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Storage & warehousing

Agenda

What is it about ?

Terminology - Functions

Storage policy

Impact – Location policy

Selected topics

Unit load storage - Racks – Safety – AS/RS

Trends

Roadmaps – Changing function – Green & Lean

Stuff-to-think about

"Density" – "Maturity" – "Resilience"

What is it about?

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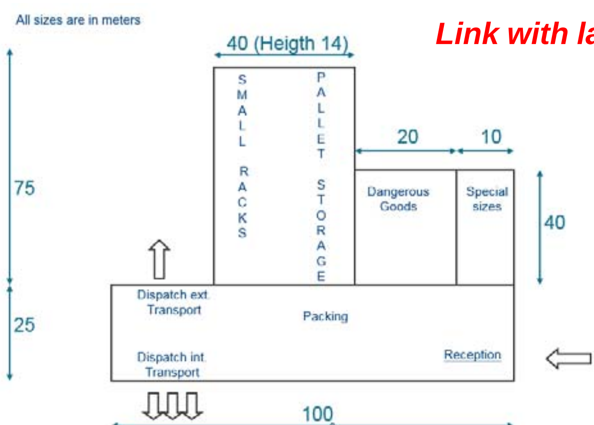
Some warehousing impressions: illustration

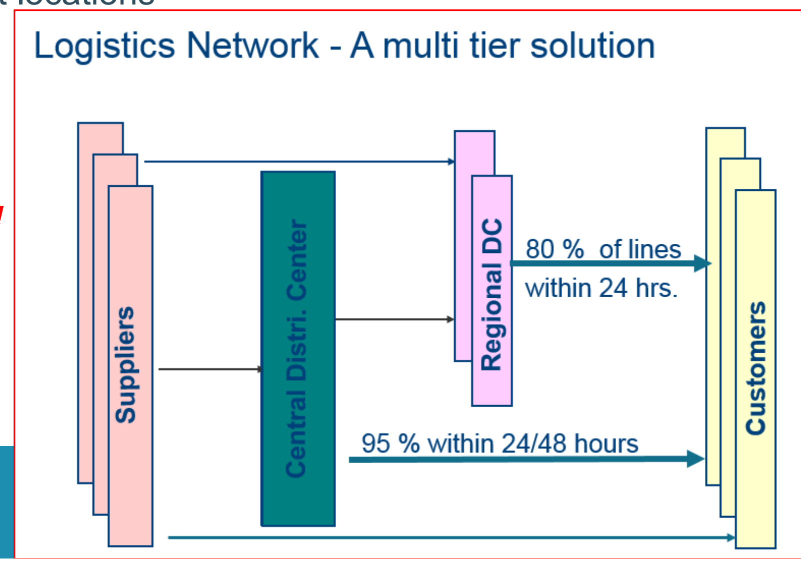
Automated warehouse
Paperless (barcode, RF terminals)
6.000 pallet locations
12.000 meter Miniload
1.500 outgoing lines / day
450 incoming lines / day
20.000 articles on stock
Extension planned
    5.600 additional pallet locations
    4.000 meter miniload

Link with material handling

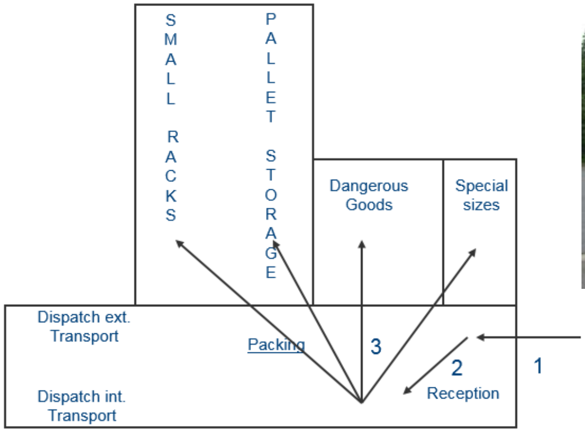
Link with layout



Link with SCM !

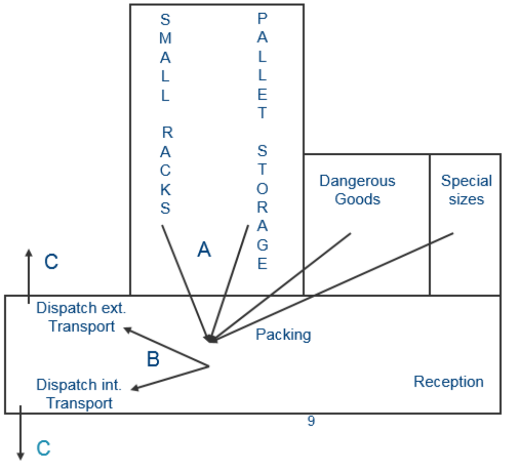


Reception

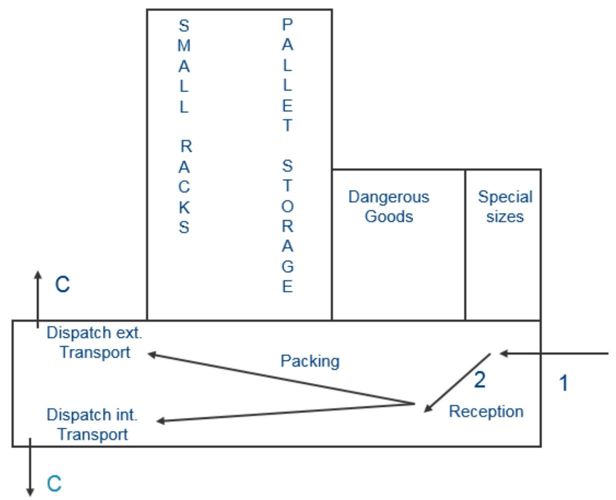


Storage

Pick & Pack / Delivery process



Crossdocking - Staging



Mission of a warehouse

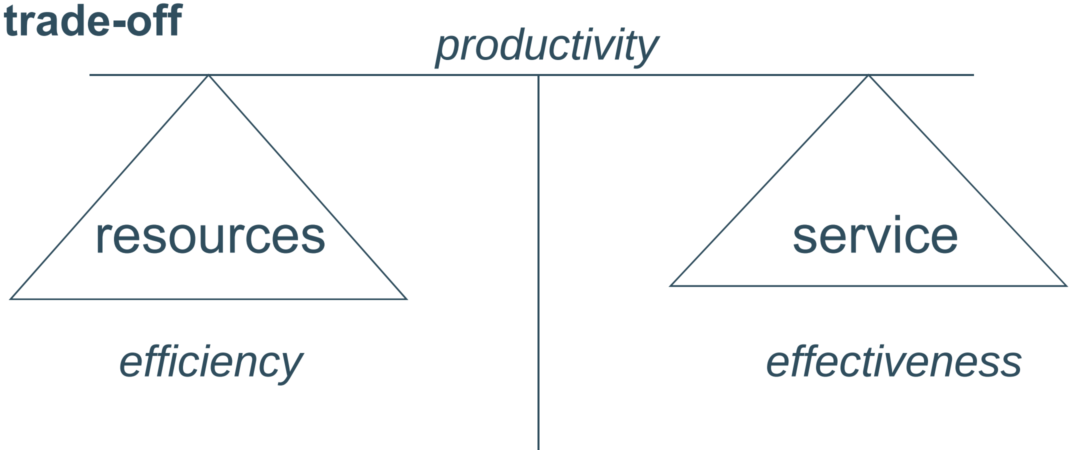
Why ?

Warehouse = <u>buffer</u>

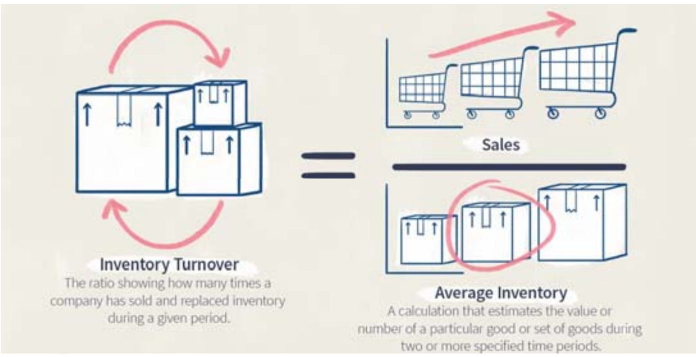
“needed when no perfect synchronization between in-flow and out-flow is possible”

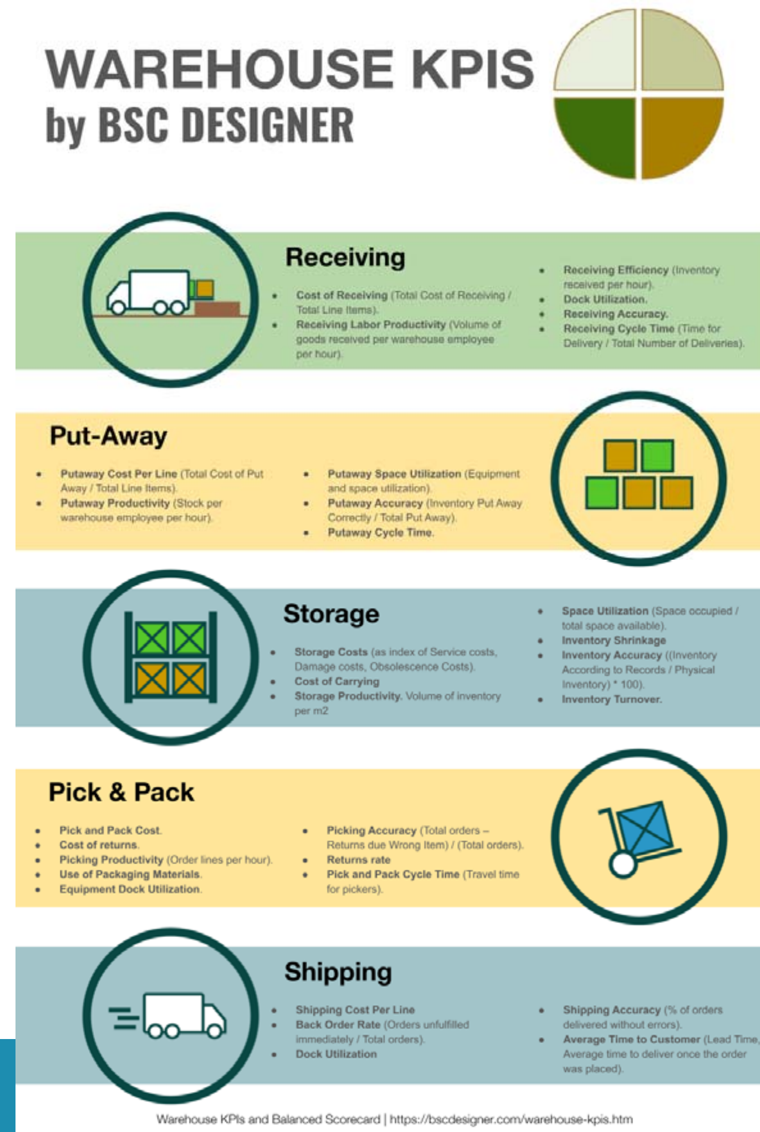
“needed to transfer products efficiently and effectively to the next step in the supply chain, i.e. internal or external customer”

Management trade-off



KPI for warehouse management: illustrations





Top 10 metrics
1. Average Warehouse Capacity Used
2. Order Picking Accuracy (percent by order)
3. Peak Warehouse Capacity Used
4. Contract Employees to Total Workforce
5. On-time Shipments
6. Overtime Hours to Total Hours
7. Part Time Workforce to Total Workforce
8. Cross Trained Percentage
9. Annual Workforce Turnover
10. Inventory Count Accuracy by Location

(see also chapter on Productivity)

Terminology

Stock = inventory

Warehouse or storage facility
- Warehousing: finished goods
- Storage: raw materials, supplies, WIP

(often used interchangeably)

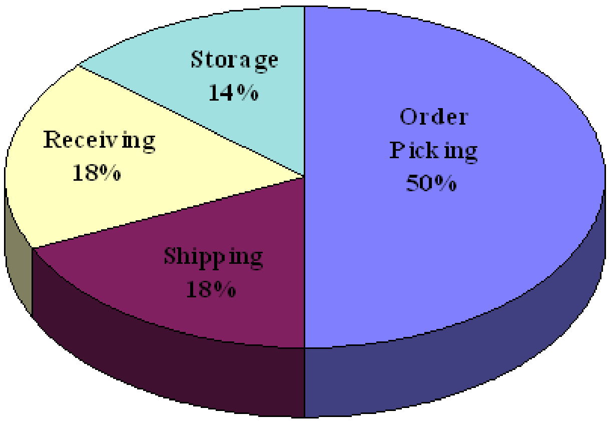
Types of stock
- Pipeline stock (transfer)
- Cycle stock (lotsize related)
- Seasonal stock (demand pattern)
- Safety stock (uncertainties)
- Dead or obsolote inventory (no use anymore)

