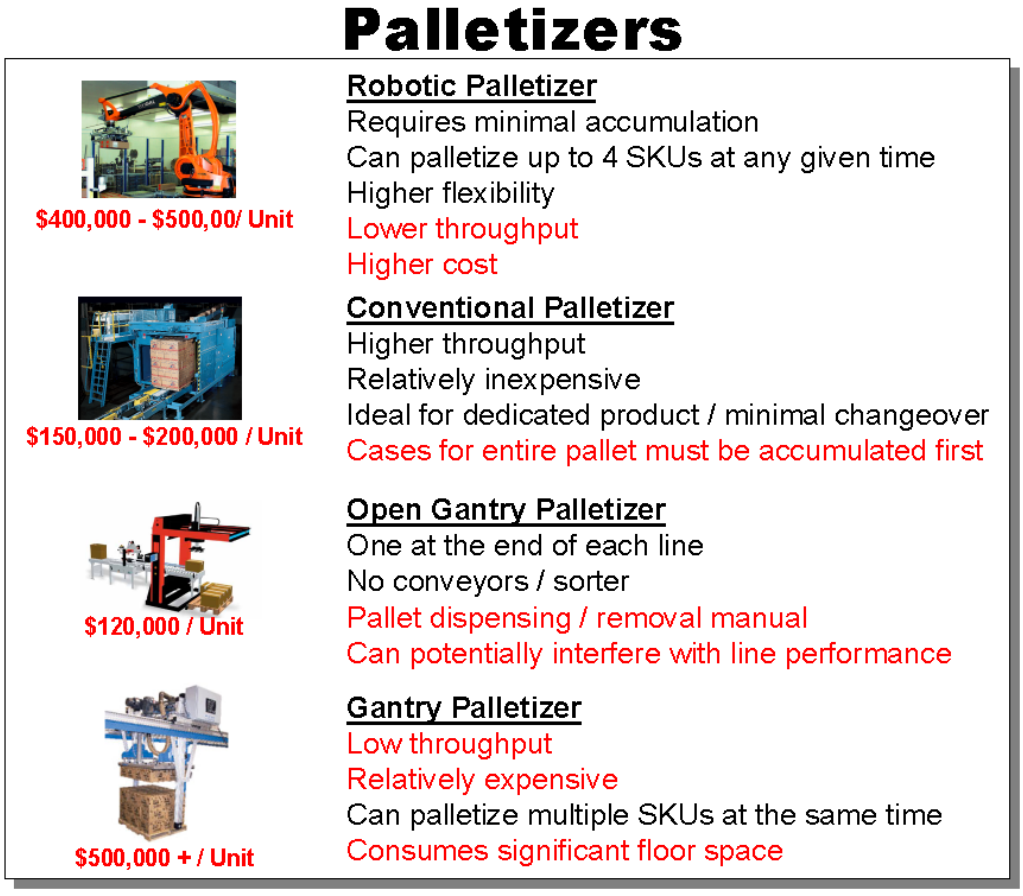


Based on sample product data, 240 feet of accumulation conveyor will be required for each production line in order to accommodate conventional palletization of that line. The following table represents a partial view of the accumulation length analysis. This table is sorted in descending order of accumulation length.

CPRODUCT ID	LINE	Case Length	Cases / Pallets	Pallet Accum in FT
224006A	61	9.13	304	231.17
228378F	61	9.06	304	229.52
862418B	63	9.06	304	229.52
019110	61	9.00	304	228.00
015015	83	9.00	304	228.00
015045D	82	9.00	304	228.00
443013D	84	9.00	304	228.00
867018H	63	9.00	304	228.00
868522S	63	9.00	304	228.00
434361C	63	11.50	192	184.00
017430R	5	6.88	318	182.19
867012S	62	6.88	318	182.19
868512E	62	11.50	168	161.00
017120R	5	9.50	192	152.00
017220R	61	9.50	190	150.42
868101F	61	9.50	190	150.42

1.3.2 Palletizing Device

In order to select the most appropriate palletizing device, a number of palletizing technologies were evaluated.



The key factor in selecting a palletizing device is throughput. The number of cases that a palletizing device can palletize depends on two key features:

1) **The speed at which the device can operate**
   Articulating arm robotic palletizers for example can make about 6 moves per minute. A typical mid-speed conventional palletizer can rake product at a rate of about 10 rakes per minute.

2) **The number of cases that the device can transfer in each move**
   Palletizer throughput is also dependent on the number of cases that can be picked up by a robot arm or raked by a conventional palletizer in a single move.

In order to maximize the overall throughput of a palletizer, the conveyor that leads product into the palletizing device must “bump” and “turn” the packages in accordance with the

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required pallet pattern. As such, the number of cases that can be moved and hence the palletizer's throughput is directly tied to the pallet patterns.

Based on analysis of package engineering specification, a total of 81 unique entries were isolated and the associated pallet patterns were cataloged. This information was then analyzed in order to determine the effective throughput requirements for a robotic and a conventional style palletizer.

