Material Handling

Movement, storage, protection & control of material throughout the manufacturing & distribution process including their consumption & disposal

Material handling needs to be:

- **Safe**
- **Efficient**
- **Low cost**
- **On time**
- **Accurate**

Material handling Equipment

- **Transport equipment**
- **Storage systems**
- **Unitizing equipment**
- **Identification & tracking System**

Material Handling

Transport

- **Industrial truck**

Hand Truck

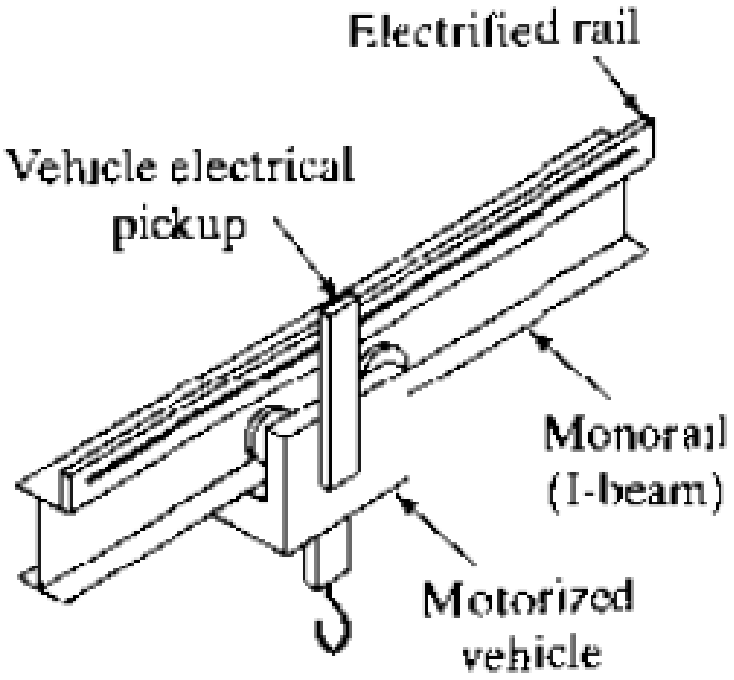
MATERIAL HANDLING

Transport

- AGV

- Monorails

Monorail


Electrified rail
Vehicle electrical pickup
Monorail (I-beam)
Motorized vehicle

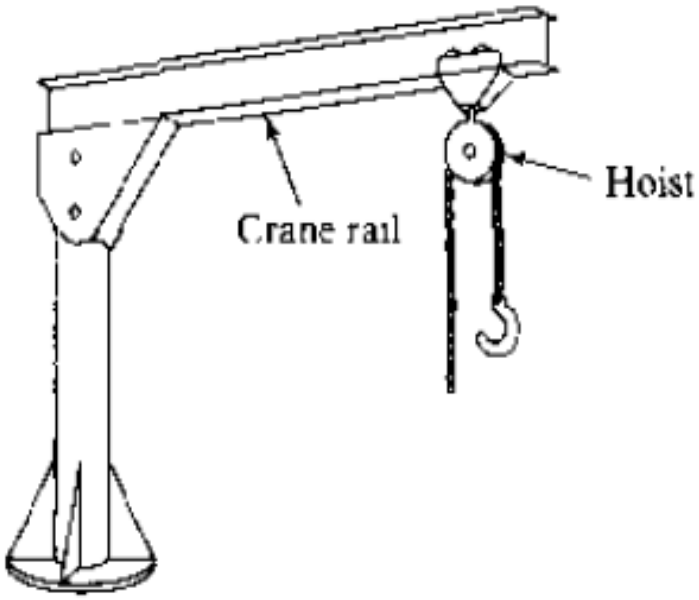
Material Handling

Transport

- **Conveyors (belt/roller)**

- **Crane**

Crane and Hoist



Material Handling

Storage systems

- **Bulk (on floor)**

- **Rack (Structural frames)**

Material Handling

Storage

- **Shelving and bins**

- **AS/RS**

AS/RS

Material Handling

Unitizing

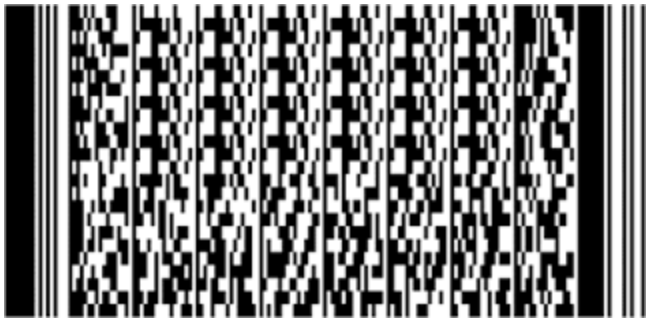
- **Pallet**

- **Palletizer**

Material Handling

Identification and Tracking

- **Bar Code**



Material Handling

Design Consideration

- Material characteristics
- Flow Rate/Routing/Scheduling
- Plant Layout

- Material characteristics

  - Physical state solid/liquid
  - Size
  - Weight
  - Shape – square, round
  - Condition – hot, cold, sticky
  - Risk of damage – fragile
  - Safety risk – explosive, flammable, toxic

Material Handling

Design Consideration

Flow Rate/Routing/Scheduling

Flow Rate

- **Large quantity – dedicated handling system**
- **Small quantity, different types – need to share**

