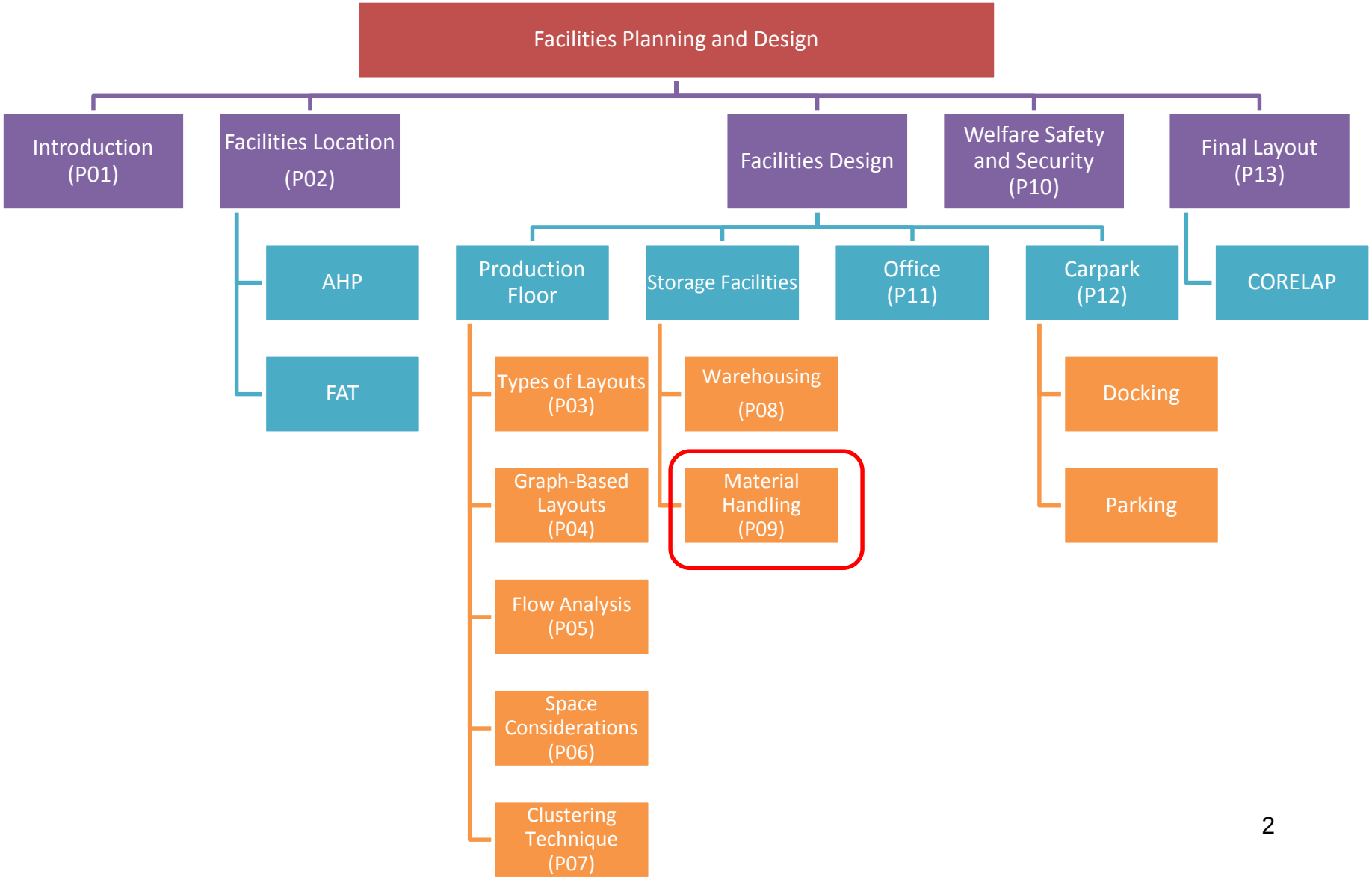
Problem 09

Material Handling Equipment

E212 – Facilities Planning and Design

SCHOOL OF ENGINEERING

E212 Facilities Planning & Design - Topic Tree



Material Handling

- Is the art and science of moving, storing, protecting and controlling material.