Activities (functions)

physical & information flow

receiving (inslag)
(quality) control
dispatching to storage
placing in storage
storage (opslag)
picking
order accumulation
packing
shipping (uitslag)

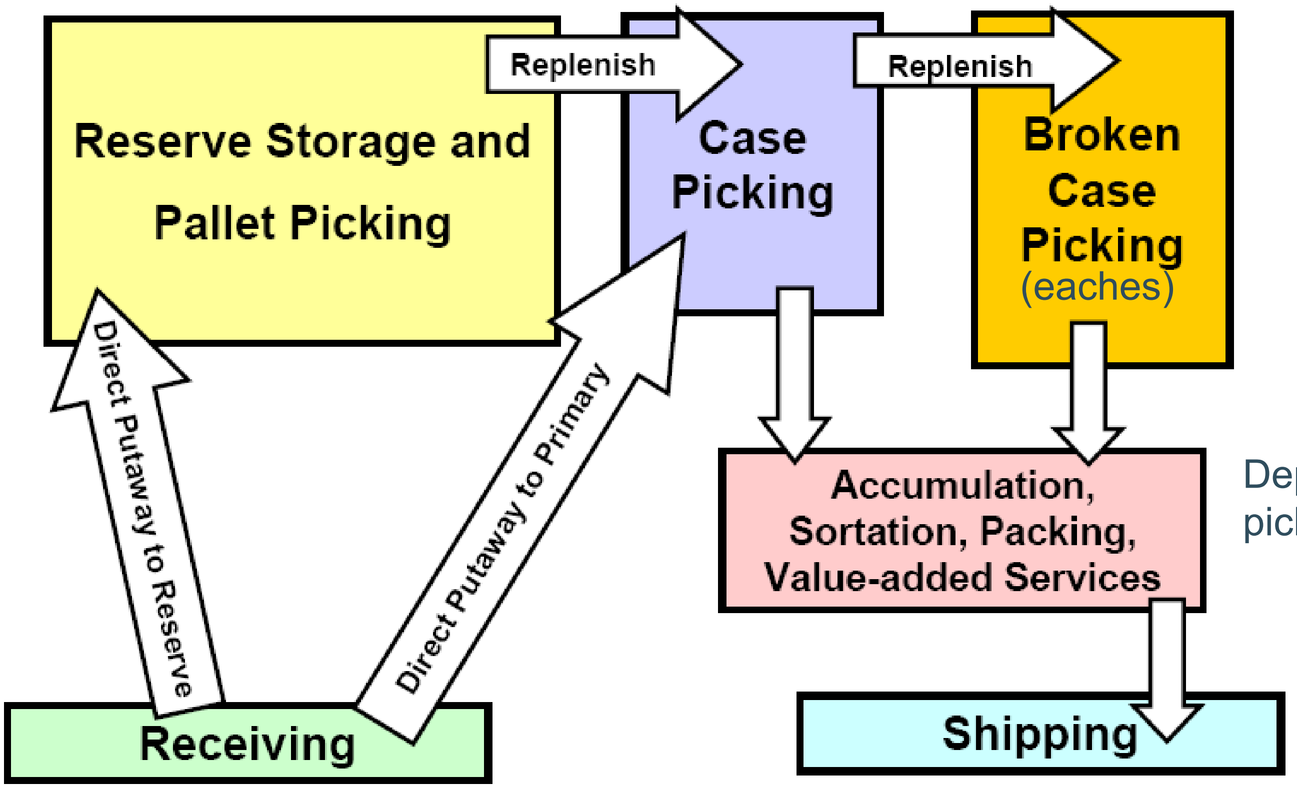
other
trashing inbound materials
repacking in standard containers
additional activities
e.g. mfg kits, VAL



Time spent on (average) – ref: Thompkins

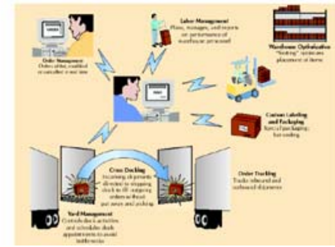
Typical warehouse

Depends on customer order size



Depends on order picking policy

Distribution centers

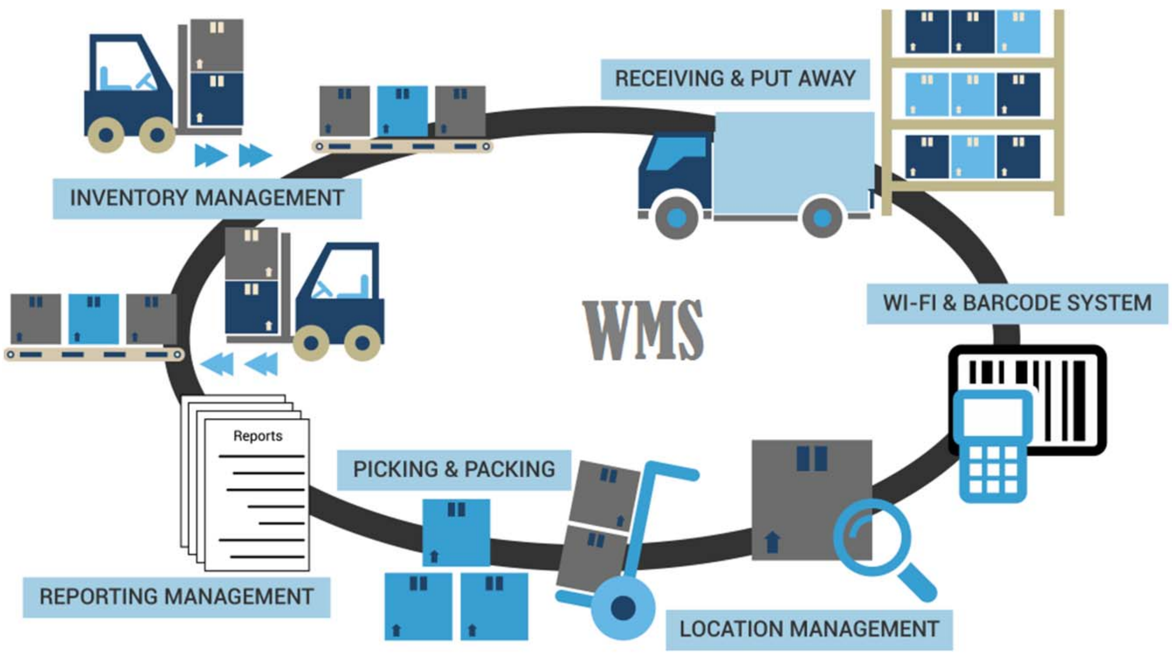


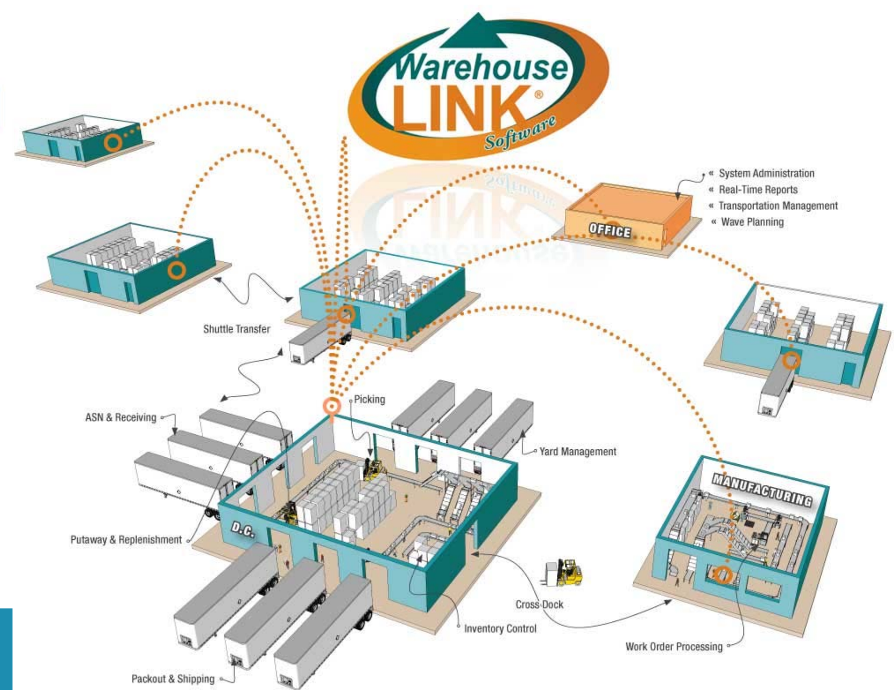
DCs (distribution centers) are some of the largest business facilities

Trends

customer: more frequent, smaller orders

supplier: flow-through facilities, automated MH and new functions in warehouse (see later)


RECEIVING & PUT AWAY
INVENTORY MANAGEMENT
WMS
WI-FI & BARCODE SYSTEM
Reports
PICKING & PACKING
REPORTING MANAGEMENT
LOCATION MANAGEMENT


Warehouse LINK Software
OFFICE
System Administration
Real-Time Reports
Transportation Management
Wave Planning
Shuttle Transfer
Picking
ASN & Receiving
Yard Management
Putaway & Replenishment
D.C.
MANUFACTURING
Cross-Dock
Inventory Control
Work Order Processing
Packout & Shipping

Information needed

Storage analysis chart

Dictated by "production"

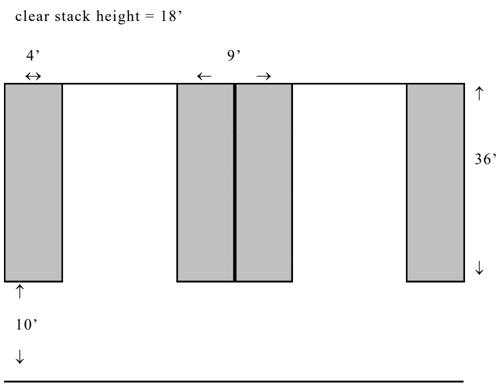
Dependent on inventory management strategy

Dependent on storage policy

COMPANY XYZ			Store ABC					
Category of goods: • raw materials • plant supplies • in-process goods • finished goods						Prepared by: Date:		
description	unit loads				# units loads stored		storage space	
	type	capacity	size	weight	max	avg	method	space standard

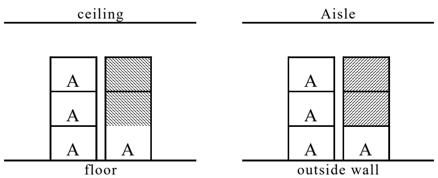
Space standard = “volume required per unit stored, including “losses”

loss in cube utilization due to aisles



total cube = 18*(10+36)*(4+10+9+10+9+4)
= 30636
aisle cube = 18*(10*36*2+10*37) = 19620
“loss” due to aisles = 19620/30636=64%

*loss in cube due to **honeycombing***



Storage policy

Storage assignment method

1. Basic types

randomized storage (floating slot)

C	F	D	D										A
A	A	C	C	C	D					C	D	F	E
A	A	C	C	C	F	C	C	C	C	B	B	B	B
A	A	C	C	C	C	C	F	F	D	B	B	B	B

dedicated storage (fixed slot)

					C				D				
			B	B	C	C	C	C	D				
	A	A	B	B	C	C	C	C	D				
A	A	A	B	B	C	C	C	C	D		F	F	
A	A	A	B	B	C	C	C	C	D	E	F	F	F

Illustration: impact on storage space required

	Products Stored		
Period	A	B	Aggregate
1	5	2	7
2	7	1	8
3	4	4	8
Max	7	4	*8 spots needed if random*
	11 spots needed if dedicated		

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What seems appropriate for ...

- *Reserve storage of a picking area for sporting apparel ?*
- *Spare parts and maintenance supplies in a manufacturing plant ?*
- *Medication in a hospital's pharmacy warehouse ?*
- *Project related materials in a central workplace ?*
- *Your kitchen cupboard ?*

Dedicated Storage

- Each stock keeping unit (SKU) is assigned a spot
- Easy to find and manage
- Pick times may be longer
- Need overflow areas
- Must plan space for maximum on hand

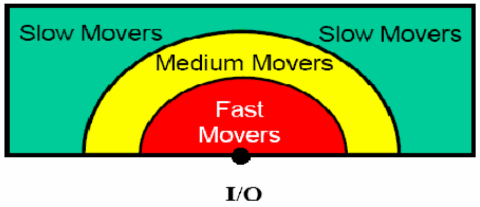
Flexibility ?