Routing

- **Distance – pickup & drop off locations**
- **Different flow patterns**

Scheduling

- **Timing of each individual delivery**
- **Maintain performance & efficiency**
- **Must be responsive for timely pick-up & delivery**

Material Handling

Design Consideration

Plant Layout

Product

- *Identical parts with high quantity*
- *Fixed route, mechanized, large flow rates*
- *Conveyor, trucks to deliver*

Process

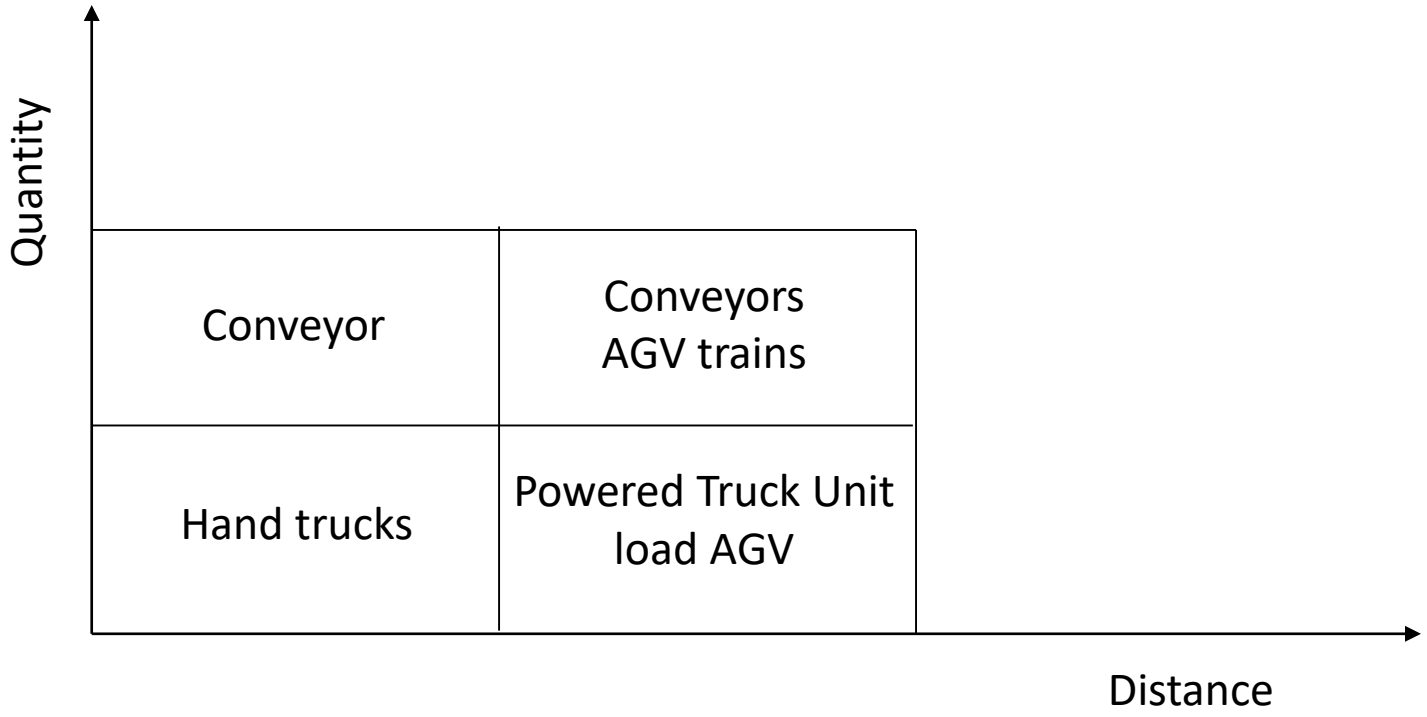
- *Flexible to deal with variation*
- *Hand trucks, Fork lift trucks to move WIPs*
- *Recently AGV*

Fixed Position

- *Large object*
- *Cranes, powered trucks*

Material Handling

Design Consideration



Material Handling

Automated Guided Vehicle

Battery powered driverless vehicles with programming capabilities for destination, path, selection & positioning

- **Can move in complicated & changing paths**
- **Handle wide variety of material & loads**
- **Provide high degree of flexibility**
- **Can perform loading/unloading operations**
- **Interaction with machines**
- **Communicate with factory computer control system**