- Means providing the:
  - Right amount of Material
  - For the right Condition
  - In the right Place
  - In the right Position
  - With the right Sequence
  - With the right Cost
  - Using the right Method

Goals of Material Handling

1. Maintain/improve product quality, reduce damage and provide for protection of materials
2. Promote safety and improve working conditions
3. Promote productivity through the following
    i. Material should ideally flow in a straight line
    ii. Material should move as short a distance as possible
    iii. Gravity should be used wherever possible
    iv. Move more material at any one time
    v. Automate material handling
4. Promote increased use of facilities
    i. Purchase versatile equipment wherever possible
    ii. Standardise material handling equipment
    iii. Maximise production equipment utilisation rate
    iv. Develop a preventive maintenance programme
    v. Integrate all material handling equipment into a system
5. Control inventory

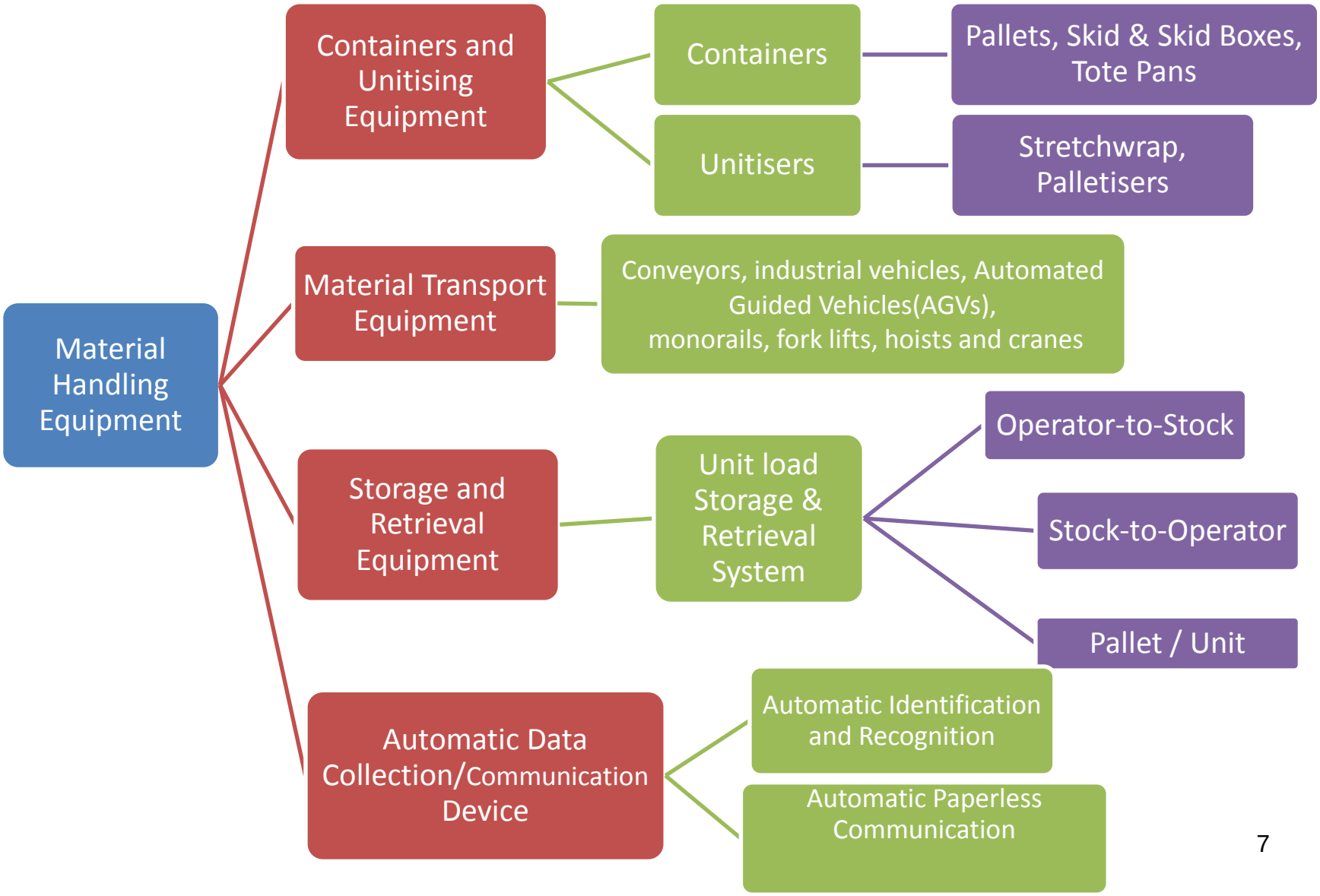
Material Handling Principles

(1) Planning Principle	• All material handling should be the result of a deliberate plan where the needs, performance objectives and functional specifications of the proposed method are completely defined at the outset.
(2)Standardization Principle	• Material handling method and equipment used should preferably have less variety and customization as far as possible
(3) Work Principle	• Material handling work should be minimized without sacrificing productivity • The measure of work = Material flow (volume, weight, or count per unit time) x Distance moved
(4) Ergonomic Principle	• Human capabilities and limitations must be considered
(5) Unit Load Principle	• Unit loads should be suitably sized and configured such that it achieves the material flow and inventory objectives at each stage in supply chain • A unit load is one that can be stored or moved as a single entity at one time (pallet, container or tote) regardless of the number of individual items that make up the load

