



**Material Handling & Logistics**  
**CONFERENCE**  
SPONSORED BY DEMATIC

# **Storage - The 10 Levels of Pallet Storage Technology**

**Track 5 Session 7**



# Marc Wulfraat

---

- Title: President
- Company: MWPVL International Inc.
- Email: [Marc.wulfraat@mwpvl.com](mailto:Marc.wulfraat@mwpvl.com)
- Phone: 514 - 482-3572 x 100
- Website: <http://www.mwpvl.com>

# Roger Stubbs

---

- Title: Global Product Manager
- Company: Dematic
- Email: [roger.stubbs@dematic.com](mailto:roger.stubbs@dematic.com)
- Phone: 616-913-7883
- Website: [www.dematic.com/na](http://www.dematic.com/na)



# Abstract

**The alternatives available to store pallets today are many and span from conventional manual handling to lights-out deep lane ASRS. This session will expose you to a broad array of technologies and compare them in terms of investment, ROI, physical capabilities, pros, cons, best fit applications and operational implications. This is a great overview for the poor soul who thinks that technology implies mile-high rack systems that require an oil well and PhD to own and operate. New hybrid solutions will pleasantly surprise you!**

# Acronyms Used

Acronym	Definition
HBW	High Bay Warehouse
ASRS	Automated Storage and Retrieval System
SRM	Storage and Retrieval Machine also known as a crane
LHD	Load Handling Device
AGV	Automated Guided Vehicle or Laser Guided Vehicle
WCS	Warehouse Control System
FPM	Feet Per Minute
P&D	Pickup and Drop Stations - refers to the stations where cranes pickup and drop off pallets
PPH	Pallets per Hour

# Agenda & Scenario Definitions

Scenario	Conventional Vs. Automated	Mobile Equipment	Equipment Lift Height	Racking System
1	Conventional	Forklift Truck – Narrow Aisle	35.2' (422")	Single Deep
2A-2F	Conventional	Forklift Truck – Narrow Aisle (“Best Case”)	42.1' (505")	Single Deep, 2-deep Push-Back through 6-deep Push-Back
3	Conventional	Swing-Reach Truck – Very Narrow Aisle (VNA)	42.8' (514")	Single Deep
4	Automated	AGV with Turrett Forks - VNA	35.0' (420")	Single Deep
5	Automated	AGV With Forks – Narrow Aisle	21.5' (258")	Single Deep
6A-6C	Automated	ASRS With Rotating Fork	54.0' (648")	Single Deep, 2-3 Deep Push-Back
7A-7C	Automated	ASRS With Aisle Captive SRM	105.3' (1264")	1-Deep. 2-Deep, 3-Deep Static Rack
8	Automated	ASRS With Aisle-Changing SRM	104.0' (1248")	Single Deep
9A-9B	Automated	ASRS With Dual Mast SRM	104.0' (1248")	1-Deep & 2-Deep Rack
10	Automated	ASRS With SRM With Mole	104.0' (1248")	6-Deep Static Rack

# Scenario 1: Manual Forklift

- **Narrow Aisle Forklift**  
**Lifting 3500 LB pallets up to 422" (35.2')** in a **Conventional Single Deep Warehouse**
  - E.g. Hyster N45ZR Narrow-Aisle Single Reach Truck
  - Selective Single Deep Racking System
  - Works in a 10'-6" (126") operating aisle (i.e. narrow aisle operation)
  - Standard conventional forklift truck



# Scenario 2A – 2F: Manual Forklift

- **Narrow Aisle Forklift lifting 3200 LB pallets up to 505” (42’) in a Conventional 1-Deep through 6-Deep Pushback Racking System**

- E.g. Crown RM 6000 S Class Narrow-Aisle Reach truck launched in 2011
- “Monolift” is a Pantograph mast originally designed for Turret trucks and differs from the traditional dual mast
- Forks capable of rising 153 FPM unloaded
- Works with Single/Double Deep static racks and 2 to 6-deep pushback racks
- Works in a 10’-6” (126”) operating aisle
- Most suitable where space is expensive and height is required



[Click Here for Movie](#)

# Scenario 3: VNA Swing-Reach Truck

- **Very Narrow Aisle Swing-Reach Forklifts are capable of lifting 3000 LB pallets up to 514" (42.8') in a Conventional Single Deep Warehouse**
  - E.g. Raymond 9700-CSR30T Swing-Reach Truck
  - Works with Single Deep Racks
  - Works in 72" Very Narrow aisles without wire guidance
  - Most suitable where space is expensive and velocity is slow - or receiving and shipping are on separate shifts



[Click Here for Movie](#)



# Scenario 4: VNA AGV w/Turrett Forks

- **Automated Laser-Guided Vehicle lifts 2,200 LB pallets up to 420” (35’)**
  - E.g. Dematic FlexVNA AGV
  - Counterbalance AGV works in 80” Very Narrow Aisles with laser-guidance system
  - Works with Single or Multi-Deep Racks
  - Forks capable of rising 65 FPM
  - Suitable where space is expensive and throughput requirement is high



[Click Here for Movie](#)

# Scenario 5: Narrow Aisle AGV w/Forks

- **Automated Laser-Guided AGV lifts 2,000 LB pallets up to 258” (21.5’) in a Single Deep Environment**
  - E.g. Dematic Flex Truck AGV
  - Counterbalance AGV works in 12’ (144”) Aisles with laser-guidance system
  - Forks capable of rising 42.5 FPM
  - Works with Single or Multi-Deep Deep Racks
  - Most suitable where flexibility is needed for multiple vehicles to work in the same aisle



[Click Here for Movie](#)

