

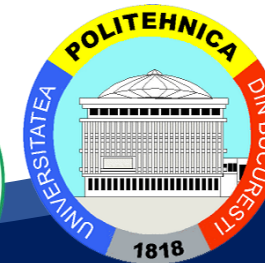


Co-funded by the
Erasmus+ Programme
of the European Union



Collaborative Material Handling System

Automated Storage and Retrieval System (ASRS)

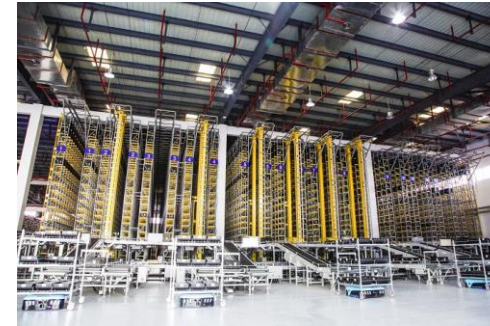
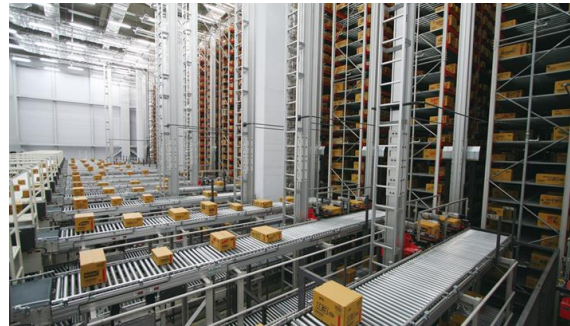


Curriculum Development
of Master's Degree Program in
Industrial Engineering for Thailand Sustainable Smart Industry

Storage Systems

Function: to store materials (e.g., parts, work-in-process, finished goods) for a period of time and permit retrieval when required.

- Important supply chain component.
- Storage system operating characteristics can be examined on two sets of issues:
 - Storage system performance
 - Storage location strategies





Storage System Performance

Various measures used to assess the performance of a storage system include:

1. Storage Capacity

- Total volumetric space available
- Total number of storage compartments (e.g., unit loads)

“Storage capacity is conveniently measured as the number of unit loads that can be stored in the system”

The physical capacity of the storage system should be greater than the maximum number of loads anticipated to be stored, to provide available empty spaces for materials being entered into the system and to allow for variations in maximum storage requirements.





Storage System Performance

2. Storage density

Storage density is defined as the volumetric space available for storage relative to total volumetric space in the storage facility.

For efficient use of space the storage system should be designed to achieve a high density. However, as storage density is increased, accessibility, another important measure of storage performance, is adversely affected.

3. Accessibility

Accessibility refers to the capability to access any desired item or load stored in the system.

In the design of a given storage system, **tradeoffs** must be made between storage storage density and accessibility.





Storage System Performance

4. System throughput

System throughput is defined as the hourly rate at which the storage system.

- Receives and puts loads into storage and/or.
- Retrieves and delivers loads to the output station.

Typical storage transaction consists of the following elements: pick up load at input station, travel to storage location, place load into storage location, and travel back to input station. A retrieval transaction consists of: travel to storage location, pick item from storage, travel to output station, and unload at output station. Each element takes time. The throughput of the storage system is determined by the sum of the element times (total transaction time). Throughput can sometimes be increased by combining storage and retrieval transactions in one cycle, thus reducing travel time; this is called a dual command cycle. When either a storage or a retrieval transaction alone is performed in the cycle, it is called a single command cycle.





Storage System Performance

5. Utilization

Utilization is defined as the proportion of time that the system is actually being used for performing storage and retrieval operations compared with the time it is available.

“It is desirable to design an automated storage system for relatively high utilization, in the range 80-90%. If utilization is too low, then the system is probably overdesigned. If utilization is too high, then there is no allowance for rush periods or system breakdowns.”

6. Availability

Availability is a measure of system **reliability**, defined as the proportion of time that the system is capable of operating (not broken down) compared with the normally scheduled shift hours.