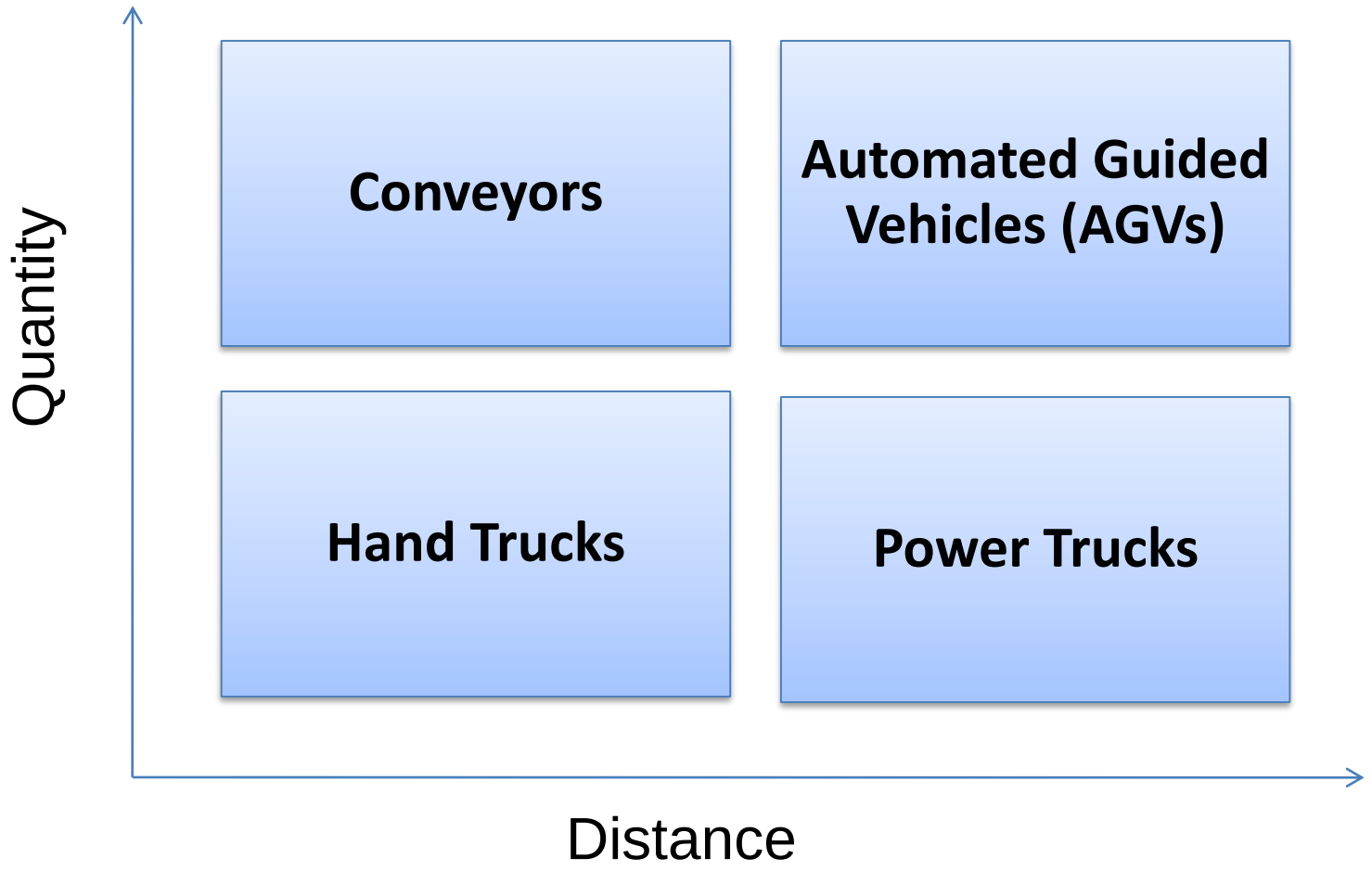
Material Handling Principles

(6) Space Utilization Principle	• All available space should be effectively and efficiently utilized
(7) System Principle	• Material movement and storage activities should be fully integrated to form a coordinated operational system
(8) Automation Principle	• Material handling operations should be automated wherever possible to improve efficiency, responsiveness, consistency and predictability
(9) Environmental Principle	• Environmental impact and energy consumption should be considered as criteria when designing or selecting suitable material handling method and equipment
(10) Life Cycle Cost Principle	• A thorough economic analysis should account for the entire life cycle of all material handling equipment and resulting systems

Material Handling Equipment



Material Transport Equipment



Material Transport Equipment - Conveyors

- A conveyor is a form of material transport equipment in the same category as industrial vehicles, hoists and cranes
- Conveyors are used when material is to be moved frequently between specific points over a fixed path
- Bases to classify conveyors:
  - The type of product being handled (bulk or unit) and
  - the location of the conveyor (overhead or floor)
- Such classification systems are not mutually exclusive, that is, the same conveyor can convey both bulk and unit materials, and can be located overhead or on the floor
- Bulk materials such as grain, dry chemicals, etc. might be conveyed using flat-belt, chute or vibrating conveyors