# Scenario 6A – 6C: ASRS Rotating Forks

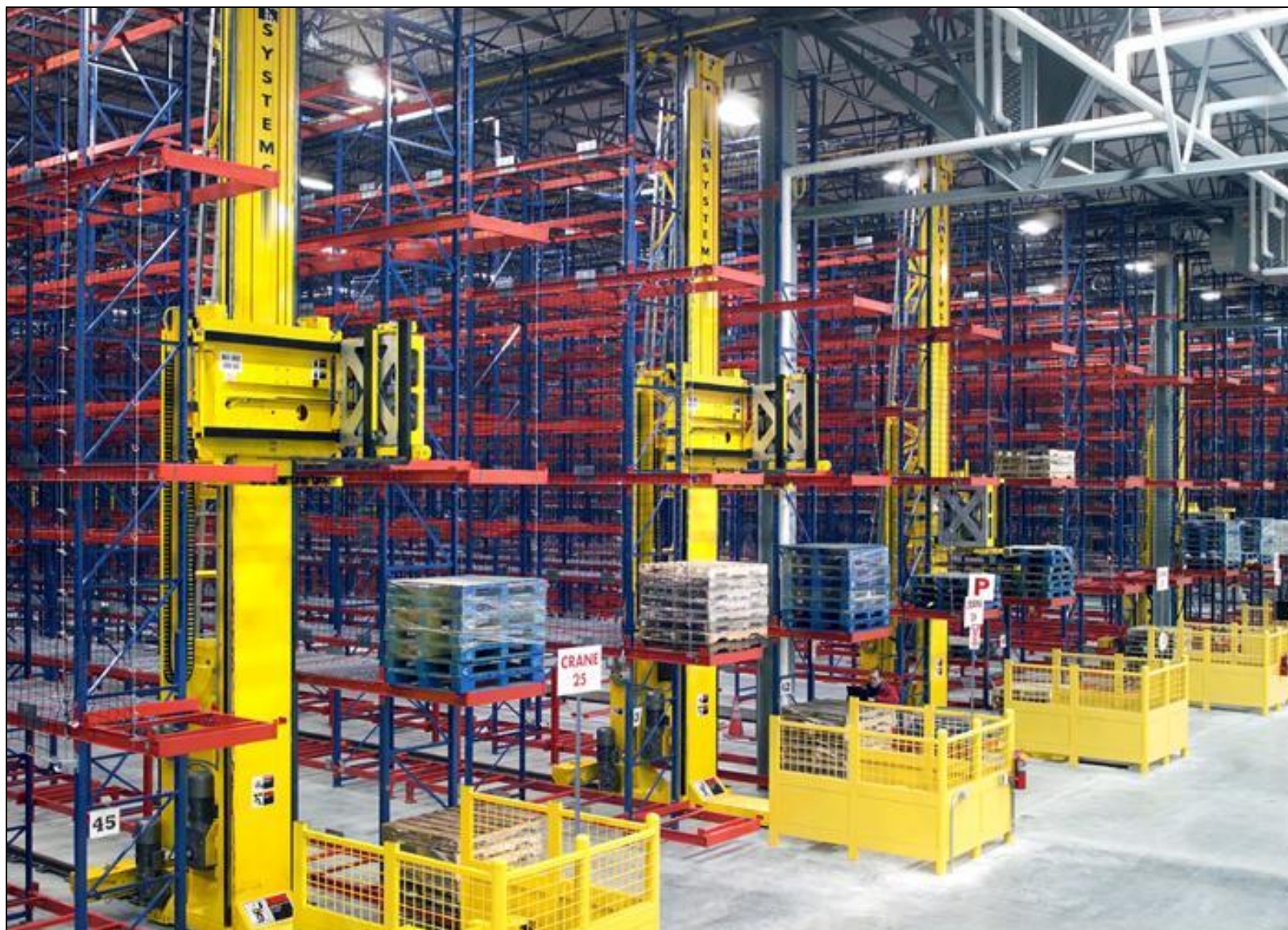
- **ASRS with Rotating Fork lifts 3,000 LB pallets up to 648” (54’)**
  - E.g. Dematic RapidStore UL 1400
  - Works in a single-deep, captive aisle environment as well as 2-deep and 3-deep push-back
  - Horizontal Speed: 350 FPM
  - Vertical Speed Empty/Loaded: 58/35 FPM
  - Works in Freezers & Coolers
  - Low bottom beam required at 8” up to 40’ and 12” for 40’ – 60’
  - Suited for case picking applications



[Click Here for Movie](#)

# Stop & Shop Installation Freetown, MA

78 Rotating Fork Single Deep RapidStore UL 1400 SRMs



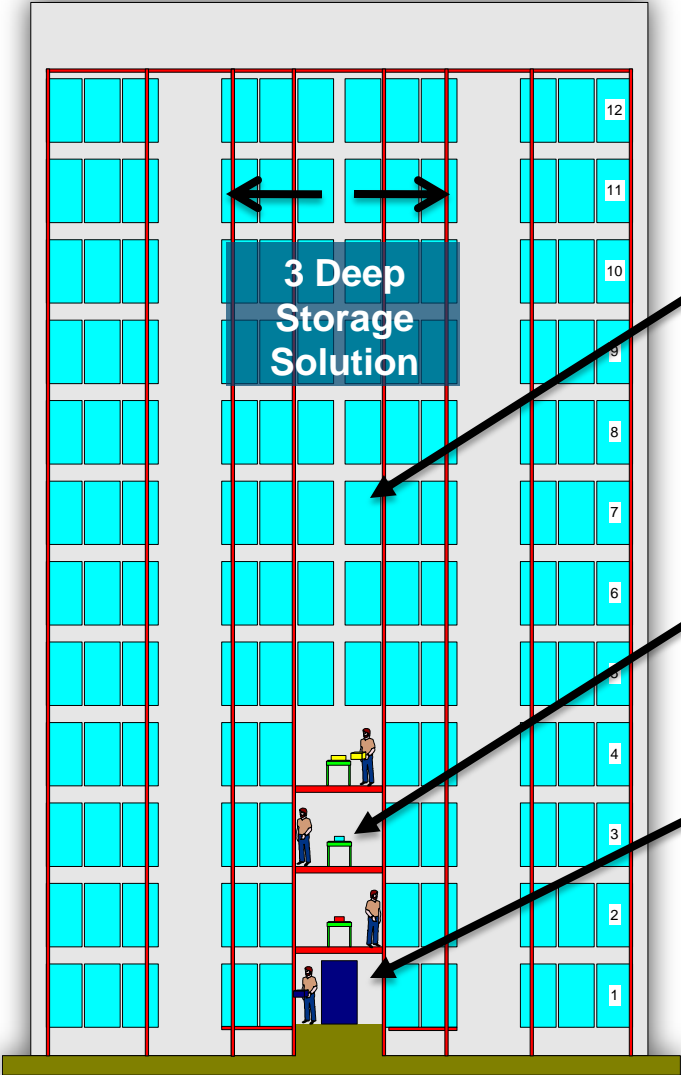
# Scenario 7A-7C: ASRS Captive-Aisle SRM