“The reliability of an existing system can be improved by good preventive maintenance procedures and by having repair parts on hand for critical components. Backup procedures should be devised to mitigate the effects of system downtime.”





Storage Location Strategies

“**Storage location** strategies try to organize stock in a storage system, with chosen location strategies having a direct impact upon the performance.” Mainly two strategies;

- 1. Randomized storage** - Items are stored in any available location in the storage system, the nearest available open location. For retrieval, SKUs are taken from storage on a first in-first-out policy so that the items held in storage the longest are moved out first. Less storage space is generally required for randomized storage systems, although this affects throughput rates by reducing them, sometimes significantly. (Each item type stored in a warehouse is known as a stock-keeping-unit (SKU)).
- 2. Dedicated storage-** SKUs are assigned to specific locations in the storage facility, so defined reservation of SKUs can take place, and the system may be designed to accommodate maximum levels of particular SKUs held in inventory. Typical bases for deciding locations: Items stored in item number sequence, Items stored according to activity level, Items stored according to activity-to-space ratios.

More storage space is generally required for dedicated storage systems, although with the consequent advantage of higher throughput times being achieved.



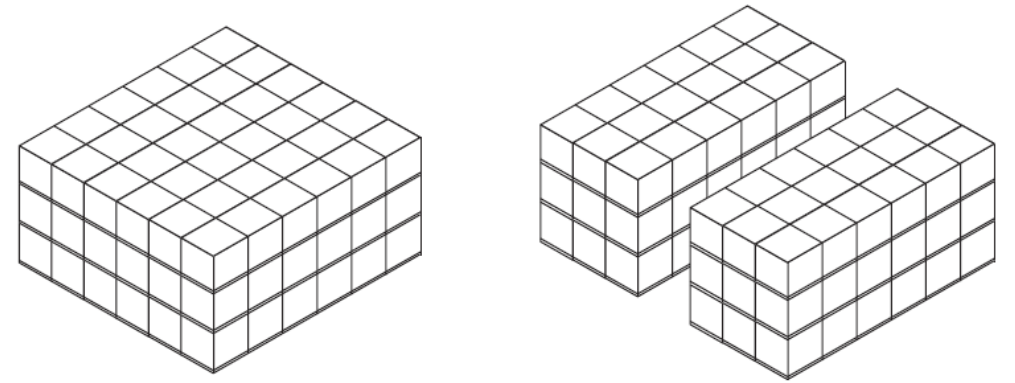
Conventional Storage Methods and Equipment

- Bulk storage
- Rack systems
- Shelving and bins
- Drawer storage
- Automated storage systems

Application Characteristics of the Types of Storage Equipment and Methods		
Storage Equipment	Advantages and Disadvantages	Typical Applications
Bulk storage	Highest density is possible Low accessibility Low cost per square foot	Storage of low turnover, large stock, or large unit loads
Rack systems	Low cost Good storage density Good accessibility	Palletized loads in warehouses
Shelves and bins	Some stock items not clearly visible	Storage of individual items on shelves and commodity items in bins
Drawer storage	Contents of drawer easily visible Good accessibility Relatively high cost	Small tools Small stock items Repair parts
Automated storage systems	High throughput rates Facilitates use of computerized inventory control system Highest cost equipment Facilitates integration with automated material handling systems	Work-in-process storage Final product warehousing and distribution center Order picking Kitting of parts for electronic assembly

Bulk Storage

- Used for the storage of stock in an open floor area, generally in unit loads on pallets or similar containers. Unit loads may be stacked on top of each other to achieve higher storage densities.
- High-density bulk storage provides low accessibility.
- Formation of rows and blocks in bulk storage can also improve accessibility.