Material Handling

Automated Guided Vehicle

Components

- Vehicle
- Guided Path
- Control Unit
- Computer Interface

Material Handling

Automated Guided Vehicle

Types of AGV

AGV Towing Vehicle

AGV Unit Load Carrier

Material Handling

Automated Guided Vehicle

Types of AGV

AGV Pallet Truck

AGV Fork Truck

Material Handling

Automated Guided Vehicle

Types of AGV

AGV Light Load Transporter

AGV Assembly Line Vehicle

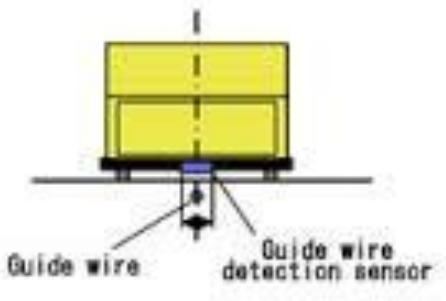
Material Handling

Automated Guided Vehicle

Guidance Technique

Wire Guided

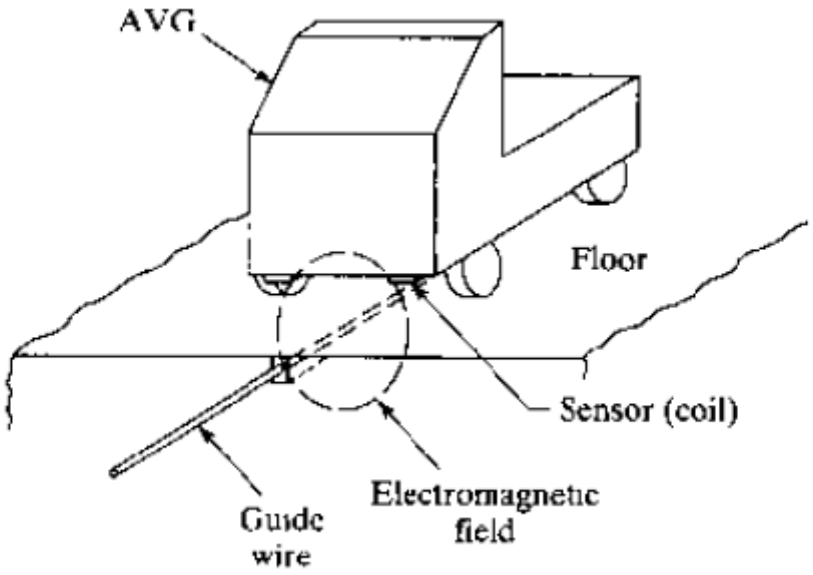
- Electric line below floor
- High frequency AC current
- At junction point, different frequency measured by programmed sensors
- Sensor pickup electro-magnetic signal



Disadvantage:

- *Wire can not be changed easily*

Guided Path of AGV



Material Handling

Automated Guided Vehicle

Guidance Technique

Line Guided

- **Fluorescents paint**
- **Use optical sensor (photo sensor)**
- **UV light source reflection**

Disadvantage:

- ***Paint deteriorated, Need to maintain, repaint***

Material Handlinǥ

Automated Guided Vehicle

Guidance Technique

Self Guided / Free Ranging

Paths are software programmable & therefore are easily alterable

- **Combination of dead reckoning & beacons located throughout the plant**
- **Identified by on-board sensors**

Advantage:

- ***Flexibility – software based***
- ***Can be extended or changed without major alteration to facility***

Material Handling

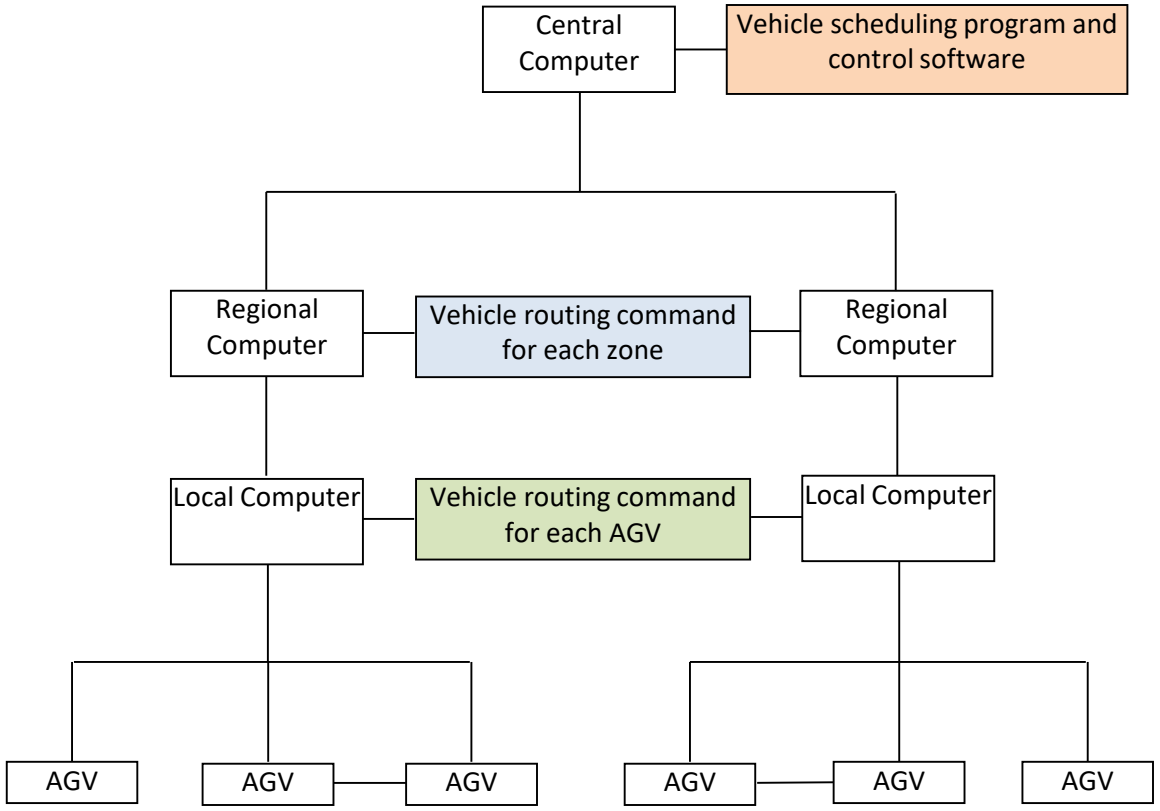
Automated Guided Vehicle

Basic Functions

- **Guidance – Ability to follow pre-determined route**
- **Routing – Selection of optimum route to specific destination**
- **Traffic Management – Ability to avoid collision & maximizing vehicle flow**
- **Load transfer – Pick-up / Delivery**
- **System management – Method of system control used to dictate system operation**

