How to Lay Out a Warehouse or Distribution Center

How to Determine Space Requirements

Main Points

1. When sizing for highly-fixed machines or special construction, use very precise methods. For general storage or offices where somewhat less is at stake, overly precise estimates add little value.
2. Calculation is accurate but time-consuming. Use it when planning new storage methods, or in Phase IV – Installation to assign slots for individual items.
3. Warehouse calculations often use item-level inventory predictions. These may have little value beyond Year 1, especially if products are changing.
4. Conversion from an adjusted current state is quick and effective for 2- to 5-year projections for Phase I – Location and Phase II – Overall Plans, or when there is no data for calculation.
5. Rough Layout is for critical areas of high investment, large or unusually-shaped machinery, or conveyor lines.
6. Space Standards may be available, but use them with care if you do not understand their basis.
7. Ratio Trend and Projection relates space history to business activity and trends their relationship (ratio) into the future. Space is estimated by applying the projected ratio to a forecast of activity. This method is for long-range projections of total area. It is the least precise method and cannot determine individual activity areas.
8. Several methods may be used on the same project. Different methods tend to check each other, boosting confidence in the results.

Five Ways to Determine Space Requirements

The Calculation Method

Storage area example

Rack:	2000 positions @ 8 positions per bay = 250 bays	
(4 tiers)	1 bay = 9.25 ft. wide x 4.5 ft. deep = 41.625 sq. ft.	
	250 bays x 41.625 = 10,406.25 = 10,400 sq. ft.	
Aisle (12'):	250 bays x (9.25 ft. x 6 ft.)	= 13,875 sq. ft.
Total Rack Area including access aisle		= 24,275 sq. ft.

The Conversion Method

Area today:	20,000 sq. ft.
Adjust for crowding	4,000 sq. ft.
"Should Have" Today	24,000 sq. ft.
Projected changes	
Increased volume	+20%
Increased storage height	-25%
Increased product variety	+30%
Increased turnover	-20%

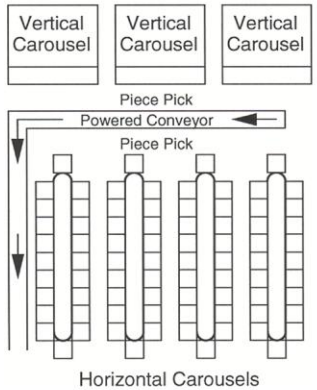
New area (space):

24,000 x 1.2 x 0.75 x 1.3 x 0.8 =

22,464 sq. ft.

rounded 22,500 sq. ft.

Rough Layout



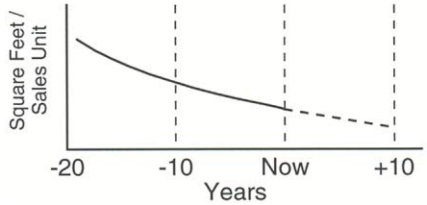
All equipment is drawn or reproduced to scale. The enclosed area is the space required.

Space Standards

General space standards

Offices	125 sq. ft. per
Car parking	300 sq. ft. per car
Break room	15 sq. ft. per person

Ratio Trend & Projection



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Notes

Main Points

1. When sizing for highly-fixed machines or special construction, use very precise methods. For general storage or offices where somewhat less is at stake, overly precise estimates add little value.
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3. Warehouse calculations often use item-level inventory predictions. These may have little value beyond Year 1, especially if products are changing.
4. Conversion from an adjusted current state is quick and effective for 2- to 5-year projections for Phase I – Location and Phase II – Overall Plans, or when there is no data for calculation.
5. Rough Layout is for critical areas of high investment, large or unusually-shaped machinery, or conveyor lines.
6. Space Standards may be available, but use them with care if you do not understand their basis.
7. Ratio Trend and Projection relates space history to business activity and trends their relationship (ratio) into the future. Space is estimated by applying the projected ratio to a forecast of activity. This method is for long-range projections of total area. It is the least precise method and cannot determine individual activity areas.
8. Several methods may be used on the same project. Different methods tend to check each other, boosting confidence in the results.