Random Storage

- SKUs are stored in any available location
- Allows for better space utilization
- Requires good control system
- "Closest-open-location" rule often used
- Space is planned for average amount of each SKU
- Safety Stock + ½(Replenishment Qty)

2. Hybrid types

- class-based storage
  - dedicated storage with randomization within class
    - zones dedicated to classes of products, based on characteristics, like e.g. rotation, use, physical properties, …



- “supermarket” storage
  - combination of dedicated storage (primary picking area) and randomized storage (reserve storage)

Dedicated storage model

Optimum assignment model

Notations:

q	number of storage locations
n	number of products
m	number of input/output (I/O) points (docks)
S_j	number of storage locations required for product j
T_j	number of trips in/out of storage for product j, I.e thruput of j
p_i	percentage of travel in/out of strorage to/from I/O point i
d_{ik}	distance required to travel from I/O point i to storage location k
x_{jk}	1 if product j is assigned to storage location k; otherwise, 0
$f(x)$	average distance travelled.

Model

n products *q storage locations* *m input/output points*

$$\min \sum_{j=1}^{n} \sum_{k=1}^{q} \left(\frac{T_j}{S_j} \right) \sum_{i=1}^{m} p_i d_{ik} x_{jk}$$

$$s.t.$$

$$\sum_{j=1}^{n} x_{jk} = 1 \ for \ k = 1,\ldots q$$

$$\sum_{k=1}^{q} x_{jk} = S_j \ \ for \ j = 1,\ldots n$$

$$x_{jk} \in \{0,1\} \ for \ \forall k, \forall j$$

Notations:

q	number of storage locations
n	number of products
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x_{jk}	1 if product j is assigned to storage location k; otherwise, 0
f(x)	average distance travelled.

Heuristics

Logic is that items that have lots of transactions AND do not take up much space should get the best locations

Items that either do not have many transaction OR ones that take up lots of space should go in the worst locations

"Cube-per-order" index

$$cube-to-order = \frac{number\ of\ storage\ locations\ needed}{number\ of\ transactions}$$

"Activity-to-space" ratio (hit rate)

$$activity-to-space\ ratio = \frac{number\ of\ transactions}{number\ of\ storage\ locations\ needed}$$

Example 1: one I/O point

$$cube-to-order = \frac{number\ of\ storage\ locations\ needed}{number\ of\ transactions}$$

Item (SKU)	Locations Needed	Transactions Per Day	COI	Hit Rate per day 1/COI
A	8	4	2	0.50
B	7	1	7	0.14
C	9	3	3	0.33
D	1	1	1	1.00

- D gets the best location, Then A-C-B

Dx from I/O

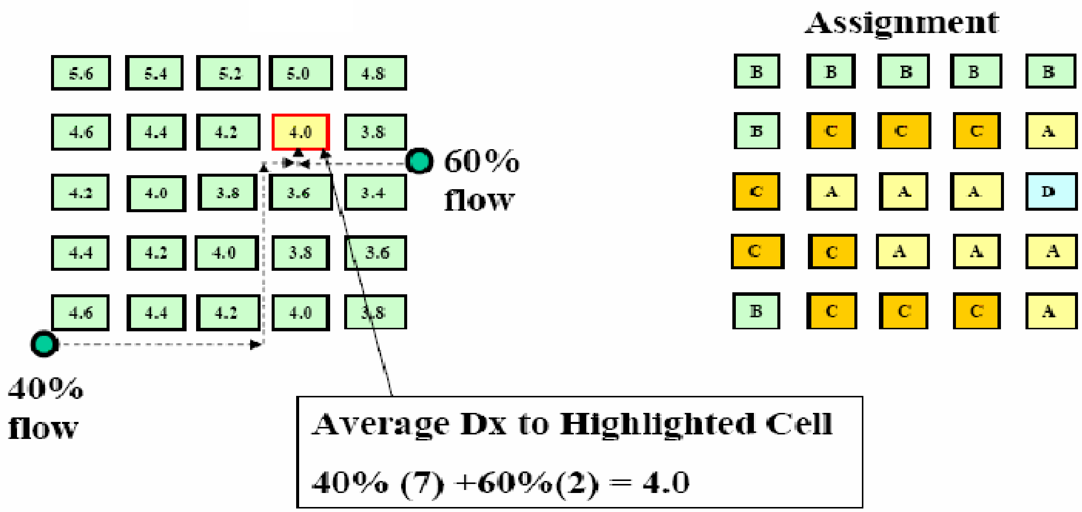
5	6	7	8	9
4	5	6	7	8
3	4	5	6	7
2	3	4	5	6
1	2	3	4	5

Assignment

C	B	B	B	B
C	C	C	C	B
A	A	C	C	B
A	A	A	C	B
D	A	A	A	C

Example 2: Multiple I/O points

Rank order locations using weighted-average dx



Multiply distance for each cell time the expected number of "hits" per time (1/COI).

Cell	Dx	Assigned	Hit Rate	Dx/Day
1	4.60	B	0.14	0.64
2	4.40	C	0.33	1.45
3	4.20	C	0.33	1.39
4	4.00	C	0.33	1.32
5	3.80	A	0.50	1.90
6	4.40	C	0.33	1.45
7	4.20	C	0.33	1.39
8	4.00	A	0.50	2.00
9	3.80	A	0.50	1.90
10	3.60	A	0.50	1.80
11	4.20	C	0.33	1.39
12	4.00	A	0.50	2.00
13	3.80	A	0.50	1.90
14	3.60	A	0.50	1.80
15	3.40	D	1.00	3.40
16	4.60	B	0.14	0.64
17	4.40	C	0.33	1.45
18	4.20	C	0.33	1.39
19	4.00	C	0.33	1.32
20	3.80	A	0.50	1.90
21	5.60	B	0.14	0.78
22	5.40	B	0.14	0.76
23	5.20	B	0.14	0.73
24	5.00	B	0.14	0.70
25	4.80	B	0.14	0.67
				36.068

Expected total distance

Example 3: Materials shipped and received in different amounts

PRODUCT	Qty Rec	Units	Rec. Unit Load	Trips to Rec	Avg. Order Size	Trips to Shipping	S/R
A	40	pallets	1	40.0	1	40.0	1.0
B	100	pallets	1	100.0	0.4	250.0	2.5
C	800	cartons	4	200.0	2	400.0	2.0
D	30	pallets	1	30.0	0.7	42.9	1.4
E	10	pallets	1	10.0	0.1	100.0	10.0
F	200	cartons	3	66.7	3	66.7	1.0
G	1000	cartons	4	250.0	8	125.0	0.5
H	1000	cartons	4	250.0	4	250.0	1.0

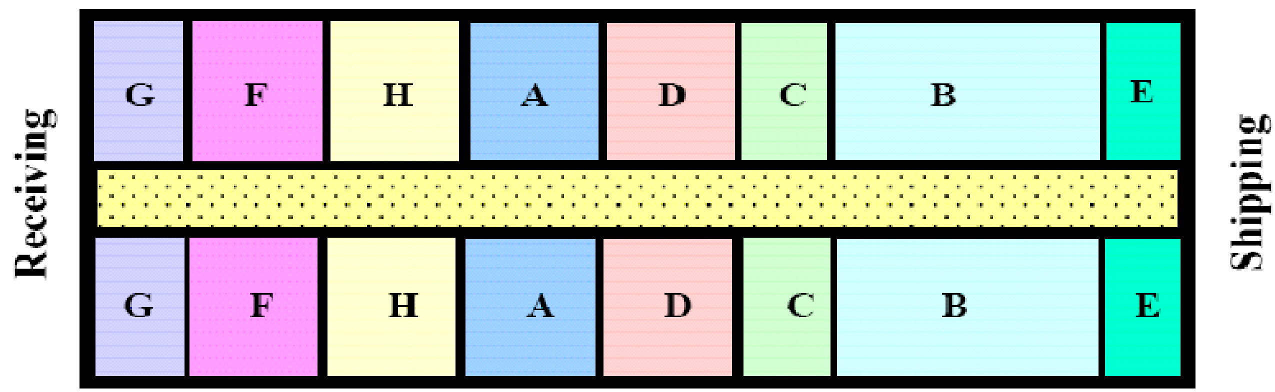
*e.g. for **C**: incoming 800 cartons : takes 200 trips of each 4 cartons to Receiving and takes 400 trips of each 2 cartons to Shipping*

Calculate Shipping/Receiving Ratio

S/R = (Trips To Shipping)/(Trips from Receiving)

- S/R<1 locate nearer to receiving
- S/R>1 locate nearer to shipping
- S/R=1 does not matter

PRODUCT	Qty Rec	Units	Rec. Unit Load	Trips to Rec	Avg. Order Size	Trips to Shipping	S/R	Location
A	40	pallets	1	40.0	1	40.0	1.0	-
B	100	pallets	1	100.0	0.4	250.0	2.5	near shipping
C	800	cartons	4	200.0	2	400.0	2.0	near shipping
D	30	pallets	1	30.0	0.7	42.9	1.4	near shipping
E	10	pallets	1	10.0	0.1	100.0	10.0	near shipping
F	200	cartons	3	66.7	3	66.7	1.0	-
G	1000	cartons	4	250.0	8	125.0	0.5	near receiving
H	1000	cartons	4	250.0	4	250.0	1.0	-



Example 4

Consider the warehouse of which the layout is given below. Storage **bays** are of size 20x20 ft. Dedicated **storage** is used. Rectilinear **travel** is used and is measured between the centroids of storage bays.

Docks P_1 and P_2 are for truck delivery; docks P_3 and P_4 are for rail delivery. Sixty percent of all item movement in and out of storage is from/to either P_1 or P_2 with each dock equally likely to be used. Forty percent of all item movement in and out of storage is equally divided between docks P_3 and P_4.

Three **products**, A, B and C, are to be stored in the warehouse with only one-type product stored in a given storage bay. Product A requires 3600 ft² of storage space and enters and leaves storage at a rate of 750 loads per month ; product B requires 6400 ft² of storage space and enters and leaves storage at a rate of 900 loads per month ; product C requires 4000 ft² of storage space and enters and leaves storage at a rate of 800 loads per month.

Find the optimum dedicated storage assignment

	1	2	3	4	5	6	7	8	
P_1 ↘	9	10	11	12	13	14	15	16	↙ P_3
P_2 ↘	17	18	19	20	21	22	23	24	↙ P_4
	25	26	27	28	29	30	31	32	
	33	34	35	36	37	38	39	40	

(a)

(Answer:

C	B	B	B	B	B		
A	A	C	C	C	B	B	B
A	A	A	A	A	C	C	C
A	A	C	C	C	B	B	B
B	B	B	B	B			

)

Selected topics

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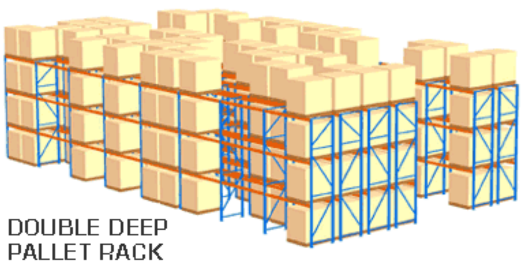
Unit load (pallet) storage alternatives



block stacking (density !)

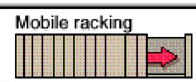
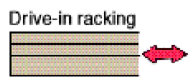
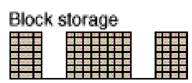
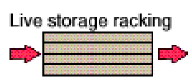
deep lane storage

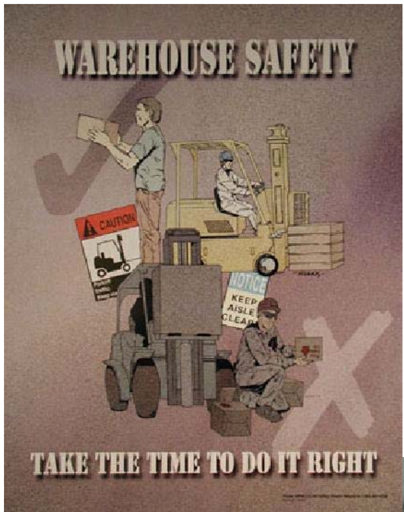
double-deep selective pallet rack

single-deep selective pallet rack (selectivity !)

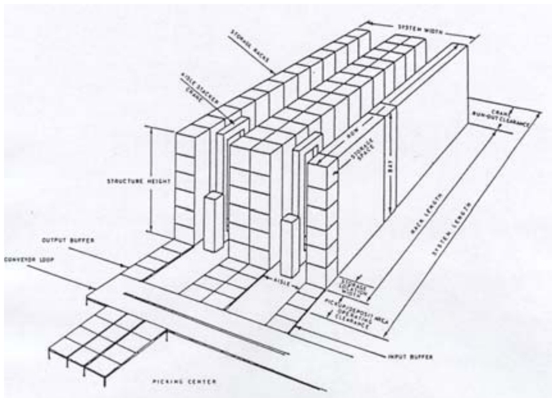
Rack storage: comparison

		% Storage area covered	% Locations normally utilized	% Immediate accessibility	Product damage	% Storage area actually utilized
Mobile racking		85	100	100	Minimum	85
Conventional pallet racking		39	100	100	Minimum	39
Drive-in racking		75	60	10-20	High	45
Block storage		70	70	5-10	High	49
Live storage		75	70	10-20	Normal	53
High bay narrow aisle racking		60	100	100	Minimum	60
Source: J.H. McLain, Storax Inc.						