- Unitized materials such as machined parts, materials in carton boxes, etc. might be conveyed using roller, trolley or flat-belt conveyors
- Conveyors characterize the product line layout in a continuous-flow manufacturing environment

*Click Here for a reference video on Conveyors

Main Conveyor Types

1. Flat-belt conveyor

- A wide belt pulled over a flat framework or rollers by a driving pulley, with the slack taken up by a driven pulley
- The belt can be made from rubber or fabric, or composed of slats or wire mesh, depending on application requirements

2. Roller conveyor

- Commonly used for packaged materials or materials on pallets
- The minimum package size is 2 roller width
- Gravity rollers (non-powered) can be applied for slight inclines
- Conveyor can be powered by running a belt below the rollers

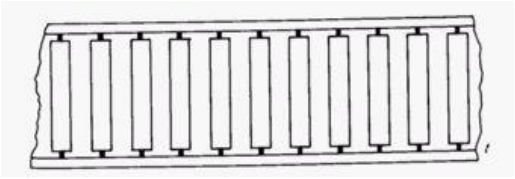
3. Trolley conveyor

- Built on I-beam, acting as the track, like a monorail
- The lower flange supports wheeled trolleys spaced at regular intervals via a chain
- The chain is pulled at constant speed by a drive mechanism located along the conveyor route
- Material is moved by placement on hooks, racks, hangers, etc attached to wheeled trolleys
- Can act as in-process storage due to conveyor variable height characteristic
- The conveyor forms a (variable height) loop within the plant, eventually returning to its starting point

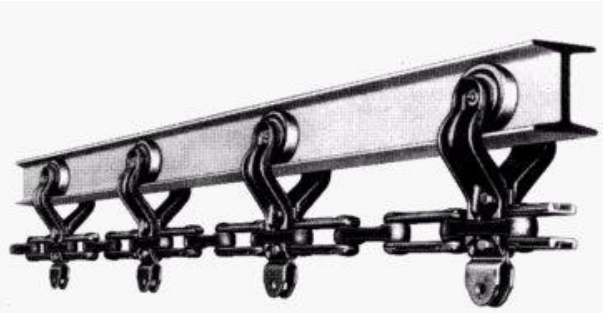
Material Transport Equipment - Main Conveyor Types

