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CERTIFIED IN LOGISTICS,
TRANSPORTATION AND DISTRIBUTION

MODULE 7:
WAREHOUSE MANAGEMENT

APICS

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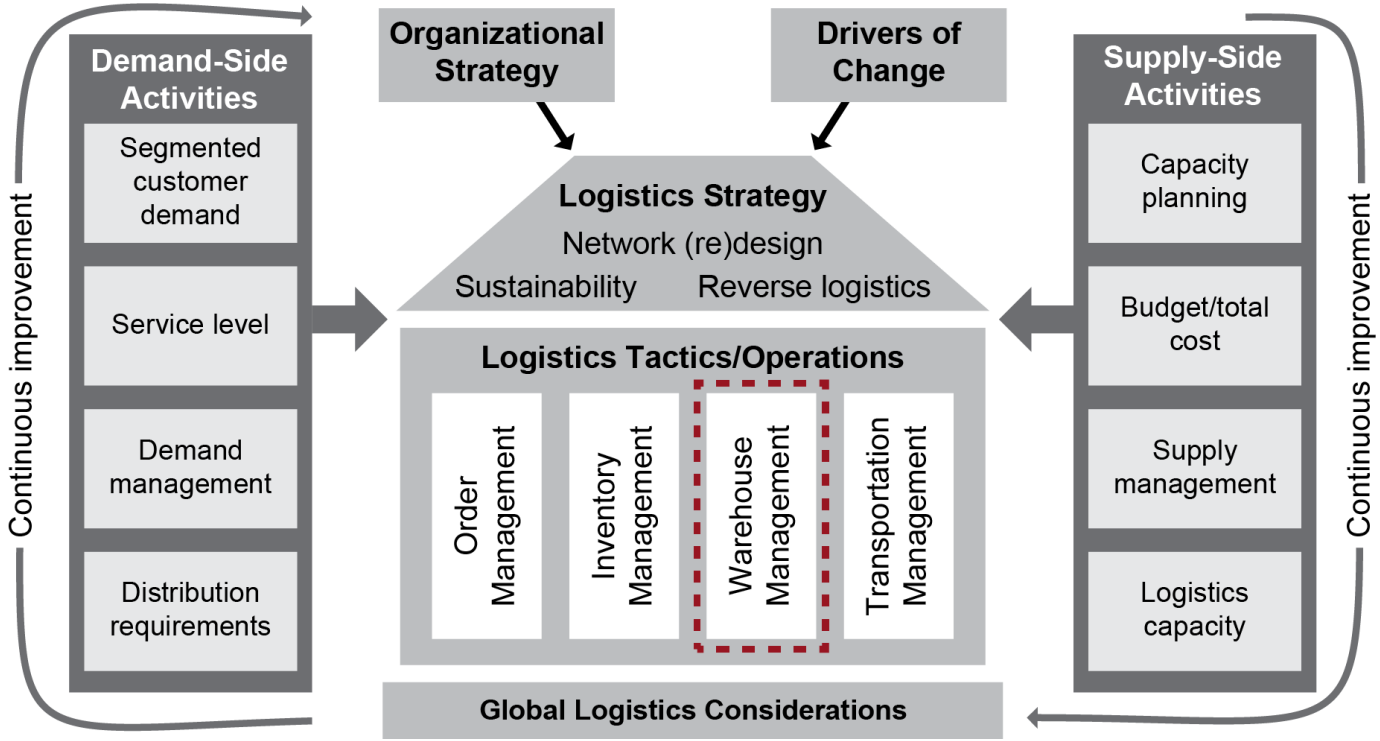
Module 7 Overview



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MODULE 7, SECTION A: WAREHOUSE STRATEGY AND TACTICS

APICS

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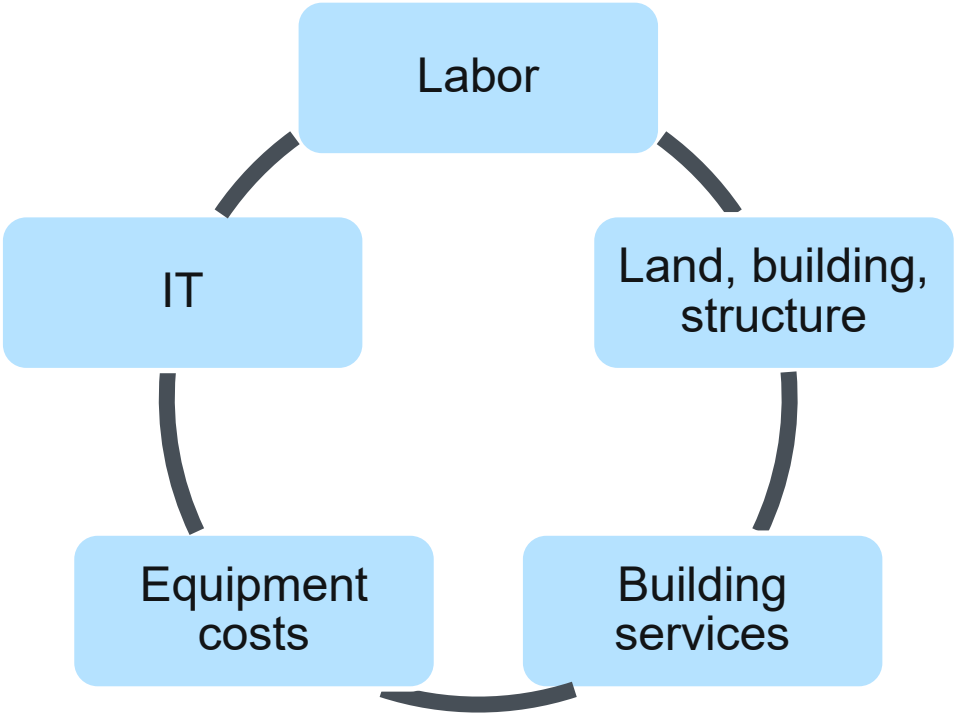
Topic 1: Warehouse Strategy

Alignment

Role of Warehousing in Business

Function	Warehousing Contribution
Meeting demand	Receive and store materials, parts, and goods and distribute them to meet internal and external demand.
Aligning supply and demand	Stock helps satisfy spikes in demand; capacity helps decouple supply and demand.
Buffering against uncertainty	Accommodate safety stock and allow businesses to react to potential threats and opportunities by building protective stockpiles of materials and finished goods.
Increasing efficiencies	Storage allows businesses to take advantage of volume discounts and hedge stock against increases in value.
Providing customer service	Meet all customer demand with quality product without error within a target time frame.

Typical Warehouse Costs



Forces Shaping the Future of Warehouses

Global supply chains	E-commerce and B2B	Increased focus on excellence	New, collaborative relationships
Changes in customer expectations	Technology	Environmental concerns	Risk management

Outsourcing

A key warehouse strategy issue is how to manage warehouse capacity and demand discrepancies.

- What should be done when demand exceeds capacity?
- What should be done when capacity exceeds demand?

Private versus Public Warehouses

Private Warehouse pros

- Greater control over operations
- Economic advantages
- Flexible asset

Private warehouse cons

- Consume capital from more strategic opportunities
- Inflexible asset
- Increased carrying costs
- Increased exposure to risks

Public warehouse pros

- Lower costs
- Increase flexibility

Public warehouse cons

- Less control
- Risk of availability

Topic 2: Warehouse Ownership Types

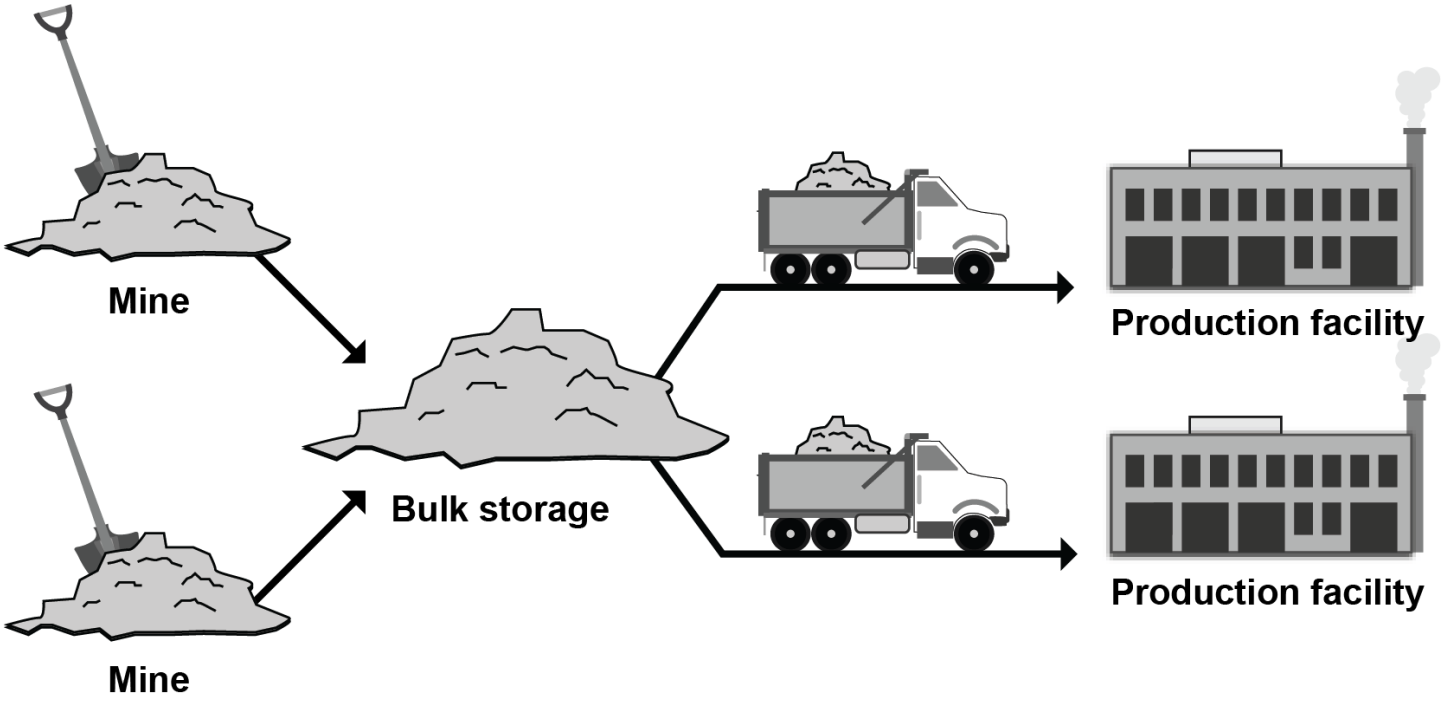
Contract Warehouses: Owner and Client Share Costs/Risks