Material Handling

AGV Management System



Material Handling

Total number of vehicles required in a system

L_d ***– total loaded travel distance (m)***

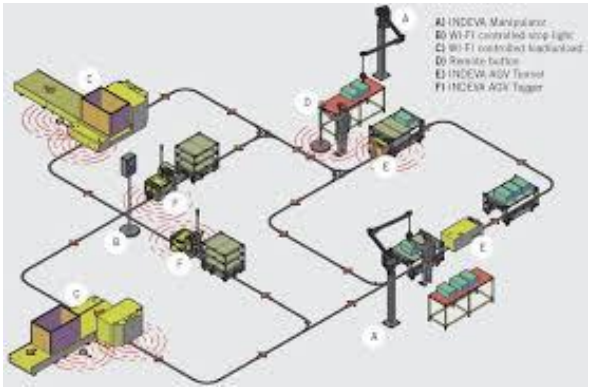
L_e ***– total empty travel distance (m)***

T_h ***– handling time = Loading + Unloading time (min)***

F_t ***– traffic factor***

- **blocking & waiting of vehicles in line & at intersections**
- **if only one vehicles – value is 1.0**
- **Normally 0.85 ~ 1.0**

V_c ***– AGV velocity (m/min)***



Material Handling

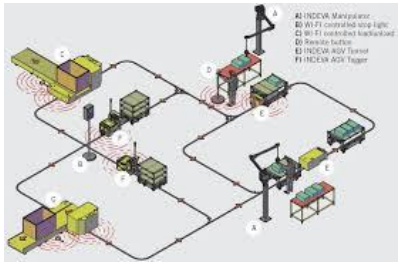
Total number of vehicles required in a system

Total time / delivery / vehicle

$$T_v = \frac{L_d}{V_c} + \frac{L_e}{V_c} + T_h$$

Number of Deliveries / vehicle / hr $= 60 \dfrac{F_t}{T_v}$

Number of vehicles = $\dfrac{\textbf{Required Number of Deliveries / hr } (R_f)}{\textbf{Number of Deliveries / vehicle / hr (Rdv)}}$



Material Handling

Number of Deliveries / vehicle / hr or rate of deliveries per vehicle $\boldsymbol{R_{dv}}$ $= 60\frac{F_t}{T_v} * A * E = \frac{AT}{Tv}$

A= Availability

E= worker efficiency

AT=Available time per hour per vehicle

total workload required and then dividing by the available time per vehicle. Workload is defined as the total amount of work, expressed in terms of time, that must be accomplished by the material transport system in 1 hr. This can be expressed as follows:

$$WL = R_f T_c \tag{10.4}$$

where WL = workload (min/hr), R_f = specified flow rate of total deliveries per hour for the system (del/hr), and T_c = delivery cycle time (min/del). Now the number of vehicles required to accomplish this workload can be written as

$$n_c = \frac{WL}{AT} \tag{10.5}$$

where n_c = number of carriers required, WL = workload (min/hr), and AT = available time per vehicle (min/hr per vehicle). It can be shown that Eq. (10.5) reduces to the following:

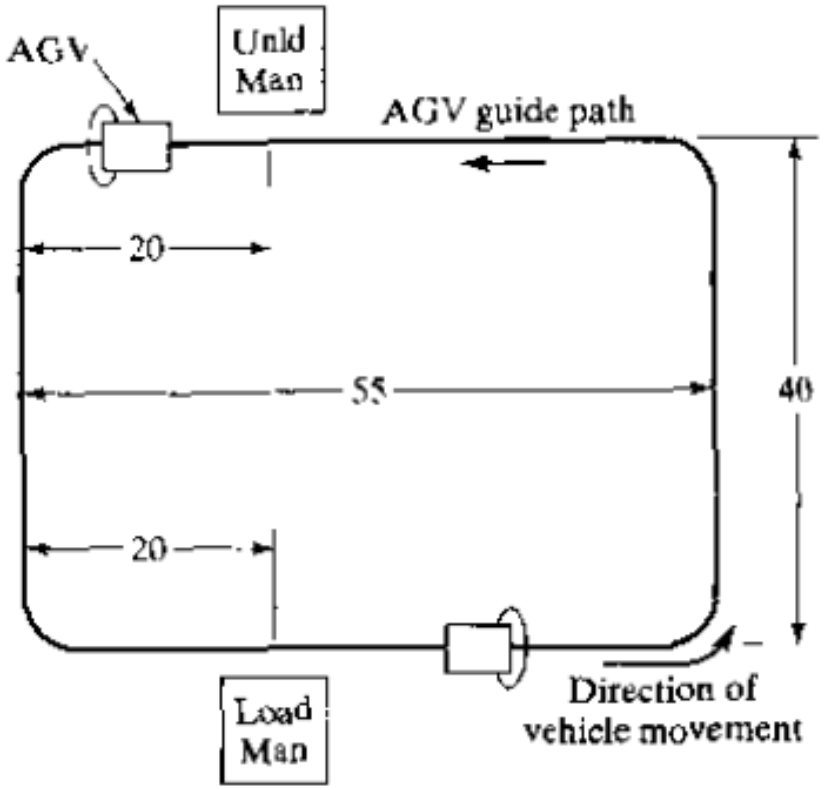
$$n_c = \frac{R_f}{R_{dv}} \tag{10.6}$$

where n_c = number of carriers required, R_f = total delivery requirements in the system (del/hr), and R_{dv} = delivery rate per vehicle (del/hr per vehicle). Although the traffic factor accounts for delays experienced by the vehicles, it does not include delays encountered

