Warehousing Management: Concepts & Tours

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Outline

source: General references [BH09, Mul94, Fra02, Kit18]

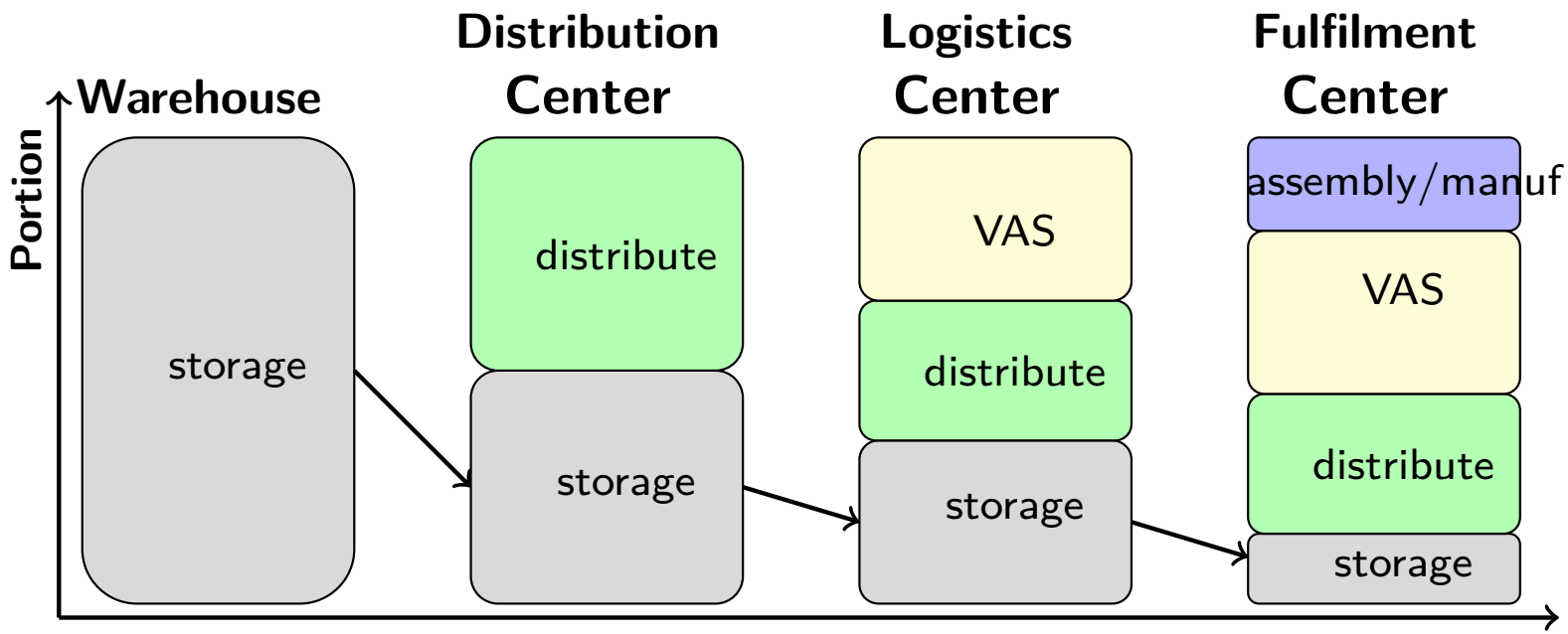
Warehouse & Logistics/Supply Chain

- Warehouse $\in$ Supply Chain
- Warehouse $\ni$ a bid dark, gloomy, & messy building
- Warehousing management $\ni$ Inventory management
- Warehouse $\ni$ DC $\ni$ Transit facility $\ni$ Silo $\ni$ Crossdock $\ni$ Fulfilment Center
- If goals of Supply Chain is to ensure that customers got

  the right item
  in the right quantity
  at the right place
  at the right time
  in the right condition
  at the right price
  at the optimum cost to the organization(s)

  then, how these related to warehouse?

Development of Warehousing Management



source: Frazelle, E. 2002. "World-Class Warehousing & Material Handling" [Fra02]

Objectives warehousing management

Objectives

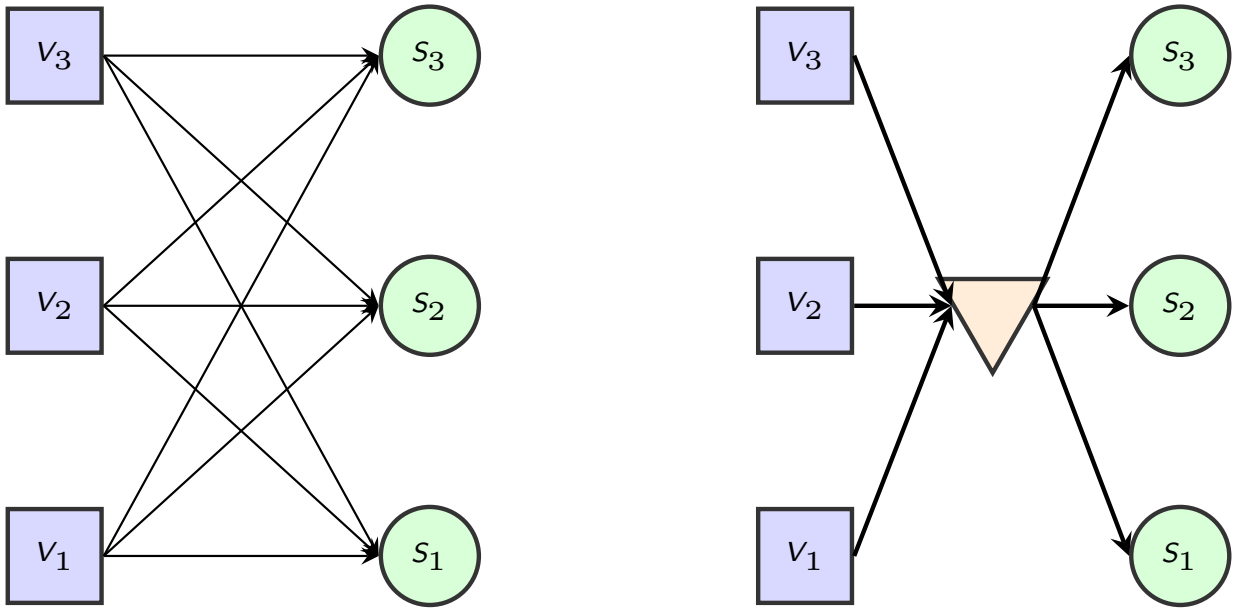
- To ensure availability of resources for planned level of business.
- To meet throughput requirements.
- To provide an cost effective service while meet business objectives.

Specifically: Time, Space, & Cost

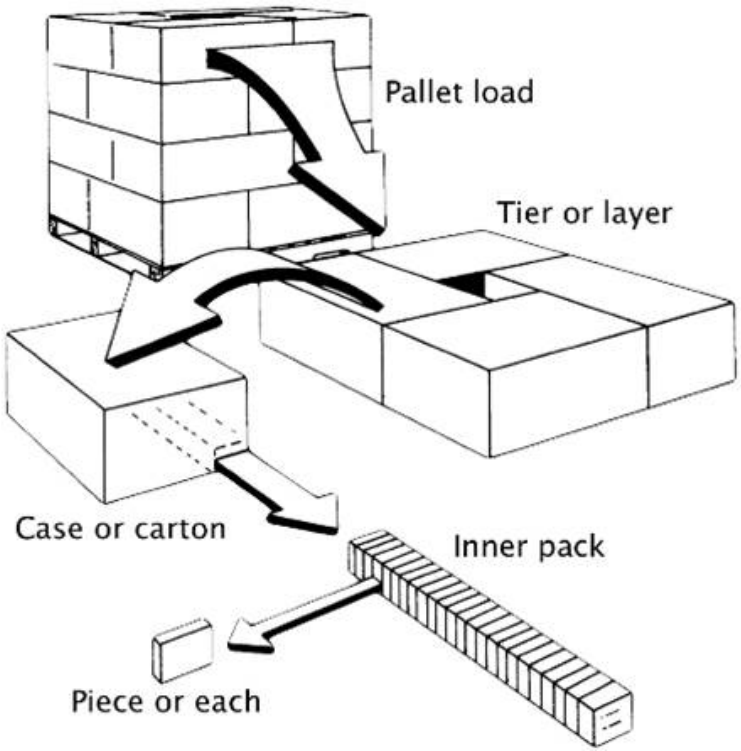
- minimizing frequency/distance of movement
- maximizing the use of cubic space
- enabling the use of standard storage & handling equipment
- speeding up loading & unloading
- minimizing damages & thieving

Why do we need warehouse?

- To prevent against fluctuations from suppliers and/or customers (Wal-Mart, SCG dealer)
- To exploit economy of scale & fright consolidation (THD)
- To perform value-added activities (e.g. HP DeskJet, NY)



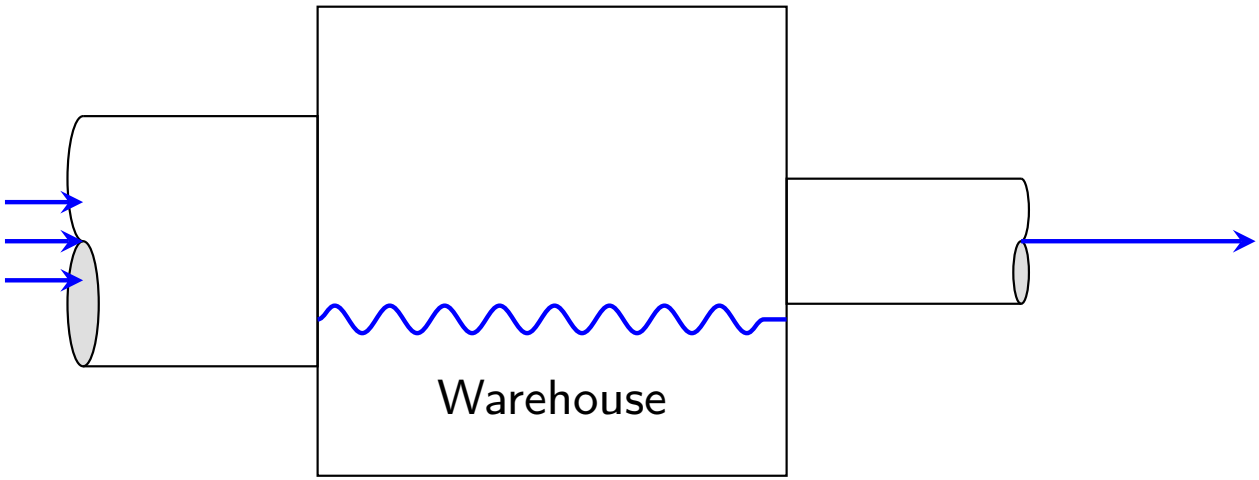
Units in warehouse



source: Bartholdi, J. & Hackmans, S. 2009. [BH09]