- **Flat-belt**

- **Roller**



- **Trolley**

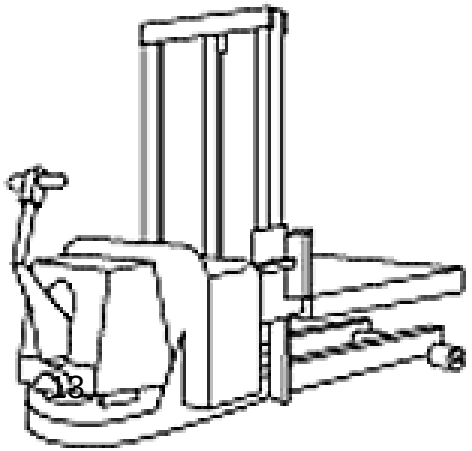


Application Challenges

	Flat-belt	Roller	Trolley
1	Belt stretch or shrinkage -> use 'take-up' device	Flow management for non-powered rollers	Low conveyor location flexibility- the I-beams are usually welded and integrated to the facility building structure
2	Maximum angle of elevation -> increase friction factor	Slippage of packages	Number of powered drives for the chain - usually 1 drive is required for every 1200 feet of conveyor length
3	Turning in and out of corners -> use turntable Jamming at intersections -> use divider/sorter on main conveyor	Maintenance of rollers	In-process storage along the conveyor- can lead to production time loss along downstream stations if upstream processes are disrupted due to machine breakdown or supply lapse

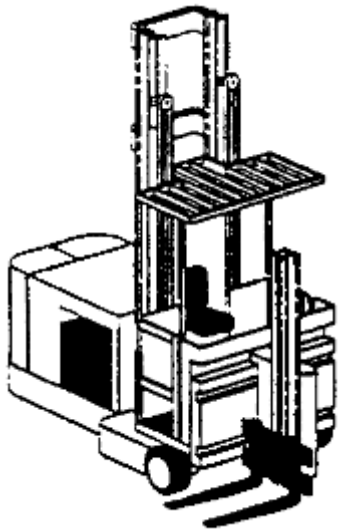
Pallet Retrieval System
- Example: Walkie Stacker

- Operator steers from a walking position behind the vehicle
- Can stack loads 3 loads high
- Offers both pallet retrieval/putaway and truck loading/unloading
- Advantage: Low cost
- Disadvantage: Short distances, small loads
- Used when low throughput, short travel distances and low vertical storage height and low cost requirements



Pallet Retrieval System - Example: Turret Truck

- Operator steers and moves up with goods from behind the vehicle
- Can stack loads 45 feet high as compared to 25 feet for a normal forklift
- Useful for stacking in high vertical racks
- Suitable for pallet retrieval/putaway
- Advantages:
  - Able to travel longer distances and handle heavier loads compared to manual trucks
  - High throughput
- Disadvantages:
  - More expensive than manual trucks
  - Limited to usage in narrow aisle system