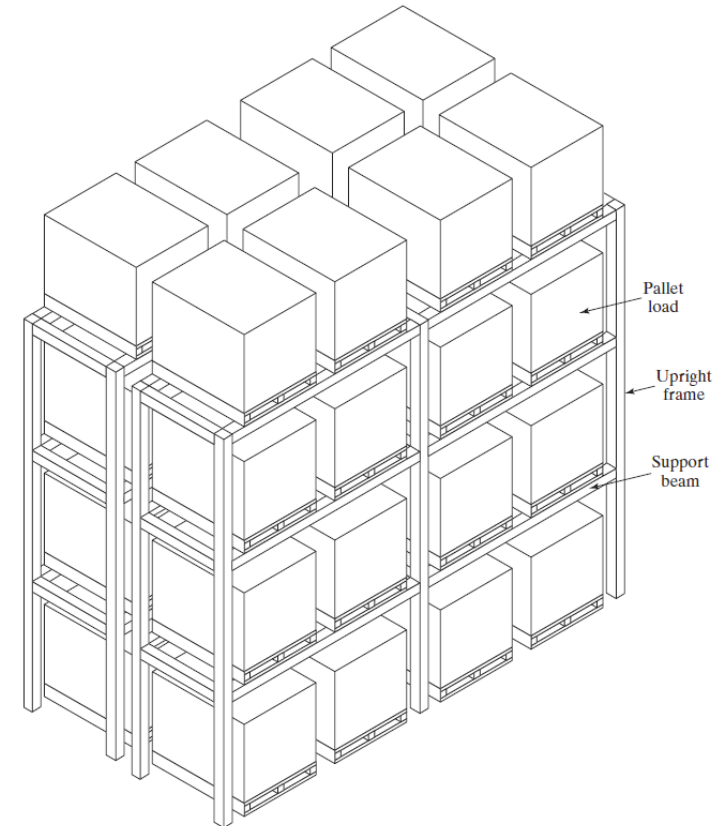


Two bulk storage arrangements: (left) high-density bulk storage provides low accessibility; (right) bulk storage with loads arranged to form rows and blocks for improved accessibility.

Rack Systems

Rack systems provide bulk storage facilities with adequate support to aid safe stacking, by means of various methods

- **Pallet racks** - consisting of a frame to support unit loads one over the other, without the weight of the top-most loads resting on loads lower down; it consists of a frame with horizontal load-supporting beams.
Low cost, Good storage density and Good accessibility
- **Drive-through racks** - consisting of a framework with aisles down the middle of two vertical beam column.
Thus providing for unobstructed storage spanning.



Pallet rack system for storage of unit loads on pallets.

Rack Systems

- **Cantilever racks** - same as pallet racks, except the horizontal beams are cantilevered from the vertical central frame.

This provides for unobstructed storage spans, which facilitates storage of long materials such as rods, bars and pipes.

- **Portable racks** - consisting of portable box-frames that hold a single pallet load.

- **Flow-through racks** - consisting of conveyor tracks capable of supporting a row of unit loads.

Which replace conventional horizontal rack beams.

Unit loads are loaded on one side of the rack, and are unloaded on the other side, thus providing first-in-first-out stock rotation.



Shelving and Bins



Shelving and Bins

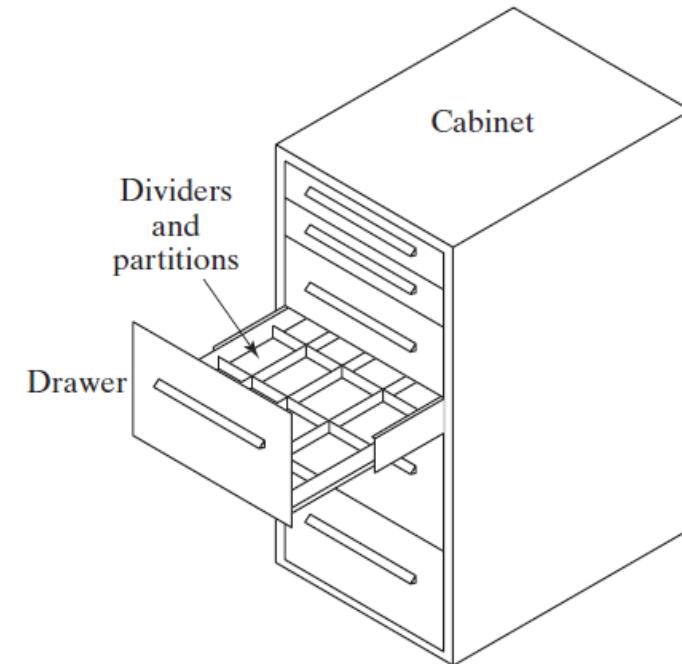
A shelf is a horizontal platform, supported by a wall or frame, on which materials are stored.