- **ASRS lifts 4,000 LB pallets up to 1263" (105.3') in a 1-Deep, 2-Deep or 3-Deep Static Rack Environment**
  - E.g. Dematic RapidStore UL 1800
  - Horizontal Speed: 900 FPM
  - Vertical Speed Empty: 210 FPM
  - Vertical Speed Loaded: 155 FPM
  - Z-Axis Speed: 200 FPM
  - Single/double/triple telescopic forks
  - Works in Freezers & Coolers
  - Workhorse for high-lift / high-density / high throughput requirements
  - Good for Pick to Pallet and Pick to Belt Applications

[Click Here for Movie](#)



# Scenario 7A-7C: 1,2,3-Deep Storage



*Product Storage*

*Pick-to-Belt*

*Pick-to-Pallet*



# Scenario 8: ASRS with Aisle-Changing SRM

- **ASRS lifts 3,300 LB pallets up to 1248” (104’) in a Single Deep or 2-deep Environment**
  - E.g. Dematic RapidStore UL 1500
  - Horizontal Speed: 790 FPM
  - Vertical Speed Loaded: 295 FPM
  - SRM can service multiple aisles to reduce capital investment
  - Suitable for slower throughput applications



[Click Here for Movie](#)

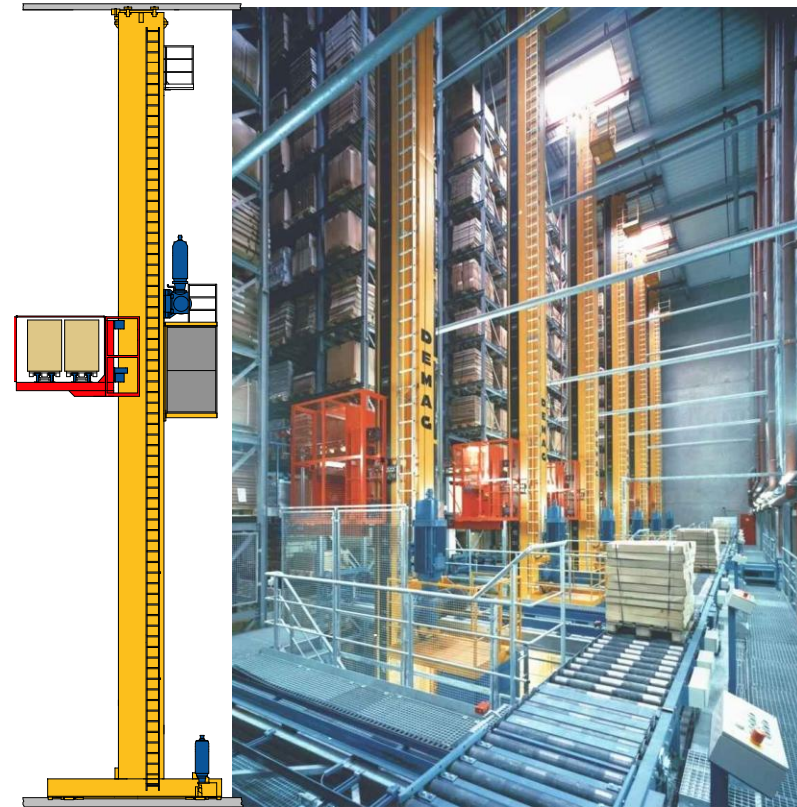
# Scenario 8: ASRS with Aisle-Changing SRM





# Scenario 9A-9B: ASRS Single Mast with Dual Load Handling Device

- **ASRS lifts 2,200 LB x 2 (pallet pairs) up to 1248" (104') in a Single or Double Deep Environment**
  - E.g. Dematic RapidStore UL 1500 Single Mast Dual Load Handling
  - Horizontal Speed: 780 FPM
  - Vertical Speed Loaded: 295 FPM
  - Z-Axis Speed: 200 FPM
  - Transports pallets in pairs with regenerative braking
  - Suitable for high velocity environments where variety of SKUs requires greater selectivity



# Scenario 10: ASRS 6-Deep Storage System With Mole

- **ASRS lifts 4,400 LB pallets up to 150' in a Multi-Pallet Deep Environment**
  - E.g. Dematic RapidStore UL 1500
  - Horizontal Speed: 790 FPM
  - Vertical Speed Loaded: 295 FPM
  - Z-Axis Speed: 180 FPM
  - 6-Deep Storage System
  - Suitable for Low Variety, High inventory, high throughput environments



[Click Here for Movie](#)

# Scenario 10: ASRS 6-Deep With Mole



# DC Designer Tool

- **MWPVL International has developed a Distribution Center Designer Tool**
  - Tool compares the economics of conventional versus automated distribution centers for multiple scenarios
    - Full pallet in/out operations
    - User-configurable inputs include:
      - ▶ Pallet storage requirements & throughput volumes
      - ▶ Pallet attributes
      - ▶ Wage & inflation rates
      - ▶ Energy Rates
      - ▶ Cost of Capital / Discount Factor
      - ▶ Operating Hours, etc.