Warehouse Decision Factors

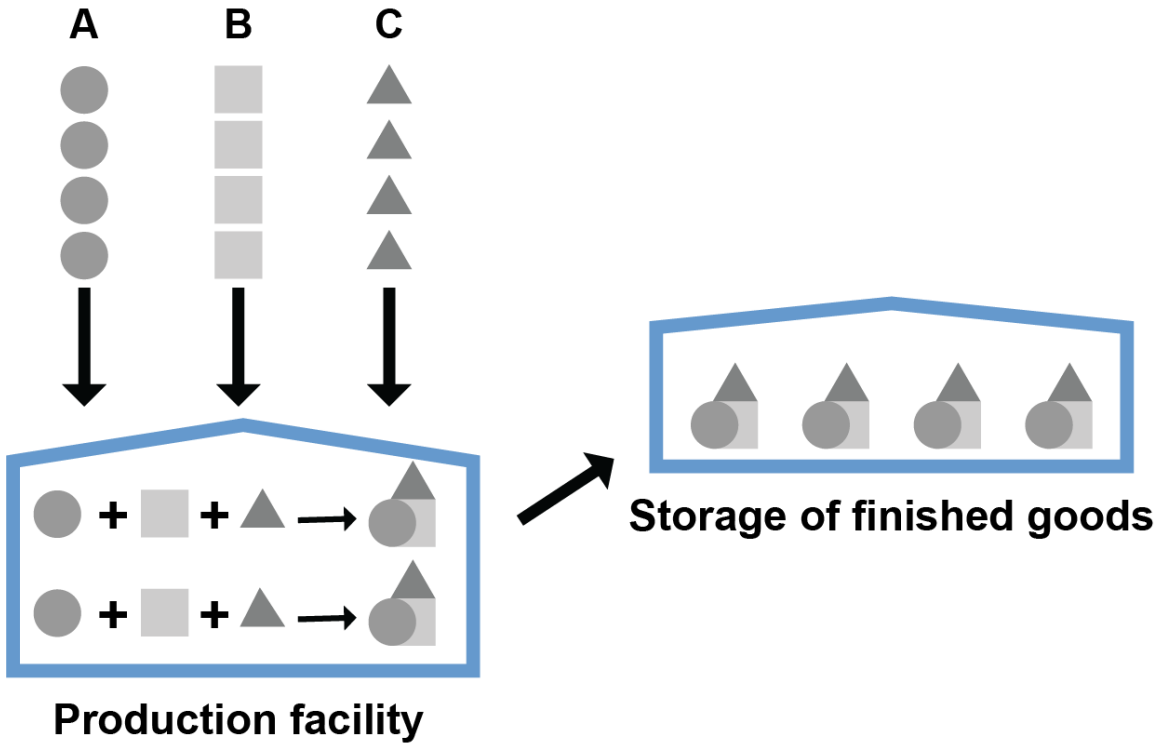
Factor	Private Warehouse	Public/Contracted Warehouse
Throughput	Higher	Lower
Demand characteristics	Stable	Fluctuating
Market density	Higher	Lower
Need for physical control	Yes	No
Security needs	Higher	Lower
Customer service requirements	Higher	Lower
Ability to meet multiple uses	Yes	No

Source: Brian J. Gibson, Ph.D., cited in *Managing Supply Chains.* Used with permission.

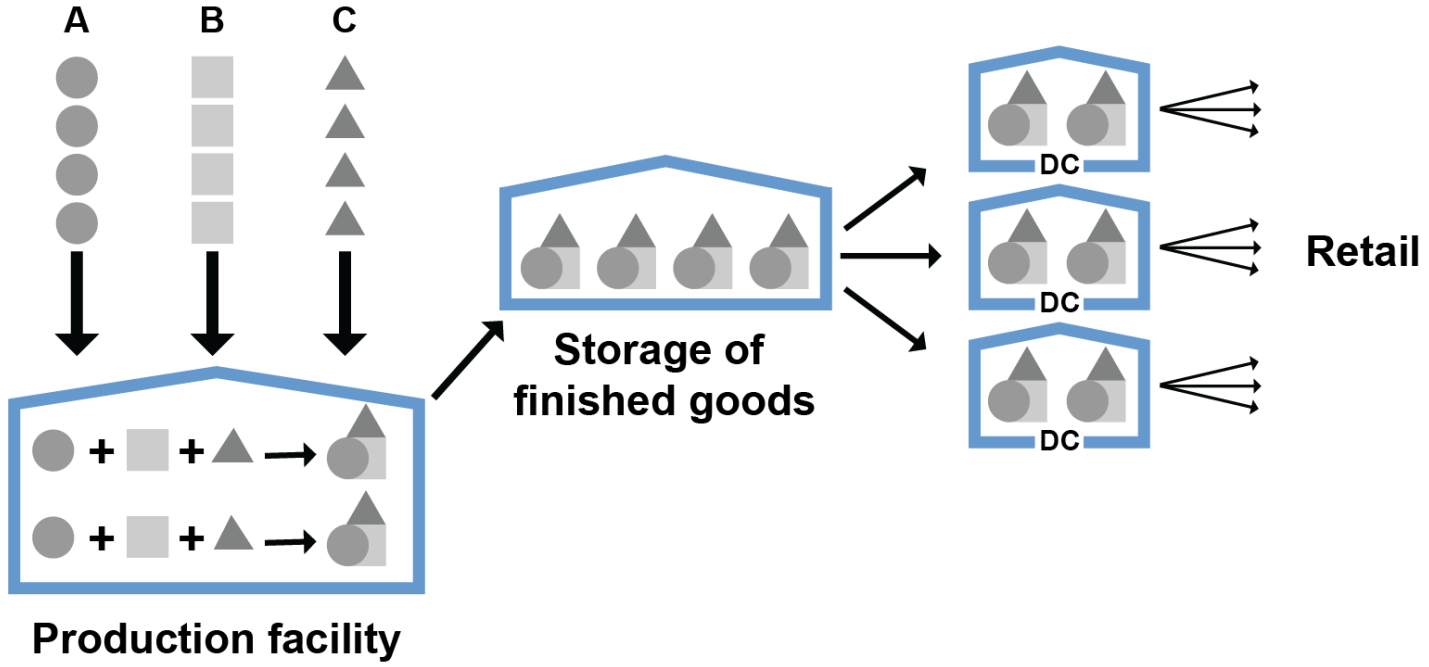
Storing Raw Materials



Warehousing Role at Production/Assembly Facilities



Managing Flow through the Distribution Channel



Warehouse Roles in Distribution Channel

Consolidation

Break-bulk

Specialized

Cross-docking

Reverse logistics

Fulfillment centers

Specialized Warehouses

Automated	▪ High construction and equipment costs ▪ Lower labor costs
Cold storage	▪ Designed to maintain inventory that would spoil at higher temperatures
Postponement	▪ Provides the ability to organize and delay assembly, picking, or shipping of a product until the last possible moment
Hazardous materials	▪ Designed to manage the risks posed by handling and storing materials that could cause environmental harm, such as radioactive, toxic, or explosive material
Records archives	▪ Store valuable paper and digital records

Warehouse Documentation

Inbound

- Material entry
- Quality
- Put-away documentation

Outbound

- Picklist
- Packlist
- Shipping documentation

Building, facility, equipment

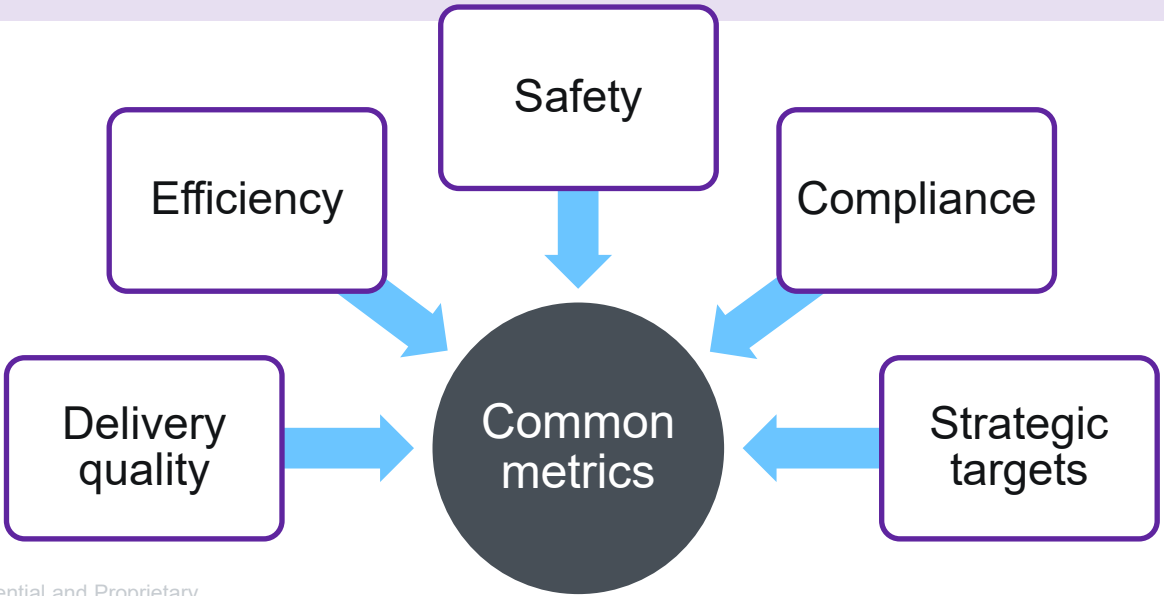
- Work records
- Safety records
- Maintenance records

Product certification and traceability

- Temperature and humidity
- Organic
- Gluten free

Selecting the Right Metrics

Criteria selected must be relevant to the way a warehouse defines its success.



Warehouse Performance Metrics

- Efficiency/ utilization
- Reliability
- Cost
- Inventory control
- Health and safety
- Compliance
- Environmental goals
- Training
- Other

Balanced Scorecard Approach to Warehouse Audits

	KPIs	Metrics	
Financial	Return on investment	▪ Inventory turns ▪ Inventory loss	▪ Asset utilization ▪ Revenue per cubic foot (or meter)
Customer	Customer satisfaction, account sales and retention	▪ Perfect order index (complete, accurate, on time)	▪ Stockouts
Business processes	Throughput, safety, risk management	▪ Throughput rates ▪ Overtime ▪ Compliance with efficient, quality-oriented processes	▪ Rates of injuries and illnesses ▪ Cleanliness and organization ▪ Waste recycling
Learning and growth	Employee retention, skill enhancement, recruitment	▪ Employee turnover rate ▪ Job applicant responses and hiring time ▪ Employee satisfaction as measured through surveys or complaints	▪ Training of supervisors and staff ▪ Implementation of automated systems

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MODULE 7, SECTION B: WAREHOUSE PROCESSES

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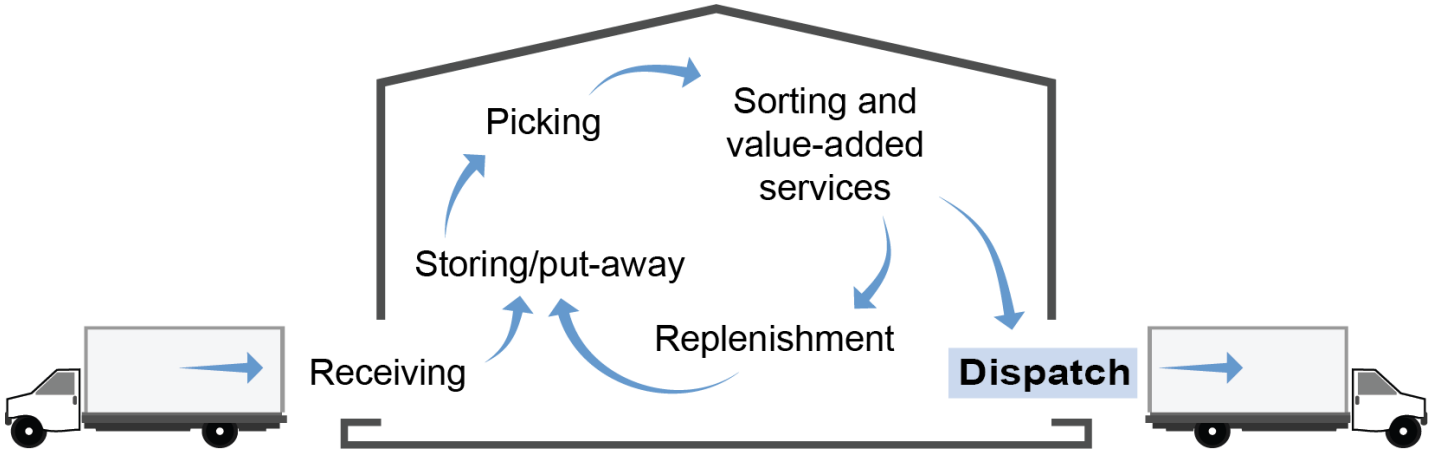
Warehouse Processes