Problem 1

Given the AGVS layout shown in Figure 10.15. Vehicles travel counterclockwise around the loop to deliver loads from the load station to the unload station. Loading time at the load station = 0.75 min, and unloading time at the unload station = 0.50 min. It is desired to determine how many vehicles are required to satisfy demand for this layout if a total of 40 del/hr must be completed by the AGVS. The following performance parameters are given: vehicle velocity = 50 m/min, availability = 0.95, traffic factor = 0.90, and operator efficiency does not apply, so E = 1.0. Determine: (a) travel distances loaded and empty, (b) ideal delivery cycle time, and (c) number of vehicles required to satisfy the delivery demand.

Problem 1

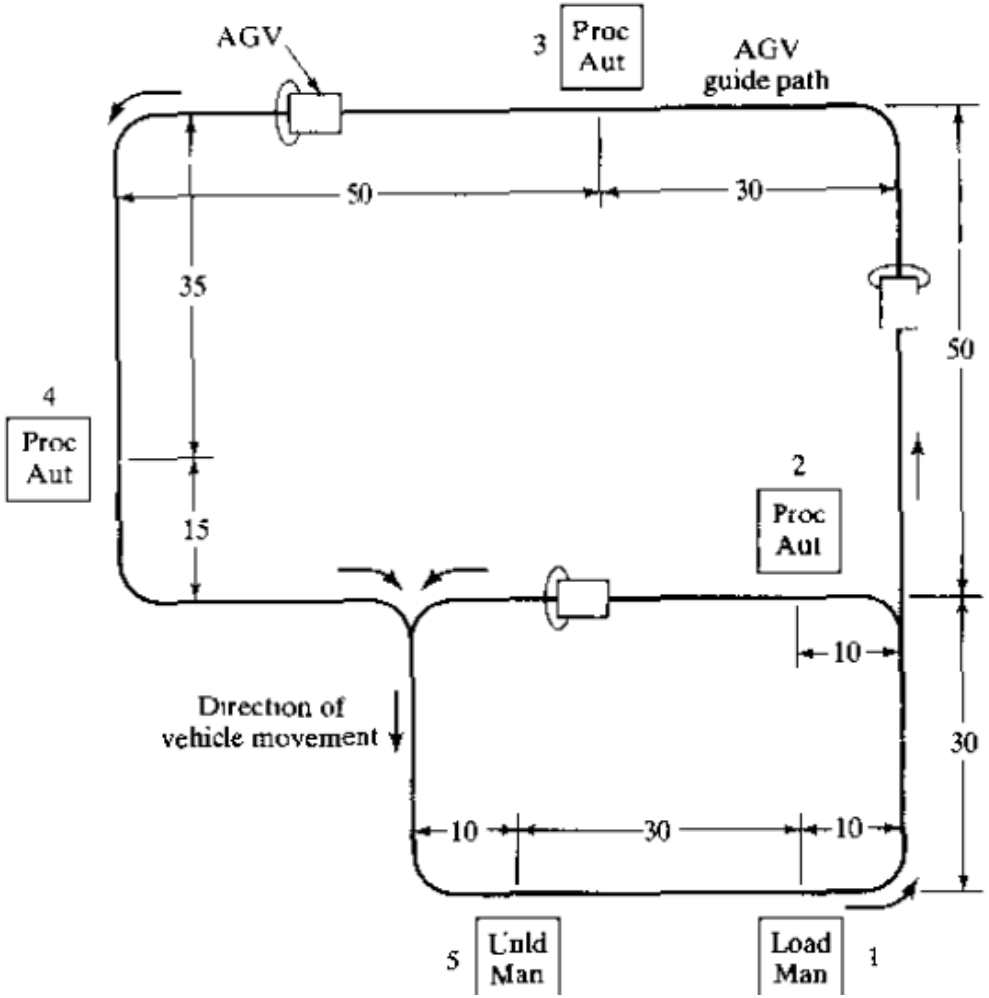

AGV
Unld Man
AGV guide path
20
55
40
20
Load Man
Direction of vehicle movement

Problem 2

TABLE 10.2 From-To Chart Showing Flow Rates, loads/hr (Value Before the Slash Mark) and Travel Distances, *m* (Value After the Slash Mark) Between Stations in a Layout