Stock Keeping Unit (SKU) a unit identification (consider difference) in a warehouse. a pallet of red pens $\neq$ a single red pen

Warehouse as flow process system



- **Water:** single SKU, and compressible flow
- **Flow balancing:** incoming flow & outgoing flow
- **Keep flow moving:** avoid double handling; space blocking
- **Smooth Flow:** resolve bottlenecks, avoid layouts that impede smooth

Components in warehouse

- **Facility:** building, yard, surrounding
- **Human:** manager, picker, checker, IT, consult
- **Material Handling:** products, storage location, equipments
- **Processes:** main activities, value-added logistics (VAL), counting, reconcile, document

Principle in warehousing management

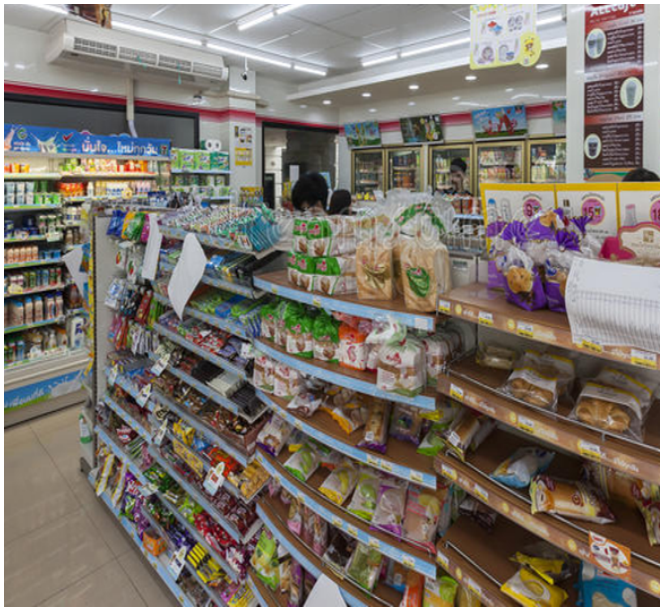
- **F.A.S.T:**
  - **Flow**: minimizing total movements/cost $\rightarrow$ no double handling
  - **Accessibility**: inside & outside buildings $\rightarrow$ no blockage
  - **Space**: $\approx$ 40% of cost related to warehouse; $\rightarrow$ use hight
  - **Throughput**: equipments $\rightarrow$ use right & flexible ones
- **Planning:** long-term goal & short-term req^m, control & feedback,
- **House keeping:** clean, neat, safety, security & eco-friendly
- **Flexibility:** free space, stacking area, multi-purpose equipment

Common Classification of Warehouse

Warehouse a physical location store inventory. Types of warehouse, providing useful insight, are:

- **Products:** finish goods, work-in-process, raw materials
- **Unit of handling:** MHE: pallet, carton, piece
- **Nature of Storage:** security, storage requirement
- **Storage Policy:** dedicated $\leftarrow$ class-based $\rightarrow$ shared/random
- **Temperature:** Frozen $\leftarrow$ Chilled – Air Condition $\rightarrow$ Ambiance
- **Management:** Public warehouse $\leftrightarrow$ Private warehouse
- **Movement:** Men-to-Goods $\leftarrow$ Goods-to-Men $\rightarrow$ Automation
- **Business:** retail, service parts, 3PL (DC), fulfillment

Example: 7Eleven store as a warehouse

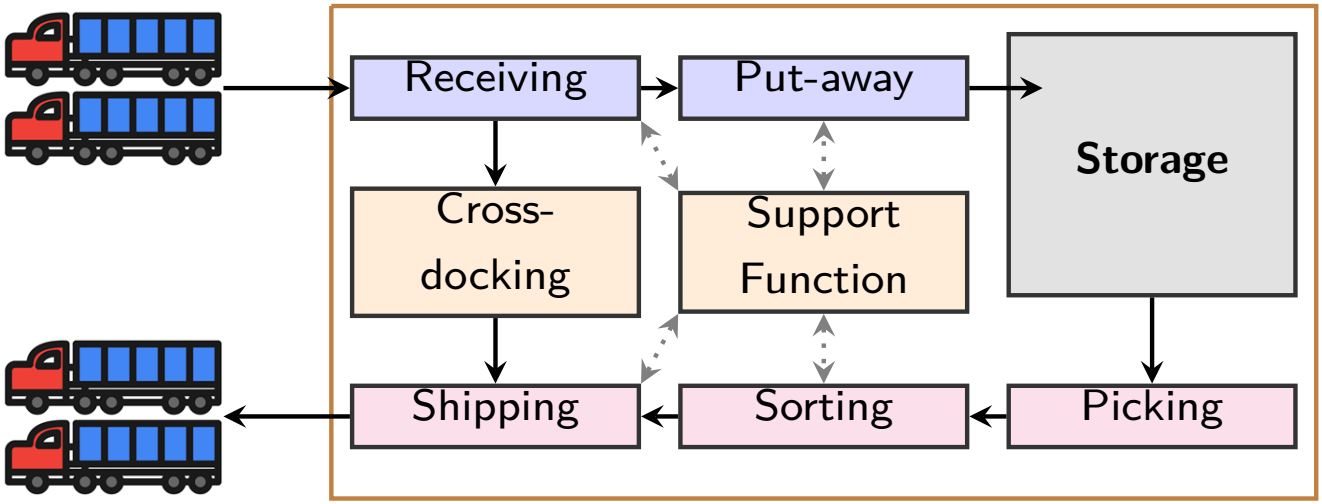


- **Unit of handling:** FG piece picking (basket)
- **Nature of Storage:** security and authorize (back counter)
- **Temperature:** frozen (ice cream, AirCon (Milk, Drink), ambiance (Grocery)
- **Policy:** dedicate-class
- **Management:** private warehouse
- **Movement:** Men-to-Goods
- **Others (TBR):** 24/7, U-shaped layout, vertical bin-shelf racking

Inside CP All DC (7Eleven warehouse)

- **Nature:** distributing products in 7Eleven for DC Fee and QC
- **Receiving:** 10w or 18w supplier delivery as carton or pallet
- **Equipment:** trolley, tote, RT, pick-to-light
- **Picking:** wave picking (heavy, pieces $\rightarrow$ tote), chilled
- **Shipping:** 4w outsource as tote + beverage

Warehousing activities



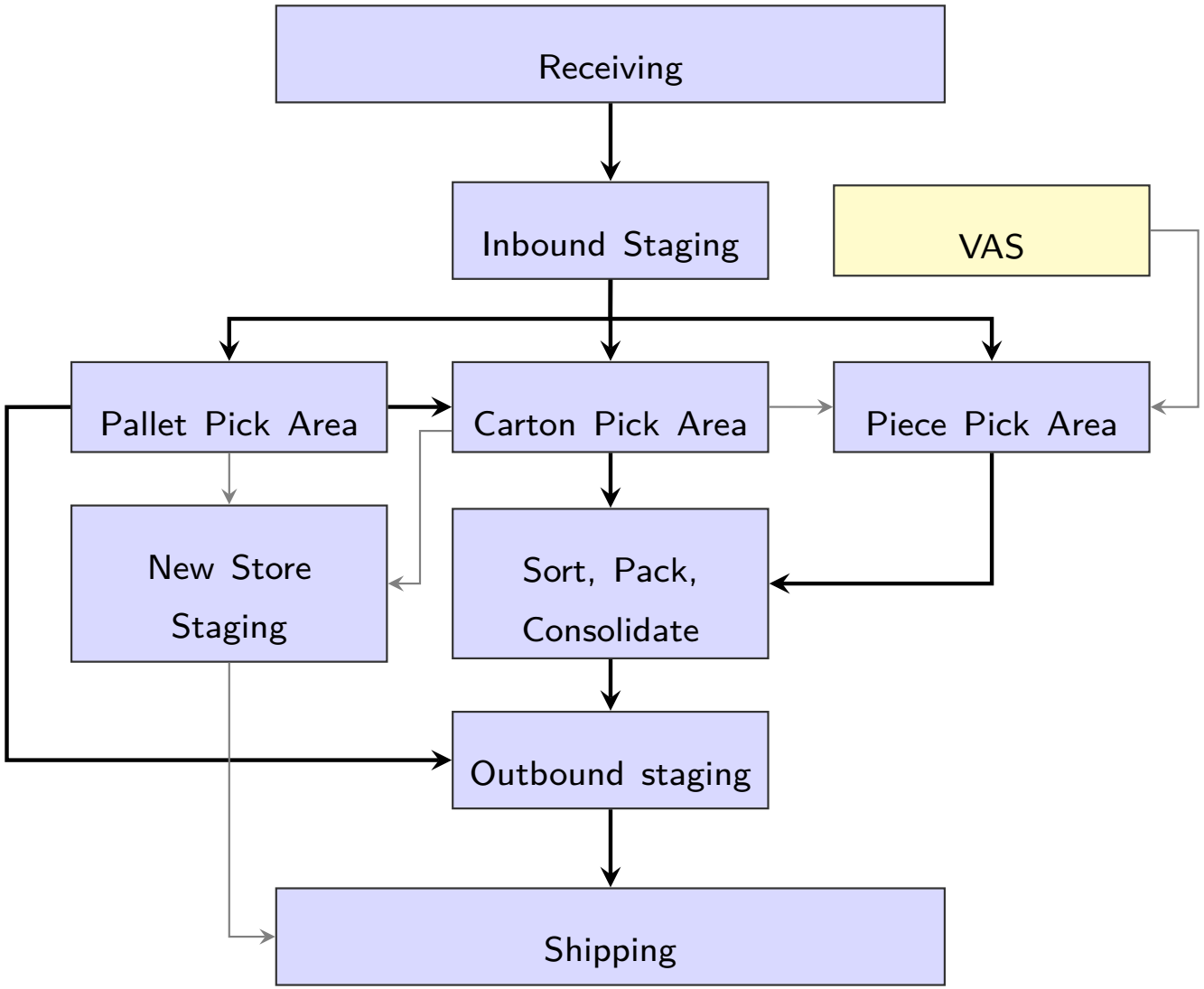
source: Frazelle, E. 2001. [Fra02]

Warehouse activity breakdown

Activities	Example
Receiving (10%)	yard mgt, inspection, unitization
Put-away (15%)	positioning, slotting, stock keeping
Picking (55%)	dispatching , routing
Shipping (20%)	sorting, loading , checker

source: Bartholdi, J. & Hackmans, S. 2009. [BH09]

Activities in Warehouse



source: Roodbergen, K. *et al.*, 2008. [?]