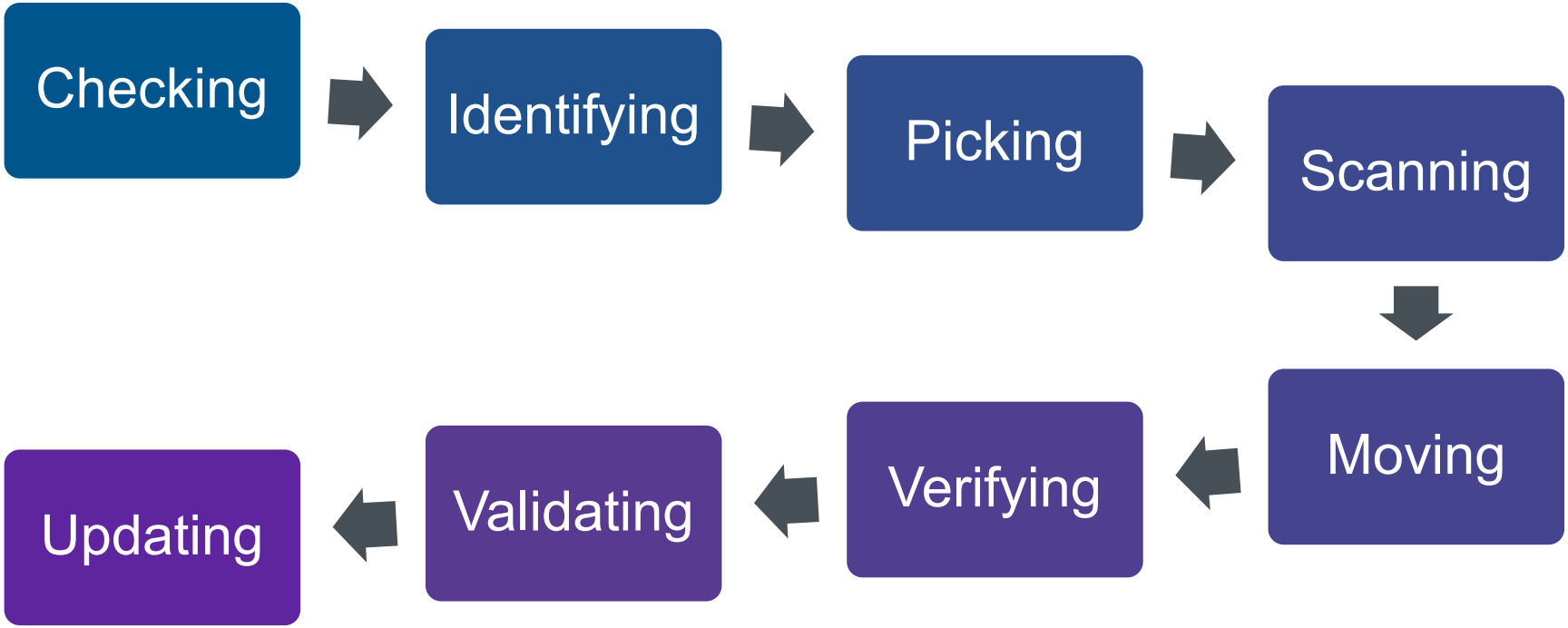


Receiving

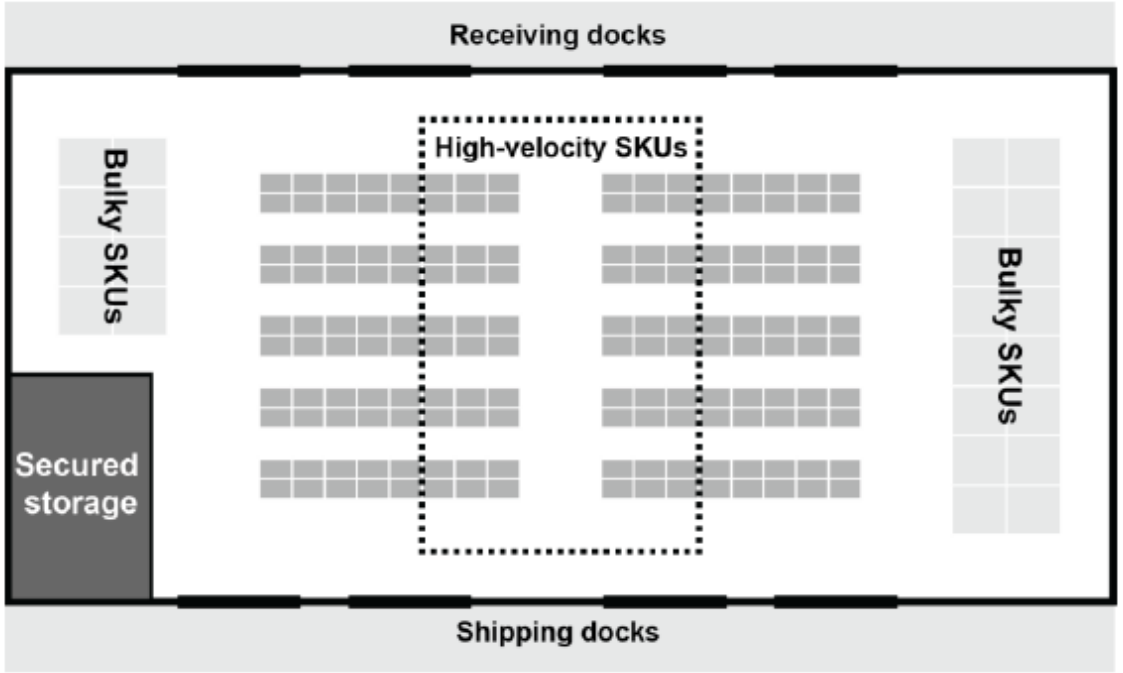
Requires coordination within the warehouse and advance planning

- Pre-receipt conditions
- Coordinating packing to the warehouse's needs
- Coordinating the means of delivery with the warehouse's abilities
- Ensuring that cases are palleted securely
- Labeling goods in an easy-to-read way
- Reviewing orders to catch errors

Storage Process



Factors Affecting Storage Performance



Warehouse's storage plan

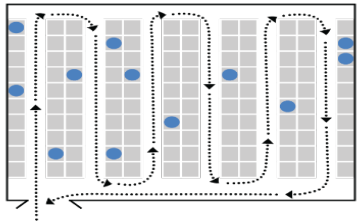
- Product velocity
- Weight
- Special storage needs

Picking

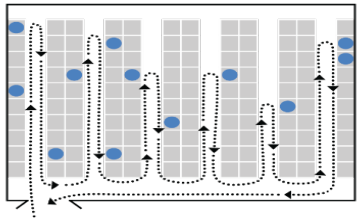
System	Order increments	Level of automation
▪ Part-to-picker ▪ Picker-to-part ▪ Tool: Picking list	▪ “Eaches” ▪ Cases ▪ Pallets ▪ Unit loads	▪ By hand ▪ Automated equipment

Routing Strategy

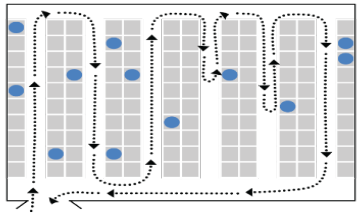
- Travel through warehouse can be up to half of picking time
- Efficiency is essential



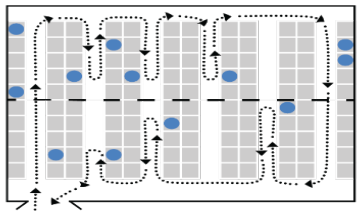
S-shape



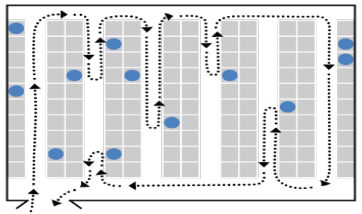
Return



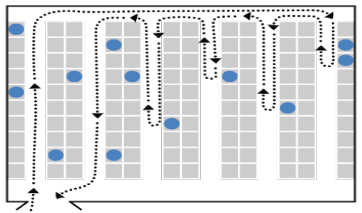
Combined



Midpoint



Largest gap



Optimal

Picking Structure

Discrete order picking

- Picked individually
- High level of customer service

Batch picking

- Fills multiple orders at same time
- Utilizes sorting area

Zone picking

- Storage area divided into zones
- Orders completed zone by zone

Wave picking

- Orders combined and released at specific times of day
- All zones picked simultaneously

Factors Affecting Picking Productivity: Best Practices

- Use efficient picking routes.
- Clearly label SKUs.
- Light the picking area well.
- Clear clutter.
- Use technology to eliminate paperwork.
- Use automation and equipment.
- Verify order with check step.
- Maintain adequate inventory.
- Cross-train pickers.
- Analyze performance data.

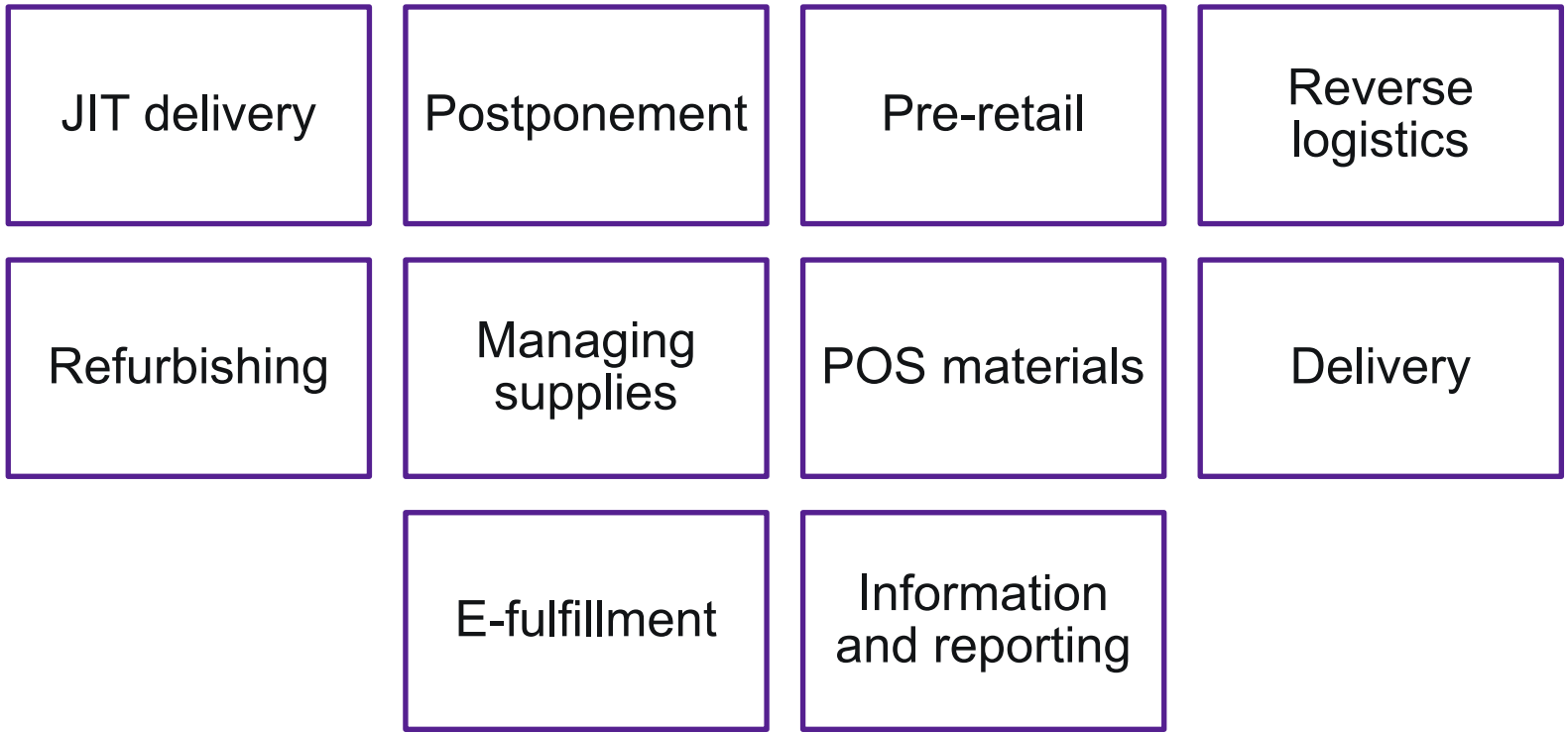
Sorting/Packing and Value-Added Services

Sorting is the function of physically separating a homogenous subgroup from a heterogeneous population of items.