Storage and Retrieval Equipment

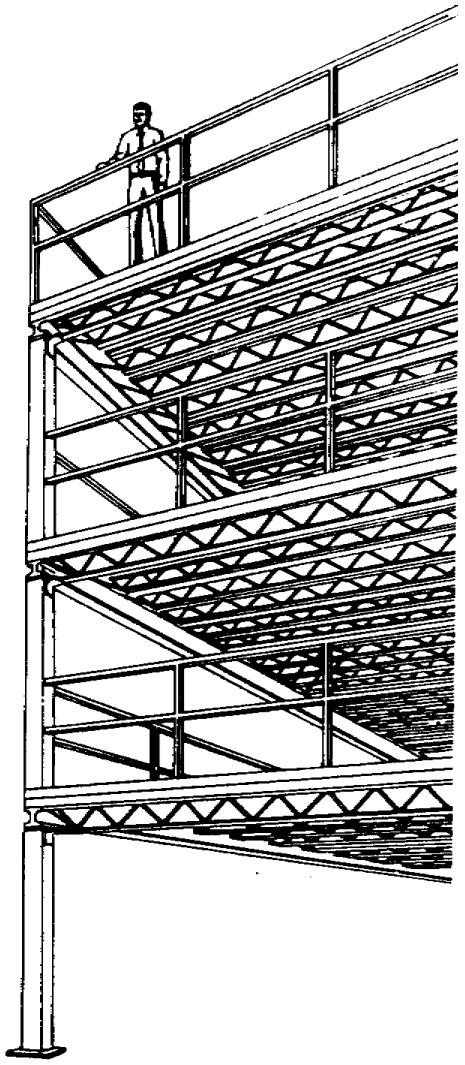
Small Load		Unit Load	
Operator-to-Stock Storage Systems	Stock-to-Operator Storage Systems	Pallet/Unit Storage Systems	Pallet/Unit Retrieval Systems
➢ Bin shelving systems ➢ Modular storage drawers/cabinets ➢ Gravity flow rack ➢Space saving systems •Mezzanines •Mobile storage systems	➢ Carousels 1. Horizontal 2. Vertical ➢ Miniload Automated storage and retrieval (AS/RS)	➢ Block stacking ➢ Pallet stacking frames ➢ Single-deep pallet rack ➢ Double-deep pallet rack ➢ Drive-in rack ➢ Drive-thru rack ➢ Flow rack ➢ Push-back rack ➢ Mobile pallet rack ➢ Cantilever rack ➢Very Narrow Aisle Systems (VNA)	➢ Walkie stackers ➢ Counterbalanced lift trucks ➢ Straddle trucks ➢ Straddle reach trucks ➢ Side loader trucks ➢ Turret trucks ➢ Hybrid trucks ➢ Automated storage and retrieval (AS/RS) machines

The ones highlighted in red are those equipment we have seen in CWT warehouse.

Operator-to-Stock Storage System
- Example: Space Saving System (Mezzanine)

Operator-to-Stock Storage System
- Example: Space Saving System (Mezzanine)

- Nearly twice as much material can be stored in the original square footage
- Cost: $10-$20 / ft^2
- Key implementation issue: Slot the products so that most of the picking activity takes place at the floor level



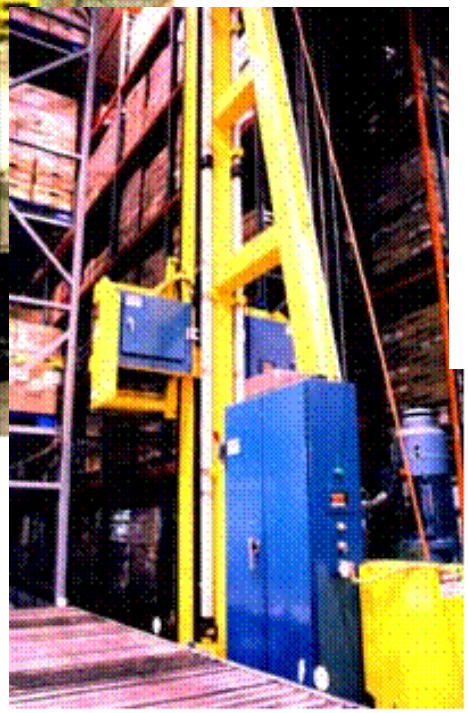
Stock-to-Operator Storage System
- Example: Automated Storage/Retrieval System

- Computer algorithms in the AS/RS control computer determine storage locations such that total distance traveled is minimized.
- When storing materials/parts, the system delivers the items to an open random location appropriate for the characteristics (i.e. size, weight, etc.) of the items and records the location for future reference so that the items may be retrieved.
- The items retrieved are accumulated at a staging area, where they are transferred to various materials handling devices for delivery to other work areas.
- Use AS/RS to
  - Increase storage capacity
  - Improve productivity
  - Improve safety
  - Improve security
  - Better inventory control
  - Increase throughput