Receiving & Put-away activities

Receiving

- **Idea:** unloading & preparation
- **Importance:** initiating all operations & activities
- **Basic:** doing paper work & checking for quantity & quality

Put-away

- **Idea:** moving SKU to 'designated' locations
- **Importance:** defining all works downstream.
- **Basic:** recording where SKUs are consistently

Grouping philosophy

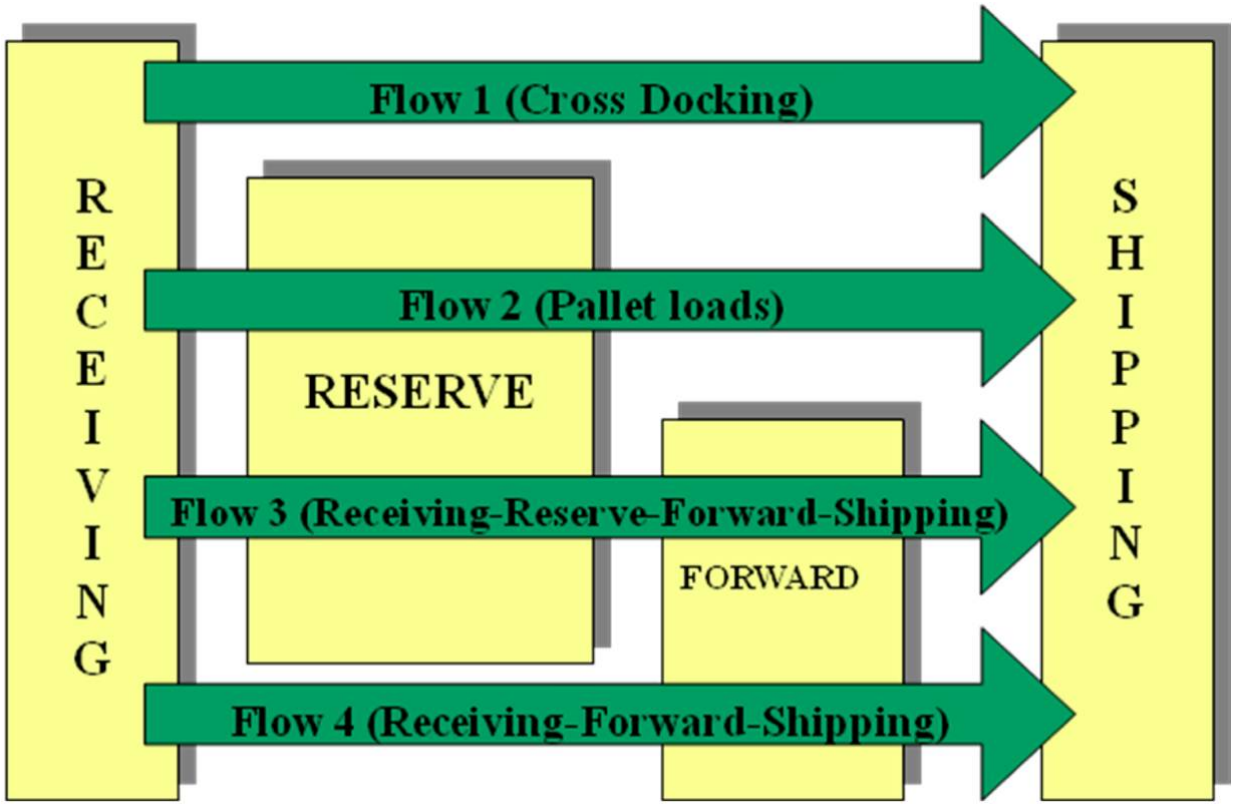
- **SKU popularity:** ABC based on frequency
- **Family group:** value, temperature, hazardous, physical, lot number, tax
- **SKU rotation:** FIFO (LILO), FILO, FEFO
- **Space utilization:** maximizing storage space; minimize congestion
- **Quality:** full pallet **VS** break bulk

Put fast-moving items at convenient & suitable locations

Non-productive activity: Storage

- **Idea:** preventing SKUs for damage and/or degrading
- **Importance:** what other thinking of warehouse
- **Basic:** utilizing space, while maintain easy access
- **storage area:**
  - Forward: storing products for carton/case/piece picking and customer delivery
  - Reserve: storing pallets for pallet picking or refill other area
- **storage policy:**
  - Dedicated: reserved specific space for each SKUs
  - Shared: no reservation

Between receiving & shipping

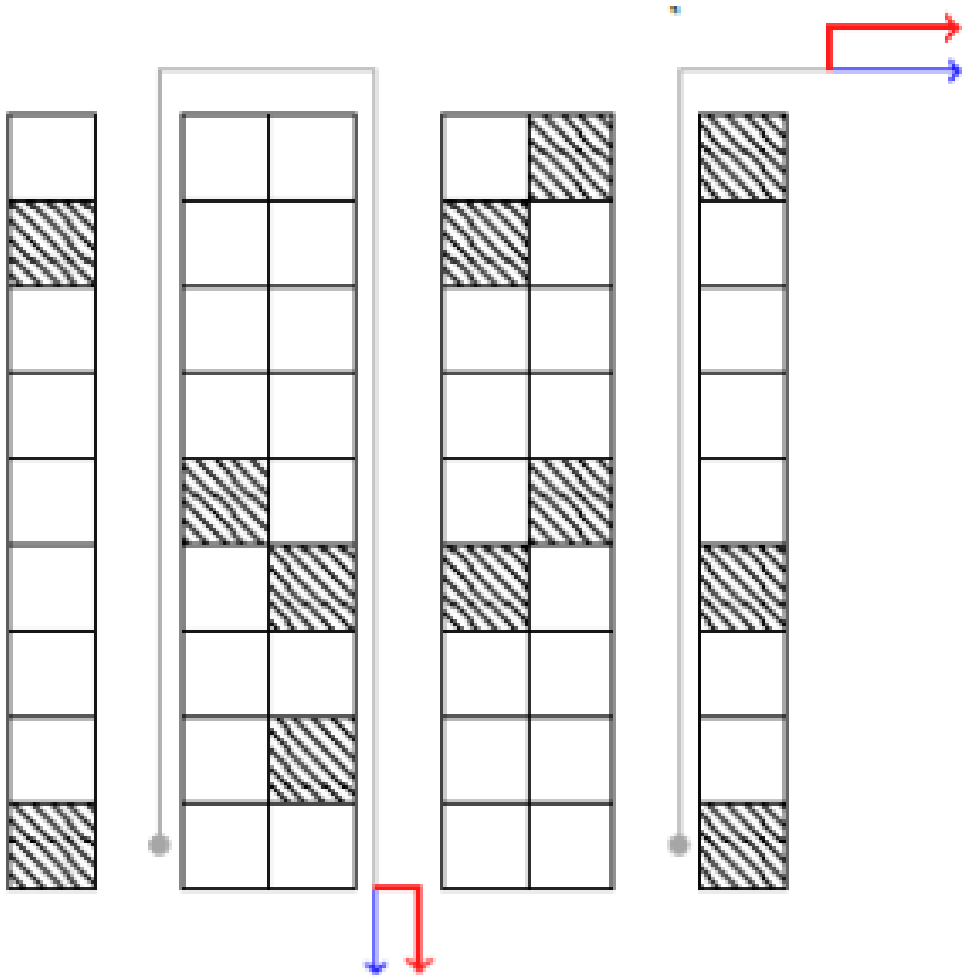


source: Mulcahy, D. 1994. [Mul94]

Picking activity

- **Idea:** getting SKU from 'designated' locations
- **Importance:** majority of costs & times incurred
- **Basic:** distributing 'order' & checking 'right' quantity
- **Principle:**
  - Minimize loose items & staging for shipping
  - Minimize paperwork & time
- **Variation:**
  - Single [order]: one tour for one order
  - Batch [order]: one tour for many orders
  - Zone: set area for each picker
  - Wave: coordinated between zones

Picking Variation



Shipping & Other activities

Sorting & Shipping

- **Idea:** preparing & checking SKU before leaving warehouse
- **Importance:** define productivity of warehouse, quality control
- **Basic:** checking SKU, documenting transactions & loading in reverse order

Others

- **Value-added logistics:** re-boxing & re-instruction (DKSH), sample assembly (Hefale), measuring & cutting (UF), MUJI price labeling (CRC)
- **Reverse logistics:** dispose product (Tesco), cleaning tote (7-Eleven)
- **Non value-added logistics:** visual inspection, counting, re-location (TUF), safety training(HomePro)

Benefits of equipment

- Reduce cost (labor + space)
- Enhance responsiveness
- Maintain qualities of products & operations

Classification of equipments

- **Unitizing equipment:** unit load → container, pallet, tote,
- **Storage & retrieval equipment:** floor stack, rack, carousel, bin-shelve
- **Material handling equipment:** forklift, hand truck, VNA, conveyor
- **Automatic identification & communication equipment:** portable bar code reader, RFID

Concept of unitizing equipment

- **Idea:** standardizing items/SKUs & making them easy to move & collect
- **Where:** supplier site, receiving & shipping area
- **Issues:** installation cost, volume, size & shape (7Eleven tote, Lotus cool box)
- **Example:** pallet, wrapping machine

Pallet & co

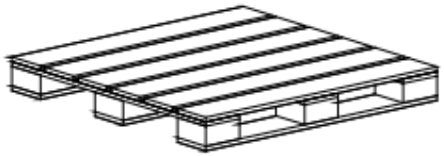
- **Idea:** creating unit load by std platform
- **Issues:** circulation, size, form

Comparison of pallet materials

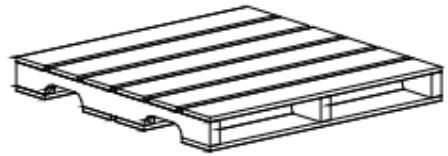
source: https://www.palltechpallets.co.uk

Material	Durability	Repairable	Env. Impact	Application
Wood	med	yes	recyclable	common
Pressed Wood	med	yes	recyclable	printing, tiber
Fiberboard	low	no	recyclable	paper, garment
Plastic	high	no	closed loop	cement, automotive
Metal	high	depends	closed loop	grocery, food, military