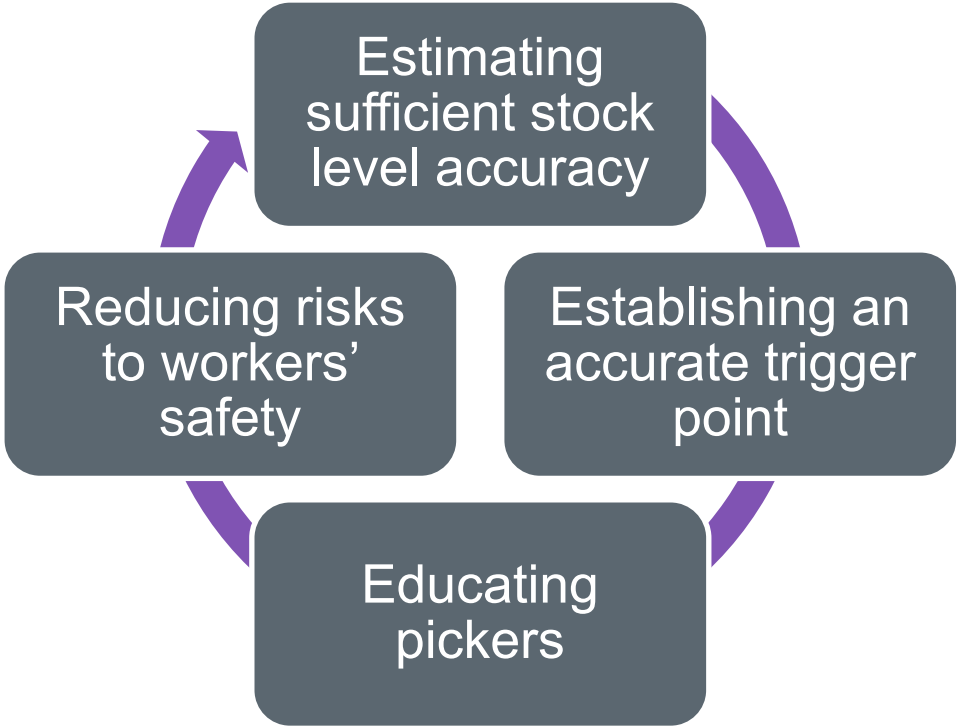
Packing occurs after goods are sorted to:

- Meet customer specifications.
- Avoid damage during shipping.
- Facilitate the most cost-efficient transportation.

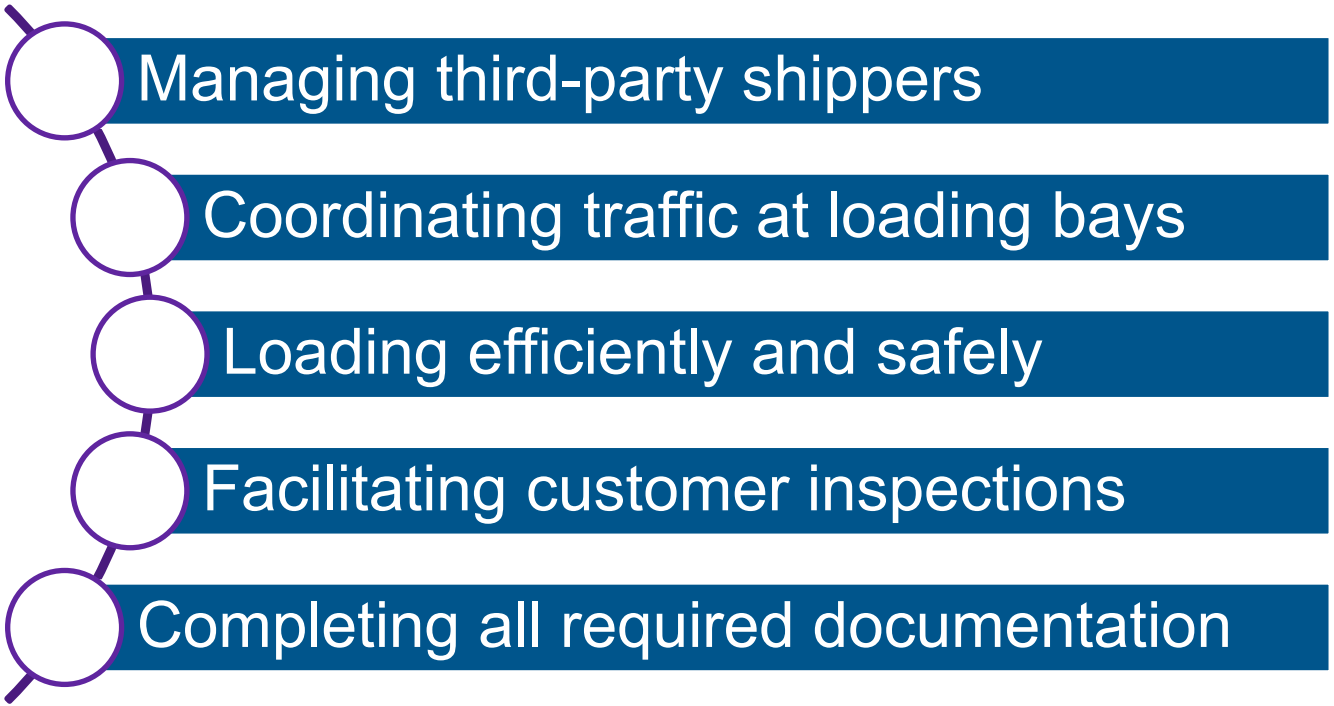
Value-Added Warehouse Activities



Keys to Replenishment



Loading Crew Challenges



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MODULE 7, SECTION C: WAREHOUSE LAYOUT

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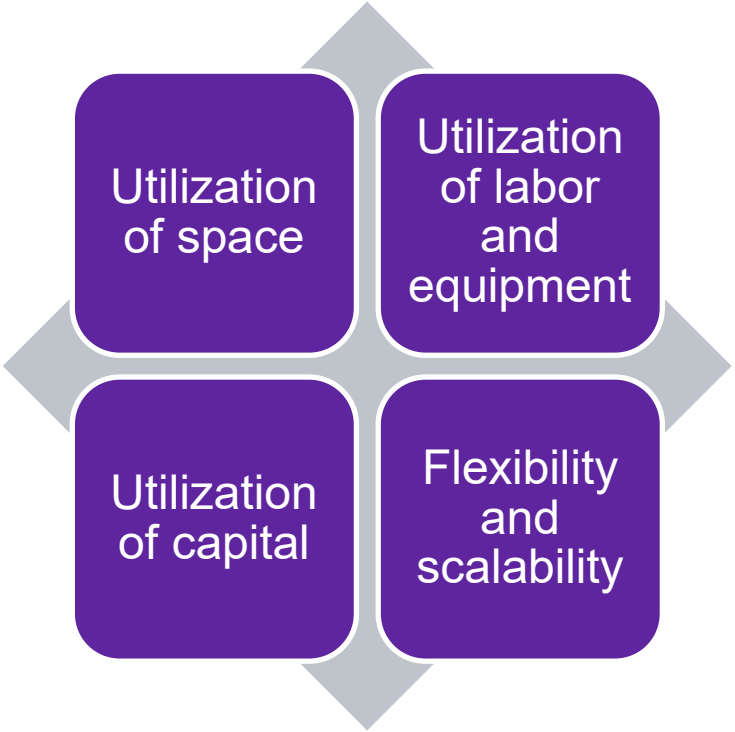
Warehouse Layout Principles