# Greenfield DC Designer Tool

- **Example of User Inputs:**

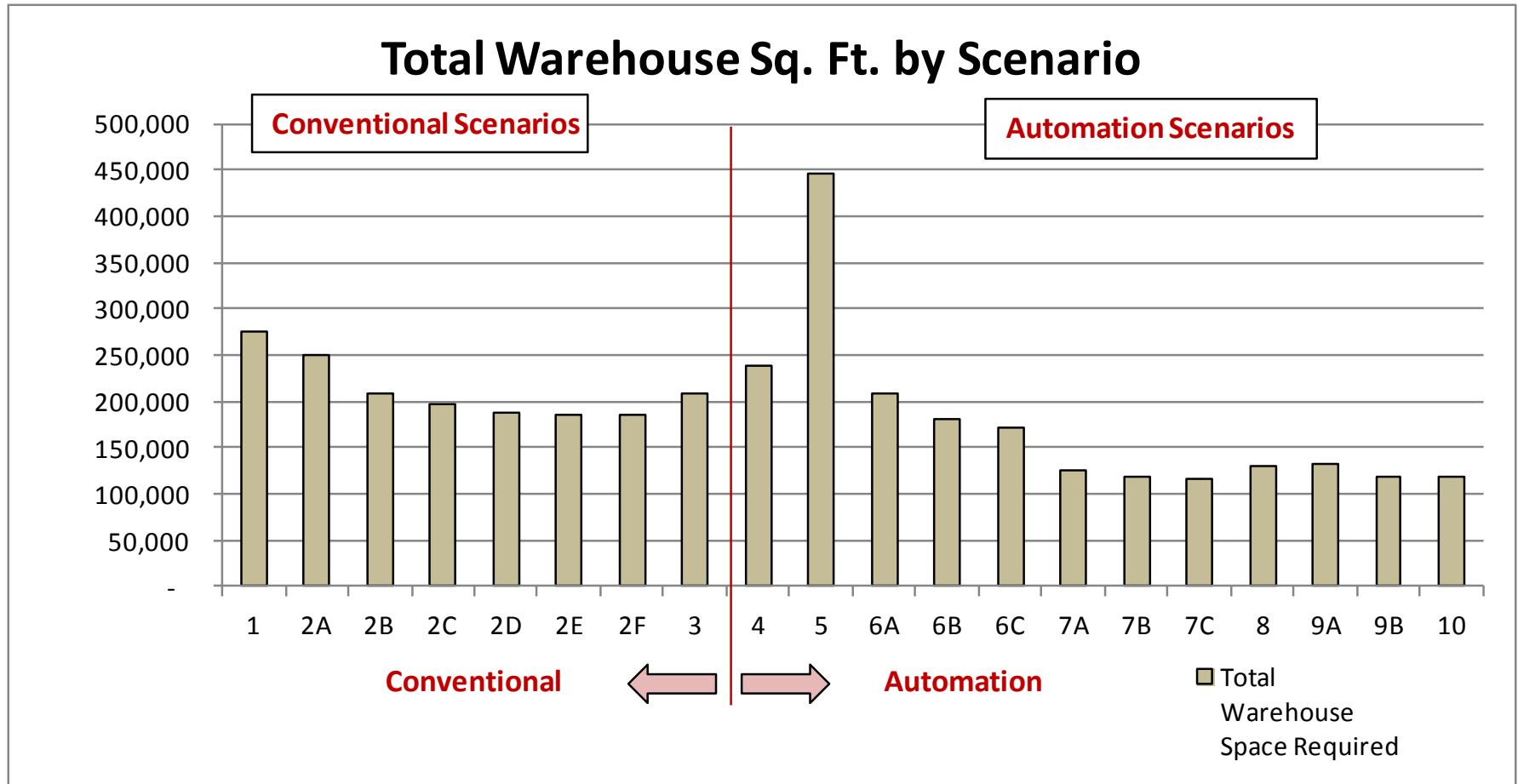
<b>Configurable Assumptions</b>	<b>Unit of Measure</b>	<b>Value</b>
Storage Requirements	Pallets	30,000
Average Hourly Throughput (In+Out)	Pallets	250
Peak Hourly Throughput (In+Out)	Pallets	500
Operating Hours/Day	Hours	22
Fully Loaded Forklift Wage Rate/Hour	\$/Hr	\$23.00
Cost/Hour Utility Rate	\$/kWh	\$0.09
Pallet Dimensions (WxLxH)	Inches	40x48x54

Note that the tool allows users to configure many more variables than shown above.

# Scenarios Evaluated

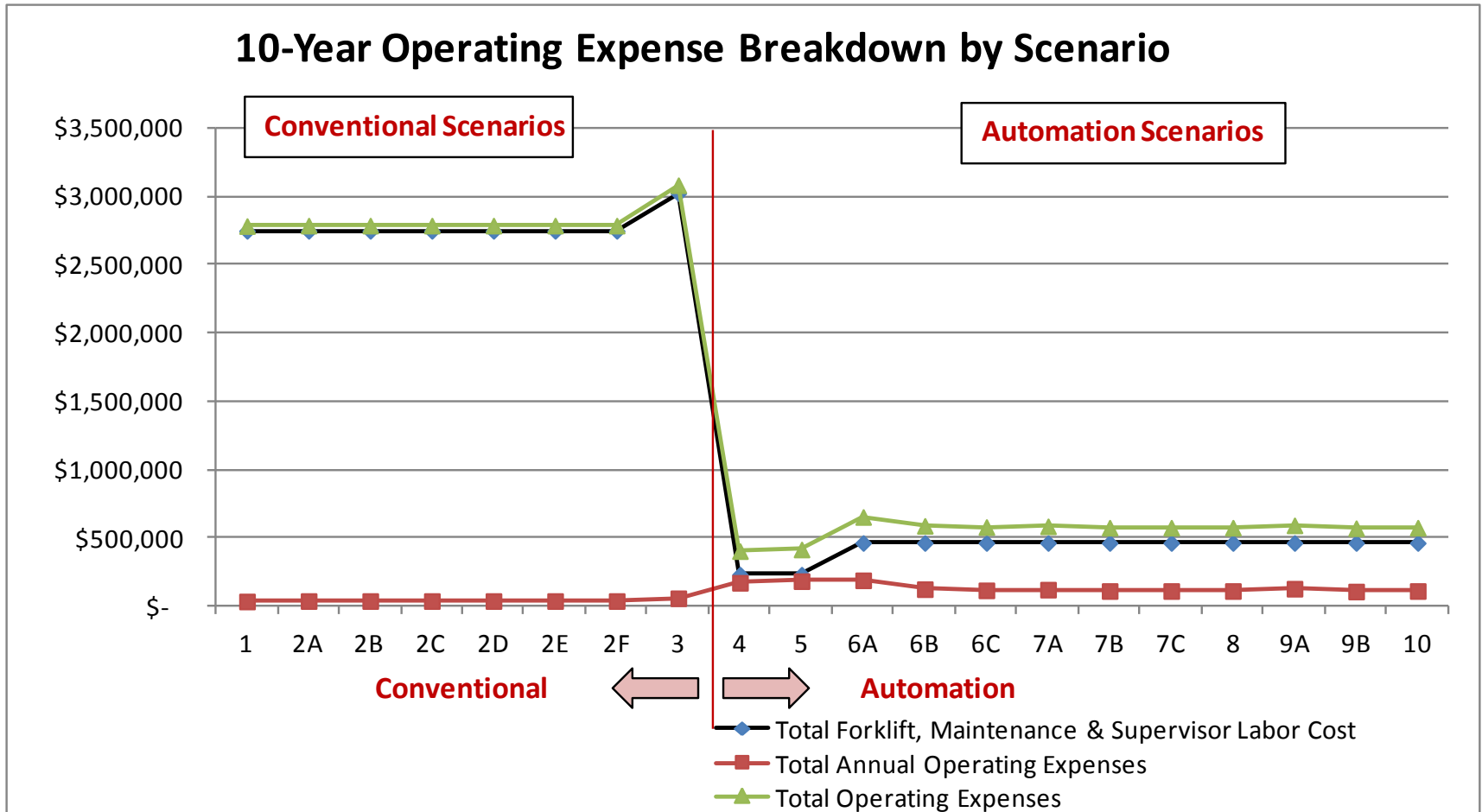
Scenario	Conventional Vs. Automated	Mobile Equipment	Equipment Lift Height	Racking System
1	Conventional	Forklift Truck – Narrow Aisle	35.2' (422")	Single Deep
2A-2F	Conventional	Forklift Truck – Narrow Aisle (“Best Case”)	42.1' (505")	Single Deep, 2-deep Push-Back through 6-deep Push-Back
3	Conventional	Swing-Reach Truck – Very Narrow Aisle (VNA)	42.8' (514")	Single Deep
4	Automated	AGV with Turrett Forks - VNA	35.0' (420")	Single Deep
5	Automated	AGV With Forks – Narrow Aisle	21.5' (258")	Single Deep
6A-6C	Automated	ASRS With Rotating Fork	54.0' (648")	Single Deep, 2-3 Deep Push-Back
7A-7C	Automated	ASRS With Aisle Captive SRM	105.3' (1264")	1-Deep. 2-Deep, 3-Deep Static Rack
8	Automated	ASRS With Aisle-Changing SRM	104.0' (1248")	Single Deep
9A-9B	Automated	ASRS With Dual Mast SRM	104.0' (1248")	1-Deep & 2-Deep Rack
10	Automated	ASRS With SRM With Mole	104.0' (1248")	6-Deep Static Rack