- Shelving often includes bins, which are containers or boxes that hold loose items.

Drawer Storage

Storage drawers solve the problem of shelving, where materials may often be overlooked, by allowing the attendant to pull the drawer out to reveal fully its contents.

- Contents easily visible, Good accessibility and Relatively high cost.



Drawer storage



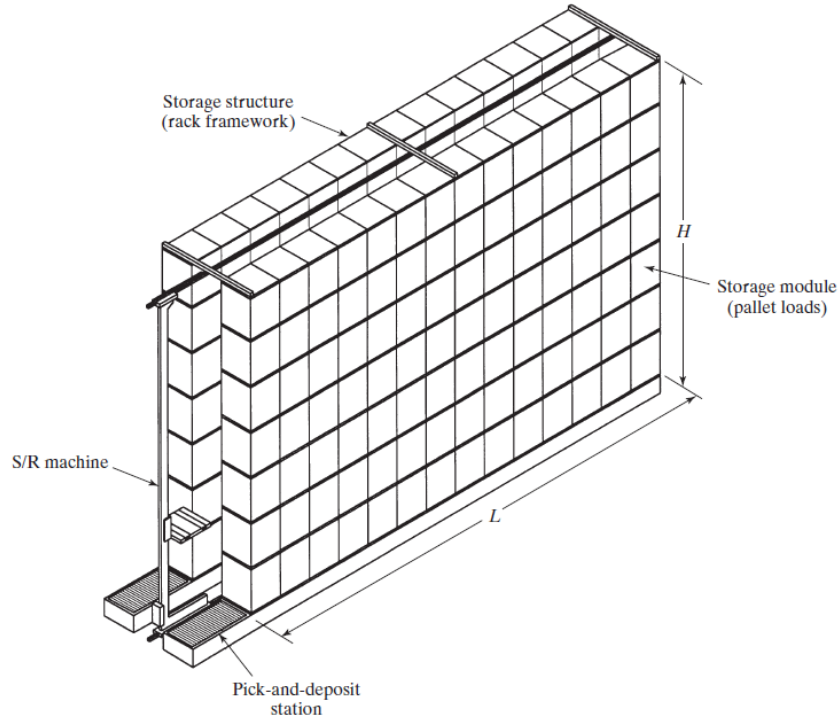
Automated Storage Systems

“Automated storage system is a mechanized and automated storage equipment to reduce the human resources required to operate a storage facility.”