Shape of Pallet



Block Pallet



Stringer Pallet

Standard Pallets

ISO pallets 1000 mm × 1200 mm

US pallet 40 in × 48 in (1016 mm × 1219 mm) or 42 in × 48 in

Euro pallet 800 mm × 600 mm & 800 mm × 1200 mm

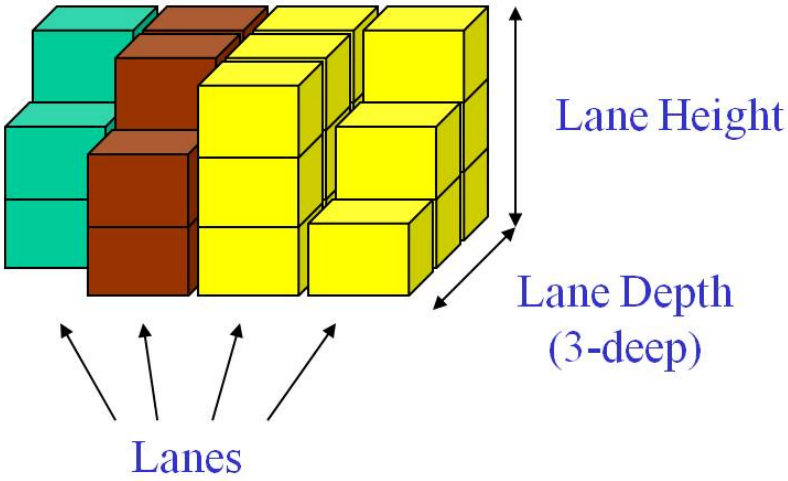
Other pallets

Other Industrial Package

Storage & retrieval equipments

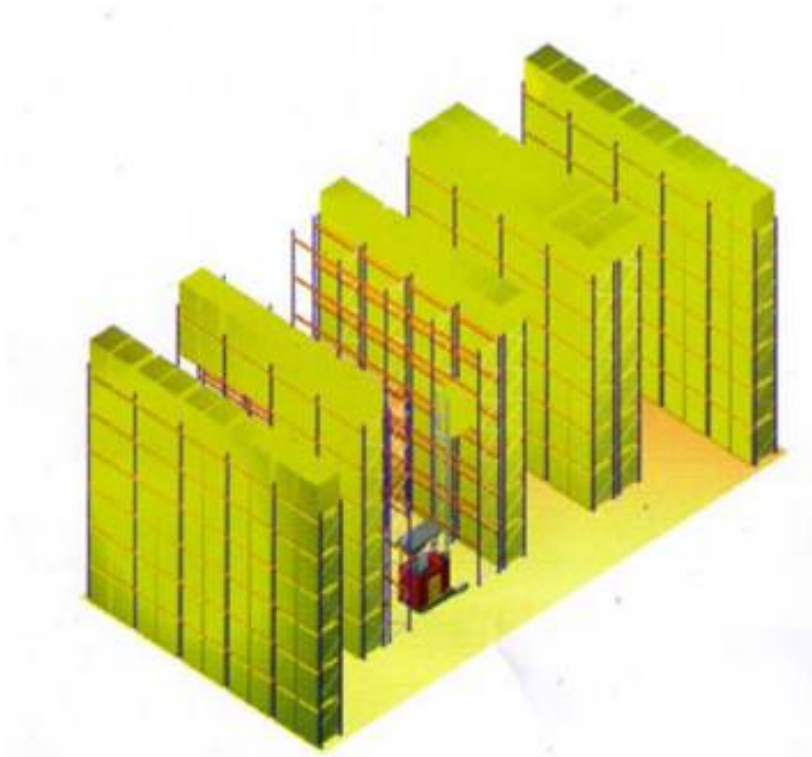
- **Idea:** cubic space saving & efficient retrieving
- **Where:** storage & picking area
- **Issue:** standardization, FIFO, safety, ergonomic
- **Example:** floor stack, selective rack (single deep & double deep), carrousel

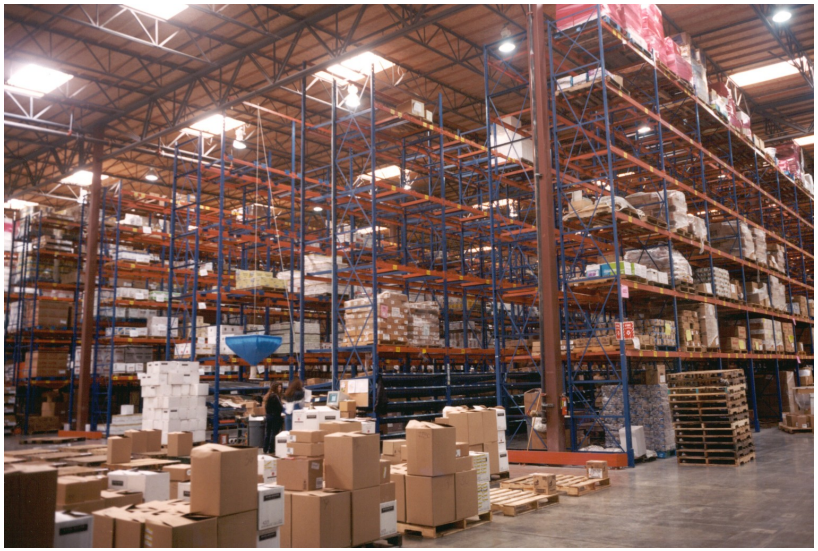
Floor stack: No equipment



- **Idea:** stack pallets up-height
- **Pro:** zero investment, multiple pallets per SKU, high inventory over
- **Con:** honeycombing problem, stability
- **Issue:** stack-ability, stack height, aisle width

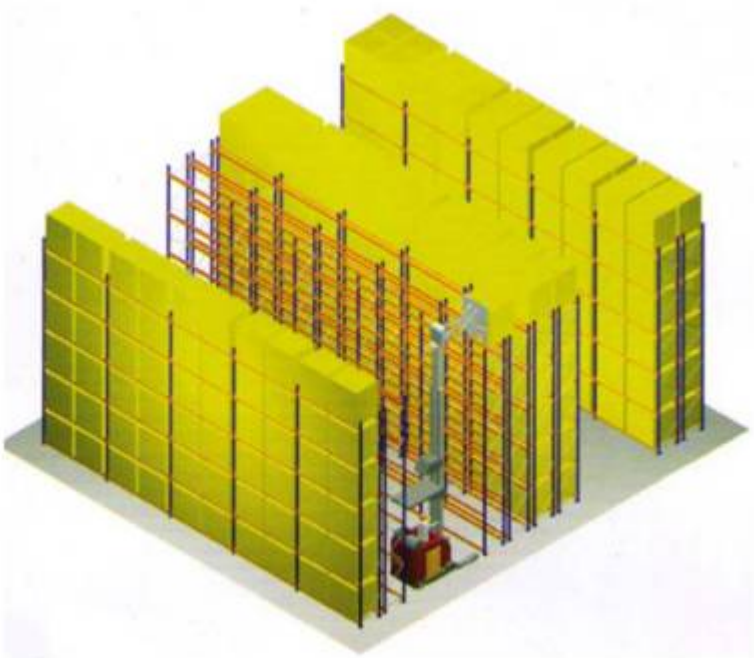
Single-deep rack





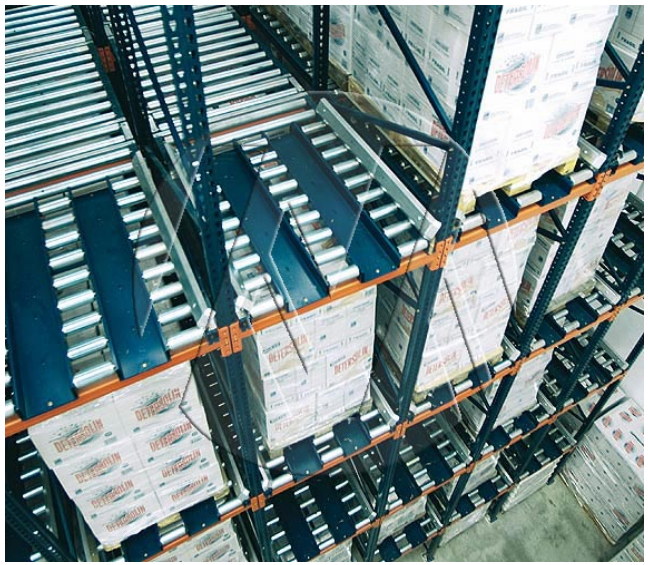
- **Idea:** a pallet rack that has a **single** storage space
- **Pro:** each pallet is independently accessible
- **Con:** too many aisles $\rightarrow$ inefficient space utilization

Double-deep rack



- **Idea:** a pallet rack that has a **double** storage space
- **Important:** Each lane dedicated to one SKU (one pallet or two pallets)
- **Pro:** Less aisle space required (upto 50% savings in aisle space)
- **Con:** More work and/or specialized equipment for retrieving

Pallet flow rack



- **Idea:** a pallet rack that **always** brings next pallet
- **Important:** separate picking & put-away
- **Pro:** high pick density, FIFO
- **Con:** space utilization, high cost

Gravity flow rack

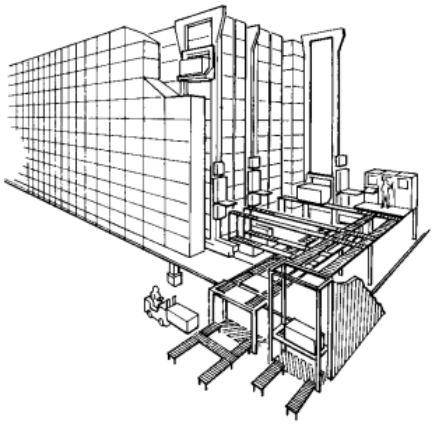
- **Idea:** a rack that **always** brings next case/carton (200+ picks/hr)
- **Pro:** high pick density, FIFO
- **Con:** space utilization, high cost

Bin shelve

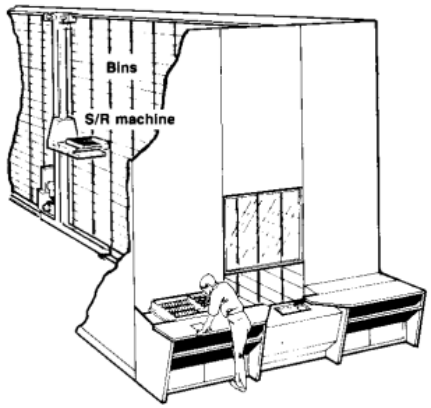
- **What:** storing cabinet for case/carton
- **Pro:** cheap,
- **Con:** single access, ID, low pick density, LIFO