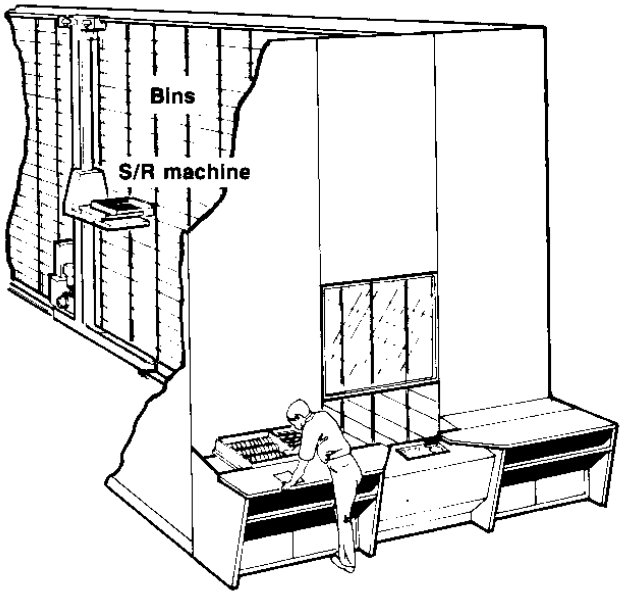
*Click Here for a reference video on AS/RS

Stock-to-Operator Storage System
- Example: Automated Storage/Retrieval System

Front View of AS/RS



Side View of AS/RS



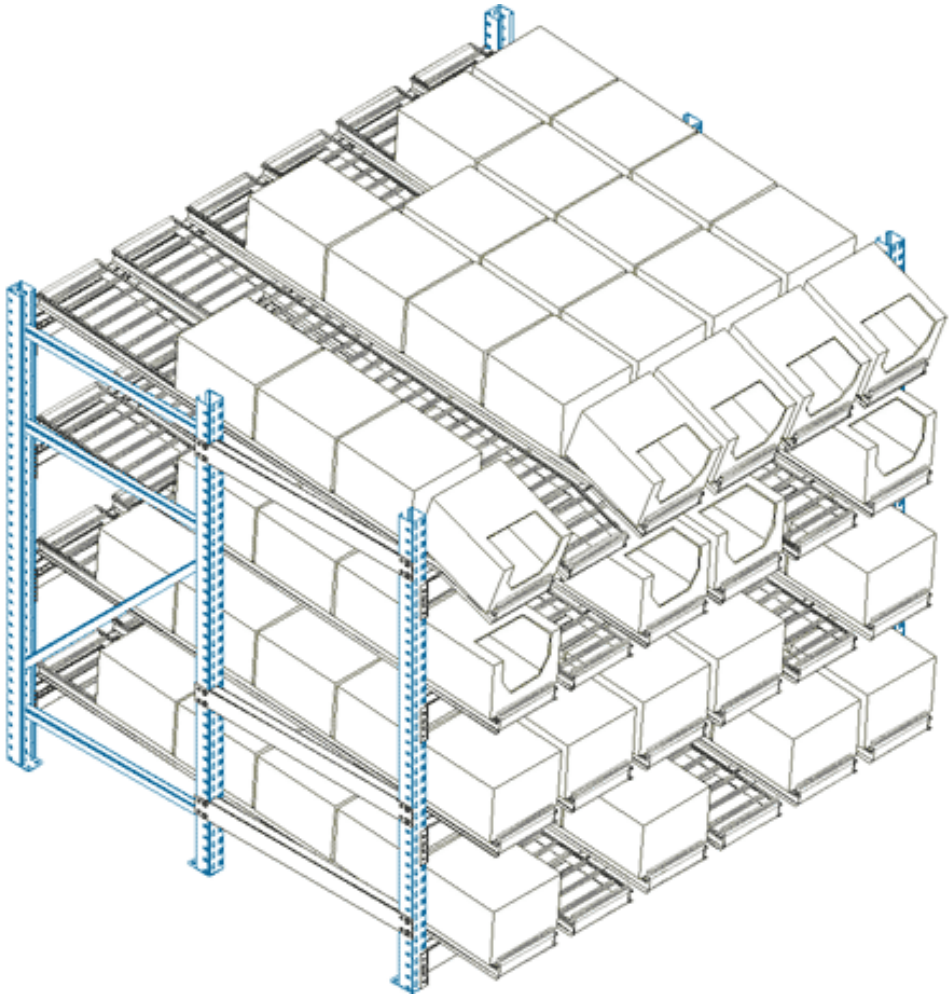
Miniload AS/RS

Miniload AS/RS

Stock-to-Operator Storage System
- Example: Automated Storage/Retrieval System (Miniload)

