

ROTTERDAM SCHOOL OF MANAGEMENT
ERASMUS UNIVERSITY

DEPARTMENT OF TECHNOLOGY AND INNOVATION MANAGEMENT

STORAGE SYSTEMS OF THE FUTURE

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NOVEMBER 16, 2011
MATERIAL HANDLING FORUM SEMINAR

The business school that thinks and lives in the future






STORAGE SYSTEMS OF THE FUTURE

1. Overview Storage systems
2. Conventional storage systems
3. More advanced storage systems
 - AS/R systems
 - AVS/R systems
 - Compact/live-cube storage systems
 - Dynamic storage systems
4. Wrap up

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DE KEUZE VAN EEN (OPSLAG)SYSTEE

Het is net jam kopen in de winkel:

1. Winkel 1: standaard jams
- Winkel 2: maatwerk jams
- Winkel 3: duurzame jams





Opslagmethoden en technieken

DE KEUZE VAN EEN (OPSLAG)SYSTEE

Naar welke winkel moet je gaan?
Welke jam is het best?

- Smaak
- Prijs
- Kwaliteit
- Duurzaam
- Uiterlijk, CSR... etc





Opslagmethoden en technieken

STORAGE SYSTEMS

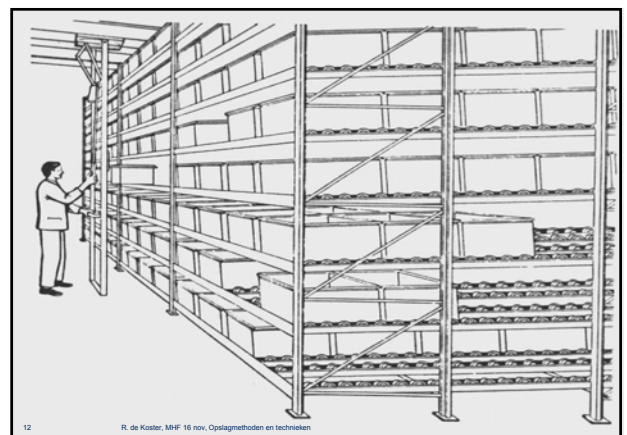
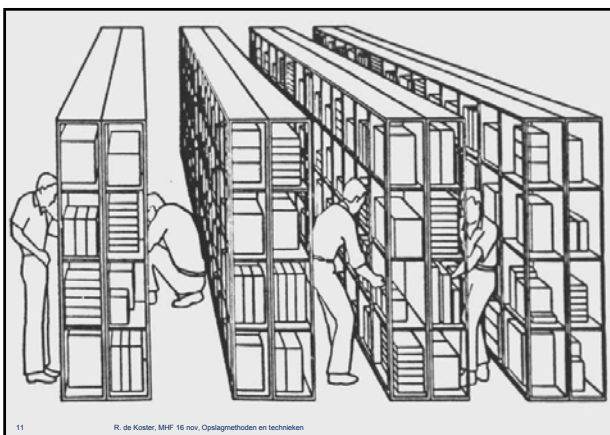
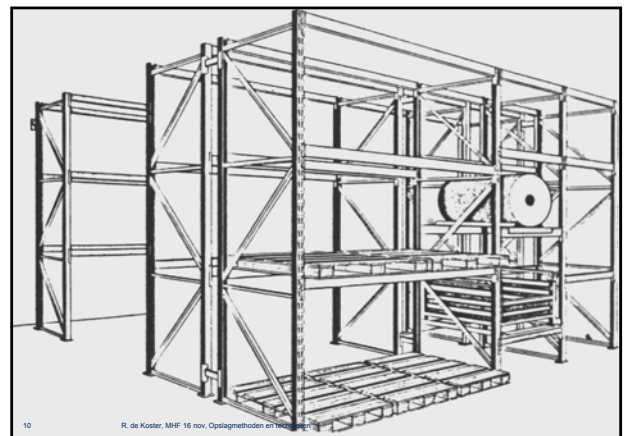
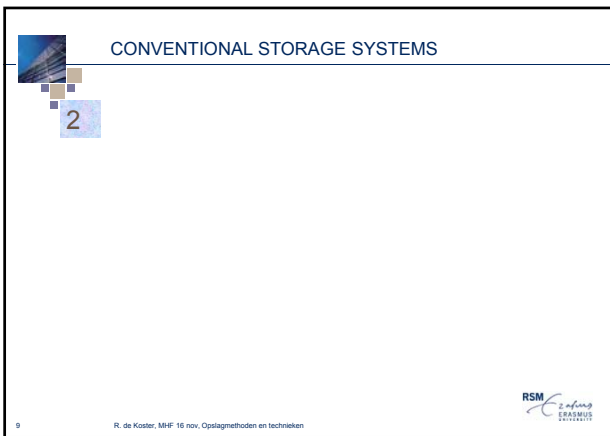
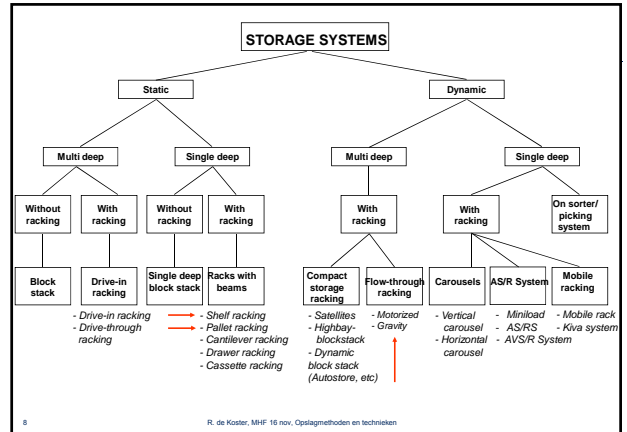
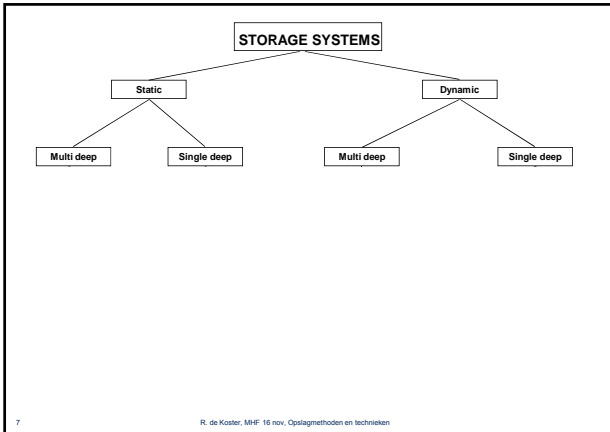
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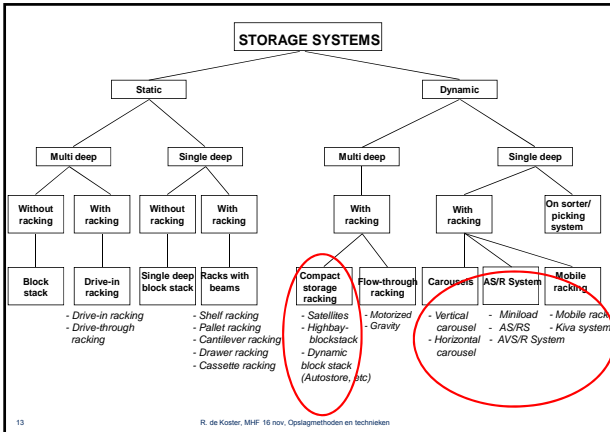
STORAGE SYSTEMS