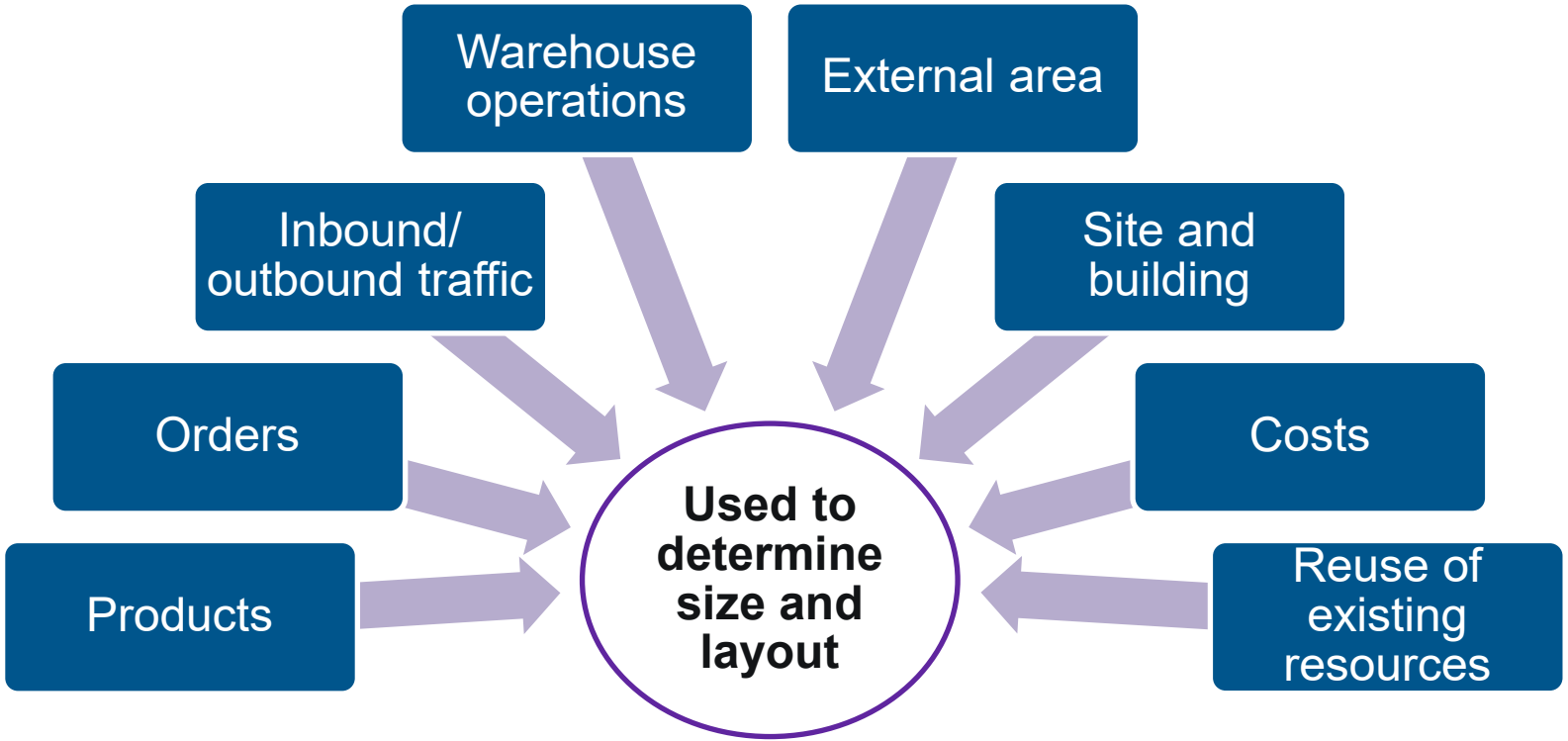


Warehouse Design Process

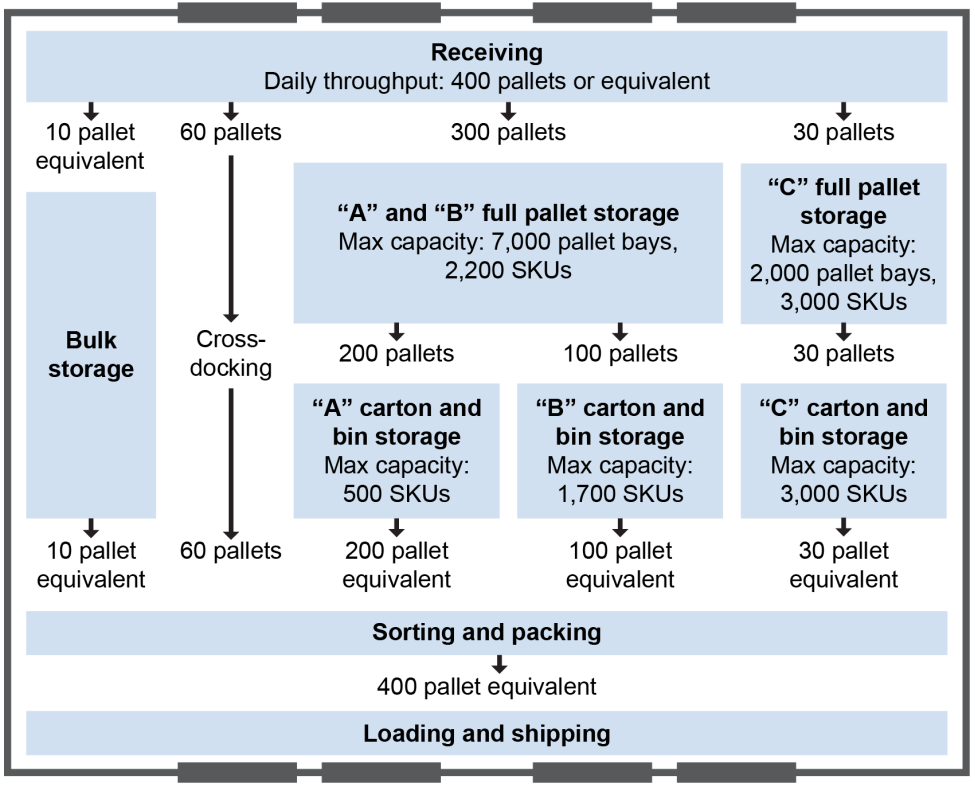
1.	Define business requirements and design constraints.
2.	Define and obtain data.
3.	Formulate planning base for defined throughput.
4.	Define and describe activity requirements.
5.	Select equipment.
6.	Create internal and external layouts.
7.	Define information system operation.
8.	Estimate capital and operating costs.
9.	Evaluate design against requirements and constraints.
10.	Finalize design.

Source: Adapted from Rushton et al., *The Handbook of Logistics and Distribution Management, fifth edition.*

Define and Obtain Data



Formulate Planning Base for Defined Throughput



Creating Internal and External Layouts

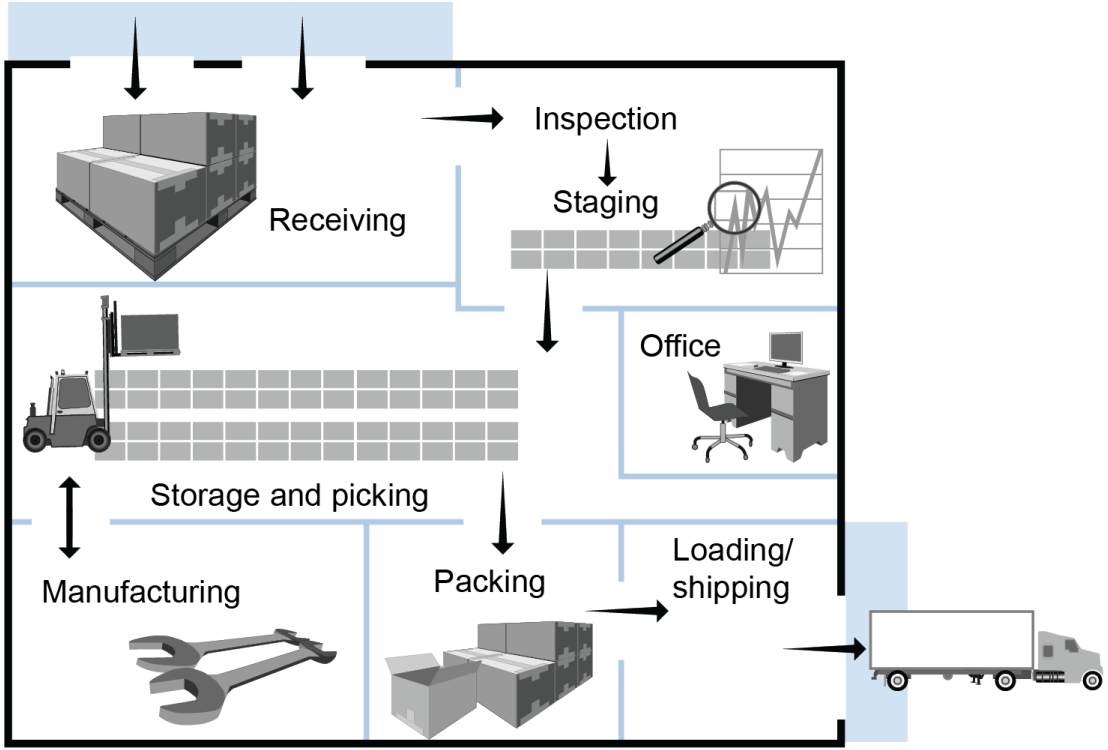
Internal layout needs

- Dock heights
- Vertical clearance
- Distance between supports
- Tolerances for floor unevenness
- Necessary services

External layout needs

- Yard
- Access roadways
- Fencing and security
- Parking areas
- Vehicle maintenance areas
- Landscaped areas

Basic Warehouse Design



Source: David F. Ross, *Distribution Planning and Control—Managing in the Era of Supply Chain Management.* Used with permission.

Space Needs in Warehouses

Interior Space Uses

- Staging areas for both inbound and outbound shipments
- Waiting areas for drivers
- Offices and communication/information system rooms
- Employee areas (e.g., rest rooms, locker rooms, break areas)
- Storage of pallets used for shipping
- Picking areas
- Value-added activities
- Storage of damaged goods waiting for return to suppliers
- Reverse logistics (for inspecting, fixing, scrapping, and reshipping)
- Holding of trash and recycling and related equipment (e.g., balers)
- Equipment storage and maintenance (e.g., recharging stations for electric vehicles)
- Building infrastructure, including utilities, HVAC, and security systems

Exterior Space

- Holding area for vehicles waiting to be loaded/unloaded
- Vehicle maneuvering
- Parking
- Fuel storage
- Outdoor recharging stations for electric vehicles
- Trash and recycling pickup
- Outdoor storage of equipment
- Security fencing and security systems
- Parking for trailers that are being utilized as inventory storage locations

Cube Utilization

"A measurement of the utilization of the total storage capacity of a vehicle storage bay, container, type of warehouse equipment, or entire warehouse. The intent is to minimize unused horizontal or vertical space." (ASCM Supply Chain Dictionary)

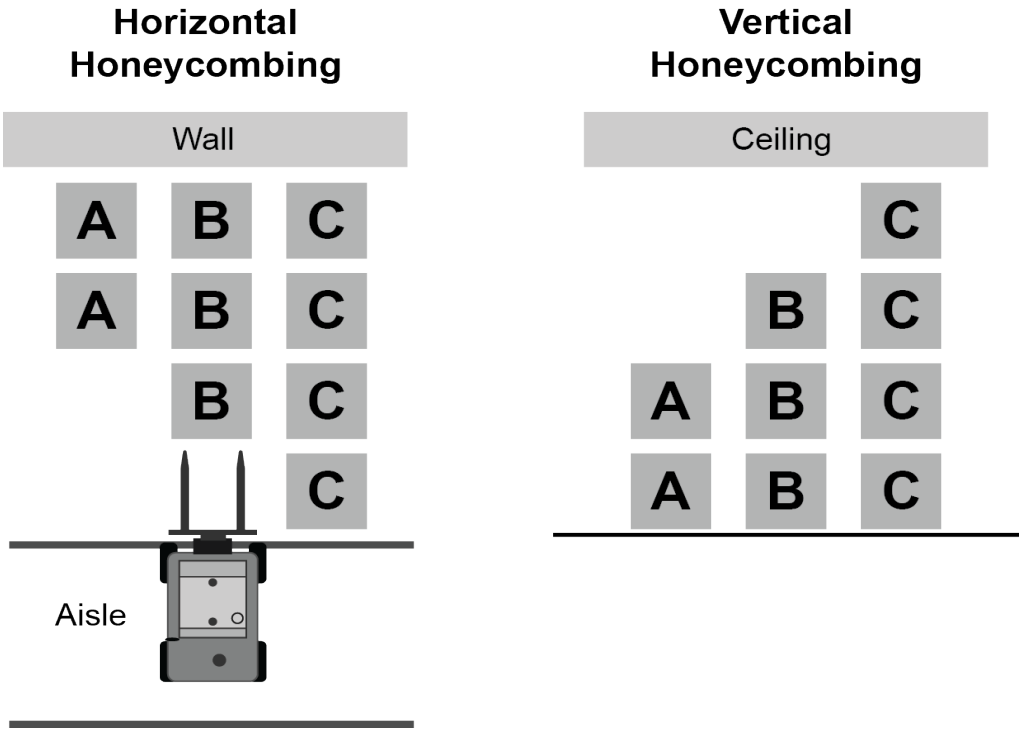
Improving cube utilization:

- Often requires different equipment (e.g., rack systems, forklift trucks)
- Finding additional unused space in existing structure
- Standardizing packaging/pallet size

Calculating Storage Space

1. Define the number of pallets required to meet inventory needs.
2. Calculate the square and cubic feet needed to store product.
3. Add space for other storage tools.