Warehouse safety



“AS/RS” design

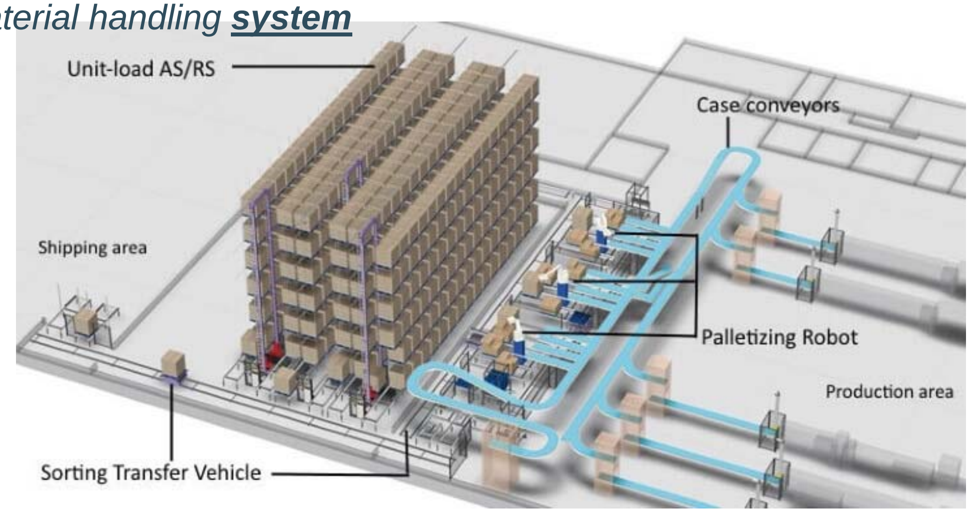


Input-output zone

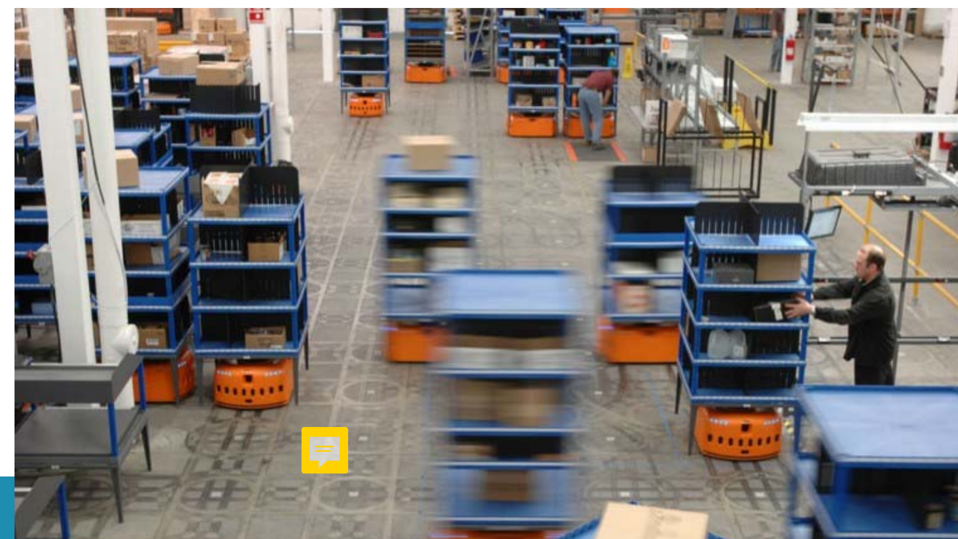
One crane per aisle

One crane serving different aisles

Material handling **system**



Interaction with humans



Some trends

#1: Changed warehousing function

Virtual warehouses	Collaborative supply chains	Outsourcing
Customizer warehousing	Value added DC	Transfer warehousing

Virtual warehouses

Virtual warehouses (multi-warehousing)

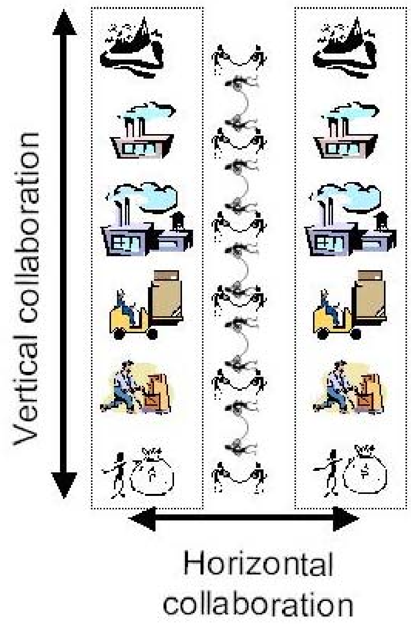
VW considers the various DC as a network. It no longer matters where the merchandise is stored, as long it can be delivered to the customer on time. Storage of merchandise close to the factory is preferred. The requested goods are transported as effciently as possible through the network of DC's when the order comes in. Full truck loads are preferred.

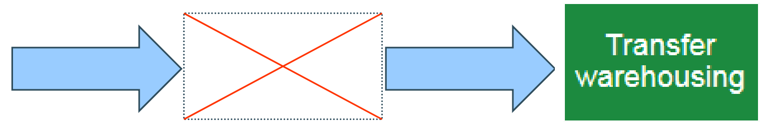
	RDC (80's)	EDC (90's)	VW (00's)
Lead time	<3-5 days	<3-5 days	<1-3 days
Stock availability	Regional	Complete	Complete
Inventory costs	High	Low	Low
Inbound transportation costs	High	Consolidated	Low
Outbound transportation costs	Low	High	Consolidated
Warehousing costs	High	Low	High

Table 1. Comparison old and new supply chain structures.

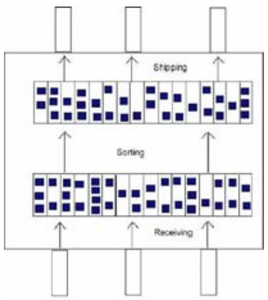
Collaborative supply chain networks

basic components: vertical and horizontal collaboration between organizations





Transfer warehousing



cross-docking

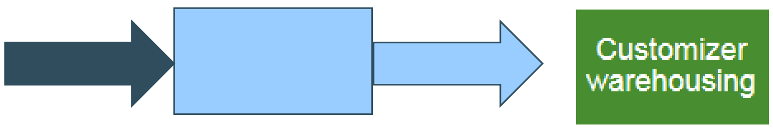
This is the ultimate in rapid handling of finished goods in shippable form between suppliers and customers. When pallets of goods hit the supplier's receiving dock, they are ideally transported directly to the shipping dock for immediate delivery to the customer in pre-set quantities.

flow-through

Able to support manufacturing as well as distribution, flow-thru warehousing is an inventory staging practice that relies exclusively on forward picking locations and fills them with only enough inventory for the immediate future, which can range from some hours to some days.

direct store deliveries,

The manufacturer delivers immediately to the customers site. The goods do not enter any warehouse (RDC, EDC, ...)



Customizer warehousing

order assembly center

- The core competence of these centers is the ability to receive and to collate products from several different warehouses or manufacturing locations into a single order shipment
- Hub-and-spoke, merge-in-transit

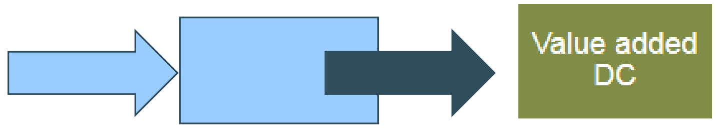
UNITED COLORS OF BENETTON.

postponement system (≈ mass customization)

- Basic idea it to manufacture products in a generic form and store them in bulk as much as possible in anticipation of an order. The variation in products comes in the form of packaging or finishing, this final step is delayed until the customer order is in hand.

adaptable manufacturing

- The philosophy here is to proactively develop subassemblies that can be combined later based on customer needs. It allows to decrease the order cycle time and the finished goods inventory levels.



Value-added service center

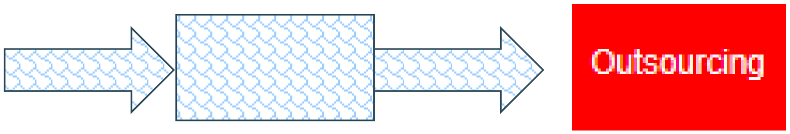
Value-added means performing a task that is beneficial to downstream supply chain operations.

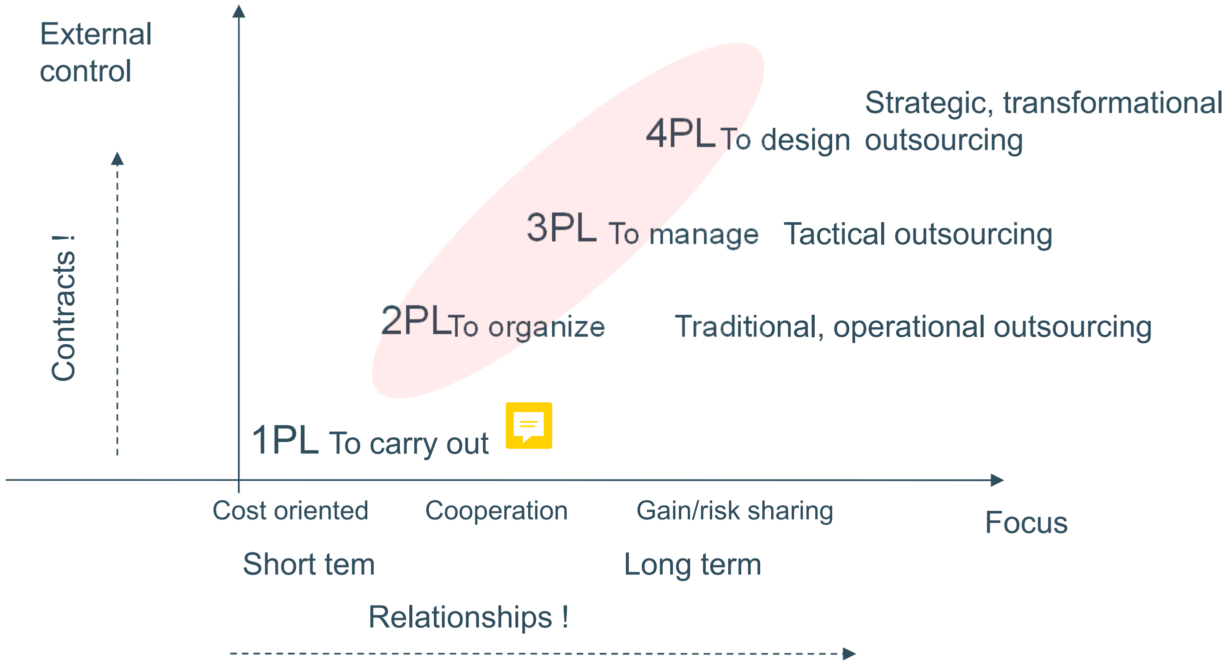
Examples

- **Vendor-managed inventory**, including management of inventory for customers and automatic restocking
- Special packaging (cartons, cases, …) to customer specifications, including speciality mixed packs or kits
- Full preparation of itms for immediate display on shelves or racks at reatial outlets
- Applying price tags and/or identification tags to individual items
- Printing shipping labesl to customer requirements and notifying them with ASN

Management of the **reverse logistics flow**: process of planning, implementing and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value of proper disposal.