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    graph TD
      A[STORAGE SYSTEMS] --> B[Static]
      A --> C[Dynamic]
    
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MORE ADVANCED SYSTEMS

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- Single-deep systems:
 - Traditional:
 - AS/RS
 - Carousels
 - Advanced:
 - AVS/R systems
 - Kiva: movable racks
- Multi-deep (compact) systems
 - Traditional:
 - Satellites
 - Block stack
 - Advanced:
 - Satellites and lifts
 - Autostore
 - Live-cube

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1. AS/RS OPERATED WAREHOUSE

Main components: racks, cranes, aisles, I/O-points, and pick positions

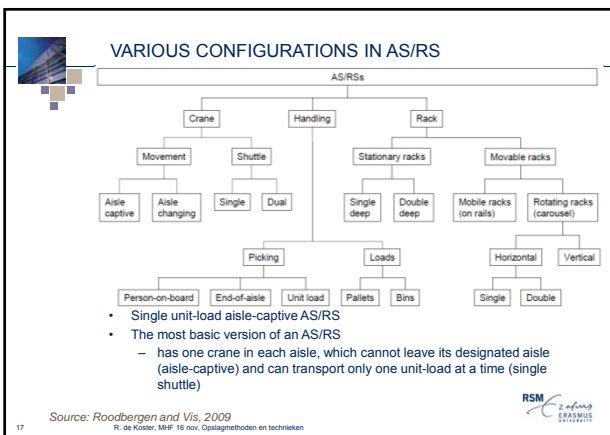
Source: <http://www.dafukuamerica.com>

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CRANE-BASED AS/RS (OPERATIONS)

- Typically one crane captive to an aisle
- Cranes have one or multiple load carriers (also known as shuttles; typically one shuttle/crane)
- Simultaneous movement of the crane in the y and z directions

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AS/RS RESEARCH

One of the best researched areas in MH literature (estimate >500 papers), studying every aspect.