Five Ways to Determine Space Requirements

Method	Description	When to Use	Limitations
Calculation	Calculate space for each area based on the quantity and physical nature of the items to be stored.	• When there is no historical or comparable information available. • When using new or significantly changed storage methods. • For slotting (detailed layout of storage areas)	• Time consuming; temptation to continually recalculate. • Requires accurate, detailed data • Tends to assume a false sense of precision.
Conversion	Make or obtain subjective, percentage estimates of factors that will increase or decrease the need for space. Use the factors to scale existing areas up or down to reflect future needs.	• When there is no time for calculations. • When comparable space is available as a basis for conversion. • When detailed data is not available. • For medium range 2 to 5 year projections.	• Time consuming; temptation to continually recalculate. • Requires accurate, detailed data • Tends to assume a false sense of precision.
Space Standards	Apply predetermined space allowances to estimates of base unit requirements.	• When frequent estimates are required. • In areas with many similar or repeating features. • For areas that have established space standards.	• May be invalidated by changes in assumptions used to develop the standards. • Can result in error by misusing published or available but undocumented standards.
Rough Layout	Arrange scaled templates of drawings of the equipment or objects required in the space. Measure the area of the resulting layout.	• When planning special, expensive areas with highly fixed equipment. • When checking other methods of estimating.	• Requires all equipment or objects to be specified. • Can lead to premature detailed layout planning.
Ratio Trend and Projection	Plot and project company history in terms of a space ratio such as square feet per sales dollar or inventory unit. Apply the projected ratio to a forecast of the base unit (sales dollars, inventory units, etc.	• When planning long range with a five to ten year horizon. • When estimating the capacity of a site or building.	• Only accurate for estimating major classes of space. • Requires ample historical data for meaningful trend projections. • Accurate only if historical trends continue. Requires thoughtful consideration of future trends.

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Notes

Combinations of Methods Are Often Required

Typical Areas	"Typical" Methods
Product Storage Space (Rack) Storage Aisles	*Calculation or Conversion Method*
Dock Space Staging Areas Seasonal Overflow Storage	*Conversion Method*
Restrooms Office Space Break Area	*Space Standards*
Areas with Automation Lift Maintenance Area Battery Changing Area Cross-Aisles	*Rough Layout Method*

Total Space Requirements

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BKG, Inc. – Storage Space Calculation

BKG has decided to store a newly acquired product line in selective, single-deep pallet rack. Pallet size is 48” x 48”. The current racks are full, so new ones must be purchased. You have been assigned to acquire enough pallet rack to hold 1000 pallets of material and to estimate the space that will be needed for this product zone in a new warehouse layout. The current sit-down, counterbalanced forklifts must be used. These require a 12-foot aisle.

Questions:

1. What are the most significant determinants of floor space required?

2. How much space will be required per pallet rack position? Per pallet of stored material?

3. What is the difference between space per position and space per stored pallet?

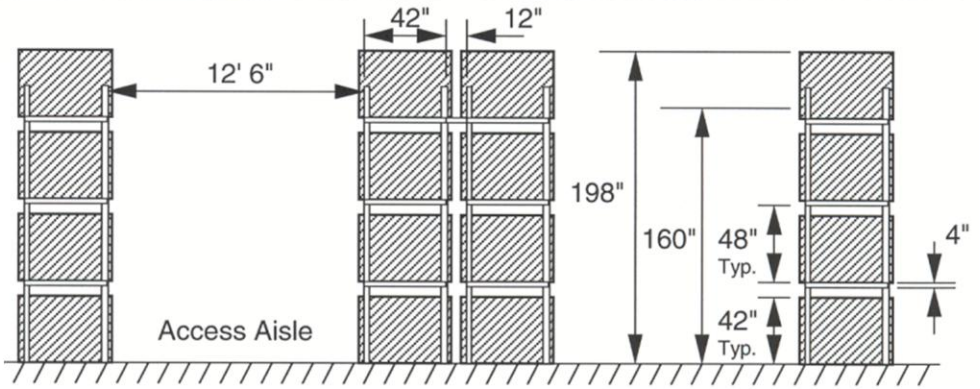
4. What is your estimate of space required, if the positions are typically 90% utilized?