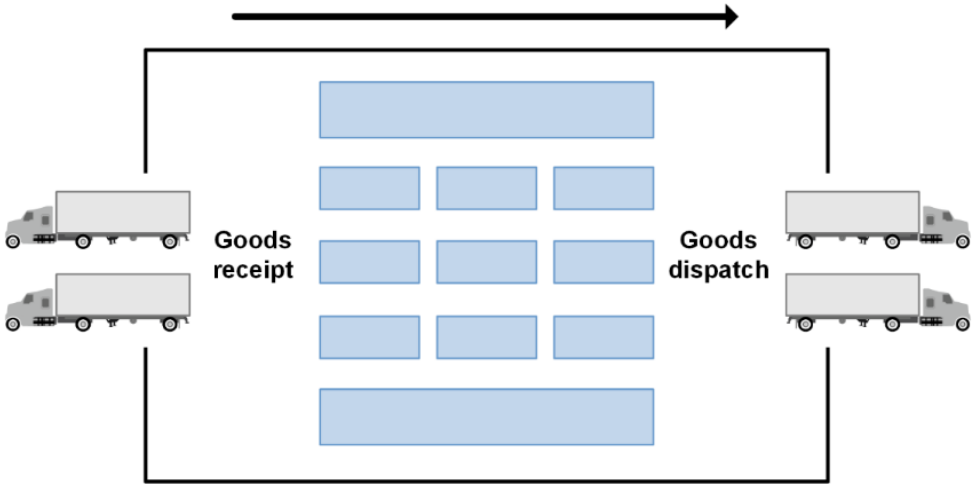
Honeycombing



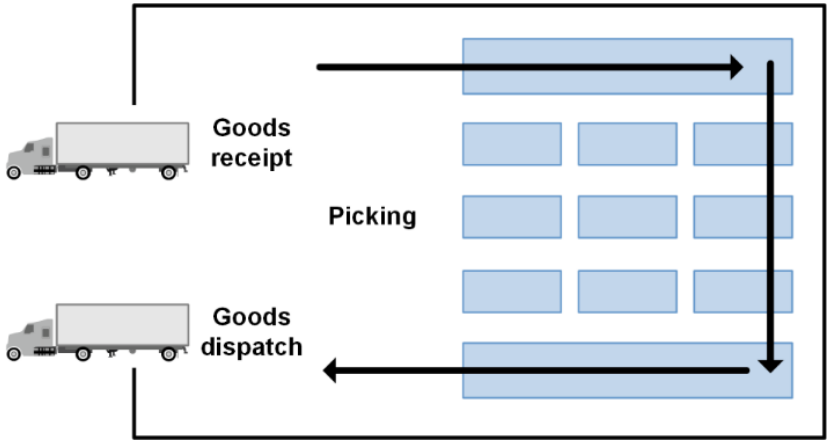
Source: David F. Ross, *Distribution Planning and Control—Managing in the Era of Supply Chain Management.* Used with permission.

Warehouse Layouts

Through-flow



U-flow

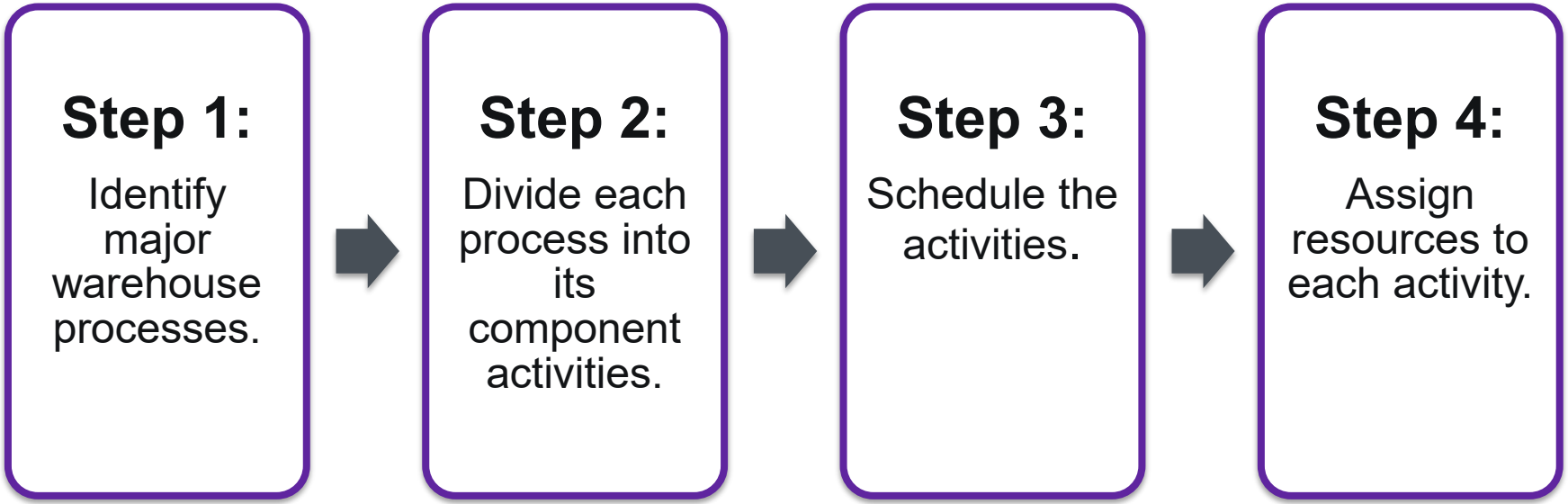


Finding Additional Warehouse Space

To increase capacity without increasing footprint:

- Consolidate stock.
- Move from fixed location to random location.
- Change storage medium or handling equipment.
- Reduce beam heights.
- Use variable height locations.
- Use temporary storage locations.

Modeling Resource Utilization



Developing Work Standards

- **Available Time** = Hours of Operation × Number of Workers or Equipment
- **Utilization Rate** $= \dfrac{\text{Hours Actually Worked}}{\text{Available Hours}}$
- **Efficiency Rate** $= \dfrac{\text{Actual Output}}{\text{Standard Output}}$
- **Rated Capacity** = Available Time × Utilization Rate × Efficiency Rate
- **Demonstrated Capacity** $= \dfrac{\text{Output for } n \text{ Periods}}{n}$

Examples of Waste in Warehouse

Equipment	♦ Driving an empty forklift
Time	♦ Time spent correcting errors in put-away or picking ♦ Delays caused by congestion in receiving and shipping areas
Motion	♦ Inefficient movements, such as staging before put-away ♦ Unnecessary steps (e.g., checking paperwork)
Space	♦ Too much inventory ♦ Inefficient use of storage space (poor use of vertical space, multiple half-empty pallets of the same SKU in different locations) ♦ Obsolete or out-of-date stock

Source: Adapted from Toby Gooley, “Lean Your Warehouse Workforce.” May 28, 2013, www.dcvelocity.com/articles/20130528-lean-your-warehouse-workforce/.

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MODULE 7, SECTION D: MATERIALS HANDLING AND WAREHOUSE AUTOMATION

APICS

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Materials-Handling Principles

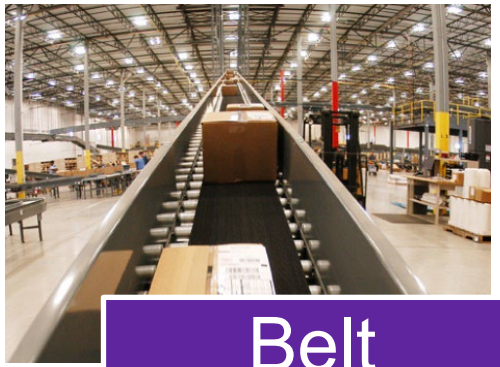
1.	Plan for materials handling through well-thought-out processes and procedures.
2.	Standardize equipment and procedures.
3.	Work smarter. Eliminate unnecessary work.
4.	Design processes to be ergonomic.
5.	Consolidate smaller unit loads into larger units.
6.	Maximize the use of space.
7.	Apply systems thinking to the materials-handling process.
8.	Use automation when possible.
9.	Minimize short- and long-term environmental impacts.
10.	Evaluate equipment and systems purchases.

Source: Adapted from “The Ten Principles of Material Handling,” Material Handling Institute, www.mhia.org.

Warehouse Equipment and Systems: Conveyor Types

Roller

Bulk



Belt

Source: Intelligrated (roller), Omni Metalcraft (bulk), Intelligrated (belt). All images used with permission.

Picking Systems

Pick-to-light system

Visual picking system

Sources: Bastian Solutions, LLC, www.bastiansolutions.com/solutions/technology/supply-chain-software/picking-technology/pick-to-light (pick-to-light). Deutsche Post DHL Group (visual picking system). Both images used with permission.

Picking Systems

Picker-to-goods

Goods-to-picker

Sources: Bastian Solutions, LLC, www.bastiansolutions.com/solutions/technology/supply-chain-software/picking-technology/pick-to-light (pick-to-light system), Intelligrated (picker-to-goods), Kardex Remstar (goods-to-picker). Both used with permission.

Robotic Systems

Layer picker

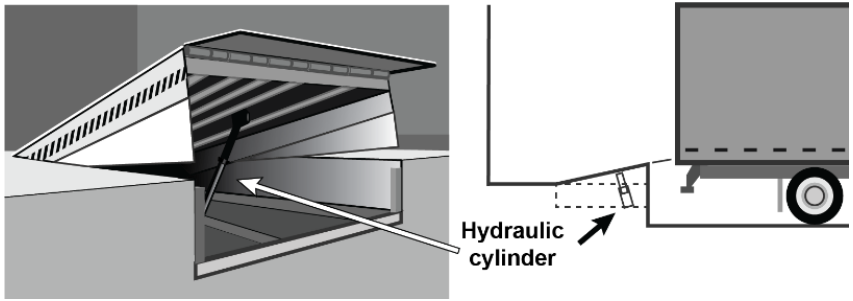
Automated guided vehicle (AGV)

Source: Bastian Solutions, LLC, www.bastiansolutions.com/solutions/technology/industrial-robotics/industrial-robotic-solutions/robotic-palletizing/robotic-mixed-load-palletizer. www.ek-automation.com (AGV). Both images used with permission.

Handling

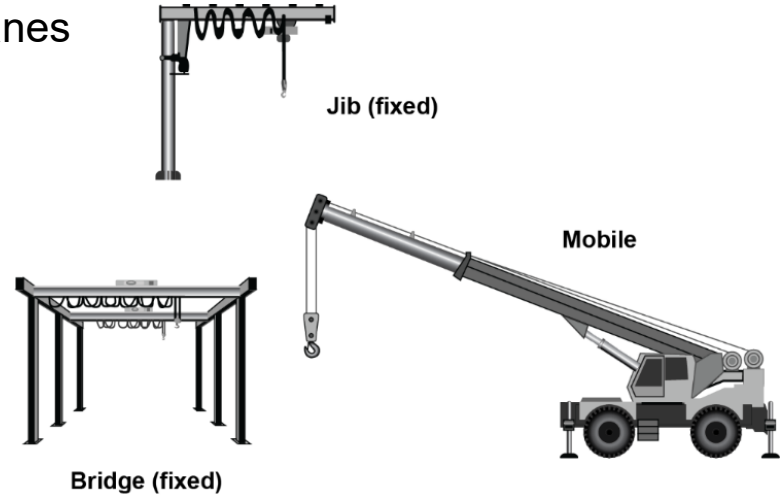
Dock equipment

- Dock levelers
- Door systems
- Wheel guides
- Bumpers
- Lighting
- Safety equipment



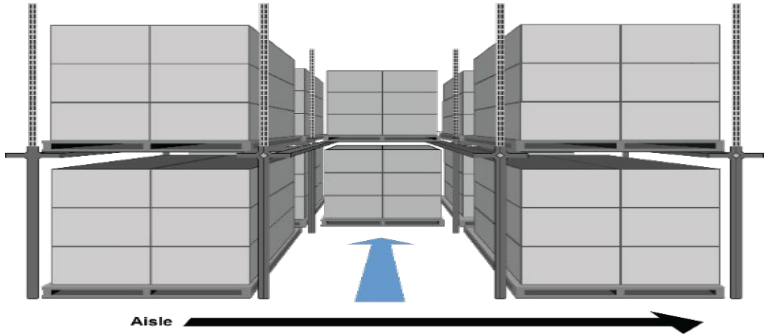
Product-handling equipment

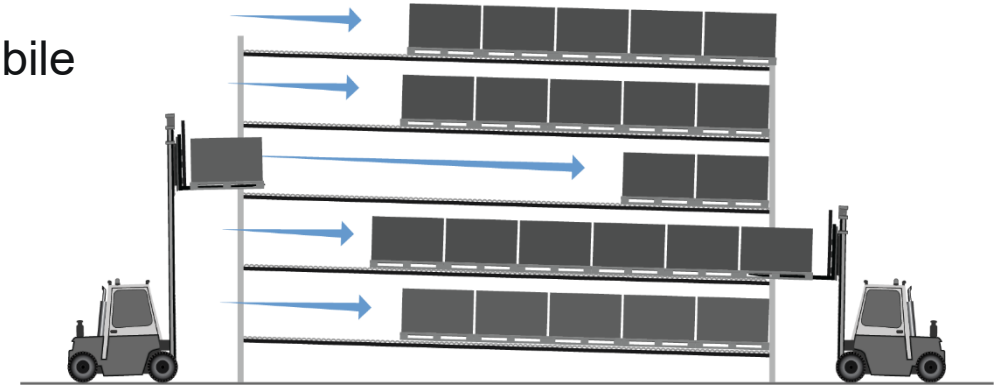
- Boom conveyors
- Forklifts
- Pallet trucks
- Cranes