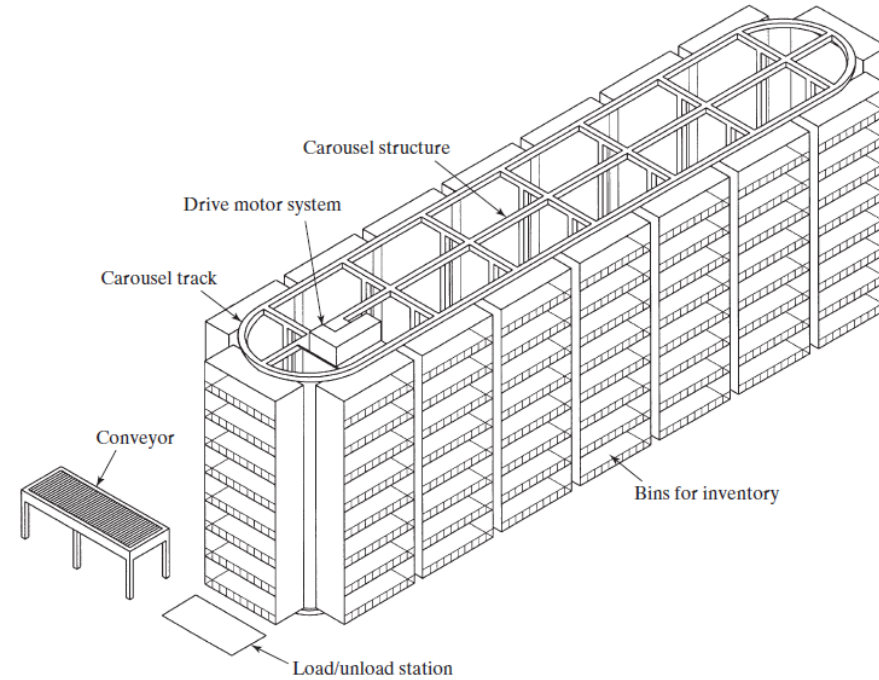
- **Level of automation varies**
 - In mechanized systems, an operator participates in each storage/retrieval transactions.
 - In highly automated systems, loads are entered or retrieved under computer control.
- **And it requires a significant investment.**
- **Types of automated storage system**
 - Automated Storage/Retrieval System (AS/RS) or (ASRS)
 - Carousel Storage System



Automated Storage Systems



One aisle of a unit load automated storage/retrieval system (AS/RS).



A horizontal storage carousel.

Automated Storage Systems

Differences Between a Fixed-Aisle AS/RS and a Carousel Storage System

Feature	Fixed-Aisle AS/RS	Carousel Storage System
Storage structure	Rack system to support pallets or shelf system to support tote bins	Baskets suspended from overhead conveyor trolleys
Motions	Linear motions of S/R machine	Revolution of conveyor trolleys around oval track
Storage/retrieval operation	S/R machine travels to compartments in rack structure	Conveyor revolves to bring baskets to load/unload station
Replication of storage capacity	Multiple aisles, each consisting of rack structure and S/R machine	Multiple carousels, each consisting of oval track and storage bins

What is ASRS ?

ASRS - Automated Storage/Retrieval System is defined as a storage system that performs storage and retrieval operations with speed and accuracy under a defined degree of automation.

- **Degree of automation** - At the most sophisticated level the operations are totally automated, computer controlled, and fully integrated with factory and/or warehouse operations.
- At the other extreme human workers control the equipment and perform the storage/retrieval transactions.
- The ASRS system is custom-designed to fit the requirements of the plant in which it is installed.





Reason to Install ASRS

- Orders spending too much time in the factory, causing customer deliveries to be late.
- Much time spent for searching
- Lost or damaged products and inaccurate records
- Waste much space
- Workers are exposed to dangers





Objectives of ASRS

Possible Objectives and Reasons for Automating a Company's Storage Operations

- To increase storage capacity
- To increase storage density
- To recover factory floor space presently used for storing work-in-process
- To improve security and reduce pilferage
- To improve safety in the storage function
- To reduce labor cost and/or increase labor productivity in storage operations
- To improve control over inventories
- To improve stock rotation
- To improve customer service
- To increase throughput





ASRS Component Terms

- **Storage Space** - It is the three-dimensional space in the storage racks used to store a single load unit of material.
- **Storage Racks** - This structural entity comprises storage locations, bays and rows.
- **Bay** - It is the height of the storage rack from floor to the ceiling.
- **Row** - It is a series of bays placed side by side.
- **Aisle** - It is the spacing between two rows for the machine operations of AS/RS.
- **Aisle Unit** - It encompasses aisle space and racks adjacent to an aisle.