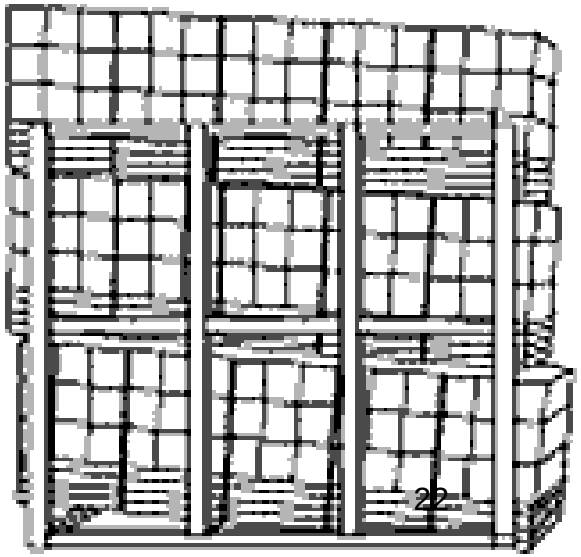
- Pick Rate: 40-200 picks/person hr
- Vary in length from 40 to 200 feet (12.2 to 61.0m) and height from 8 feet to 50 feet (2.4 to 15.2m)
- Storage containers are transported to and from an order picking station
- Cost: $150,000-$300,000 /aisle
- 500 feet/minute or 152m/min horizontal speed
- 120 feet/minute or 36.6m/min vertical speed

Pallet Storage System
- Example: Flow Rack



Pallet Storage System
- Example: Flow Rack

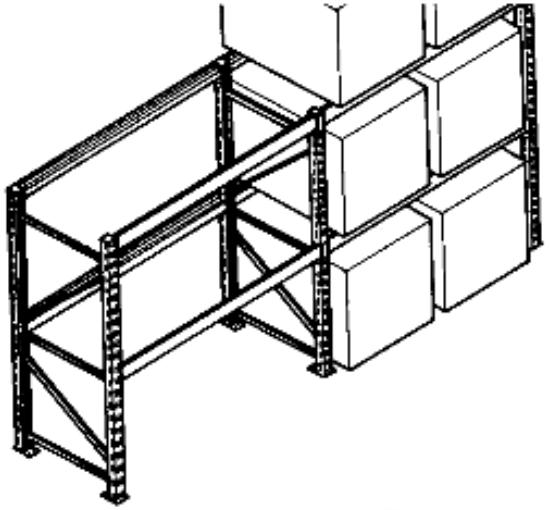
- Based on a **First-In-First-Out (FIFO)** concept
- As the load is removed from the front of a storage lane, the next load advances to the pick face.
- High-throughput unit storage and retrieval *and* good space utilization
- Used for items with high inventory turnover and with several units on hand



Pallet Storage System

- Example: Standard (Single-Deep or Double-Deep Pallet Rack)

- Most popular type of storage rack
- Pallets are supported between load-supporting beams
- Special attachments and decking can be used to make the racks capable of supporting other types of unit loads besides pallets (e.g., coils, drum, skids)
- There are a few variations on the racks:
  - Single-Deep Pallet Rack – the standard racking
  - Double-Deep Pallet Rack – Deep-Reach, usually combine two racks side by side
  - Narrow-Aisle – Single-Deep or Double-Deep rack using narrow-aisle lift truck.



Pallet-Storage System

- Example: Very-Narrow-Aisle (VNA) storage system

- Provide significant reduction in floor aisle space due to designs.
- Capable of storing up to height of 40 – 50 feet.
- VNA systems are accessed with turret or side loader lift trucks
- Key implementation issues:
  - Very compact layout
  - Height safety and maintenance is a concern

Learning Objectives

- Identify the different types of storage systems and its uses
- Apply the storage requirements for different products
- Explain the objectives of selecting the different type of material handling equipment
- Apply the material handling principles based on suitability for the function required

Overview of E212 Facilities Planning and Design