Palleted Storage

- Block stacking
- Drive-in/drive-through racks
- Adjustable pallet racks (APR)
- Powered mobile racks

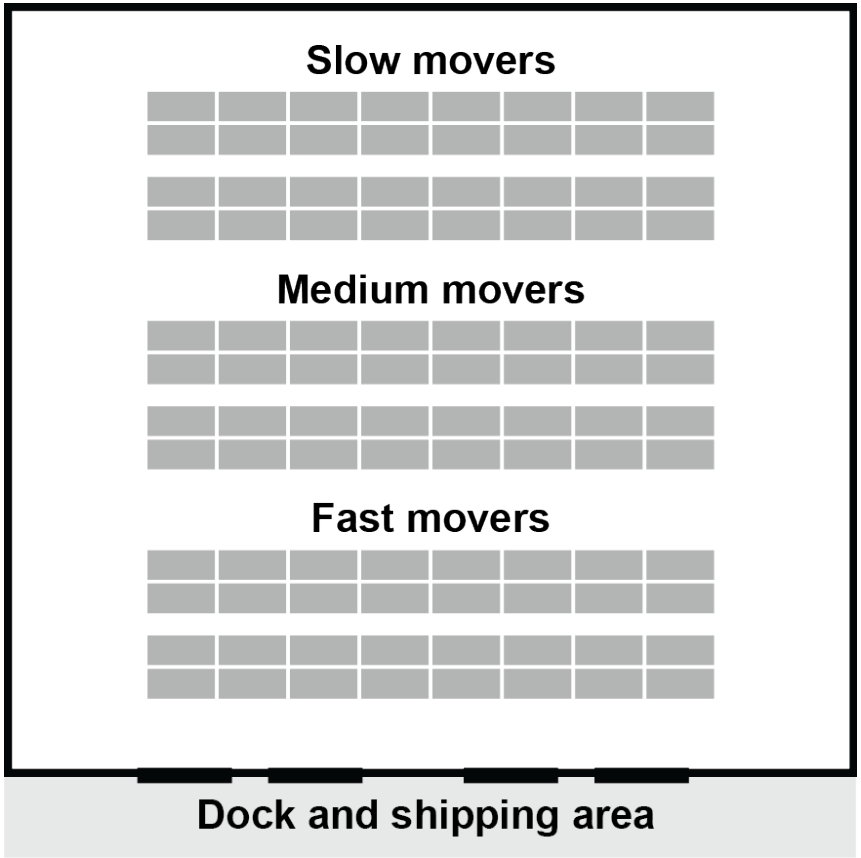




Source: Spacesaver Corporation. Used with permission.

Topic 5: Slotting Strategy

ABC Slotting



Source: David F. *Ross, Distribution Planning and Control—Managing in the Era of Supply Chain Management.* Used with permission.

Warehouse Safety Measures

- Training
- Redesigning processes
- Redesigning workplace
- Policies
- Protective equipment
- Safeguard devices
- Periodic audits

Securing Warehouse Assets and Contents

- Damage and destruction of the facility and its contents from natural and human-made causes
- Vandalism and theft by outsiders and insiders
- Cyber theft and hacking
- Gradual degradation of inventory shelf life

C-TPAT's Warehouse Security Measures

Security plan focus areas:

- Physical security
- Standard operating procedures
- Personnel
- Access controls
- Information technology
- Customer evaluation

Information Systems

Warehouse management systems (WMS)

- Manage orders and inventory
- Organize warehouse work
- Monitor and analyze performance
- Can manage multiple warehouses

Warehouse control systems (WCS)

- Communicate directly with warehouse automated equipment
- Operate in real time
- Provide a single user interface

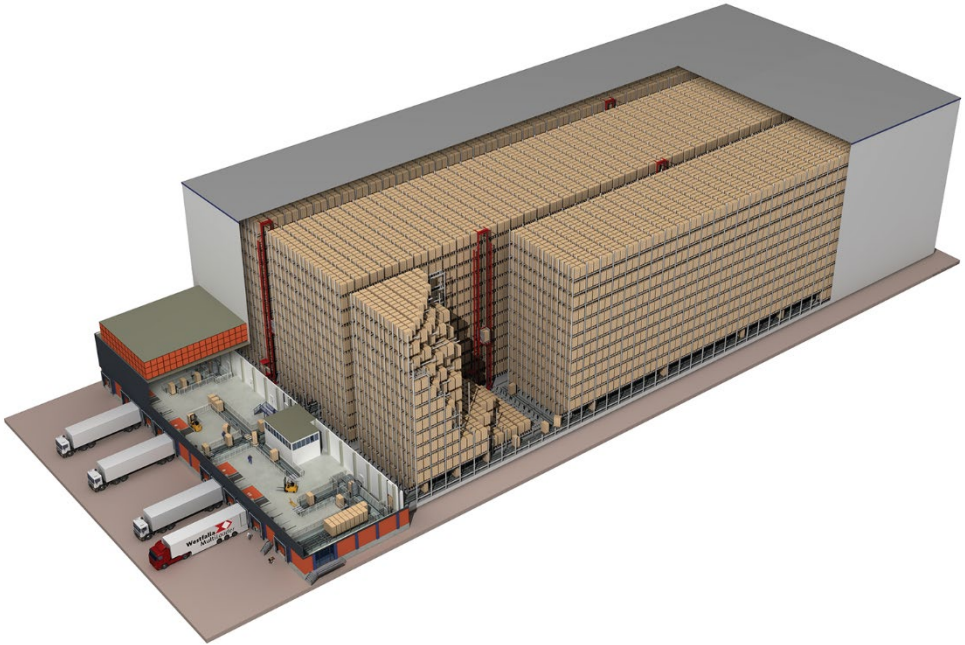
Selecting a WMS

- Ability to interface or integrate with existing systems
- Modularization and scalability
- Accessibility from internet
- Analysis and reporting capabilities
- User-friendliness
- Support of best warehouse practices
- Support of specialized functionality

Yard Management Systems

- Coordinate inbound and outbound shipments
- Account for equipment and goods in yard and warehouse
- Reduce delayed trailer return
- Manage shunting work

Automated Storage and Retrieval Systems (AS/RS)



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CERTIFIED IN LOGISTICS,
TRANSPORTATION AND DISTRIBUTION

MODULE 7, SECTION E: PACKAGING

APICS

ASCM

Product State

Solids

- Bulk or packaged forms.
- Bulk includes materials too large for pallets and dense raw materials.

Liquids

- Differentiated by viscosity level.
- May be transported by pipeline or in units, such as barrels, drums, or tanks.

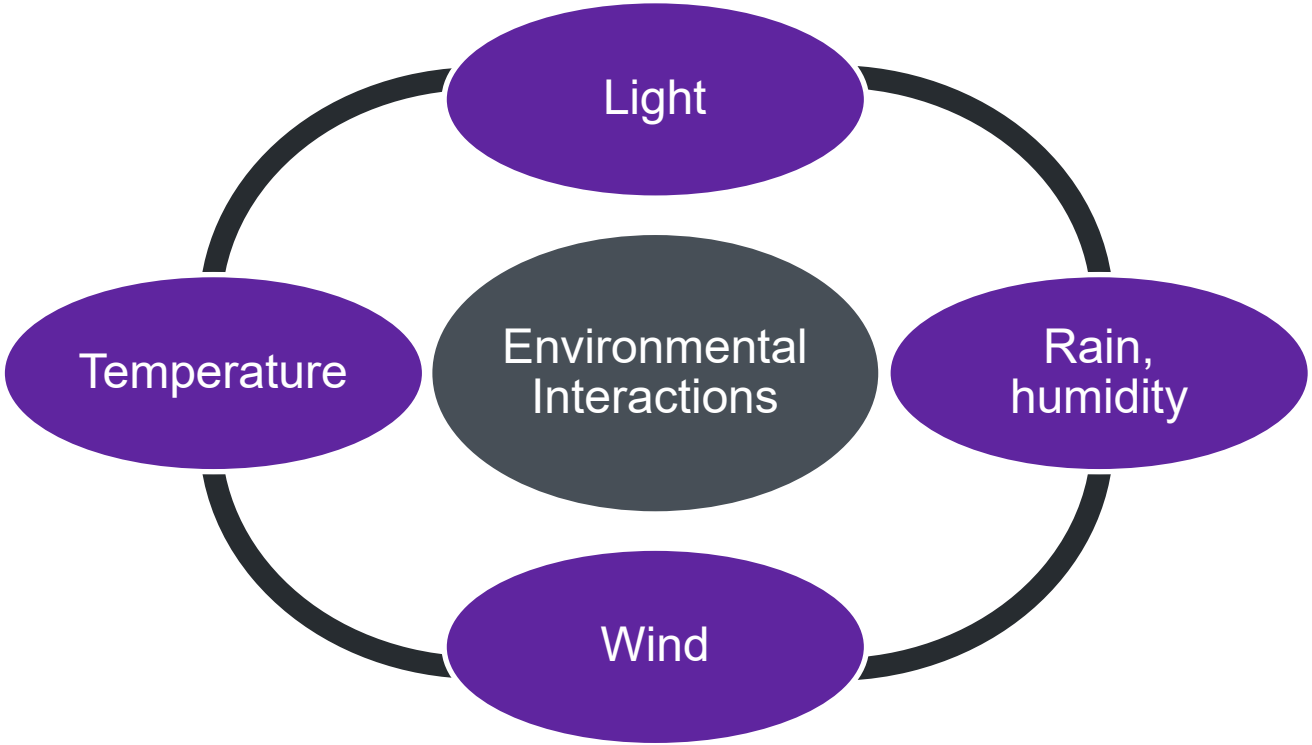
Gases

- Gases are compressible.
- Transported in bulk by pipeline or large pressurized tankers.