Small storage item equipments

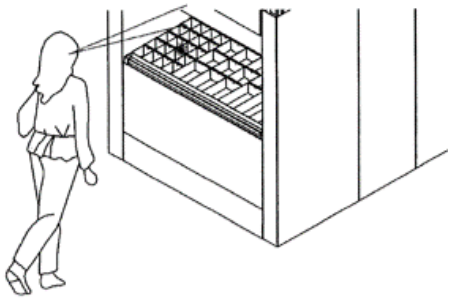
Other Automatic Storage Equipment



Unitload ASRS



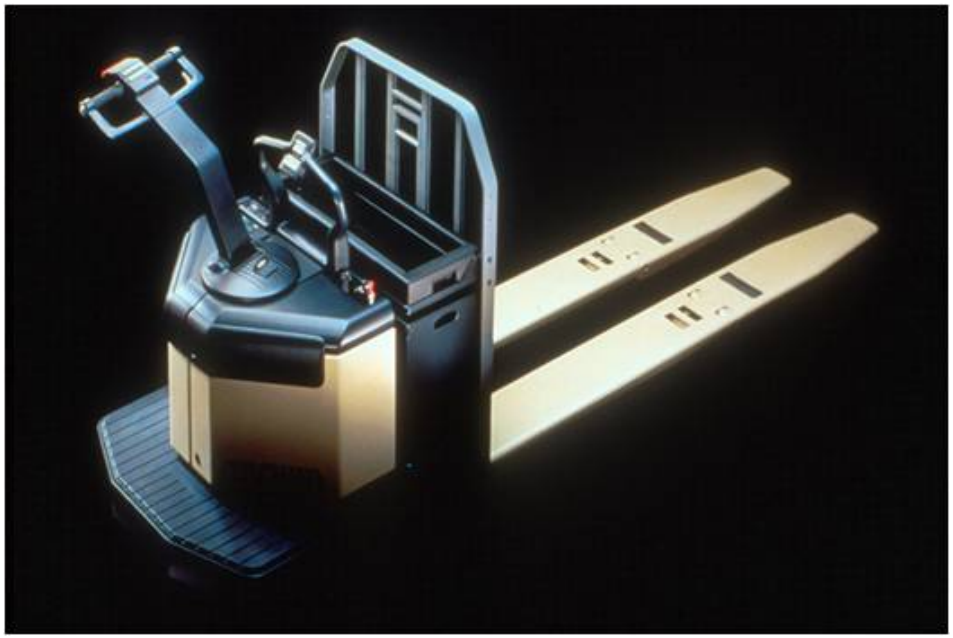
Miniload ASRS



Vertical Shutter

- **Idea:** combine put-away, picking, storing
- **Pro:** high hight, little labor
- **Con:** investment, may double handling

Material Handling Equipment



- **Idea:** moving items/SKUs
- **Where:** everywhere
- **Issue:** reach, automation, space footprint, congestion
- **Example:** hand truck, forklift, conveyor

Counter balance forklift truck

- **Idea:** unit-load mover equipped with motor & hydriodic
- **Pro:** very useful
- **Con:** wide turn $\rightarrow$ wide aisle

Manual Equipment

- **Idea:** manual equipment for moving pallet or tote (no driving cab)
- **Pro:** small, cheap
- **Con:** more manual, fixed height (i.e., not apply for reversible pallet)

Industrial Trucks

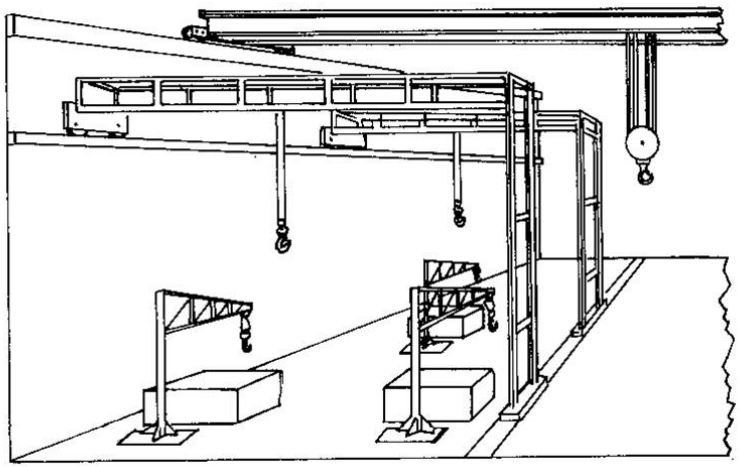
Swing Mast

Reach Truck

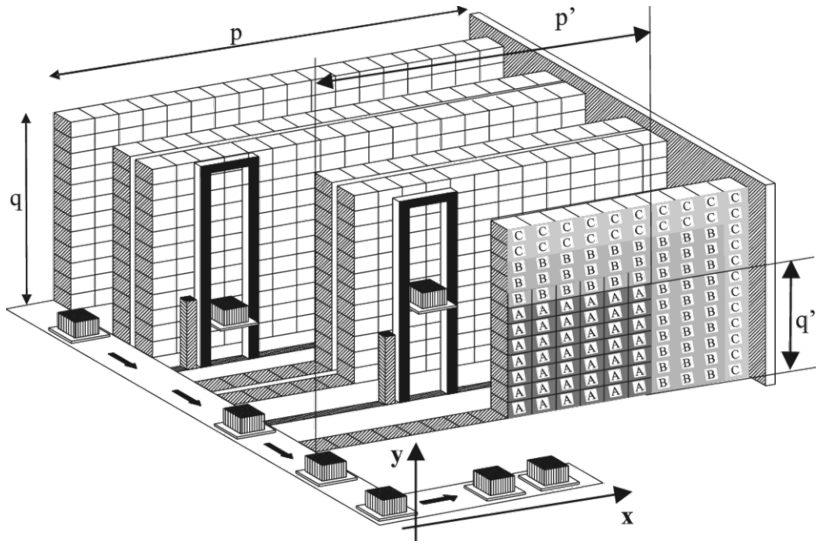
VNA truck

- **Idea:** moving pallet from A $\rightarrow$ B with power
- **Type:** turret, footprint, drivable, # pallets
- **Pro:** save time & labor
- **Con:** price, storage equipment

Crane



bridge crane



stacker crane in AS/RS

- **Idea:** moving items overhead
- **Pro:** flexible shape/size
- **Con:** restricted area, congestion with others

Others MHE: Rail

Tow Line

AGV

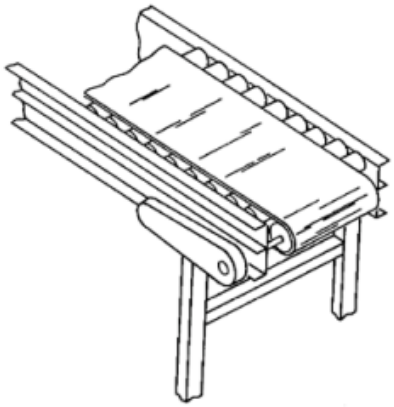
RGV

- **Idea:** moving items on fixed paths usually as loop
- **Pro:** eliminate worker
- **Con:** restricted area, investment

Conveyor

- **What:** automatic moving 'regular' shape pallet
- **Pro:** free labor
- **Con:** large moving huge std. size, fixed paths

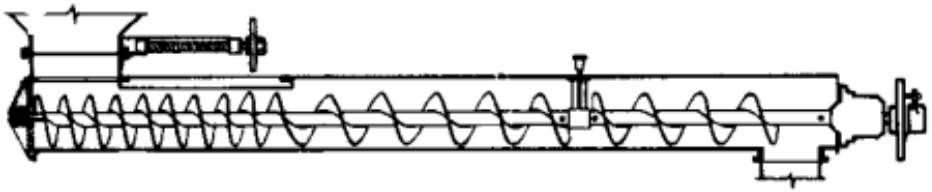
Variation of Conveyors



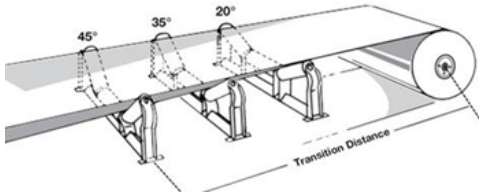
belt

chain

gravity



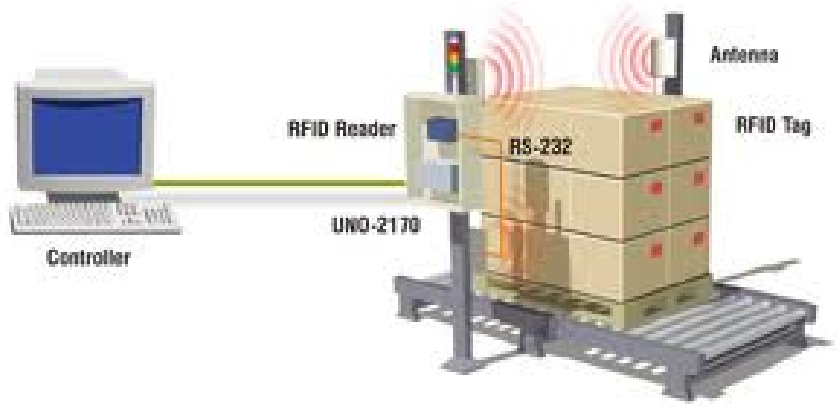
screw



troughted

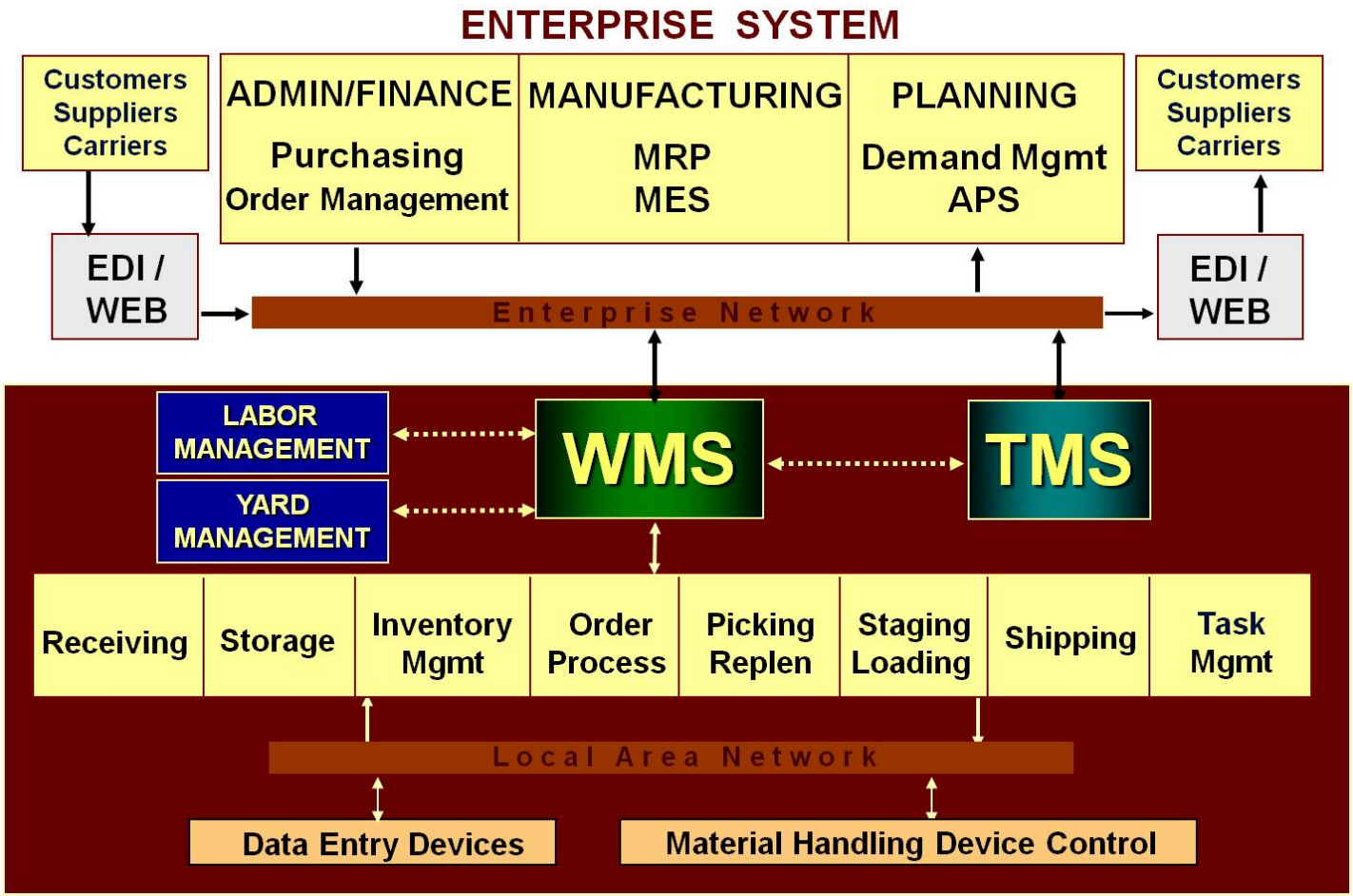
- **Selection:** materials, slope, price, weight