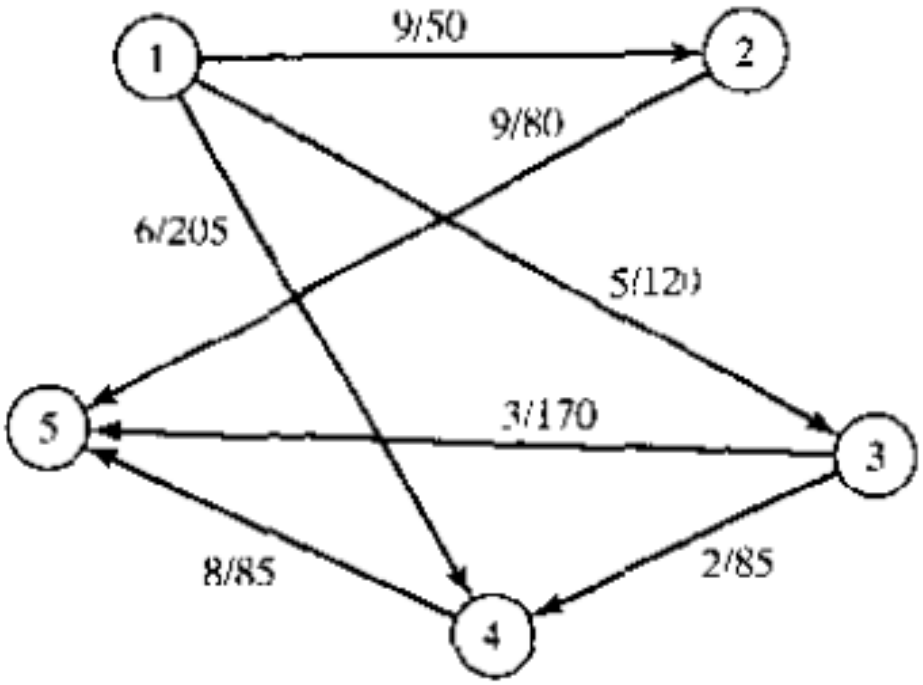
	To	*1*	*2*	*3*	*4*	*5*
From	1	0	9/50	5/120	6/205	0
	2	0	0	0	0	9/80
	3	0	0	0	2/85	3/170
	4	0	0	0	0	8/85
	5	0	0	0	0	0

Problem 2



- **Draw the flow and distance with the help of nodes.**
- **How can you minimize the empty travelled distance?**

Problem 2



Material Handling

Automated Storage and Retrieval (AS/RS) System

A combination of equipment & controls that handles stores & retrieves material with precision, accuracy and speed under a defined degree of automation

- **Consists of a series of storage aisles that are serviced by one or more S/R machines**
- **Aisles have storage racks**
- **S/R machines (cranes) are used to deliver & retrieve material to from racks**
- **Each aisle has one or more input/output stations**

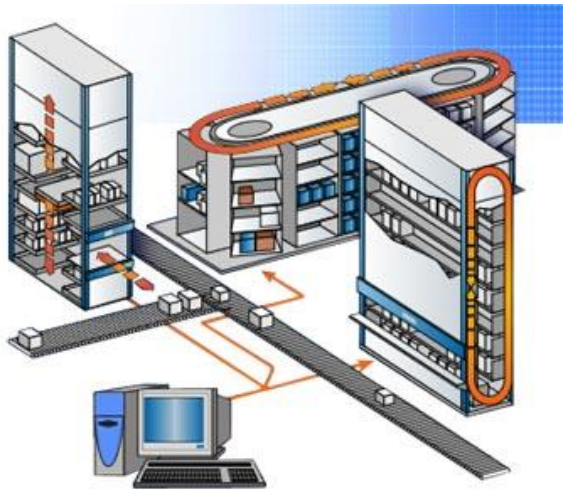
Material Handling

Automated Storage System

- **Reduces or eliminate amount of human intervention required to operate the System**
- **In less-automated System, human operator is required in each storage/retrieval transaction**
- **In highly automated system, loads are entered or retrieval under computer control, with no human participation**

Objectives

- Increased storage capacity – better floor utilization
- Improved security, reduced pilferage
- Reduced labor cost
- Improved safety & customer service
- Improved control over inventories
- Improved stock rotation
- Improved customer service
- Increased throughput

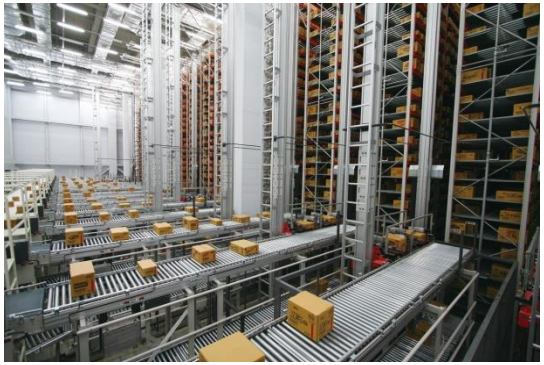


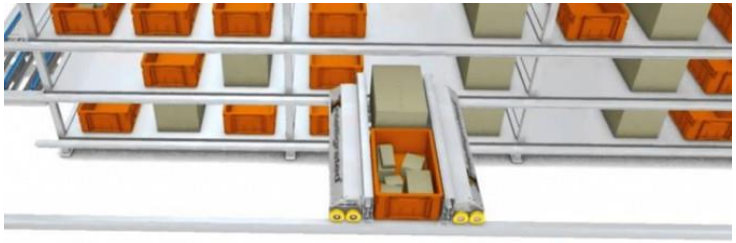
Material Handling

Automated Storage and Retrieval System

Types

- Unit load AS/RS – typically a large system designed to handle unit loads stored on pallets.
  - *Computer controlled*
  - *S/R machines are automated & designed to handle the unit load containers*
- Mini load AS/RS – for small loads contain in bins or drawers