# The Model Determines Warehouse Sizing Requirements



This chart shows the square feet of warehouse space required for each scenario.

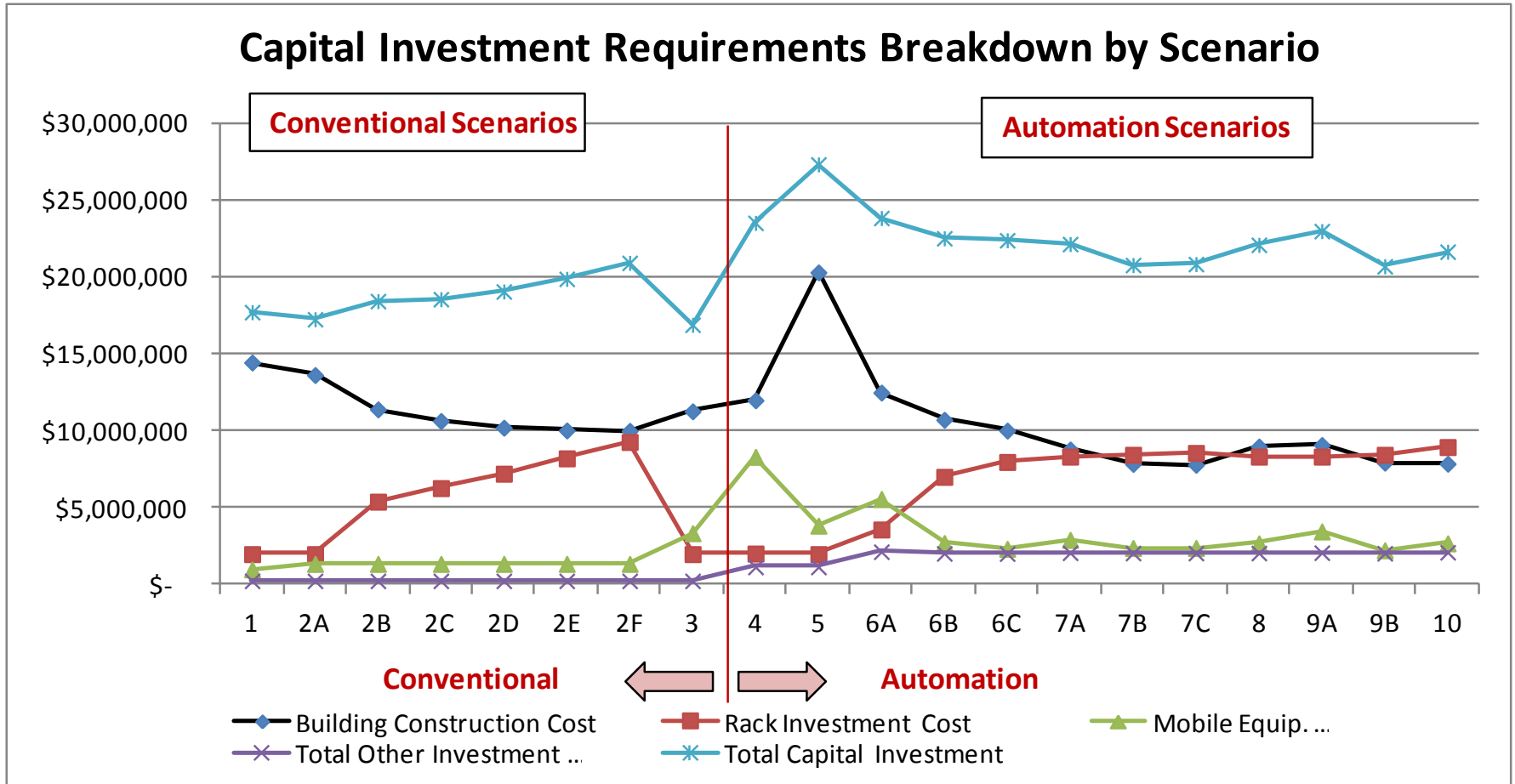
# The Model Determines Operating Expenses