Palletizer Throughput

Throughput a Function of Pallet Pattern

16 CPM	27 CPM
13.5 CPM	30 CPM
22.5 CPM	37.5 CPM
33 CPM	55 CPM
Avg 20 CPM	40 CPM

Given the specific pallet patterns, it was concluded that an articulating arm robotic palletizer servicing 4 different pick-to pallets could achieve an average effective throughput of 20 cases per minute. A conventional style palletizer could achieve an average effective throughput of 40 cases per minute.

The following table is a summary of the comparison between the packaging line throughput requirements and the effective throughput from a robotic and conventional palletizer. It is noted that articulating arm robotic palletizer technology is not well suited for some of the packaging lines. The throughput/pallet pattern for lines 62, 63 and 84 exceed the throughput capabilities of a robotic palletizer. In addition, robotic palletizers are a challenging option for packaging lines 84, 85, 86 & 87 producing trays of product.

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Family	Line #	Max CPM	Conventional Palletizer	Robot Palletizer
Zone D	5	9	✓	✓
	8	12	✓	✓
	61	10	✓	✓
	62	25	✓	---
	63	14	✓	---
Zone C	80	6	✓	✓
	81	9	✓	✓
	82 (RP 31)	8	✓	✓
	83 (RP 10)	10	✓	✓
	84	14 CPM 3 TPM	✓ ✓	--- ---
	85	1.5 TPM	✓	---
	86	6 CPM 2 TPM	✓ ✓	✓ ---
	87	2 CPM 2 TPM	✓ ✓	✓
Zone A	32	3.3	---	✓
	36	3.3	---	✓
	40	2.5	---	✓
	41	2.5	---	✓
	45	4	---	✓
	50	1	---	✓
	51	1	---	✓
	57	3.6	---	✓
Zone B	17	2.5	---	✓
	70	7	---	✓
	71	2.2	---	✓
	72	2.2	---	✓
	78	1	---	✓
	79	1.2	---	✓

Based on this analysis, a conventional palletization solution was identified as the preferred technology for the higher volume Zone C & D packaging lines. Articulating arm robotic palletizers were identified as the preferred technology for the lower volume Zone A & B packaging lines. The resulting hybrid solution consists of four robotic palletizing cells and 3 conventional palletizers. Each robot cell is capable of palletizing up to 4 products.

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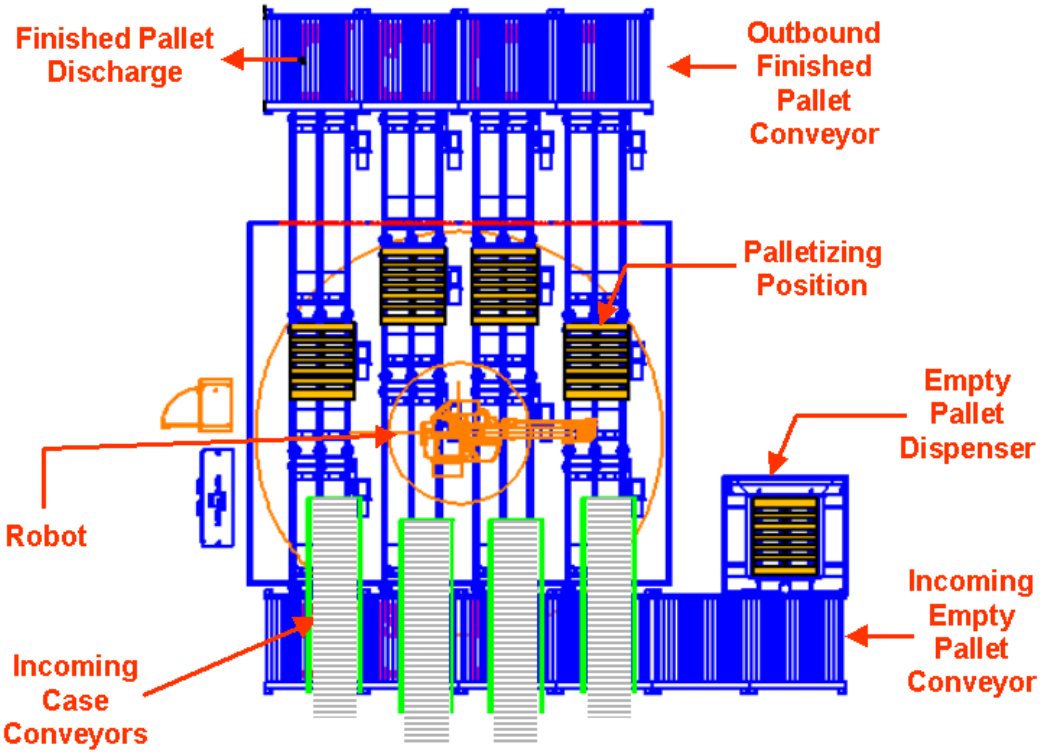

The following table represents a theoretical distribution of packaging lines across three conventional and three robotic palletizers. The cases per minute (CPM) rate for each packaging line is assigned to a specific palletizer and the total CPM for each palletizer is summarized at the bottom of the table. Conventional palletizers are at or below the 40 CPM average rating. Each robotic palletizer services up to 4 packaging lines with a total throughput demand less than the 20 CPM average rating.