BKG Selective Pallet Rack Sketch – Counterbalanced Lift Trucks

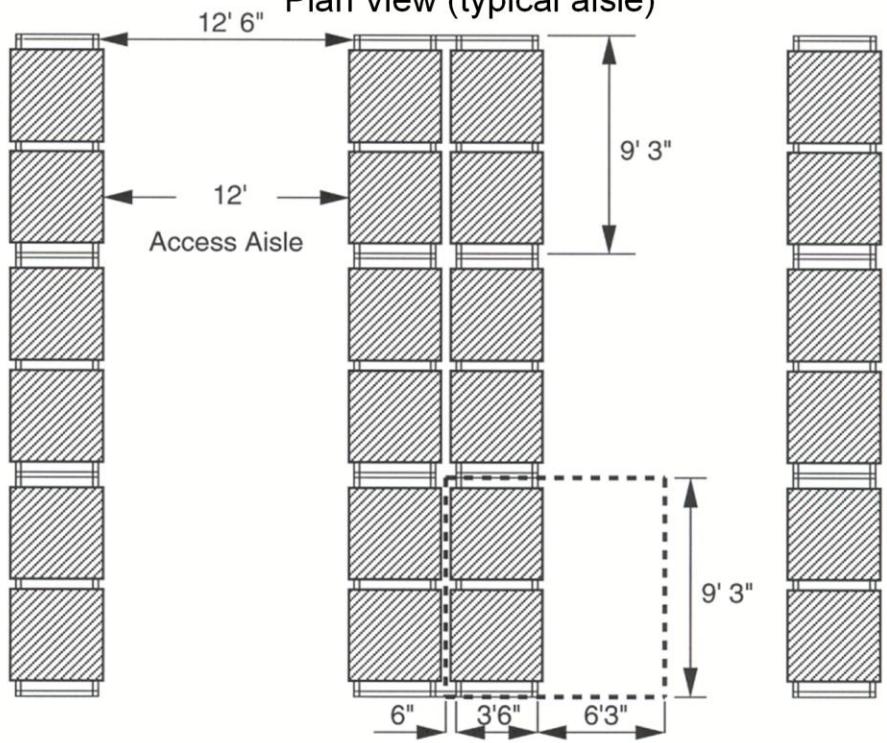
Questions:

1. How many tiers high?
2. How many positions per cross-beam?
3. How many positions rack section?
4. How to allow for aisle space?
5. How much floor area per rack section?
6. How much space per position?
7. How much space per stored pallet assuming 90% utilization.

Elevation sketch



Plan view (typical aisle)

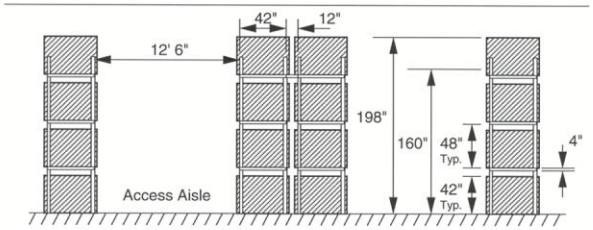


Main Points

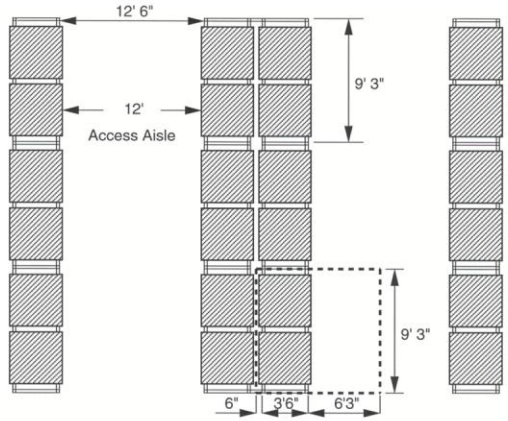
1. The calculation method rests on plans and/or assumptions about storage and handling methods.
2. For clarity and to avoid errors and oversights, prepare sketches to illustrate intended methods and dimensions.
3. Check dimensions against the materials to be stored, the space available, and the capabilities of material handling equipment, including the handlers themselves.
4. Recognize that column spacing and the manner in which columns are accommodated in the actual layout may influence rack placement, aisle width, and flue space between back-to-back rows of pallet rack.
5. Because 100% utilization of available positions is rarely achieved or desirable, recognize that space per storage position will be less than space per pallet actually stored.
6. If you are planning to store a specific number of pallets, then divide the calculated storage space per position by an appropriate utilization factor to arrive at storage space per pallet.

Calculating Storage Space

Elevation sketch



Plan view (typical aisle)



- Establish storage tiers & height.
- Check clear height.
- Check lift-off height of equipment.
- Check vertical clearances.