This chart shows the 10-Year total operating expenses for Forklift Labor, Maintenance, Supervision, Utilities, & other expenses (we only included expenses that change by scenario)

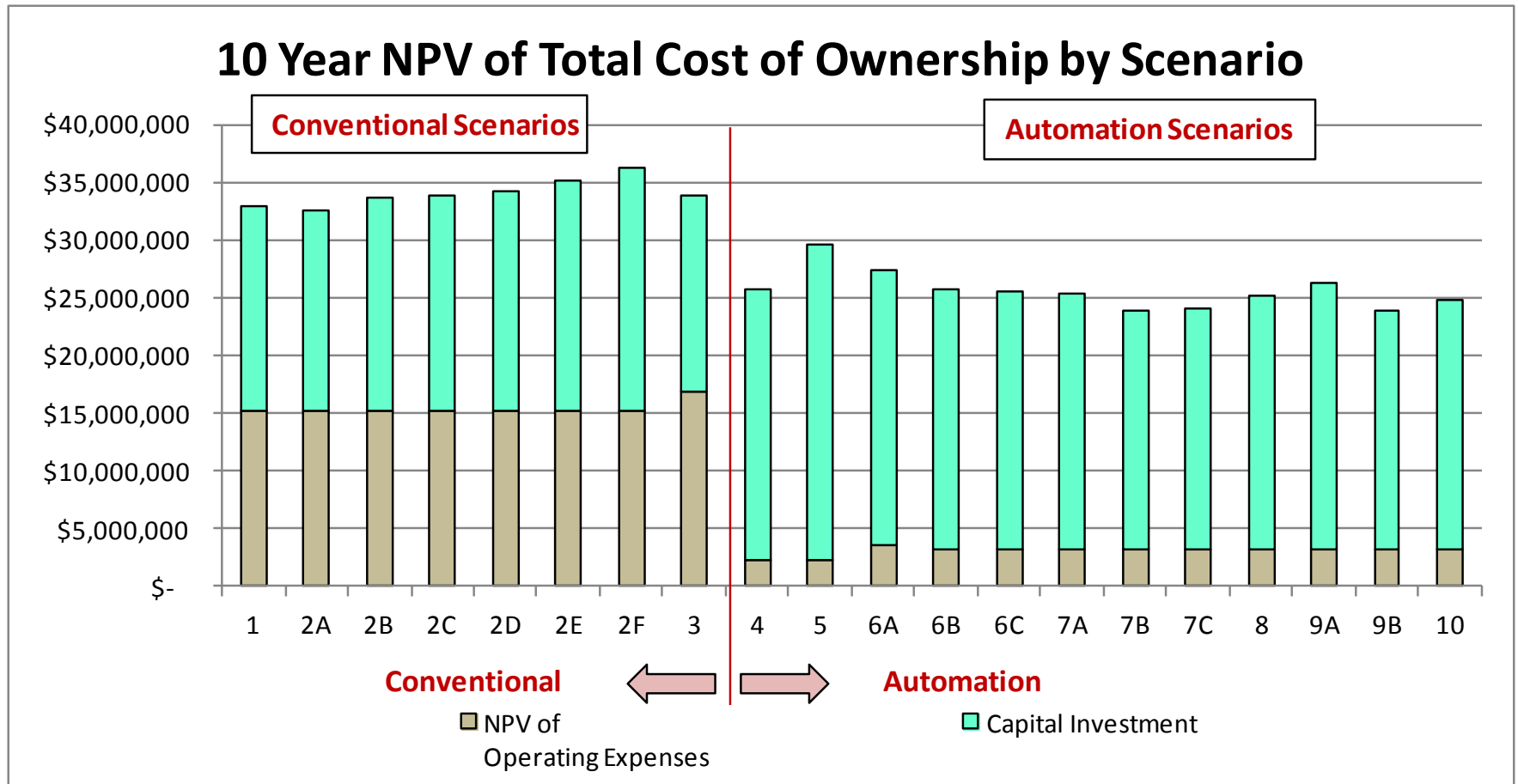


# The Model Determines Capital Investment



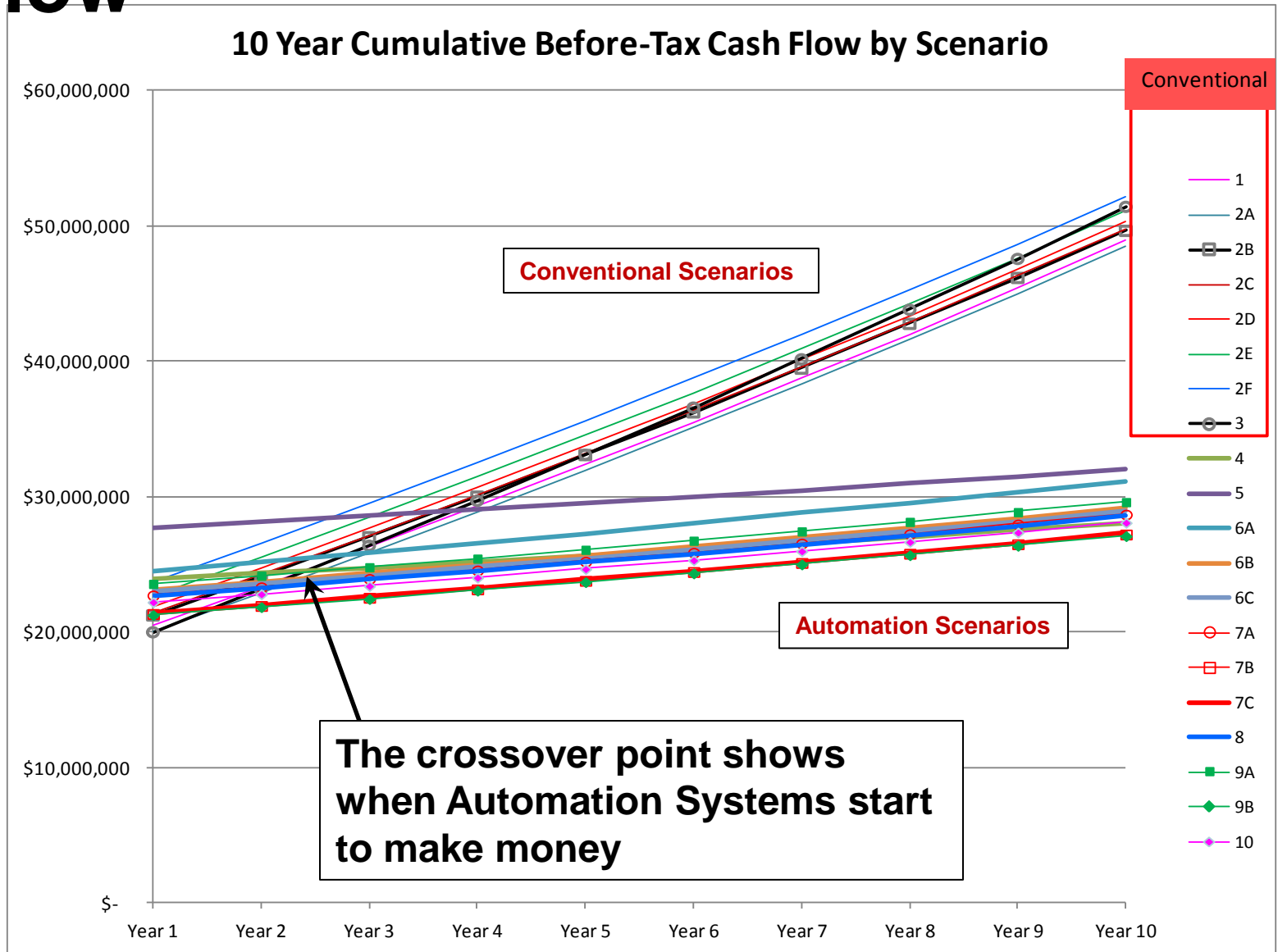
This chart shows the capital investment requirements for building, fixed equipment, mobile equipment, Engineering Services, WCS Integration, Hardware, & Spare Parts