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Family	Line #	Max CPM	Palletizer 1	Palletizer 2	Palletizer 3	Robot 2	Robot 3	Robot 4
Zone D	5	9	*Idle line*					
	8	12	12					
	61	10	10					
	62	25		25				
	63	14	14					
Zone C	80	6		6				
	81	9		9				
	82 (RP 31)	8			8			
	83 (RP 10)	10			10			
	84	14			14			
	85	1.5 TPM			1.5			
	86	6			6			
	87	2	2					
Zone A	32	3.3				3.3		
	36	3.3				3.3		
	40	2.5				2.5		
	41	2.5				2.5		
	45	4					4	
	50	1					1	
	51	1					1	
	57	3.6					3.6	
Zone B	17	2.5						2.5
	70	7						7
	71	2.2						2.2
	72	2.2						2.2
	78	1	*Idle line*					
	79	1.2	*Idle line*					
		Total CPM	**38**	**40**	**39.5**	**11.6**	**9.6**	**13.9**

1.4 Finished Pallet Handling Subsystem

The finished pallet handling subsystem is comprised of two key components:

- Pallet Transport
- Stretchwrapper

1.4.1 Pallet Transport

Finished pallets must be transported from the palletizing device to a stretchwrapper and ultimately to a staging location. A number of pallet transport alternatives were considered. These alternatives are summarized below:

Pallet Transport

$25,000 - $30,000 / Unit
+ $60,000 / Year per operator

Fork Lift
Already used throughout the plant
Can readily add labor for peak volume
Travels at about 350 feet/minute
Lower capital outlay / higher operating cost
Operators require breaks
Requires multiple operators to handle each shift

$125,000 - $175,000 / Unit

Automated Guided Vehicle (AGV)
Operates unattended & uninterrupted
Travels at about 200 feet/minute
Can operate 24x7
System must be sized for peak demand
Maintenance and parts are specialized

About $2,000 / foot

Pallet Conveyor
Operates unattended & uninterrupted
About 12 pallets/minute throughput
System must be sized for peak demand
Limits access & traffic pattern
Maintenance and parts are specialized

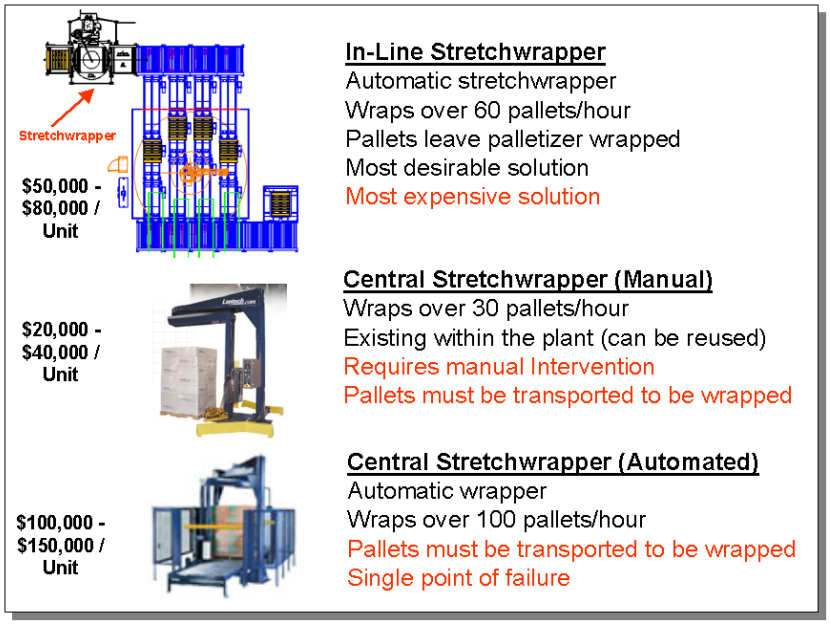
For short distance pallet transports (i.e. palletizer output to stretchwrapper), pallet conveyors are the preferred and recommended alternative. They are relatively inexpensive and provide a timely and reliable transport of the finished pallets. For transporting pallets long distances (i.e. stretchwrapper output to staging area), either traditional forklifts or Automated Guided Vehicles (AGVs) can be considered. The AGV alternative becomes more viable as the transport distance increases.

The best transport method is a function of the layout and distances and as such is further evaluated as the specific concepts and layouts are considered.

1.4.2 Stretchwrapper

There are a number of options available for stretchwrapping the finished pallets. These options were evaluated and are summarized below:

Stretchwrapper



In order to streamline the palletizing operation, the in-line stretchwrapper options were identified as the preferred method for stretchwrapping the finished pallets.