- Establish aisle width appropriate for planned equipment.
- Establish rack dimensions based on load dimensions, planned overhangs and desired clearances.

$$\frac{9'3'' \times ((3'6'' + 6'') + (6'3''))}{8 \text{ positions}}$$

= 11.9 sq. ft. per position

11.9 / 0.90 = 13.2 sq. ft. per stored pallet at 90% utilization

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Notes

BKG, Inc. – Storage Space Calculation

Handling & Storage Method	**Assumptions** 48” x 48” x 42” palletized unit load	**Space per pallet position** (at 100% utilization)	**Space per stored pallet** (at 90% utilization)
Single-deep, selective pallet rack; Counterbalanced, sit-down forklift	• 4 pallets high • 9’ wide by 4” high beam • 42” uprights; 12” spacer, back-to-back • 12’ aisle • Counterbalanced truck	11.9 sq. ft. per pallet	13.2 sq. ft. per pallet
Single-deep, selective pallet rack; Narrow-aisle, stand-up reach truck	• 4 pallets high • 9’ wide by 4” high beam • 42” uprights; 12” spacer, back-to-back • 8’6” aisle • Narrow-aisle reach truck	9.8 sq. ft. per pallet	10.9 sq. ft. per pallet

1. How many square feet are needed to store 1000 pallets?

2. How many pallet positions are needed to store 1000 pallets?

3. How much space can be saved by using a narrow-aisle (stand-up) truck?

4. How many aisles must you have before the reach truck gains you one more aisle?

Main Points

1. The clear height of a building is the distance from the floor to the bottom of the lowest obstruction.
2. In unit load storage, the height needed to operate is generally the distance from the floor to the top of the tallest load when it is lifted off the highest storage beam of the planned storage equipment.
3. In other areas, height is needed to accommodate any elevated structures such as multi-level picking modules or mezzanines, and their equipment or storage.
4. Fire codes generally require a 3-foot clear space between sprinkler heads and the highest tops of stored loads. Thus, the effective storage height may be less than the available clear height.
5. Some types of operations benefit from high clearance, but others do not. Those benefiting the most are: retail distributors; E-commerce and consumer direct fulfillment; public and contract fulfillment.

   Those benefiting the least: unit load operations; wholesale operations; inbound logistic centers.
6. Unused overhead space must still be heated and cooled, adding costs.
7. As the top storage beam rises above 30 feet, the importance of floor flatness goes up, adding to the building's cost.
8. Extra height is valuable in expensive real estate markets and when the alternative is a satellite facility.

Clear height

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Notes

Main Points

1. Clear height is the distance from the floor to the lowest-hanging ceiling member or hanging objects (beams, joists or truss work, fans, light fixtures, sprinklers) descending down into a substantial portion of the industrial work area.
2. Obviously, increased height can be used to reduce floor area required. However, this depends in practice on the height of stored loads and the capabilities of material handling equipment.
3. In new construction, increased height adds to cost per square foot or square meter, but may be justified by constructing less area underroof.
4. In truck-based warehousing, increased height can slow the operation and its throughput, especially when using turret trucks in very narrow aisles.
5. Slow-down can be avoided with more expensive automated storage/retrieval machines. But capital saved with less area will be given back for material handling.

Impact of clear height: <24’, 24’, 28’, 32’, 36’, >36’

<7.3m, 7.3m, 8.5m, 10m, 11m, >12m

Consideration	Impact of additional height.
Floor space required	Depends upon average pallet height. May permit another tier in rack storage areas, thus reducing floor area in rack storage by 15% to 40% when compared to lower heights.
Mezzanine potential	May be able to get 2 or 3 mezzanine levels for picking from shelf stock.
Operational speed & throughput	Likely slower with increased height, especially with narrow or very narrow aisles.
Material handling equipment: Truck vs. S/R Machine	More expensive trucks with additional mast. Or, more expensive storage/retrieval machines if needed.
Floor strength	Depending upon weight of stored material, may need thicker, higher-rated floors.
Floor flatness	Above 32’, flatness becomes a concern. Specifications and special effort may be needed.
Fire protection	More costly with increased height.
Lighting	More challenging with increased height.

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Notes

Main Points

1. The need for additional space is typically driven by the factors listed here.
2. Some factors affect only a certain kind of space or a specific activity-area. Planners need to understand which ones are active and to what extent.
3. Projecting the key inputs of PQRST will help to identify and measure the relevant factors.

What drives your need for additional space?