What is known (f.e.):

- Crane cycle time (depending on rack size, storage strategy, etc.)
- Optimal shape of the rack
- Optimal ABC zone shape and size (for given demand Pareto curve)
- Optimal number of ABC storage classes

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AS/RS RESEARCH

Pallet storage rack (side view). Rack length=height = 20 sec crane travel time. Random storage.

What is the average travel time to go to a rack location and back to the I/O point (neglect acceleration/deceleration)?

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AS/RS RESEARCH

Travel time: () = 27 sec

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AS/RS RESEARCH

2. Pallet storage rack (side view). Height 20 m. Optimal length?

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AS/RS RESEARCH

2. Pallet storage rack (side view). Height 20 m. Optimal length?

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AS/RS RESEARCH

Pallet storage rack (side view). Height 20 m. Optimal length?

Minimize crane travel time ()

Constraint: rack must have given capacity

Answer: rack must be square in time =

Since crane drives about 4 times faster than it lifts: L=80 m.

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AS/RS RESEARCH

3. Optimal shape and size of the ABC storage area?

Example overhead crane for carpet rolls

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AS/RS RESEARCH

3. Optimal shape and size of the ABC storage area?

I/O point

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AS/RS RESEARCH

3. Optimal shape and size of the ABC storage area?

I/O point

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AS/RS RESEARCH

4. Optimal number of storage classes?

Travel time with the 20%/90% ABC curve
Yu et al. 2011

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2. AN AVS/RS OPERATED WAREHOUSE

Source: Savoye Logistics (savoye.com)

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3. COMPACT STORAGE

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3. LIVE-CUBE COMPACT STORAGE

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ENVIRONMENTAL IMPACT LIVE STORAGE

Parking type	Live-cube parking	Traditional car park
Average (fossil fuel-based) CO2 emission (gram/car)	96	3897
Total electrical (lighting, vent, moving) energy (kWh/car)	0.12	9.60


In addition: 40%-50% smaller footprint area (smaller building) for the same number of parking slots (Hyundai Elevator, 2011)

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RESEARCH QUESTIONS

Q1: What is the performance (response time) of the system, given layout, configuration, and storage strategy

Q2: How to optimize live-cube storage system dimensions yielding minimum system response times



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Method: mathematical model: $\min E[RT]$

Such that $l \times w \times h = V$



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Q1: What is the performance (response time) of the system, given layout, configuration, and storage strategy

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Such that $l \times w \times h = V$

A: Zaerpour et al., 2011: cubic in time is nearly optimal



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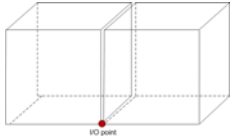
RESEARCH QUESTIONS

Q: Lift in the middle (same system capacity)?

A: 20% reduction in response time compared to a system with lift at the corner

Q: storage based on duration of stay?


A: 25% shorter travel time for a 20/70 curve.



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4. KIVA GOODS TO MAN SYSTEMS

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4. KIVA GOODS TO MAN SYSTEMS

Q: To which rack should we allocate products?

Q: To which rack should we allocate orders?

Q: How to schedule orders and racks?


Q: how many AGVs do we need?

Q: how to schedule the AGVs?


Q: Where to store the racks?

Q: Should one picker pick complete orders, or only a part?
Etc.

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WRAP UP

- Er is veel keuze op het gebied van geautomatiseerde opslagsystemen
- Veel wetenschappelijke resultaten bekend. Vooral van AS/R systemen.
- Veel nieuwe systemen op de markt die nog nauwelijks onderzocht zijn
- Nog nauwelijks tools beschikbaar voor gestructureerde afweging van systemen met meerdere criteria

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WRAP UP

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- Nog nauwelijks tools beschikbaar voor gestructureerde afweging van systemen met meerdere criteria

Kortom, er is veel te beleven op het gebied van opslagsystemen
Veel keuze en nog veel uit te zoeken!



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