Identification equipment



- **Idea:** speeding receiving & shipping
- **Where:** receiving & shipping
- **Issue:** integration with system
- **Example:** RFID, bar code reader, magnet

ERP/WMS/TMS



source: Brett Peters. "Collect-Industry Council on Material Handling Education"

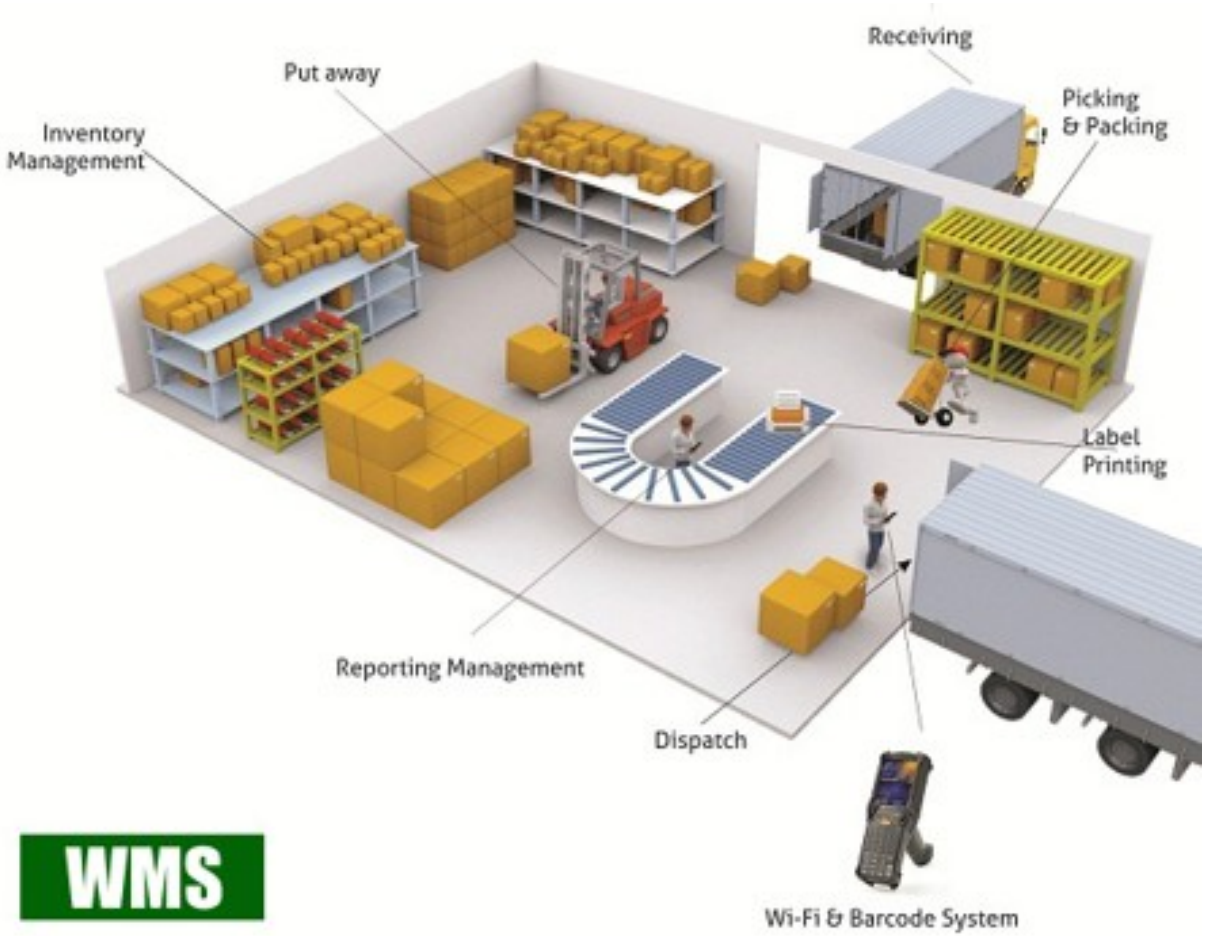
What is ERP?

- **Stand for:** Enterprise Resources Planning
- **Information System:** IT/IS for transaction in company
- **Integration:** collect, analyze, & report all activities
- **Important:** backbone of business
- **Industry:** complex, retail, education
- **Standard Function:** order mgt, sale, demand/material planning, HR,finance
- **Advance Function:** inventory control, report, document control

What is WMS?

- **Stand for:** Warehouse Management System
- **Information System:** IT/IS for operational in warehouse
- **Integration:** collect, analyze, & report all activities
- **Important:** strategic decision to modernize WH
- **Industry:** high transaction, require tracking, computerize MHE
- **Standard Function:** search & track SKU, batch processing, individual report
- **Advance Function:** cycle count, profiling, RF, data transfer, WCS

WMS Workflow



source: ten Hompel & Schmidt. "Structure of a WMS from the Example of myWMS" [**?**]

Useful information

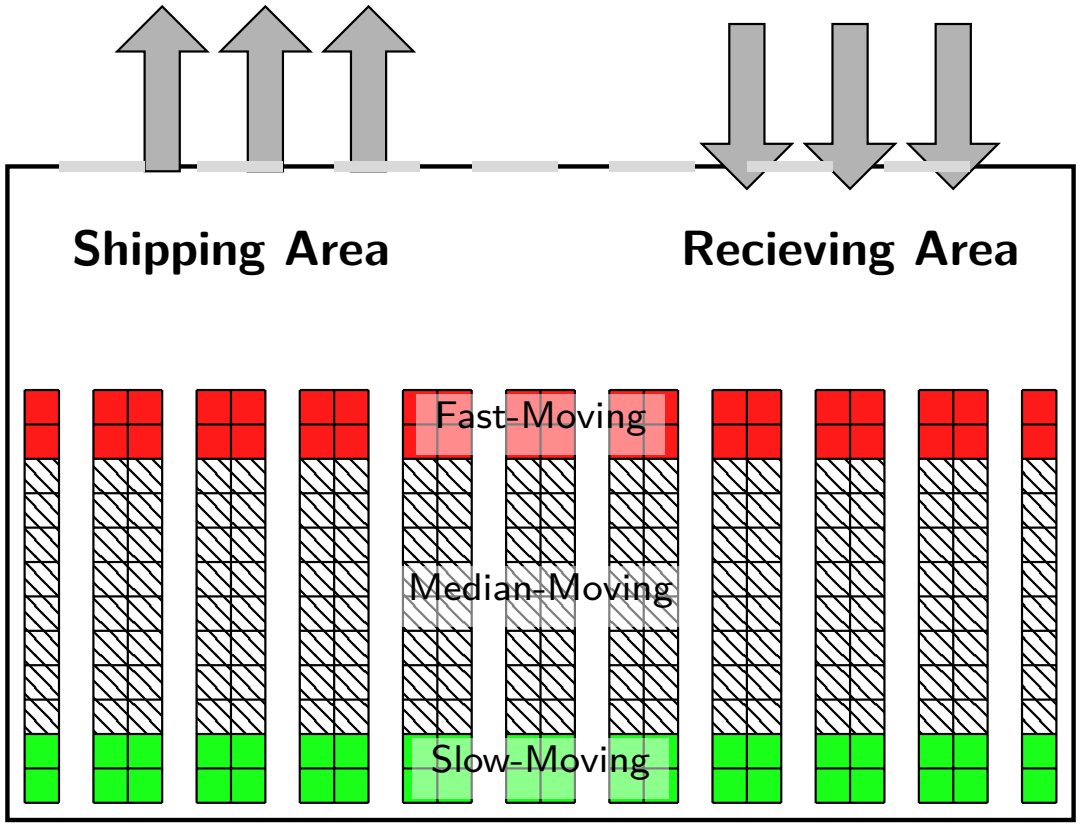
Material Handling

- **Material Handling Taxonomy:** http://www.mhia.org/industrygroups/cicmhe/resources/mhe_tax.htm
- **Material Handling Pictures:** https://www.cirrelt.ca/mhmultimediabank/

Warehouse Tours

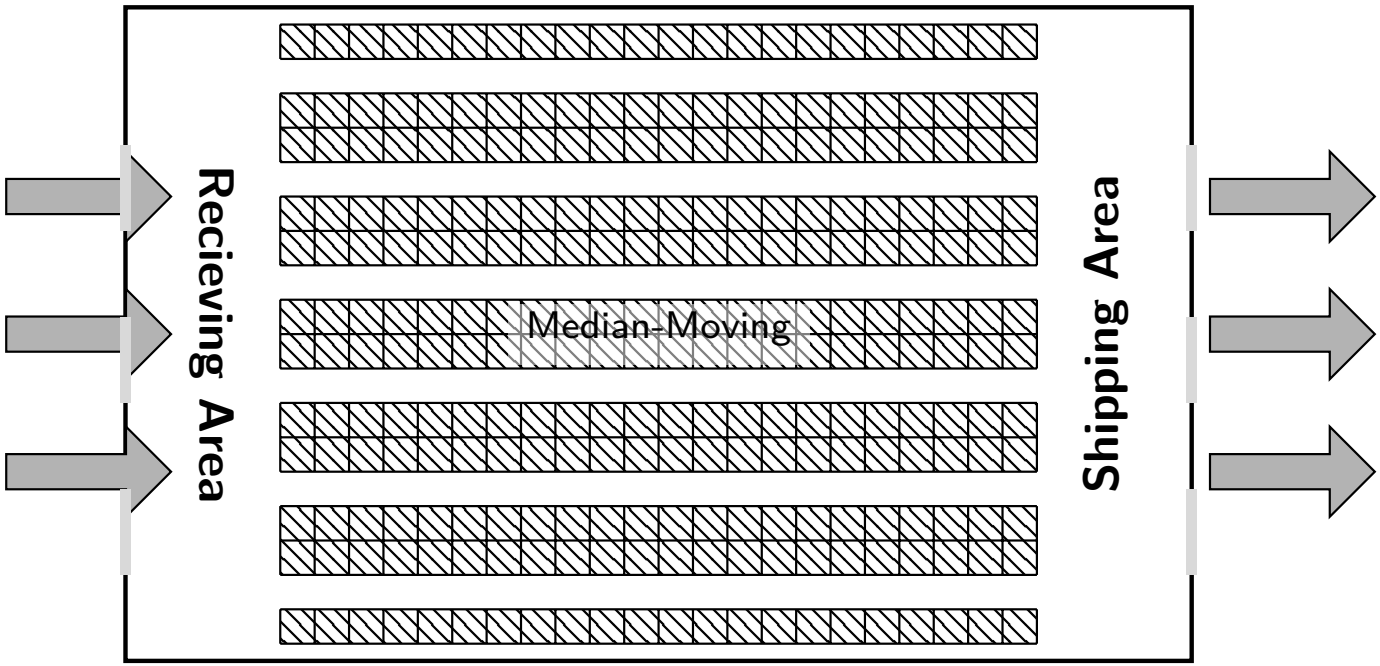
- **Interactive Tour:** http://www.roodbergen.com/warehouse/
- **Warehouse Science:** http://www2.isye.gatech.edu/~jjb/wh/sites/sites.html