Components and Operating Features of ASRS

1. Storage structure

Made of Fabricated steel

Rack framework

Supports the load contained in the ASRS

To store Inventory items

2. Storage/Retrieval Machine

It is capable of both horizontal and vertical movement

Used to move items in and out of the inventory

A rail system along the floor guides the machine





Components and Operating Features of ASRS

3. Storage Modules

Unit load containers is used to hold an inventory items such as pallets, steel wire baskets, containers etc.

The modules are generally made to a standard base size capable of being stored in stored in the structure and moved by S/R Machines.

4. Pickup and Deposit (P/D) Stations

Loads are transferred in and out of the AS/RS stations.

Located at the end of aisles to facilitate easy access by the S/R machines from the from the external material-handling system.

The location and number of P/D stations depends upon the origination point of point of incoming loads and the destination of output loads.

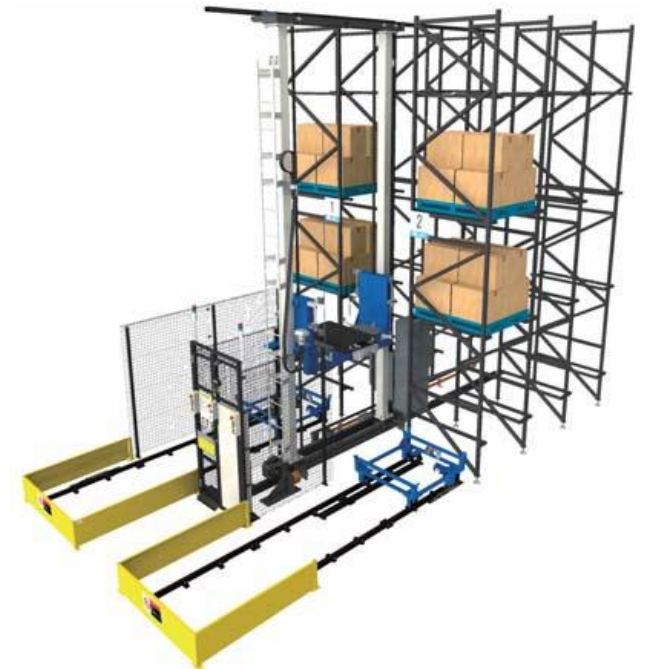


AS/RS Types

Several important categories of fixed-aisle automate storage/retrieval system can be distinguished. The following are the principal types:

1. Unit load AS/RS

- Is typically a large automated system designed to handle, unit-loads stored on pallets or in other standard containers.
- The system is computer controlled.
- The S/R machines are automated and designed to handle the unit load containers. Usually, a mechanical clamp mechanism on the S/R machine handles the load. However, there are other mechanisms such as a vacuum or a magnet-based mechanism for handling sheet metal.
- The unit load system is the generic AS/RS.



AS/RS Types

2. Deep-lane AS/RS

- A high-density unit load storage system that is appropriate for storing large quantities of stock
- The items are stored in multi deep storage with up to 10 items in a single rack, one load behind the next. Each rack is designed for flow-through, with input and output on the opposite side.
- Machine is used on the entry side of the rack for input load and loads are retrieved from other side by an S/R- type machine.



AS/RS Types

3. Miniload AS/RS

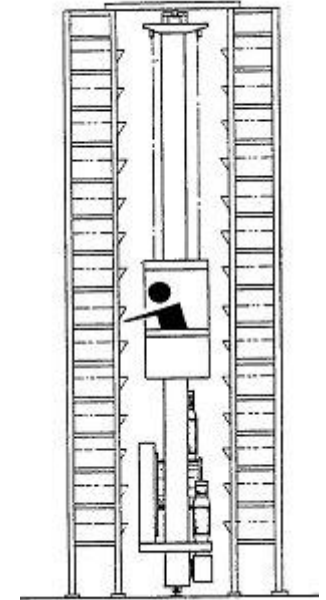
- This system is designed to handle small loads such as individual parts, tools, and supplies that are contained in bins or drawers in the storage system.
- Such a system is applicable where the availability of space is limited. It also finds its use where the volume is too low for a full-scale unit load system and too high for a manual system.
- The S/R machine retrieves the bin and delivers it to a P&D station at the aisle's end, aisle's end, so that individual items may be withdrawn. The P&D station is usually operated manually. The bin is then returned to its location in the storage system.
- A mini load AS/RS is generally smaller than a unit load AS/RS and is often enclosed for security of items stored.