- More business volume – with no change in inventory policy.
- More product variety.
- Changes in product packaging and density.
- New activities and services.
- Changes in product and service mix.
- Changes in processing and methods and practices.
- Changes in sourcing & inventory management.

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Notes

Common Conversion Indices – Warehouse Space Requirements

Volume Index	In the absence of increased turns or denser storage methods, space requirements will grow in some proportion to volume. Must be defined case by case. If space is fully-utilized then use future throughput divided by current throughput.
Turns Index	Space is a function of average inventory and average inventory is a function of turnover. Space requirements will decrease as turns inbcrease. Defined as current turns divided by future turns, where turns is defined as either annual Cost of Goods Sold (COGS) divided by average COGS in inventory, or as annual item volume, divided by average number of items in inventory.
Variety Index	Greater variety usually results in the need for more space because the number of product facings increases, and because variety leads to complexity which usually results in less efficient use of space. The index is not linear if items added or eliminated lie at either end of the P-Q distribution. Defined as number of items (Stock keeping units or SKUs) divided by current number of items, modified up or down depending upon the nature of the items added or eliminated.
Storage Index	Used to reflect changes in storage method. For example: moving to taller, higher-density storage methods will reduce the amount of floor space required. Defined based upon the unit of measure being observed and the method being changed.
Product Index	Changes to the product itself and/or its packaging for storage. Physically smaller; more or less stackable; dimensional changes that impact floor space and cube. Defined based upon the unit of measure being observed and the nature of the changes.
Max Index	Optional multiplier which can be used to reflect changes in seasonality, peak-to-average ratios, unusual Purchasing "buys", or other factors not covered in the indices above.

Main Points

1. The Conversion Method can be used to estimate space in square feet, square meters, acres, etc.
2. It can also be used to estimate capacity; e.g. pallet positions, lineal feet of shelving, number of dock doors, etc.
3. Current utilization of space and/or capacity must first be assessed and adjusted to what should be in place for current volume and conditions.
4. Then, a forecast is made of future volumes and relevant conditions based on data or informed opinion and assumptions.
5. Ratios are established to quantify the expected changes in volume and conditions. Each becomes an index or factor that is applied to today's "should have" space or capacity.
6. Factors or indices are presumed to be concurrently at work on requirements. Therefore, they are multiplied rather than added when arriving at a total conversion index or factor.

Overview of Conversion Method

Steps	Notes and Working Forms
1 Identify material-storage groups	• Factors Affecting the Grouping of Materials • Material Characteristics Form (RMA 221) • Product-Quantity Plot
2 Select units of measure	Select the unit of measure: Space or Capacity • Square feet or square meters • Lineal feet or meters • Pallet positions • Etc.
3 Assess current situation and adjust	Adjust current capacity or space up or down to reflect current over- or under-use; tight or loose: • Storage in aisles, or outdoors, or in trailers • Excessive obsolete inventory • Empty racks or floor space
4 Select appropriate conversion indices	Select indices relevant to the situation. See Common Conversion Indices RMA S-2156
5 Obtain data for indices	Project each index over the planning horizon.
6 Convert or factor for future requirements	Multiply factor indices to get total (compound) index. Then multiply by adjusted current space or capacity. (See RMA 156 or 7111-2).

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Notes

Art Supplies, Inc.

Art Supplies, Inc. has outgrown their current facility and is looking for a new location. You have been assigned to estimate 5-year space requirements for the pallet rack area. Today, this area occupies 20,000 square feet. Racks are four tiers high with case picking at floor level.

Today's rack area is overflowing. Many pallets are stored in aisles and several rented trailers. You should have 20% more rack area for today's needs.

Business volume is expected to increase by 20% over the next 5 years with no changes expected in sourcing or inventory policy.

The number of items stored is expected to increase by 10%. But no changes are expected to product packaging or overall pallet dimensions.

At the new location you plan to store five tiers high.

You also plan to use narrow-aisle trucks. These should reduce floor space needed by about 10%.

Question:

What is your 5-year estimate of pallet rack space (rounded to the nearest 1000 sq. ft).

Navarro, Inc.

To keep pace with recent growth, Navarro, Inc., has decided to enlarge their distribution center. You have been assigned to determine the 5-year storage capacities needed for the major storage groups. These are:

a. Small items – stored on metal shelves

b. Full (unbroken) pallet loads – pallet racks (single deep)

c. Big and bulky items stored outside – with sideloader on gravel pad

d. Big and bulky items stored inside – in pallet rack openings (2 pallets wide)

Current storage capacity is shown on RMA 7111-2a. The inside pallet racks are overflowing with product. Many items are stored in aisles and decreasing operational efficiency. The warehouse should have 20% more inside rack for today's needs.