U-Shaped Layout



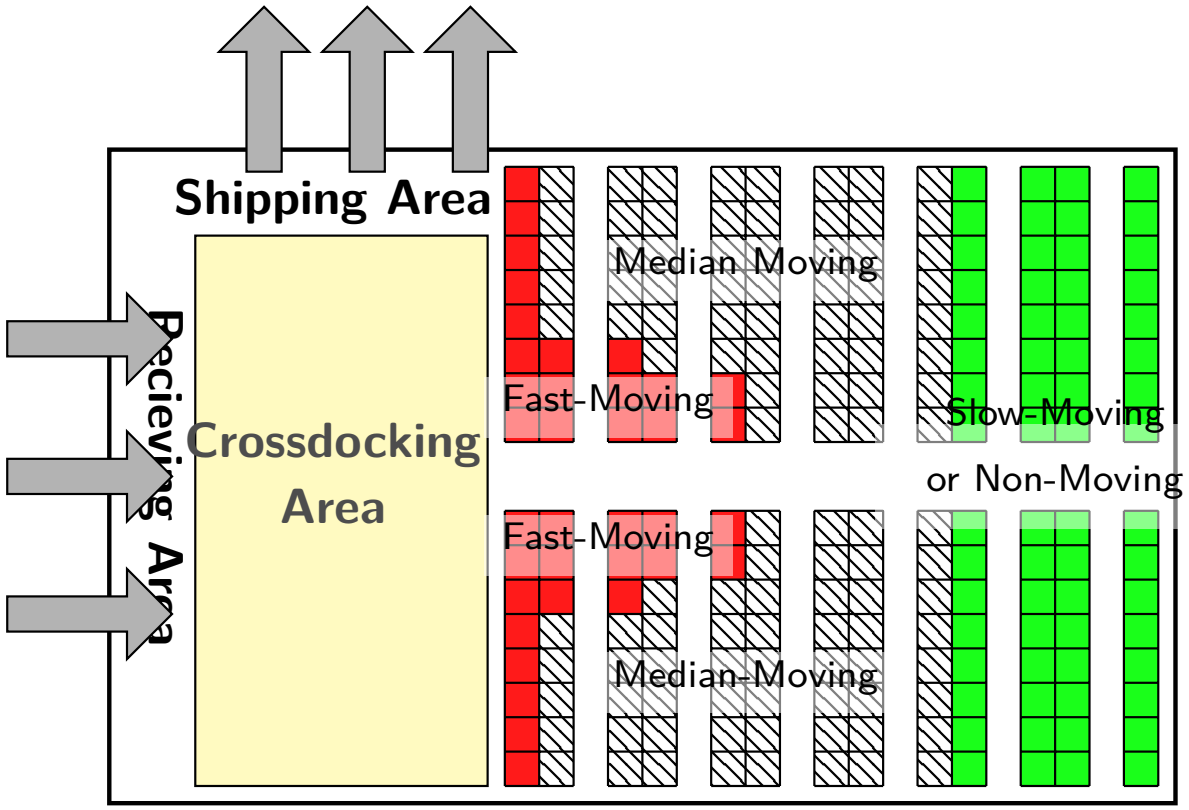
- **Idea:** single I/O point, very convenient locations
- **Where:** distribution network
- **Issue:** congestion near receiving & shipping

I-Shaped Layout



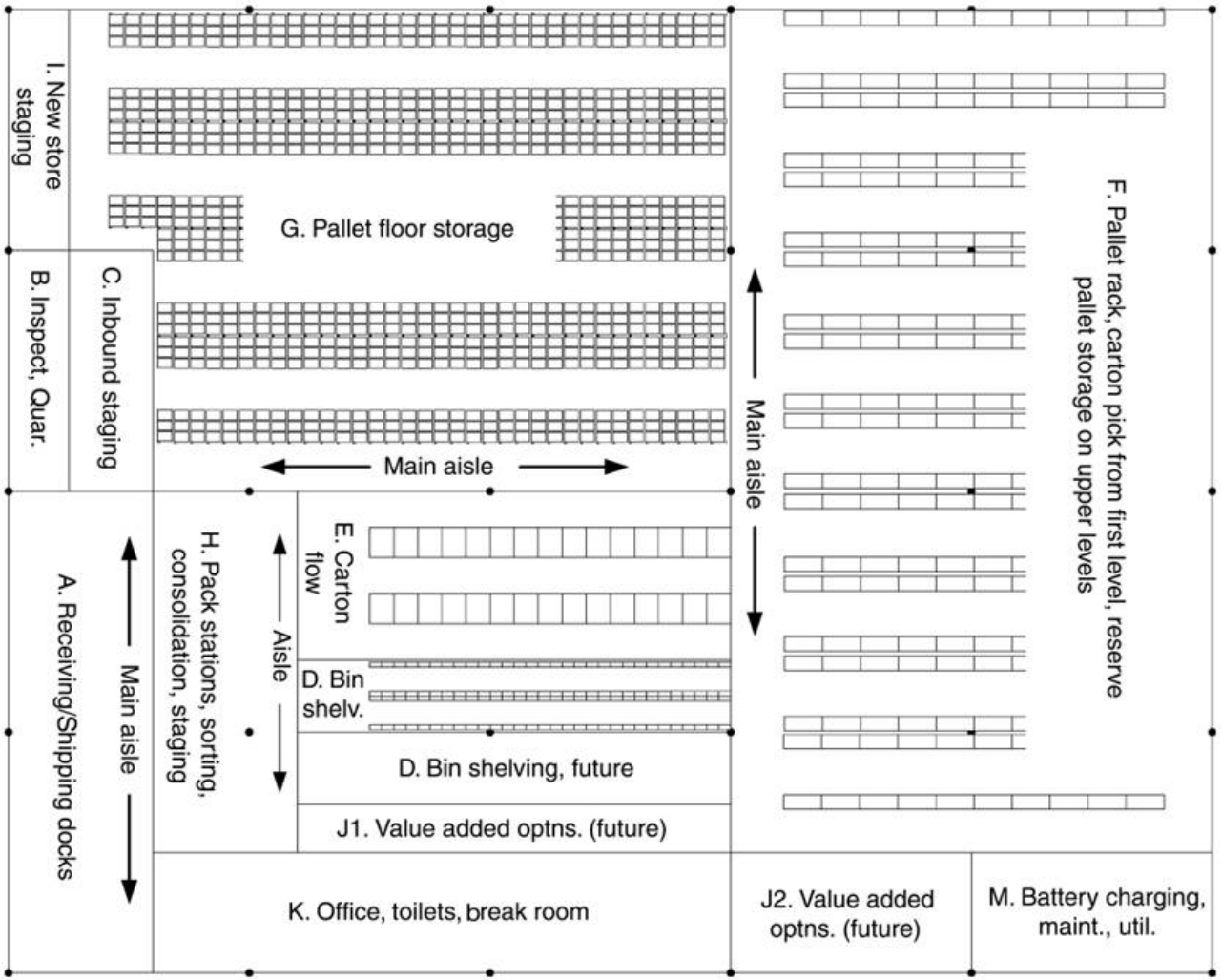
- **Idea:** two I/O point, many convenient locations
- **Where:** manufacturing warehouse
- **Issue:** traveling distance, # of admin, & combine works

Custom Layout



- **Idea:** mixed crossdock with storage
- **Where:** ≪depends≫
- **Issue:** ≪depends≫

Real layout



- What do you observe in this layout?

Exercise I: Defining fast moving pallet

Description	SKU A	SKU B
Dimension (L × W × H)	50 × 40 × 30	50 × 40 × 30
Price (dollar/pallet)	20	20
Annual Sale (pallet/year)	48	48
Quantity Per Order (pallet/month)	4	4
Space in Warehouse (pallet)	4	4
Demand	1 pallet/week	4 pallet/month

Which SKU should put in a connivent location? & **why**

Exercise II: Defining fast moving case

Description	SKU A	SKU B
Dimension (L $\times$ W $\times$ H)	10 $\times$ 4 $\times$ 4	10 $\times$ 4 $\times$ 4
Price (dollar/case)	20	20
Annual sale (case/year)	480	480
Quantity per order (case/month)	40	40
Space in warehouse (case)	40	40
Space in warehouse (pallet)	1	1
Demand	10 cases/week	20 case/biweekly

Which SKU should put in a connivent location? & why

Warehouse Tours

- **Goals:** sharing experiences & problems, connecting to industry
- **Organization:** looking pro-con, brainstorm, discussion
- **Observe:**
  - What are units handle in each warehouse?
  - What are equipments in each warehouse? (Is it make sense?)
  - What are the problems/issues in each warehouse?
- **Next steps:** Field trips, Project