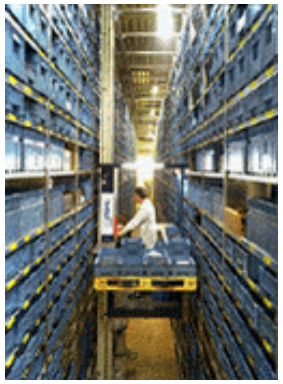


Material Handling

Automated Storage and Retrieval System

Types

- Man-on-board AS/RS – individual items to be picked directly at storage location
- Automated item retrieval system for individual item – stored in lanes rather than bins. Pushed from lanes & drop on conveyor
- Deep lane AS/RS – another variation of multi-load
  - *High density – upto 10 items per row instead of 1 or 2*
  - *Enter from one side – deliver other side*



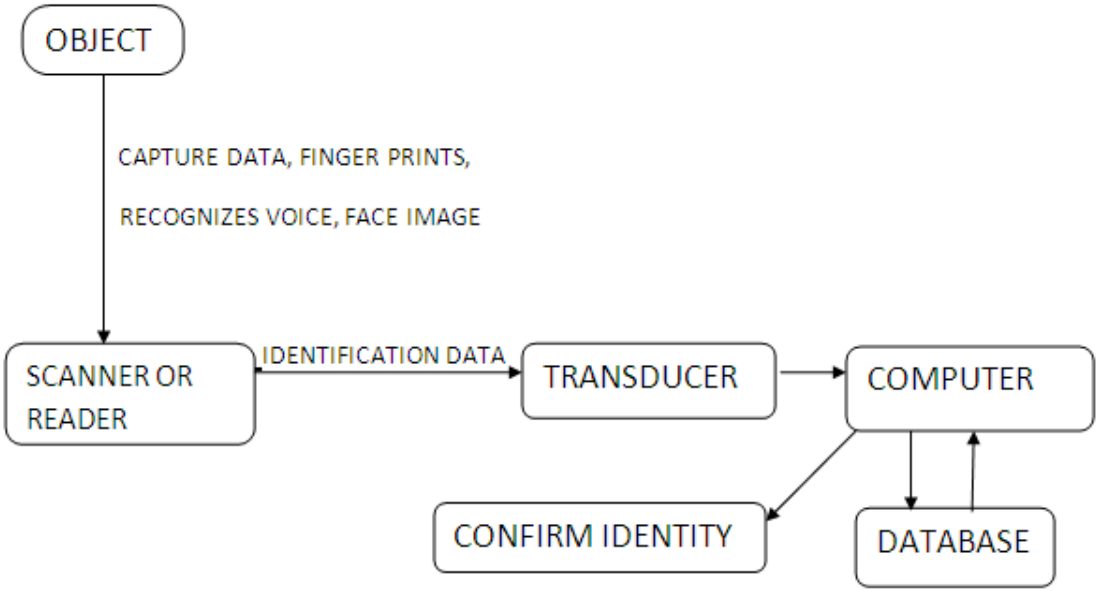
Material Handling

Automatic Data Capture

Refers to the technologies that provide direct entry of data into a computer or other microprocessor-controlled system without using a keyboard

Benefits

- Reduced error
- Reduced time
- Reduced man power
- Better control over inventories



Material Handling

Automatic Data Capture

Components

- **Encoded data – code is a set of symbols or signals representing alphanumeric characters**
  - **When data are encoded, the characters are translated into machine-readable code**
- **Machine reader/scanner – reads encoded data & converts to electrical signal**
- **Decoder – transforms electrical signal into digital data & finally back into original alphanumeric character**

Bar code is the leading ADC

Errors in ADC

- ***FRR – first read rate – probability of a successful (correct) reading by the scanner in its initial attempt***
- ***SER – substitution error rate – probability or frequency with which the scanner incorrectly reads the encoded character***

Material Handling

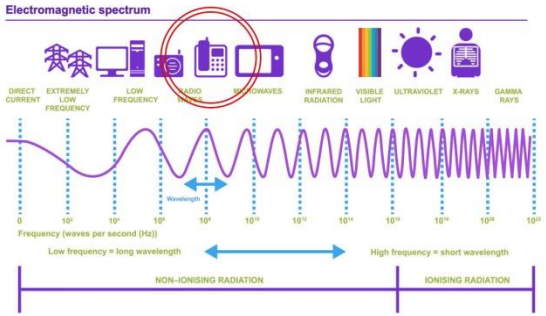
Automatic Data Capture

Categories

- **Optical – high contrast graphical symbol**
  1D&2D bar codes

- **Magnetic – recording tape – credit card**

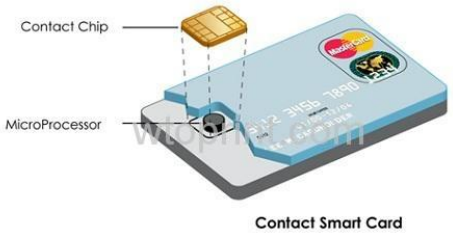
- **Electromagnetic – Radio frequency identification**