Unit volumes for all storage groups are expected to increase as shown below:

Year	0	+1	+2	+3	+4	+5
Volume	100	110	121	130	142	160

Navarro, Inc. continued…

Inventory turns are expected to increase through new partnerships with suppliers. These will reduce incoming lot sizes and leadtimes.

Storage Group	Current Turns	+5-year Future Turns
a. Small items	2	4
b. Full (unbroken) pallets	12	18
c. Big & bulky items – outside	6	8
d. Big & bulky items inside	6	8

The number of stock-keeping units (SKUs) is expected to increase over the next five years as shown below. Most of the new SKUs will be "average" movers; neither top selling or slow moving.

Storage Group	Current SKUs	+5-year Future SKUs
a. Small items	4000	5000
b. Full (unbroken) pallets	200	220
c. Big & bulky items – outside	40	50
d. Big & bulky items inside	30	30

Navarro, Inc. continued…

The market and technology are changing rapidly for the small items. Technical innovations will likely shrink the size of the small items by half in the next few years.

Peak seasonality for these small items is also expected to increase by 20%.

Problem:

1. Use the Warehouse Space Conversion Worksheet RMA 7111-2a to determine the 5-year storage requirements for each material-storage group.

2. Are current capacities adequate for expected growth?

3. Which group will need the most additional capacity?

WAREHOUSE SPACE CONVERSION WORKSHEET

Plant *Navarro* Project *New Warehouse Space*
By *CP* With *Team*
Date *5/28* Sheet *1* of *1*

#	Material Class	Unit of Measure	Present Capacity	+ or - Adjust.	Should Have Now	Volume Index	Turns Undex	Variety Index	Storage Index	Product Index	Max Index	Total Index	Planning Horizon (5-year) Reqmt.
a	Small Items	feet of shelving	5,000										
b	Full (unbroken) pallet loads	pallet positions	2,000										
c	Big, bulky items outside	square feet	20,000										
d	Big, bulky items inside	pallet rack openings	40										

Space Requirements -- Converting

Main Points

1. The Space Requirements Converting form summarizes current space, adjustments required, and future estimates.
2. This example compares estimates for two future periods of +1 and +3 years. It shows that Area 4 Home Goods will shrink over time while Areas 6 Footware and 7 Direct Shipment will grow.
3. To avoid projecting over-crowded (or poorly used) space into the future, be sure to observe current conditions and adjust current space up or down, as needed.
4. Check current utilization rates in storage areas and adjust to practical targets before projecting future requirements.
5. Note that the space unit at the top of each column can be varied, depending upon unit of measure (sq. ft., acres, sq. m., etc.) or whether an amount or a percentage is used in columns c, e, and h.
6. Column g. remains empty until the planned layout is selected and its areas are then posted.

SPACE REQUIREMENTS -- CONVERTING

Plant *Homart Distributors* Project *Rearrangement*
By *HK* With *RMA*
Date *4/21* Sheet *1* of *1*

Basis (year, period, quantity) of Columns e, f, g *+1 year* Columns h, j, k *+3 years*

a Activity-- Area or Dept.	b Current Space	c + or - Adjstmt.	d Should Have Now	e Increase Decrease	f Req'd for (Year)	g Plan-For Area (Year)	h Increase Decrease	j Req'd for (Year)	g Plan-For Area (Year)
Unit →	Sq. M.	Sq. M.	Sq. M.	Sq. M.	Sq. M.	Sq. M.	Sq. M.	Sq. M.	Sq. M.
1. Receiving	75	0	75	0	75		0	75	
2. Check-In	75	0	75	0	75		0	75	
3. Return Goods	60	-10	50	0	50		0	50	
4. Home Goods	750	0	750	-150	600		-100	500	
5. Apparel	800	0	800	0	800		0	800	
6. Footware	800	0	800	50	850		50	900	
7. Direct Shipment	75	25	100	50	150		50	200	
8. Sales Display	50	0	50	0	50		0	50	
9. Order Assembly & Pack	325	-25	300	0	300		0	300	
10. Stage	100	0	100	0	100		0	100	
11. Ship	150	0	150	0	150		0	150	
12. Packing Materials	100	0	100	0	100		0	100	
13. Office	150	0	150	0	150		0	150	
14. Restrooms	50	0	50	0	50		0	50	
15. Supplies & Maintenance	50	0	50	0	50		0	50	
16.									
17.									
18.									
19.									
20.									
TOTALS	3610	-10	3600	-50	3550		0	3550	