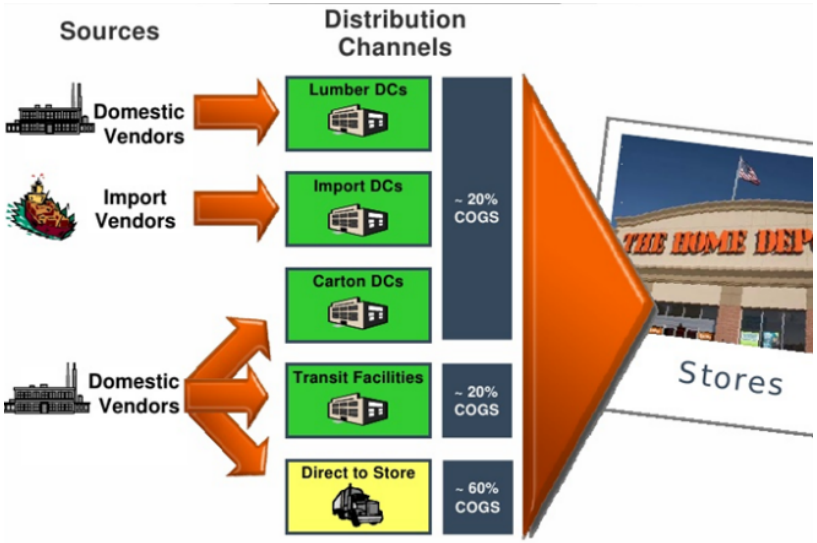
Warehouse Intuition: Ace DC

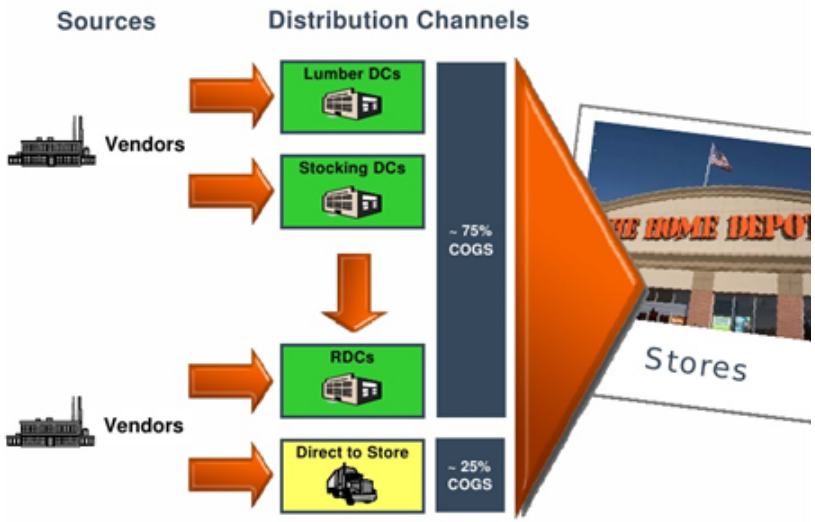
source: Tours of warehouses, distribution centers, crossdocks. http://www2.isye.gatech.edu/jjb/wh/sites/sites.html

Warehouse Intuition: Pepsi, Atlanta

source: Tours of warehouses, distribution centers, crossdocks. http://www2.isye.gatech.edu/~jjb/wh/sites/sites.html

Warehouse Intuition: THD





Warehouse Intuition: Boon Tha Vorn

What is KPI?

- **What:** a way to measure performance of organization/activity
- **Important:**
  - indicate success of each activity
  - evaluate main objectives
  - measure progress of implementation (historical comparison)
  - measure productivity & efficiency
- **Issues:** data collection, measurement, consistency

Type of KPI?

- **Financial related KPI:** % warehousing cost per total cost, cost per shipped SKU
- **Non-Financial related KPI:**

Example of Non-Financial KPI

- **Service Customer View:** response time (order cycle time), shipment accuracy (correct qty/total qty), fill rate (qty shipped/ordered qty)
- **Service Warehouse View:** dock-to-stock time, inventory accuracy, % cross-docking order
- **Productivity:** lines per man-hour, cases per person-hour, cubic space utilization, equipment up-time
- **Situation:** lines shipped per SKU, inventory turnover, investment pick accuracy, % of new SKUs, % active SKUs, labor turnover, lines per order, total lines shipped per day

Adopted from Hackman, S. 1982.

Rating of Selected KPIs

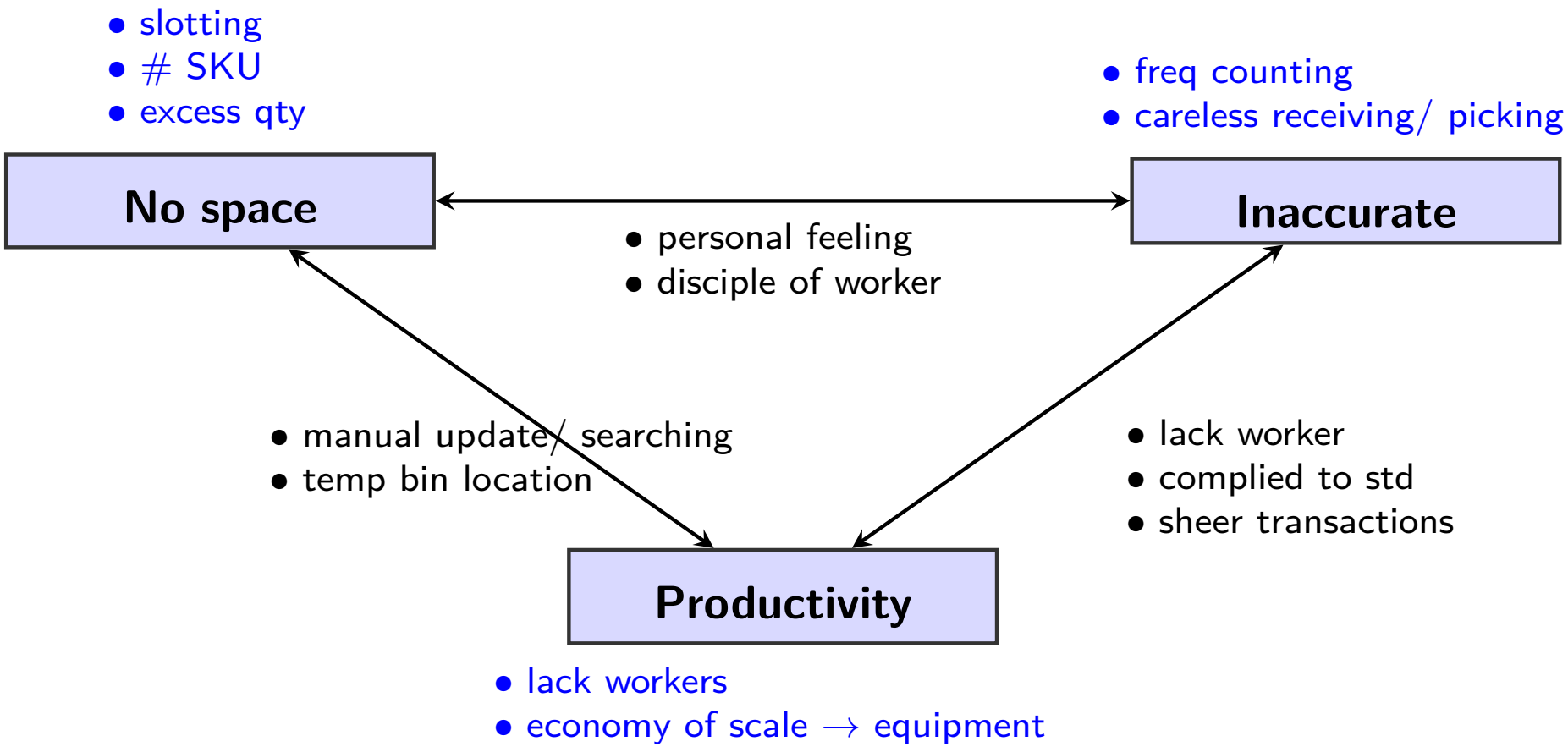
KPI/Rating	Poor	Sub-Par	Par	Superior	Outstanding
responding time (hrs)	>48	24-48	12-24	4-12	<4
dock-to-store time (hrs)	>48	24-48	8-24	2-8	<2
lines per man-hour	<5	5-10	10-20	20-50	>50
cases per man-hour	8-25	25-50	50-100	100-250	>250
cubic utilization (%)	<65	65-75	75-85	85-95	0.95
annual lines per SKU	<50	50-100	100-250	250-400	>400
inventory accuracy (% qty)	>5.0	1.0-5.0	0.5-1.0	0.05-0.5	<0.05
inventory turn	<1.0	1.0-3.0	3.0-6.0	6.0-10.0	>12.0

source Hackman, S. *et al.* 2001 [HFG+01, **?**].

Nature of warehouse

- Warehouse is labor intensive
- Warehouse is, in general, the last frontier in Supply Chain before start collaborate
- Investment in warehouse depends on values of SKUs in warehouse
- Broken pallets/cases tend to be damaged & lost
- Flows of material in a warehouse is rarely balance at particular time
- Works & effort warehousing activities are unbalance
  - Put-Away $\leq$ Pick-Up
  - Receiving $\leq$ Shipping

Typical issues in warehouse



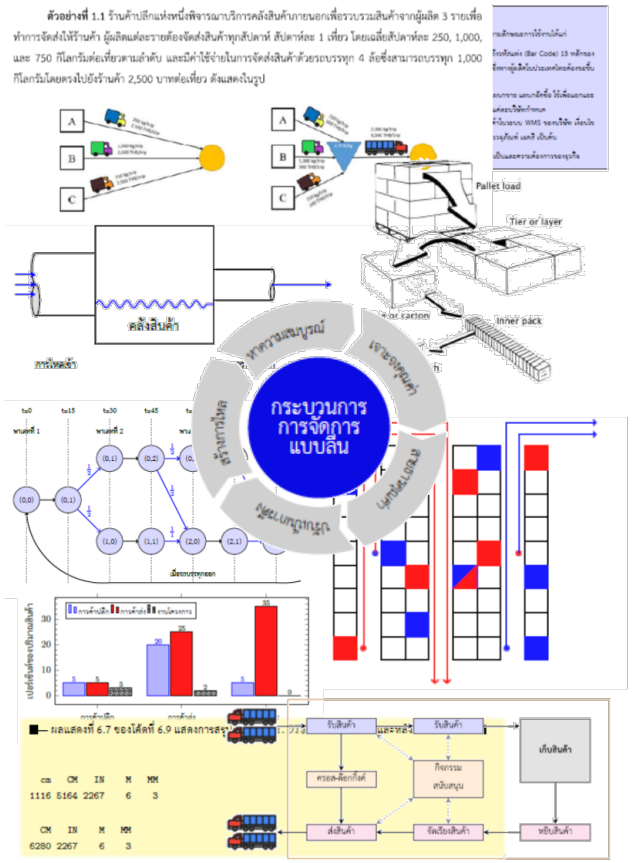
- **Other:** fire, safety, quality, use of data

Summary: Warehouse $\in$ Supply Chain

- **Warehouse** $\neq$ storage room because balance flows, system, policy, equipments, *etc*
- **Warehousing management:** maximizing usage of warehouse 'resources' at 'right' service level
- **Warehousing activities:** focus on main activities, minimize non-value activities
- **Equipments:** easy to handling/ storage/ track;
- **Layouts:** put a fast moving items in convenient locations

F.A.S.T = Flow/ Accessibility/ Space/ Throughput

WH WHS MGT Textbook



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