Outsourcing





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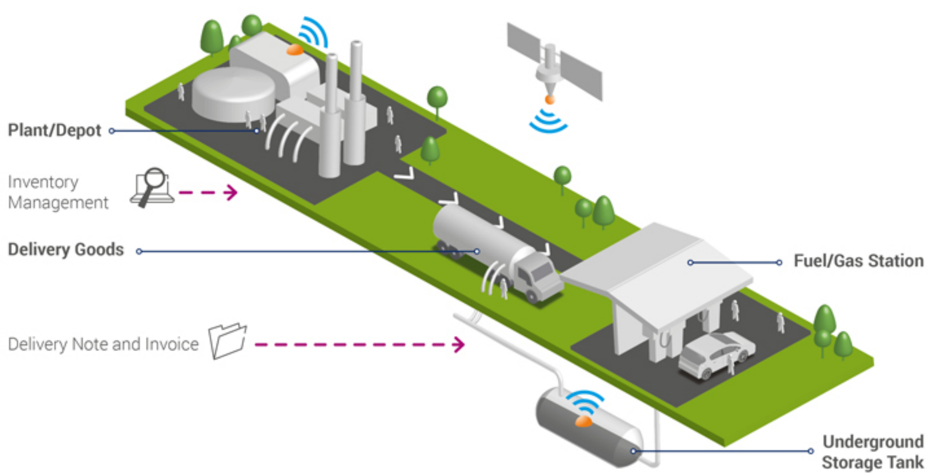
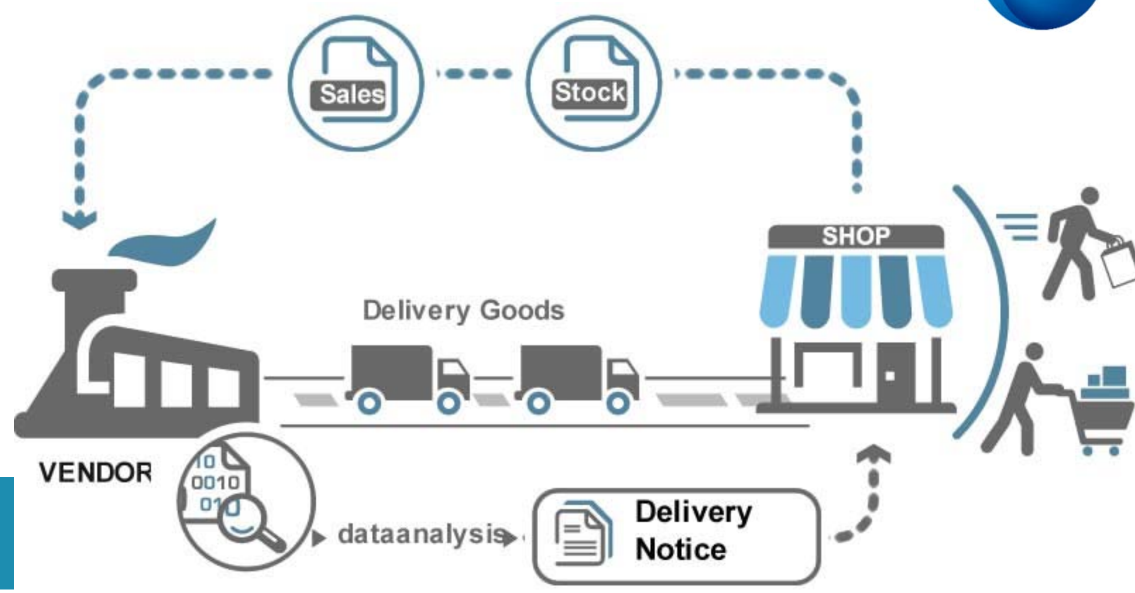
Vendor Managed Inventory



Walmart P&G



#2: Green (sustainable) warehousing

Illustrations

Climate Control in the Warehouse

e.g. cool roofing, insulation

Warehouse Operation

e.g. solar light, pallet tracking, eco-friendly cleaning

Reducing Around the Warehouse

*e.g. charging electrical equipment in non-peak hours, biodegradable packaging mater*ial

Reusing Around the Warehouse

e.g. durable pallets, totes, containers

Recycling Around the Warehouse

e.g. hazardous materials, recycling bins, employee incentives

(http://www.premierhandling.com/latest-news/earth-day-green-warehouse-ideas/)

Many aspects …

Figure 2 Guiding Principles that enable large scale environmental impact reduction

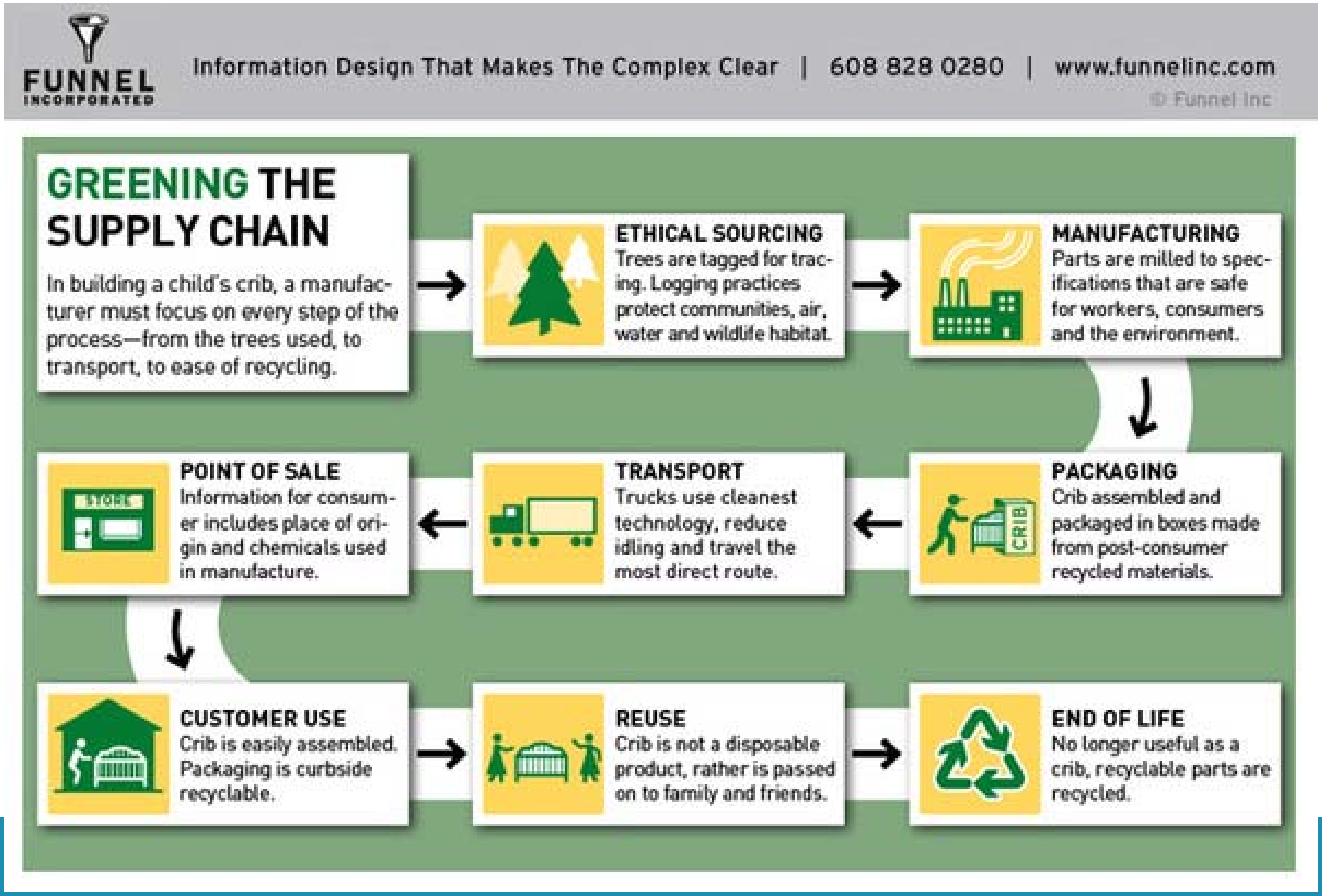
What about the € impact ?

IMPACT ON THE BOTTOM LINE

Parameter	Cost Factor	Cost Driver	Volume Driver	Impact on Bottom Line
Supply Chain Cost Reduction	Handling Storage Transport	$ manhours $/m2/day $/km	# transfers, etc. # storage points, storage time # kilometres	High Medium (depending on value of goods) High
CO_2 Emissions	CO_2 taxation	$/kg CO_2 (modality dependence)	# kilometres	Relatively low
Traffic Congestion	Delays	Manhours lost Delayed replenishment/ out-of-stocks	# vehicles delayed, storage of m2/day	Medium
Infrastructure Simplification	Duplication	Duplication of costs in the supply chain	# storage points/ # of separate chains	High

Source: Global Commerce Initiative, Capgemini

Not only green warehouses, but green supply chain …



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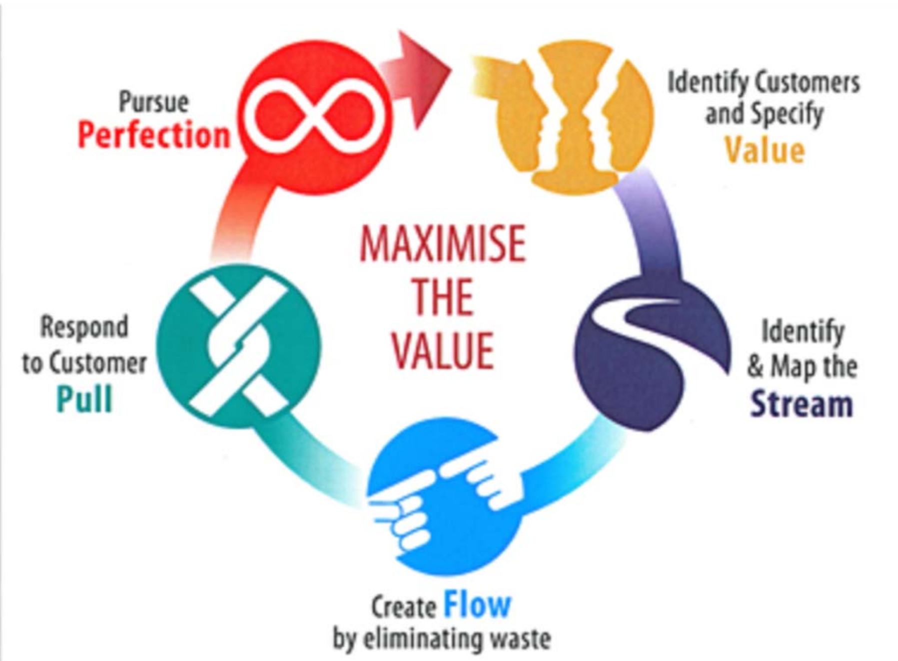
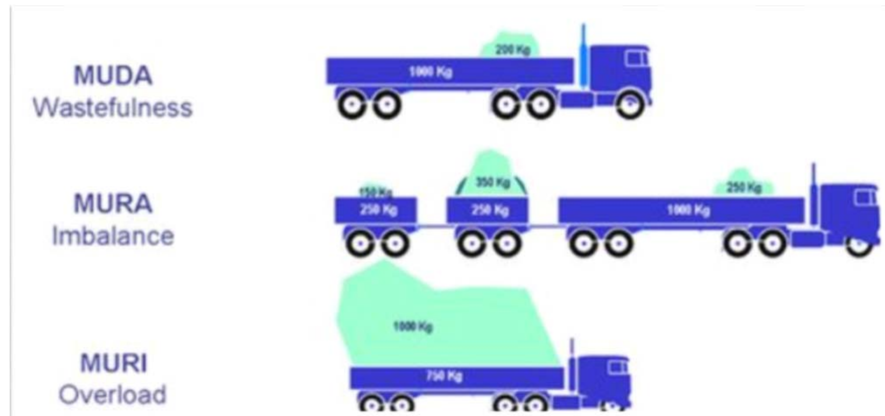
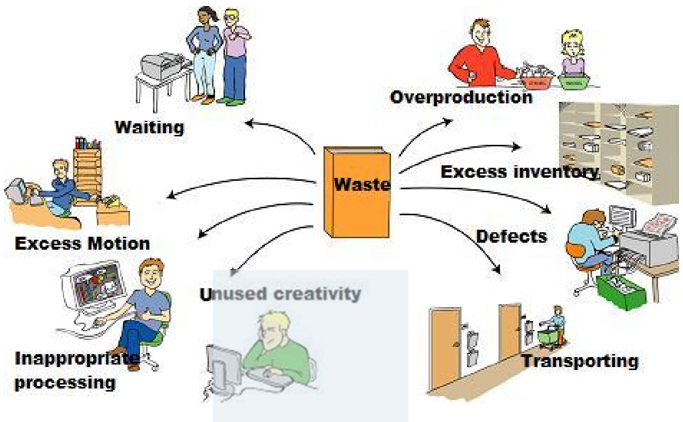
#3: Lean warehousing