AS/RS Types

4. Man-on-board AS/RS

- Human operator rides on the carriage of the S/R machine to pick up individual items from a bin or drawer.
- The system permits individual items to be picked directly at their storage locations. This provides an opportunity to increase system throughput.
- The operator can select the items and place them in a module. It is then carried by the S/R machine to the end of the aisle or to a conveyor to reach its destination.



5. Automated item retrieval

- This system is designed for retrieval of individual items or small product cartoons

AS/RS Types

6. Vertical lift storage modules (VLSM)

- Also known as vertical lift automated storage/retrieval systems (VLAS/RS).
- Here the same principles as the above AS/RS types are followed, except that instead of a horizontal aisle, the aisle is vertical.



ASRS Features

1. High density storage (in some cases, large, high-rise rack structures)
2. Automated handling systems (such as elevators, storage and retrieval carousels and conveyors).
3. Materials tracking systems (using optical or magnetic sensors)
4. Some of the special features of AS/RS are:
 - Aisle transfer cars
 - Full/empty bin detectors
 - Sizing stations
 - Load identification stations





ASRS Applications

AS/RS technology has generally been associated with warehousing and distribution operations, although it can also be used for raw material storage, and storage of work-in-process in manufacturing. Three application areas of interest are:

1. Unit load storage and retrieval

- Warehousing and distribution operations
- AS/RS types: unit load, deep lane (food industry)

2. Order picking

Used to store and retrieve materials in less than full unit load quantities such as man-on-board or mini-load applications

3. Work-in-process storage

Helps to manage WIP in factory operations





What is WIP ?

“**WIP – Work In Progress** is defined as a storage system that performs storage and retrieval operations with speed and accuracy under a defined degree of automation.”

- Degree of automation - At the most sophisticated level the operations are totally automated, computer controlled, and fully integrated with factory and/or warehouse operations.
- At the other extreme human workers control the equipment and perform the storage/retrieval transactions.
- The ASRS system is custom-designed to fit the requirements of the plant in which it is installed.





Reasons to Introduce WIP Automated Storage System ?

- **Buffer storage in production** : The automated storage system can be used as a buffer storage zone between two processes whose production rates differ.
- **Support of just-in-time delivery** : To reduce the chance of stock out, owing to the failure of delivery by suppliers in the just-in-time systems, automated storage systems may be installed as storage buffers for incoming materials.
- **Kitting of parts for assembly** : The storage system is used to store components for assembly of products or subassemblies. When orders are received from storage they are put together into kits and deliver to production.
- **Compatible with automatic identification systems** : The systems can be interfaced with other automated systems throughout production, such as automatic identification devices.
- **Computer control and tracking of materials** : Automated WIP storage system allows the location and status of WIP to be known.
- **Support of factory-wide automation** : Given the need for storage of work-in-process in batch production, an appropriately sized automated storage system can be an important subsystem in a fully automated factory.



Conclusion

AS/RS is a great system which was developed to improve the storage systems used in industries to handle, store and retrieve materials with precisions, accuracy and speed under defined degree of automation.





Co-funded by the
Erasmus+ Programme
of the European Union



Thank You

Together We Will Make Our Education Stronger



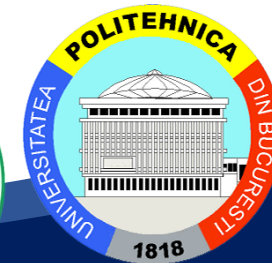
<https://msie4.ait.ac.th/>



@MSIE4Thailand



MSIE 4.0 Channel



Curriculum Development
of Master's Degree Program in
Industrial Engineering for Thailand Sustainable Smart Industry