# The Model Determines 10-Year NPV of TCO



This chart shows the 10-Year net present value of the total cost of ownership for before-tax cash flows of each scenario.

# The Model Determines 10-Year Cash Flow



# Identifies Best Solution Based on Parameters of the Operation

Scenario	Conventional Versus Automated	Racking System	Maximum Lift Height Feet	Year 0 Capital Investment	10-Year NPV of Total Cost of Ownership by Fully Loaded Forklift Hourly Wage Rate (\$ Millions)																													
					\$5.00	\$6.00	\$7.00	\$8.00	\$9.00	\$10.00	\$11.00	\$12.00	\$13.00	\$14.00	\$15.00	\$16.00	\$17.00	\$18.00	\$19.00	\$20.00	\$21.00	\$22.00	\$23.00	\$24.00	\$25.00	\$26.00	\$27.00	\$28.00	\$29.00	\$30.00				
1A	Conventional	Single Deep	35	\$ 17,714,055	\$21.2	\$21.8	\$22.5	\$23.1	\$23.8	\$24.4	\$25.1	\$25.7	\$26.4	\$27.1	\$27.7	\$28.4	\$29.0	\$29.7	\$30.3	\$31.0	\$31.6	\$32.3	\$32.9	\$33.6	\$34.2	\$34.9	\$35.5	\$36.2	\$36.9	\$37.5				
1B	Conventional	Single Deep	42	\$ 17,256,331	\$20.7	\$21.4	\$22.0	\$22.7	\$23.3	\$24.0	\$24.7	\$25.3	\$26.0	\$26.6	\$27.3	\$27.9	\$28.6	\$29.2	\$29.9	\$30.5	\$31.2	\$31.8	\$32.5	\$33.1	\$33.8	\$34.5	\$35.1	\$35.8	\$36.4	\$37.1				
1C	Conventional	2-Deep	42	\$ 18,434,061	\$21.9	\$22.6	\$23.2	\$23.9	\$24.5	\$25.2	\$25.8	\$26.5	\$27.1	\$27.8	\$28.4	\$29.1	\$29.8	\$30.4	\$31.1	\$31.7	\$32.4	\$33.0	\$33.7	\$34.3	\$35.0	\$35.6	\$36.3	\$36.9	\$37.6	\$38.2				
1D	Conventional	3-Deep	42	\$ 18,560,208	\$22.0	\$22.7	\$23.3	\$24.0	\$24.7	\$25.3	\$26.0	\$26.6	\$27.3	\$27.9	\$28.6	\$29.2	\$29.9	\$30.5	\$31.2	\$31.8	\$32.5	\$33.1	\$33.8	\$34.5	\$35.1	\$35.8	\$36.4	\$37.1	\$37.7	\$38.4				
1E	Conventional	4-Deep	42	\$ 19,060,460	\$22.5	\$23.2	\$23.8	\$24.5	\$25.2	\$25.8	\$26.5	\$27.1	\$27.8	\$28.4	\$29.1	\$29.7	\$30.4	\$31.0	\$31.7	\$32.3	\$33.0	\$33.6	\$34.3	\$35.0	\$35.6	\$36.3	\$36.9	\$37.6	\$38.2	\$38.9				
1F	Conventional	5-Deep	42	\$ 19,879,284	\$23.4	\$24.0	\$24.7	\$25.3	\$26.0	\$26.6	\$27.3	\$27.9	\$28.6	\$29.2	\$29.9	\$30.5	\$31.2	\$31.9	\$32.5	\$33.2	\$33.8	\$34.5	\$35.1	\$35.8	\$36.4	\$37.1	\$37.7	\$38.4	\$39.0	\$39.7				
1G	Conventional	6-Deep	42	\$ 20,916,177	\$24.4	\$25.0	\$25.7	\$26.4	\$27.0	\$27.7	\$28.3	\$29.0	\$29.6	\$30.3	\$30.9	\$31.6	\$32.2	\$32.9	\$33.5	\$34.2	\$34.8	\$35.5	\$36.2	\$36.8	\$37.5	\$38.1	\$38.8	\$39.4	\$40.1	\$40.7				
2	Conventional	Single Deep	43	\$ 16,895,926	\$20.8	\$21.5	\$22.2	\$23.0	\$23.7	\$24.4	\$25.1	\$25.8	\$26.6	\$27.3	\$28.0	\$28.7	\$29.4	\$30.2	\$30.9	\$31.6	\$32.3	\$33.0	\$33.8	\$34.5	\$35.2	\$35.9	\$36.6	\$37.3	\$38.1	\$38.8				
3	Automated	Single Deep	35	\$ 24,553,571	\$25.9	\$25.9	\$26.0	\$26.0	\$26.1	\$26.1	\$26.2	\$26.2	\$26.3	\$26.4	\$26.4	\$26.5	\$26.5	\$26.6	\$26.6	\$26.7	\$26.7	\$26.8	\$26.8	\$26.9	\$27.0	\$27.0	\$27.1	\$27.1	\$27.2	\$27.2				
4	Automated	Single Deep	22	\$ 27,313,519	\$28.6	\$28.7	\$28.7	\$28.8	\$28.8	\$28.9	\$28.9	\$29.0	\$29.0	\$29.1	\$29.1	\$29.2	\$29.3	\$29.3	\$29.4	\$29.4	\$29.5	\$29.5	\$29.6	\$29.6	\$29.7	\$29.7	\$29.8	\$29.8	\$29.9	\$30.0				