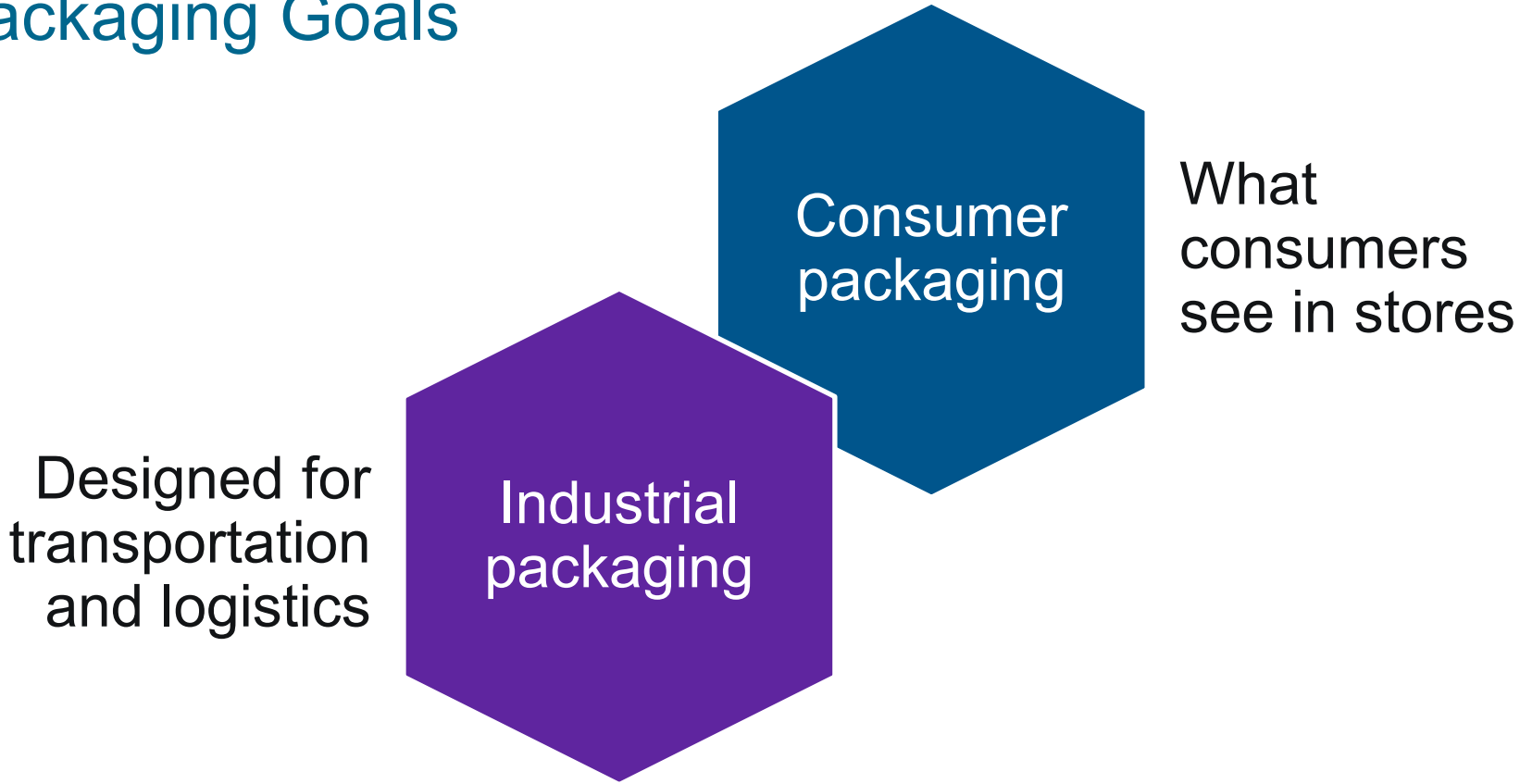
Density

- Refers to the ratio of mass to volume.
- Highly dense products “weigh out” before they “cube out,” so a load reaches a vehicle’s weight limit before it fills the container.
- Iron ore (left image) will typically **weigh out** a river barge (highly dense).
- Coal (right image) will typically **cube out** a river barge (less dense).

Environmental Interactions



Packaging Goals



Protecting Against Damage from Typical Causes

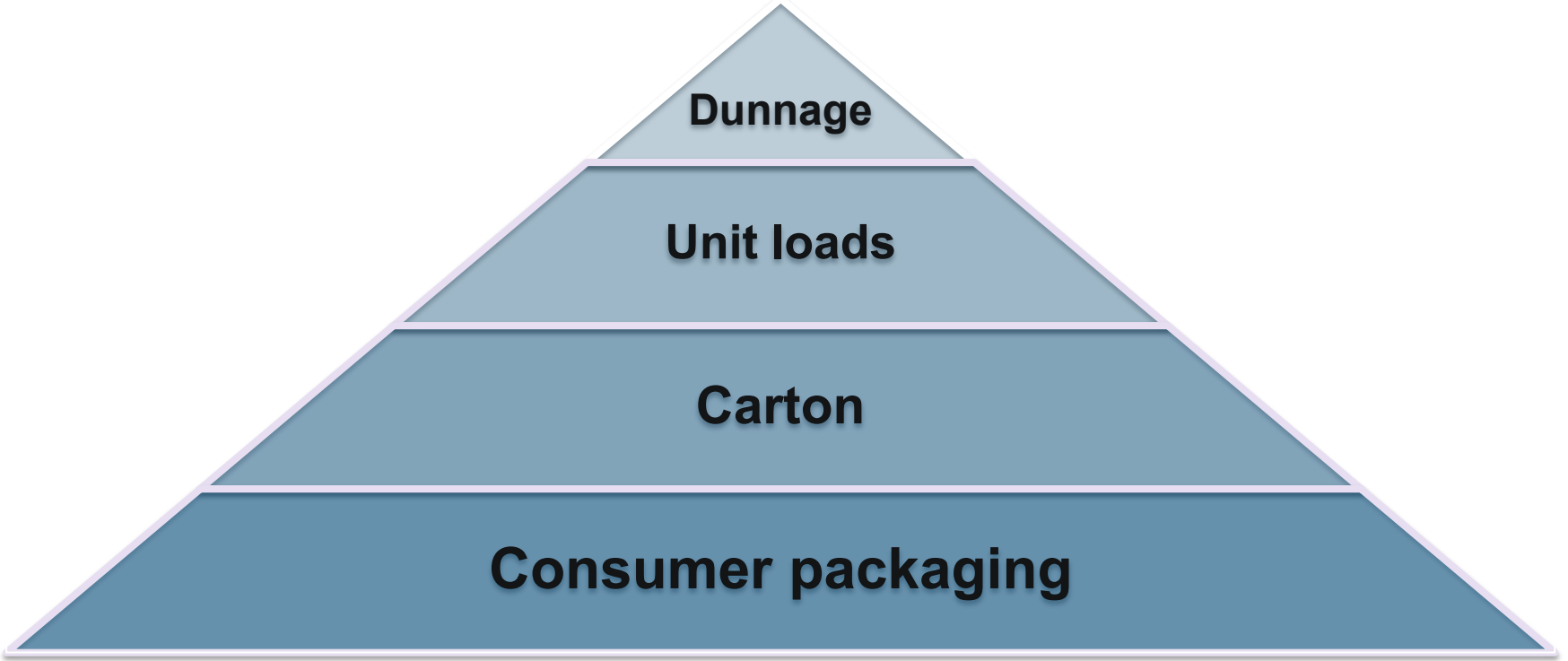
Impact and vibration

This is provided by cushioning material, shrink wrap, etc.

Compression and puncture

This is provided by a sturdy outside box or rigid container, protective corner additions to pallets, shrink wrap, etc.

Building Blocks of Packing



Sustainable Packaging

- Reusable packaging includes
  - Rigid containers
    - Stackable plastic bins, kegs, barrels, or metal containers
  - Reusable cushioning material
    - Inflatable dunnage bags
- Reusable packaging may require the use of tracking or a deposit system to ensure return of rigid containers.

Unit Labeling

Bar codes

- A machine-readable code that identifies, at minimum, a product manufacturer and stockkeeping unit (SKU)
- Examples:
  - UPC
  - 2D bar code

RFID

- Used to identify and locate units—primarily at case and/or pallet level due to cost issues.
- Electronic tags are smart chips whose signals are automatically picked up by readers/interrogators.

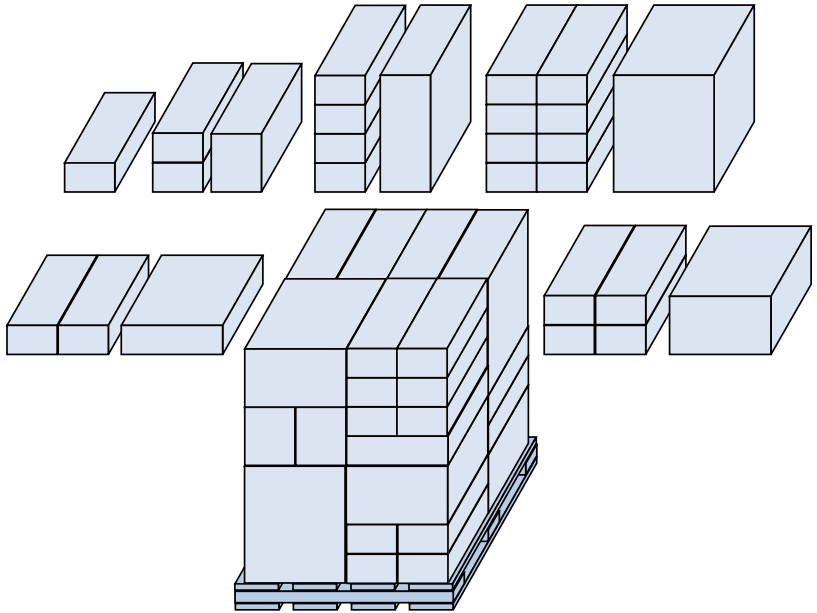
RFID Tag Types

Active tag	Passive tag	Semipassive tag
▪ Broadcasts information ▪ Has power source ▪ Can transmit data to reader at long ranges ▪ Most expensive type ▪ For containers or pallets	▪ Does not send out data ▪ Not self-powered ▪ Reader temporarily powers tag ▪ Can transmit data at short range ▪ Cheap if purchased in bulk	▪ Tag sends out data ▪ Self-powered ▪ Widens range by harnessing power from reader

Master Cartons

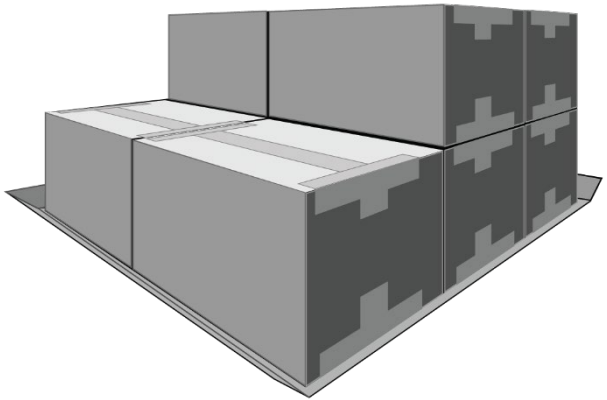
Criteria that affect size of master carton:

- Ease of handling
- Economies of scale in transportation
- Customer preference
- Packaging efficiency
- Sales velocity

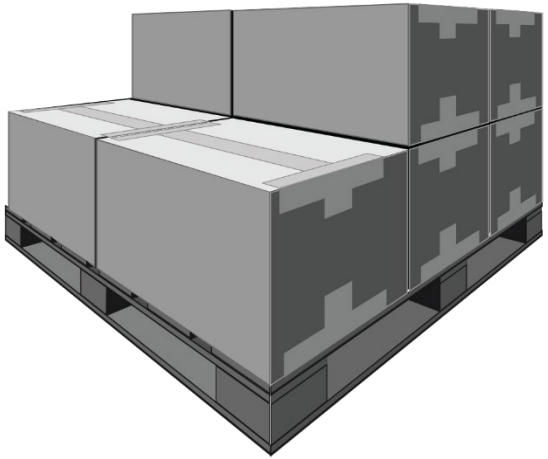


Pallet Types

Slip sheet pallet



Wood pallet



ISO Standard Pallet Sizes

Dimensions (mm) W x L	Dimensions (inches) W x L	Country of Use
800 × 1 200	31.50 × 47.24	Europe (euro pallet)
1 000 × 1 200	39.37 × 47.24	UK and Asia (UK or industrial pallet)
1 067 × 1 067	42.00 × 42.00	Most countries
1 100 × 1 100	43.30 × 43.30	Asia
1 165 × 1 165	45.87 × 45.87	Australia
1 219 × 1 016	48.00 × 40.00	North America