Material Handling

Automatic Data Capture

Categories



Contact Smart Card

- **Smart card – chip card, IC card**

- **Touch – touch screen**

- **Biometric –voice recognition, finger print, eye scan**

Material Handling

Automatic Data Capture

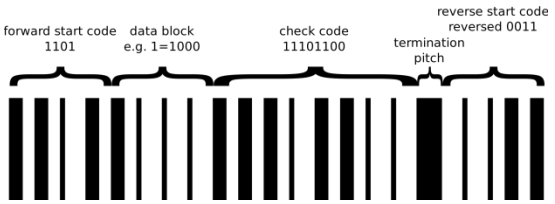
Bar Code Technology

1D Barcode

Most widely used automatic identification & data collection technique

Types

- Height modulated – varying height
- Width modulated – varying width of bars & spaces



Material Handling

Automatic Data Capture

Bar Code Technology

1D Barcode - Width Modulated

***Symbol* consists of a sequence of wide & narrow colored bars separated by wide & narrow spaces – black & white for high contrast**

- *Bar code readers* interpret the code by scanning & decoding the sequence of bars
- Consist of *Scanner* & *Decoder*

Material Handling

Automatic Data Capture

Bar Code Technology

Scanner

- Emits a beam of light
- Swept past the code
- Senses light reflections to distinguish between bars & spaces
- Light reflections are sensed by a photo detector
- Converts the spaces into electrical signal & bars into absence of signal
- Duration of corresponding signal is related to the width of the bars and spaces

Material Handling

Automatic Data Capture

Bar Code Technology

Decoder

analyzes the pulse train to interpret corresponding data

Commonly used Barcodes

- UPC – Numeric – Grocery & Retail stores
- Code 39 – Alphanumeric – Department of Defense

Material Handling

Automatic Data Capture

Bar Code Symbol – Code 39

Code 39 uses a series of wide & narrow elements (bars & spaces) to represent alphanumeric & other characters

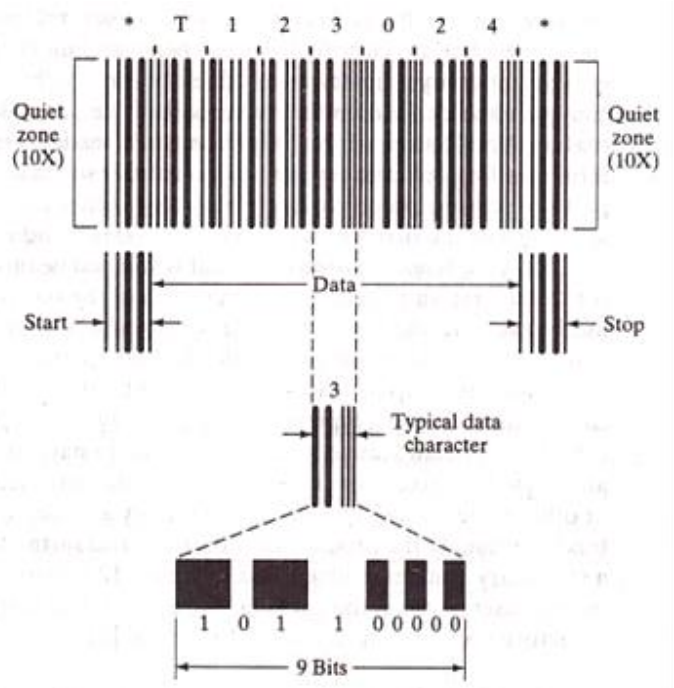
Wide Element -- 1
Narrow Element -- 0 → **Both for white and black**

- 9 elements are used for each number or character
- Any 3 elements are wide, 9 are narrow – either bar or space

Material Handling

Automatic Data Capture

Bar Code Symbol – Code 39



Char.	Bar pattern	9 bits	Char.	Bar pattern	9 bits
1		100100001	K		100000011
2		001100001	L		001000011
3		101100000	M		101000010
4		000110001	N		000010011
5		100110000	O		100010010
6		001110000	P		001010010
7		000100101	Q		000000111
8		100100100	R		100000110
9		001100100	S		001000110
0		000110100	T		000010110
A		100001001	U		110000001
B		001001001	V		011000001
C		101001000	W		111000000
D		000011001	X		010010001
E		100011000	Y		110010000
F		001011000	Z		011010000
G		000001101	-		010000101
H		100001100	.		110000100
I		001001100	space		011000100
J		000011100	*		010010100

Material Handling

Automatic Data Capture

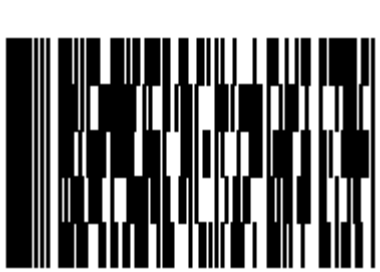
Bar Code Technology

2D Barcode

- **High area density – can store much greater amount of data**
- **Special scanning equipment is required – more expensive**

Types

- Stacked – multiple rows of linear conventional bar codes stacked
- Matrix– capability of containing more data than stacked code
  - More complicated
  - Both horizontally and vertically



Material Handling

Automatic Data Capture

Bar Code Reader

- **Manual – Contact – using pen**
- **Automatic – Non-contact**
  - Fixed beam
  - Moving bean – high rotational speed, 1440scans/sec, stationary/portable