5A	Automated	Single Deep	54	\$ 23,832,457	\$25.4	\$25.5	\$25.6	\$25.8	\$25.9	\$26.0	\$26.1	\$26.2	\$26.3	\$26.4	\$26.5	\$26.6	\$26.7	\$26.9	\$27.0	\$27.1	\$27.2	\$27.3	\$27.4	\$27.5	\$27.6	\$27.7	\$27.8	\$28.0	\$28.1	\$28.2				
5B	Automated	2-Deep Push-	54	\$ 22,515,047	\$23.8	\$23.9	\$24.0	\$24.1	\$24.2	\$24.3	\$24.4	\$24.5	\$24.6	\$24.7	\$24.9	\$25.0	\$25.1	\$25.2	\$25.3	\$25.4	\$25.5	\$25.6	\$25.7	\$25.8	\$26.0	\$26.1	\$26.2	\$26.3	\$26.4	\$26.5				
5C	Automated	3-Deep Push-	54	\$ 22,386,166	\$23.6	\$23.7	\$23.8	\$23.9	\$24.0	\$24.1	\$24.2	\$24.3	\$24.5	\$24.6	\$24.7	\$24.8	\$24.9	\$25.0	\$25.1	\$25.2	\$25.3	\$25.5	\$25.6	\$25.7	\$25.8	\$25.9	\$26.0	\$26.1	\$26.2	\$26.3				
6A	Automated	Single Deep	105	\$ 22,139,159	\$23.4	\$23.5	\$23.6	\$23.7	\$23.8	\$23.9	\$24.0	\$24.1	\$24.2	\$24.3	\$24.5	\$24.6	\$24.7	\$24.8	\$24.9	\$25.0	\$25.1	\$25.2	\$25.3	\$25.5	\$25.6	\$25.7	\$25.8	\$25.9	\$26.0	\$26.1				
6B	Automated	2-Deep Static	105	\$ 20,777,802	\$21.9	\$22.1	\$22.2	\$22.3	\$22.4	\$22.5	\$22.6	\$22.7	\$22.8	\$22.9	\$23.0	\$23.2	\$23.3	\$23.4	\$23.5	\$23.6	\$23.7	\$23.8	\$23.9	\$24.0	\$24.1	\$24.3	\$24.4	\$24.5	\$24.6	\$24.7				
6C	Automated	3-Deep Static	105	\$ 20,841,058	\$22.0	\$22.1	\$22.2	\$22.3	\$22.4	\$22.6	\$22.7	\$22.8	\$22.9	\$23.0	\$23.1	\$23.2	\$23.3	\$23.4	\$23.5	\$23.7	\$23.8	\$23.9	\$24.0	\$24.1	\$24.2	\$24.3	\$24.4	\$24.5	\$24.6	\$24.8				
7	Automated	Single Deep	104	\$ 22,884,628	\$24.1	\$24.2	\$24.3	\$24.5	\$24.6	\$24.7	\$24.8	\$24.9	\$25.0	\$25.1	\$25.2	\$25.3	\$25.4	\$25.6	\$25.7	\$25.8	\$25.9	\$26.0	\$26.1	\$26.2	\$26.3	\$26.4	\$26.5	\$26.7	\$26.8	\$26.9				
8A	Automated	Single Deep	104	\$ 22,981,488	\$24.2	\$24.3	\$24.5	\$24.6	\$24.7	\$24.8	\$24.9	\$25.0	\$25.1	\$25.2	\$25.3	\$25.4	\$25.6	\$25.7	\$25.8	\$25.9	\$26.0	\$26.1	\$26.2	\$26.3	\$26.4	\$26.6	\$26.7	\$26.8	\$26.9	\$27.0				
8B	Automated	2-Deep Static	104	\$ 20,696,740	\$21.8	\$22.0	\$22.1	\$22.2	\$22.3	\$22.4	\$22.5	\$22.6	\$22.7	\$22.8	\$22.9	\$23.1	\$23.2	\$23.3	\$23.4	\$23.5	\$23.6	\$23.7	\$23.8	\$23.9	\$24.0	\$24.2	\$24.3	\$24.4	\$24.5	\$24.6				
9	Automated	6-Deep Static	104	\$ 21,642,931	\$22.8	\$22.9	\$23.0	\$23.1	\$23.2	\$23.4	\$23.5	\$23.6	\$23.7	\$23.8	\$23.9	\$24.0	\$24.1	\$24.2	\$24.3	\$24.5	\$24.6	\$24.7	\$24.8	\$24.9	\$25.0	\$25.1	\$25.2	\$25.3	\$25.5	\$25.6				

This chart shows green where the solution is economically strong based on a range of wage rates being tested on the Y-Axis.

# Key Takeaways

- **We have reviewed 10 different full pallet storage and handling systems**
- **Each system has a fit depending on the operation profile**
- **No single pallet storage system is the “best system” because there are many operational dynamics involved**
  - For more help in understanding which solutions work best for you please see us about our DC designer tool



**Material Handling & Logistics**  
**CONFERENCE**  
SPONSORED BY DEMATIC

**Questions?**