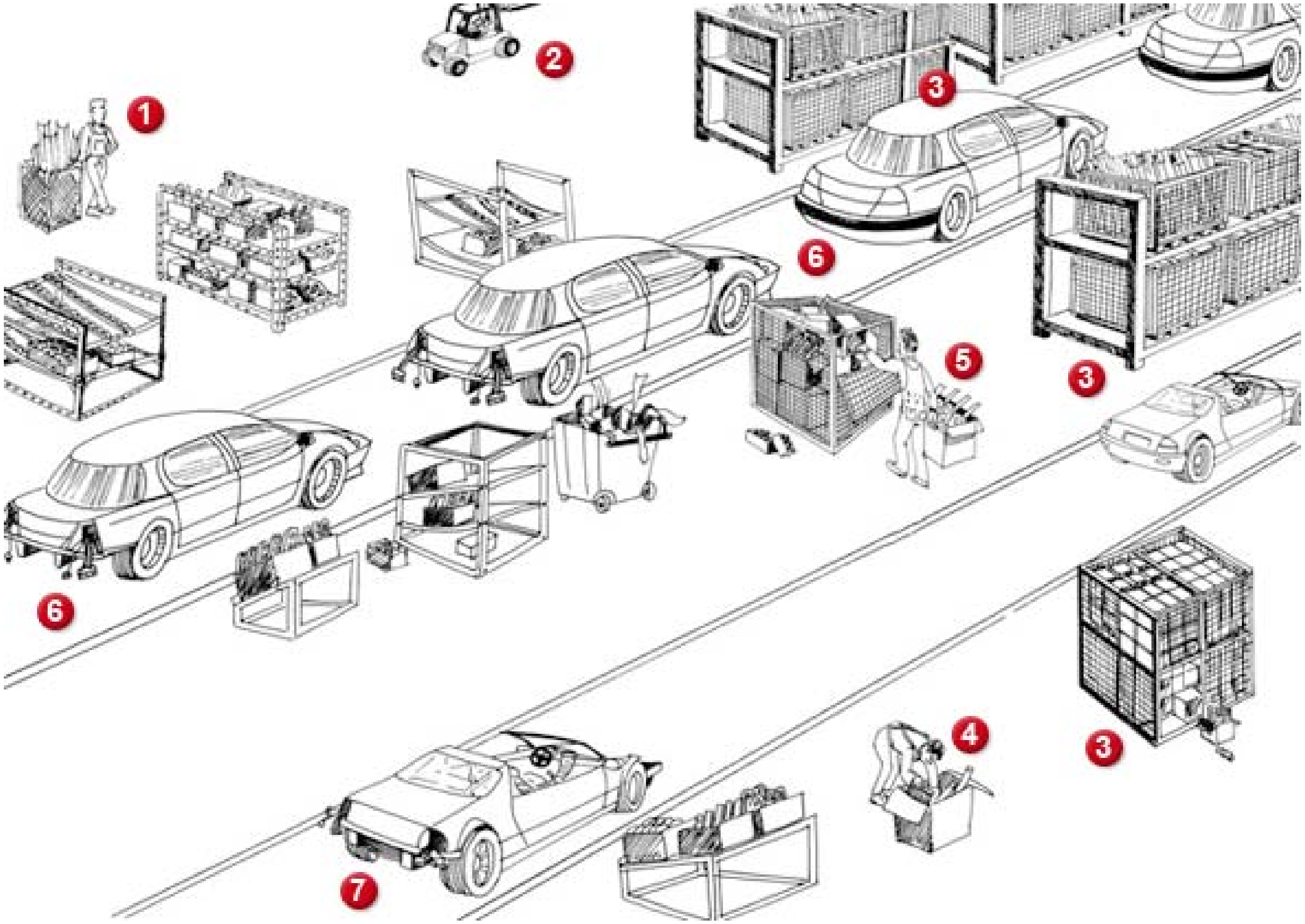
Originated as TPS
Management philosophy (with many tools)

Closer look at the MUDAs



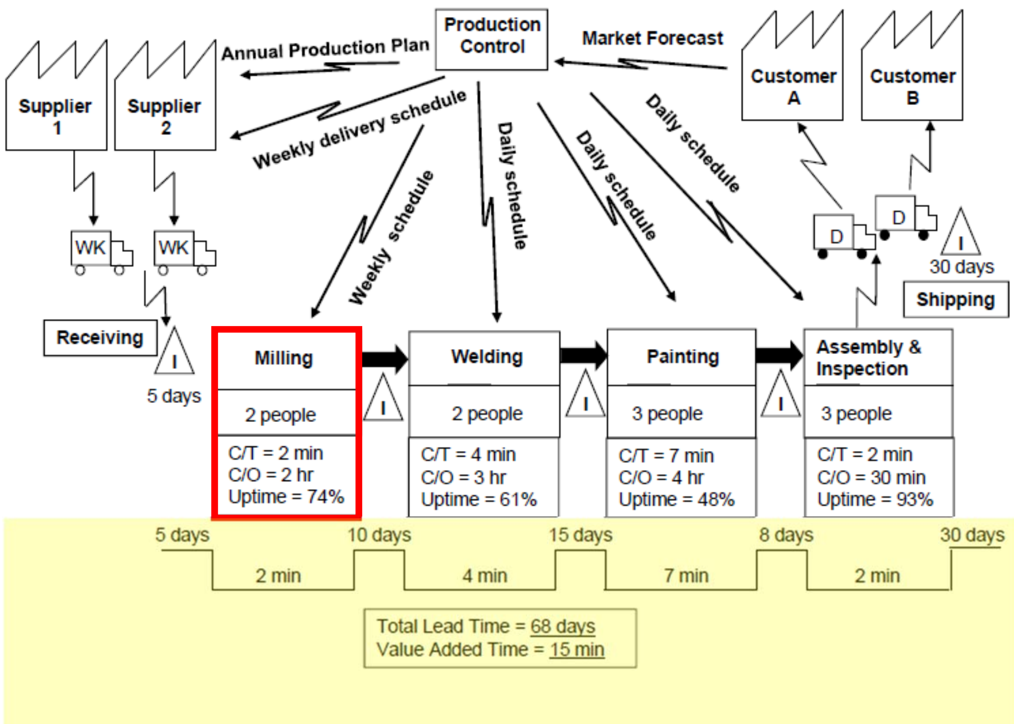
Waste	Definition	Consequences	Ideal state
Overproduction	To produce more or earlier than requested from the customer.	Excessive lead and storage times. Large WIP-stocks and detection of defects are impeded.	To produce what the customers want when they want it.
Waiting	Appears whenever goods are not moving or being processed.	Time is not used efficient, which affects both workers and goods.	No waiting time with a consequent faster flow of goods.
Transportation	Any movement in a production plant that is non-value adding.	Reduced quality due to distance of communication. A fixed cost is generated.	Minimisation of transportation rather than elimination.
Over processing	When too complex solutions are found for a simple task. Over processing can also imply unnecessary machining of a part.	A product is produced with higher quality than required.	Manufacture according to the expected and required quality.
Inventory	Inventory in itself is a waste, since it does not add any real customer value.	Increased lead-time and space. Prevents rapid identification of problems, since they are hidden by the inventory.	Reduced inventory levels.
Motion	Implies ergonomic issues for the employees. To stretch, bend and pick up when these actions could be avoided.	Tiring for the employees. Can lead to poor productivity and quality problems.	Unnecessary motions are eliminated.
Defects	Products with faults.	Defects result in either discard or reprocessing, both costly for the company.	Zero defects.

Identifying the types of waste on the workfloor

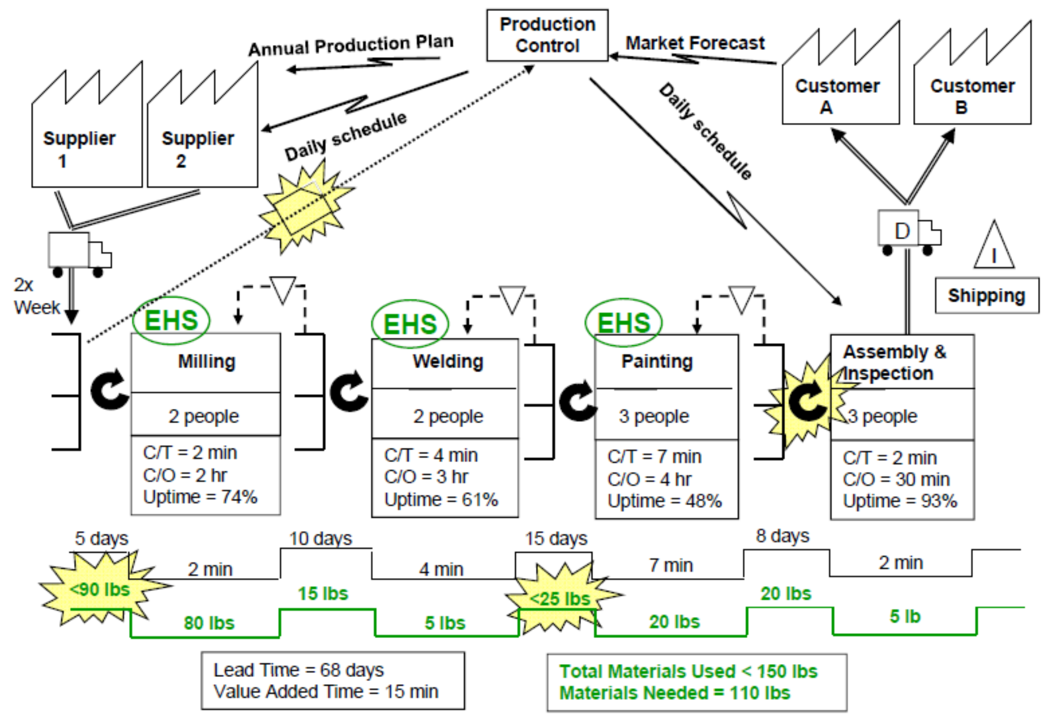


Typical lean tool : Value stream mapping (VSM)

Current state map



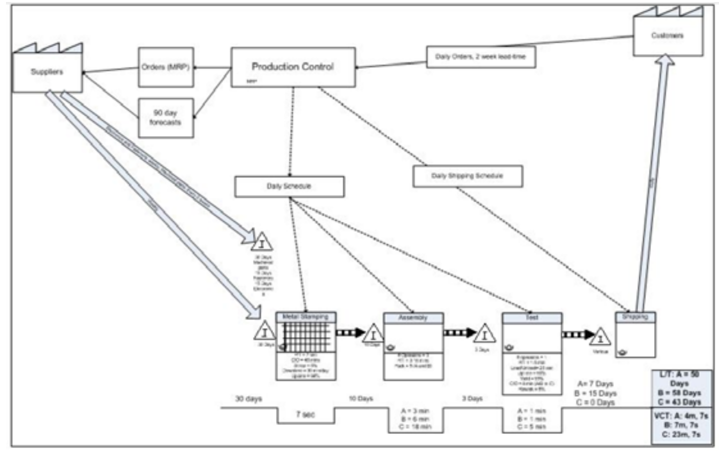
Future state map



http://www.epa.gov/lean/environment/toolkits/environment/ch3.htm

EXAMPLE

MED DEVICE ONLINE



Guest Column | July 17, 2015

Value Stream Mapping For Medical Device Companies

Terminology of a “lean warehouse”

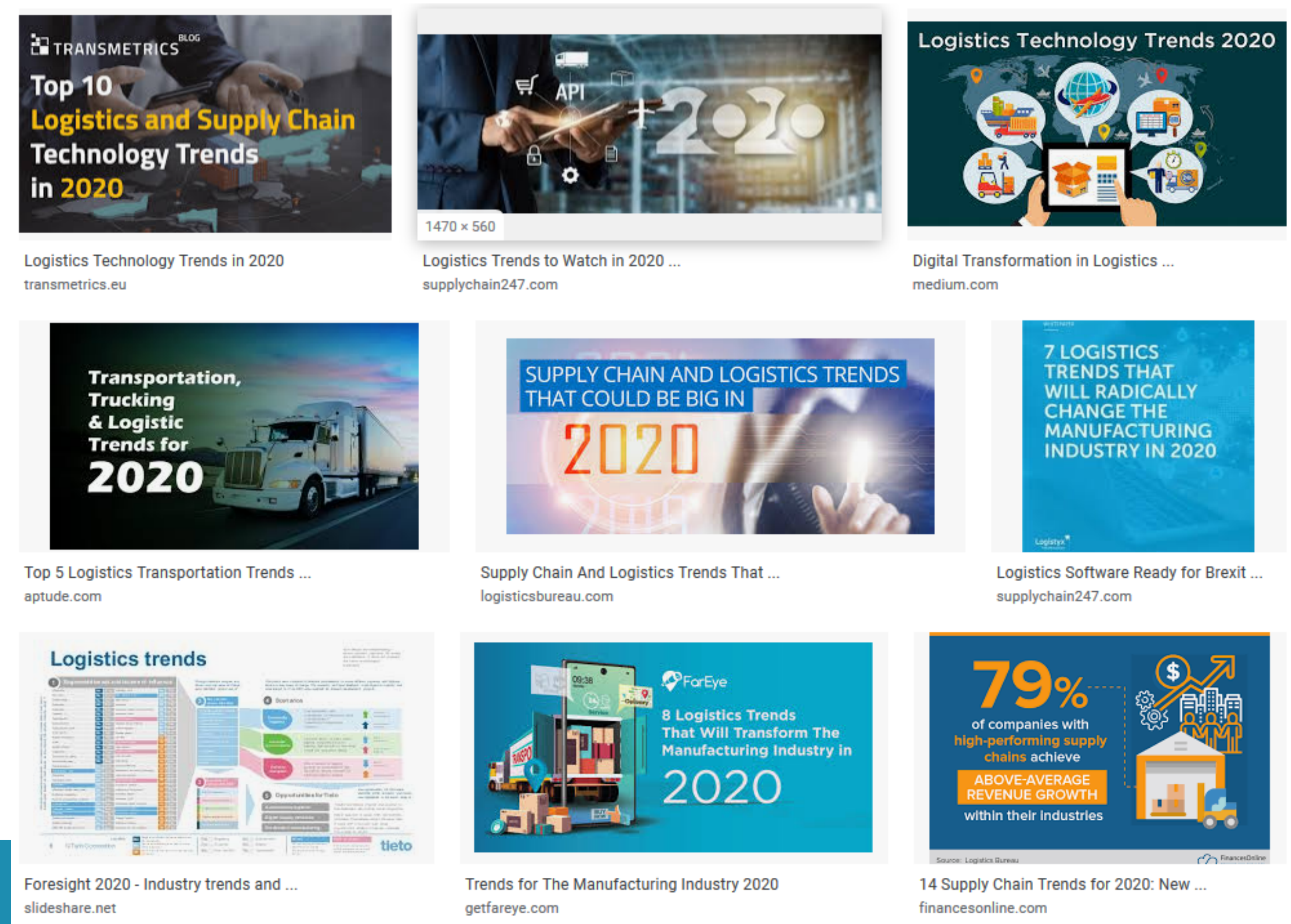
(http://www.leancor.com/blog/wp-content/uploads/2013/11/lean-warehousing.jpg)

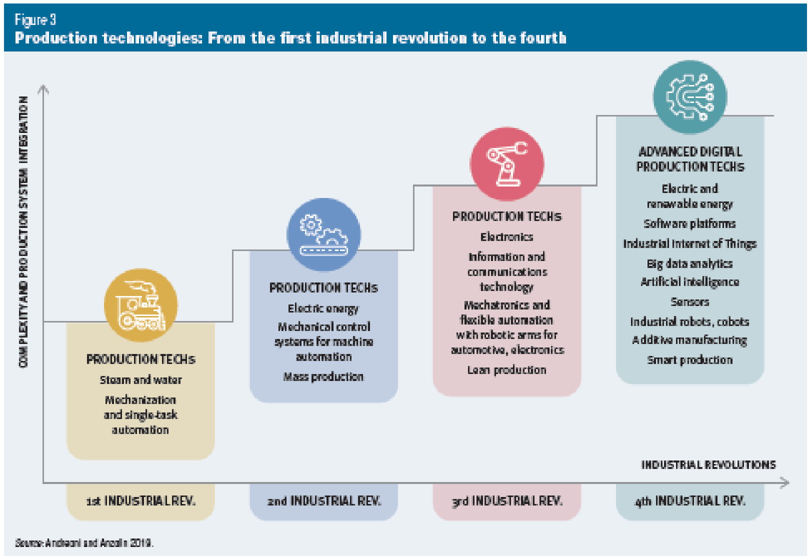
#4: Predicting 2020 (and beyond)

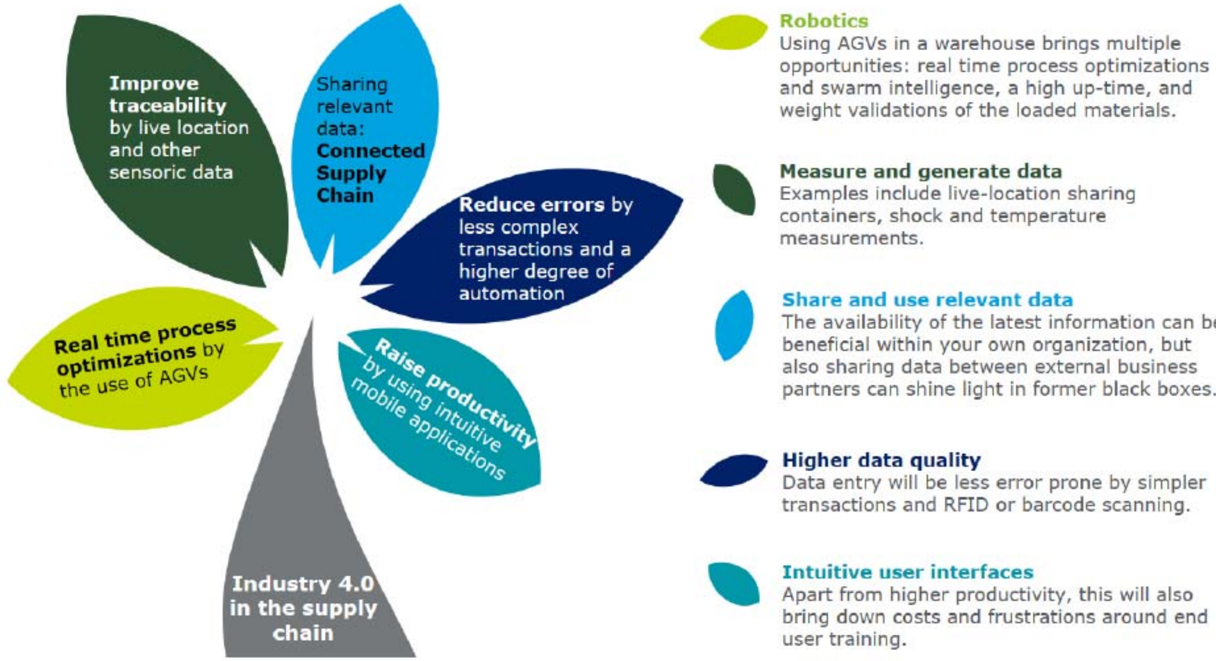
Lots of papers & publications

Some take-aways:
Automation
    robots, cobots, drones, AGV
AI – big data
Wearables
Blockchain

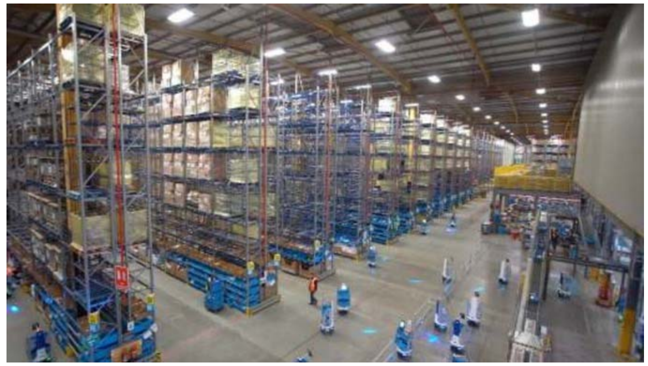
also
impact of new business models
and supply chain choices

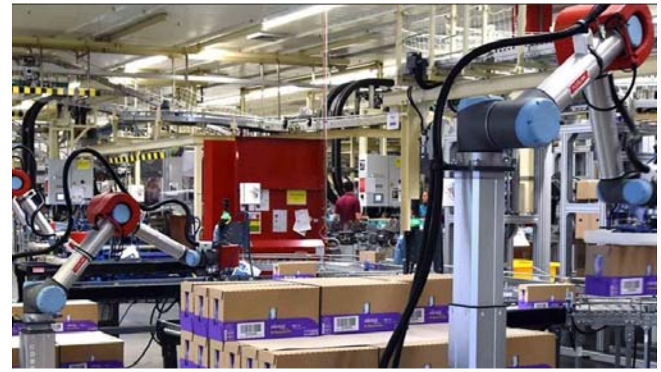


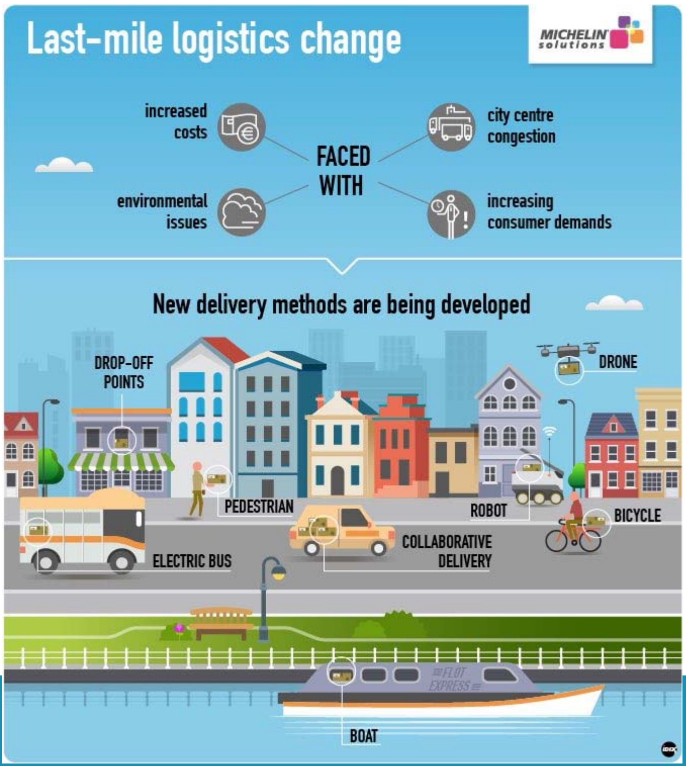




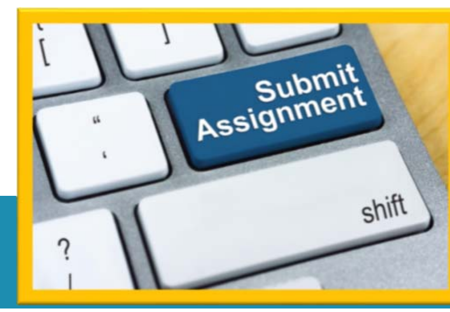
(Deloitte, 2020)






Last-mile logistics change
MICHELIN solutions
increased costs
city centre congestion
FACED WITH
environmental issues
increasing consumer demands
New delivery methods are being developed
DROP-OFF POINTS
DRONE
PEDESTRIAN
ROBOT
BICYCLE
ELECTRIC BUS
COLLABORATIVE DELIVERY
BOAT


Augmented Reality and Warehouse
Aisle 17
Shelf 3


Submit Assignment
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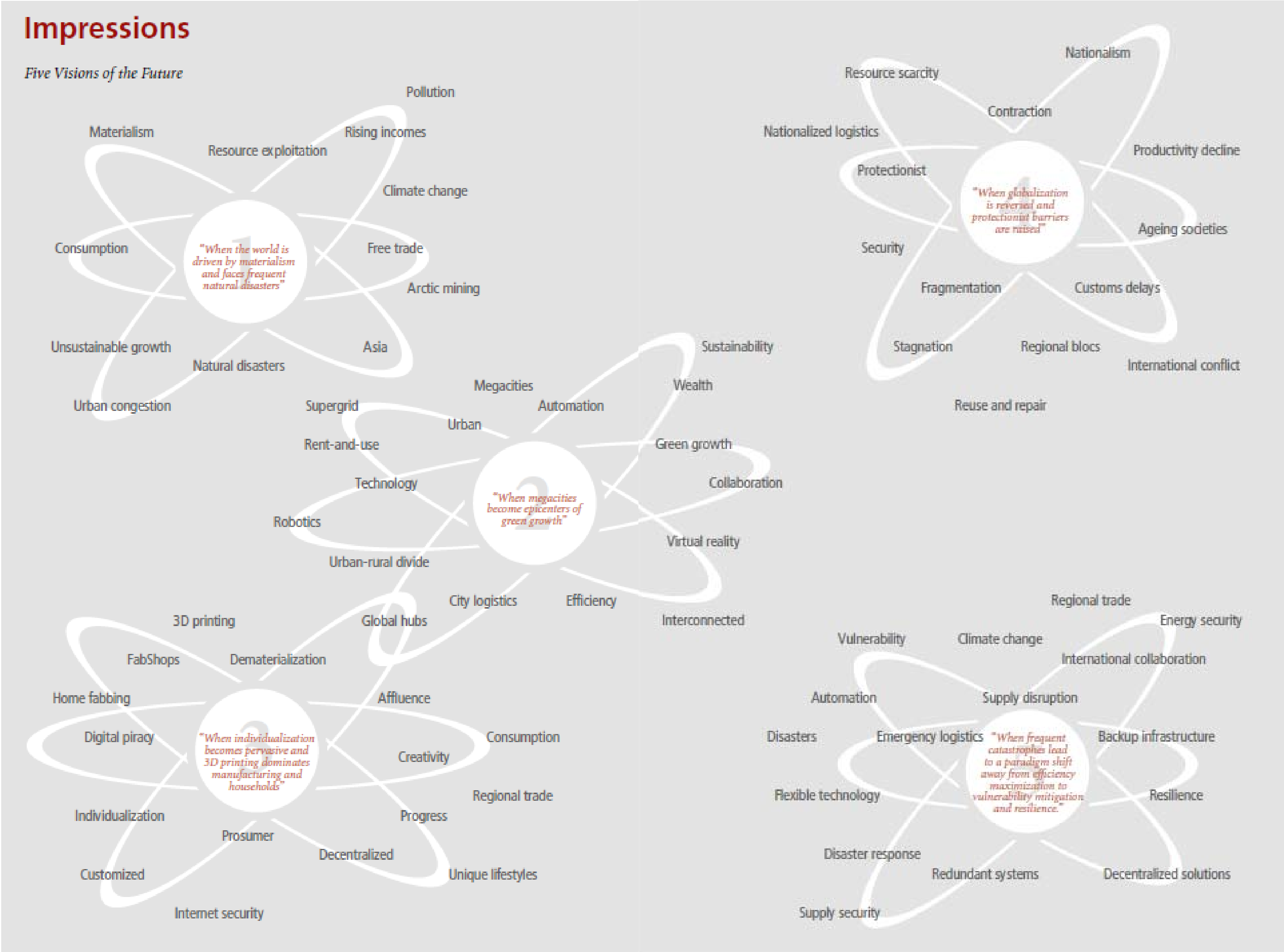
“Logistics 2050”



(Ehrhart, 2012: Logistics 2050)

MATERIAL HANDLING & LOGISTICS U.S. ROADMAP 2.0

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MATERIAL HANDLING & LOGISTICS U.S. ROADMAP 2.0

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CONTENTS

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EXAMPLE

MATERIAL HANDLING & LOGISTICS U.S. ROADMAP

WORTH NOTING

Additive Manufacturing

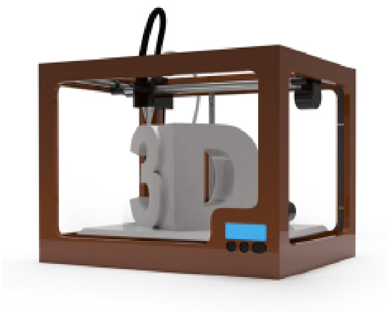
Additive manufacturing (often called "3D printing" in the popular press) is the process of forming a three-dimensional object from a powder or other raw, bulk material. The type of object formed is almost arbitrary—as long as it can be represented in digital form.

The ability to create "almost anything out of almost nothing" understandably has captured the attention of the public, and the potential implications are profound. Entire new models of manufacturing could spring up, with "plants" located in basements and garages everywhere. It is also possible that economics or regulation would constrain the technology to more traditional, large-scale manufacturing methods and sites.

ADDITIVE MANUFACTURING IS LIKELY TO ADD TO THE TREND TOWARD "MASS PERSONALIZATION," AS CUSTOMERS GAIN THE ABILITY TO CUSTOM-DESIGN PRODUCTS IN SOME CASES

Implications for logistics systems

Where this technology will lead by the year 2025 is a matter of speculation, but some things are pretty certain. First, additive manufacturing is likely to change the spare parts industry, allowing firms to eliminate stock of legacy items and to replace them with digital representations and the ability to make on demand. For example, makers of industrial vehicles such as John Deere and Kubota currently must hold replacement parts for decades because the vehicles they produce are in service for that long. Holding thousands of part types for hundreds of vehicles over decades leads to enormous quantities of slow- and non-moving inventory, much of which could be eliminated by additive manufacturing.



Second, additive manufacturing is likely to add to the trend toward "mass personalization," as customers gain the ability to custom-design products in some cases. This trend would increase the demand for B2C distribution channels.

Third, significant additive manufacturing would create the need to handle and transport bulk raw materials to new points—perhaps many new points—of manufacture. It is conceivable that many of these new "manufacturing plants" would be very small, and that bulk replenishment would be in very small batches.

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#5: “Past predictions”

EXAMPLE

21 warehousing trends
in the 21st century

Which innovations

are likely to have staying power?

21 warehousing trends in the 21th century, Thompson Brockmann, IIE Solutions, July 1999, pp 36-40

	Trends
1	Focussing on the customer
2	Consolidation
3	Continuous flow of material and information
4	Value-added services
5	Information technology
6	Space compression
7	Time compression
8	Distribution requirements planning
9	Reverse logistics
10	Leadership
11	Crossdocking
12	Warehousing for customers
13	The paperless warehouse
14	EDI and the internet
15	Supply chain synthesis partnering
16	Customized warehousing
17	Third-party warehousing
18	Performance measurement
19	The incredibly shrinking order
20	Automation
21	Educated workforce

Stuff-to-think-about

“Density”

Car parking

What benefits do you see ?
What about drawbacks ?

Hotel

“Maturity”

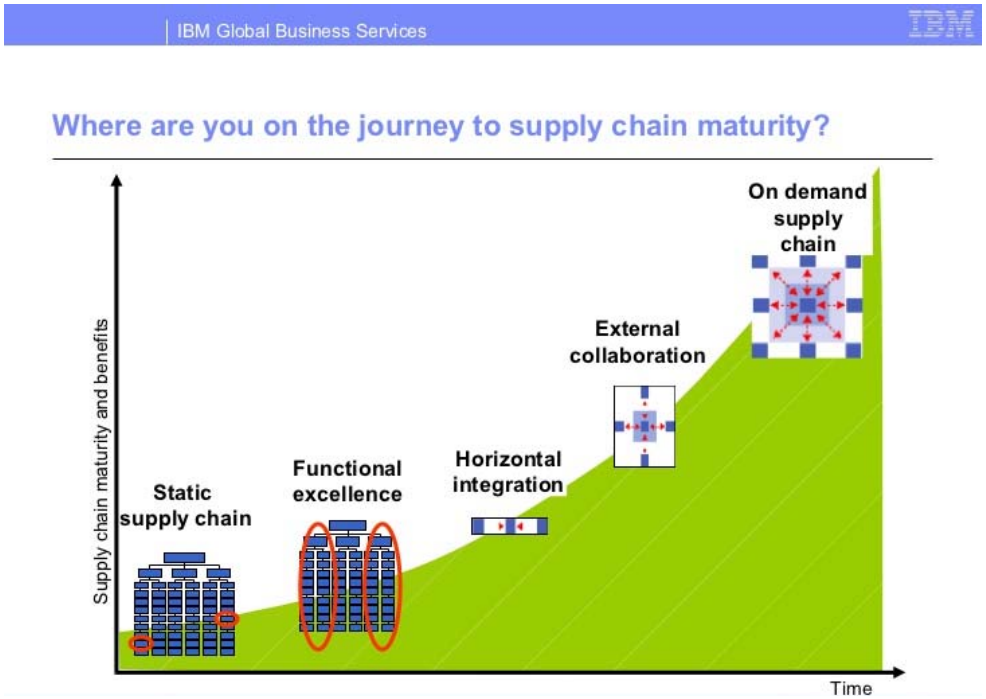
Tabel 2 - Toelichting maturiteitsmodel

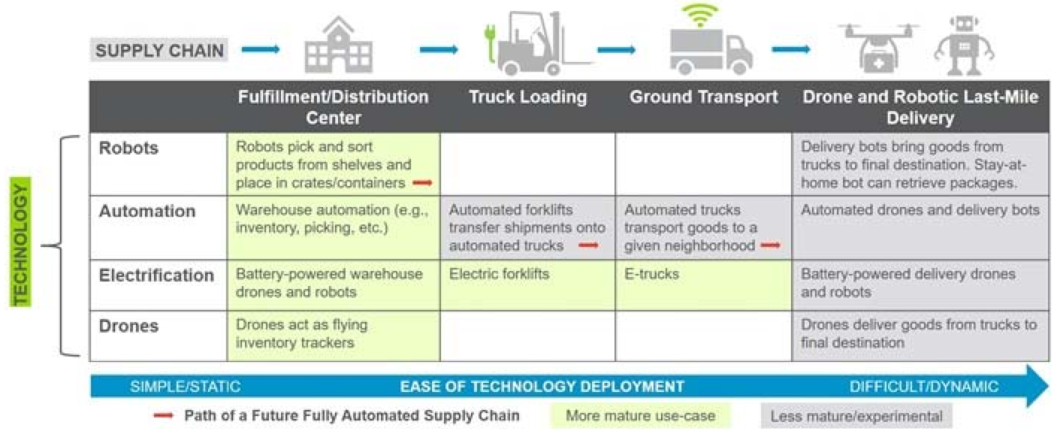
Maturiteit	Toelichting	Binnen Dyplor
Reactief	De basis voor een operatie waarbij de processen onvoldoende of op functioneel niveau werden opgetekend, er regelmatige bijsturing nodig is van de activiteiten en beheersystemen die niet op correcte wijze opgezet of aangewend worden.	• Proces- en knelpuntanalyse • Opstellen registratiepunten
Effectief	Het formaliseren en standaardiseren van het beheer van het magazijn. Vanuit een strategisch, tactisch en operationeel standpunt worden de afspraken met ketenpartners vastgelegd, interne processen en procedures uitgewerkt, en indicatoren en KPI’s bepaald.	• Opstellen van normtijden • Analyse van prestatie-indicatoren
Responsief	Via het aanwenden, beter integreren of beter benutten van technologie en IT (bv. WMS) een betere inzage verkrijgen, sneller kunnen anticiperen en effectiever kunnen bijsturen.	• Gap analyse van WMS systemen
Collaboratief	De operatie bekijken vanuit het standpunt van een distributieketen en de interactie met de ketenpartners verder uitdiepen om betere voorspellingen en beslissingen te maken betreffende planning.	• Informatie-uitwisseling met ketenpartners

Bron: Jeroen van den Berg, Highly Competitive Warehouse Management, 2012.

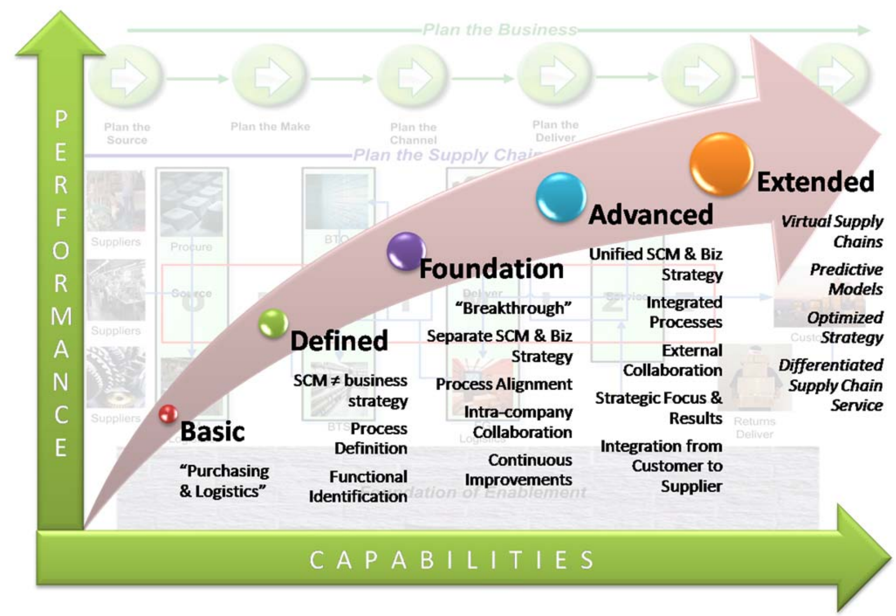
Many different models exist
Interesting subject

Warehousing as part of SCM !

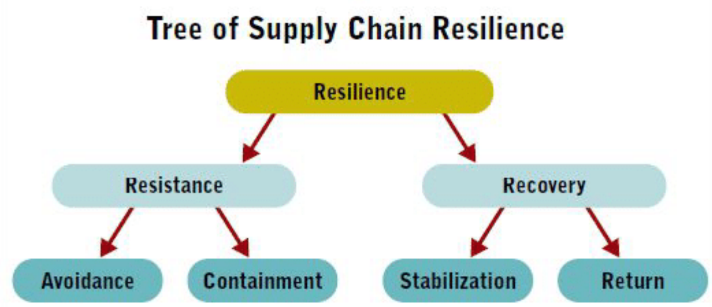




	Fulfillment/Distribution Center	Truck Loading	Ground Transport	Drone and Robotic Last-Mile Delivery
Robots	Robots pick and sort products from shelves and place in crates/containers			Delivery bots bring goods from trucks to final destination. Stay-at-home bot can retrieve packages.
Automation	Warehouse automation (e.g., inventory, picking, etc.)	Automated forklifts transfer shipments onto automated trucks	Automated trucks transport goods to a given neighborhood	Automated drones and delivery bots
Electrification	Battery-powered warehouse drones and robots	Electric forklifts	E-trucks	Battery-powered delivery drones and robots
Drones	Drones act as flying inventory trackers			Drones deliver goods from trucks to final destination



“Resilience”



Source: Michigan State University

Resilience and innovation at Gap Inc.

Just months before the start of the 2016 holiday season, one of Gap Inc.’s distribution centers was destroyed by fire. Here’s the story of how resilience and innovation saved the day.

Twitter Facebook Linkedin

By Bob Trebilcock · November 12, 2018

System Report in the News

Latest Whitepaper

Wrap-up

Important issues

Terminology

Basic insights

e.g. dedicated vs randomized storage, selectivity vs density, …

“Big picture”

warehouse < supply chain & logistics < business

very dynamic environment

Evolution

e.g. automation (see also other chapters)