NOTES:

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Notes

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Space Requirements -- Converting

Main Points

1. The Space Requirements Converting form summarizes current space, adjustments required, and future estimates.
2. This example compares future estimates for 1 and 2 shifts. The form can also be used to show estimates for two future periods, such as +3 and +5 years.
3. To avoid projecting over-crowded (or poorly used) space into the future, be sure to observe current conditions and adjust current occupancies up or down, as needed.
4. Note that the space unit at the top of each column can be varied, depending upon unit of measure (sq. ft., acres, sq. m., etc.) or whether an amount or a percentage is used in columns c, e, and h.
5. In this example, Columns e and h are expressed as percentages of Column d.

SPACE REQUIREMENTS -- CONVERTING

Plant *Socks, Inc.* Project *L-R Plan*
By *PR, BA, LH* With *BL, TM*
Basis (year, period, quantity) of *Sq. Ft. Today* Columns e, f, g *+5 Yrs 1 Shift* Columns h, j, k *+ 5Yrs 2-Shift* Date *1/20* Sheet *1* of *1*

a Activity-- Area or Dept.	b Area Now Occupied	c + or - Adjstmt.	d Should Have Now	e Increase Decrease	f Req'd Area Determined	g Plan-For Area	h Increase Decrease	j Req'd Area Determined	k Plan-For Area
Unit→	(SqFt)	(SqFt)	(SqFt)	(% Col. d.)	(SqFt)	(SqFt)	(% Col. d.)	(SqFt)	(SqFt)
1 *Receiving*	10,700	1,500	12,200	+44%	17,600	17,600	+44%	17,600	17,600
2 *QC Offices*	1,800	0	1,800	0	1,800	1,800	0	1,800	1,800
3 *Stage for Put Away*	2,050	0	2,050	0	2,050	2,050	0	2,050	2,050
4 *Returns & General Staging*	5,500	0	5,500	0	5,500	5,500	-20%	4,400	4,400
5 *FGs Full Case Storage*	9,900	0	9,900	0	9,900	9,900	0	9,900	9,900
6 *FGs Full & Broken Pallet Storage*	35,250	4,100	39,350	+20%	47,200	47,200	+20%	47,200	47,200
7 *FGs Stump Case Storage*	650	0	650	0	650	650	0	650	650
8 *Stage for Picking: Line 1*	4,200	-2,100	2,100	0	2,100	2,100	0	2,100	2,100
9 *Stage for Picking: Lines 2 & 3*	2,300	-750	1,550	+50%	2,300	2,300	+50%	2,300	2,300
10 *Order Pick: Flow Rack*	10,500	0	10,500	+25%	13,100	13,100	0	10,500	10,500
11 *Order Pick: Flex Flow*	3,500	0	3,500	+25%	4,400	4,400	0	3,500	3,500
12 *Order Pick: Flex & Bulk*	3,500	1,100	4,600	+25%	5,750	5,750	0	4,600	4,600
13 *Carton Seal, Label & Inspect*	3,000	0	3,000	0	3,000	3,000	0	3,000	3,000
14 *Sort to Pallets*	2,700	0	2,700	+25%	3,200	3,200	0	2,700	2,700
15 *Store Ship Pallets*	5,600	2,100	7,700	+30%	10,800	10,800	+30%	7,700	7,700
16 *Shipping*	2,000	1,300	3,300	0	3,300	3,300	0	3,300	3,300
17 *Store Pack Supplies*	600	0	600	0	600	600	0	600	600
18 *Rework/Customer Sticker*	1,600	0	1,600	0	1,600	1,600	0	1,600	1,600
19 *Office Areas*	3,250	-800	2,450	0	2,450	2,450	0	2,450	2,450
20 *Personnel Facilities*	2,000	0	2,000	0	2,000	2,000	0	2,000	2,000
21									
22									
TOTALS	110,600	6,450	117,050	0	139,300	139,300	0	129,950	129,950

NOTES: *The plan-for space reqts assume no methods improvements and a single site facility.*

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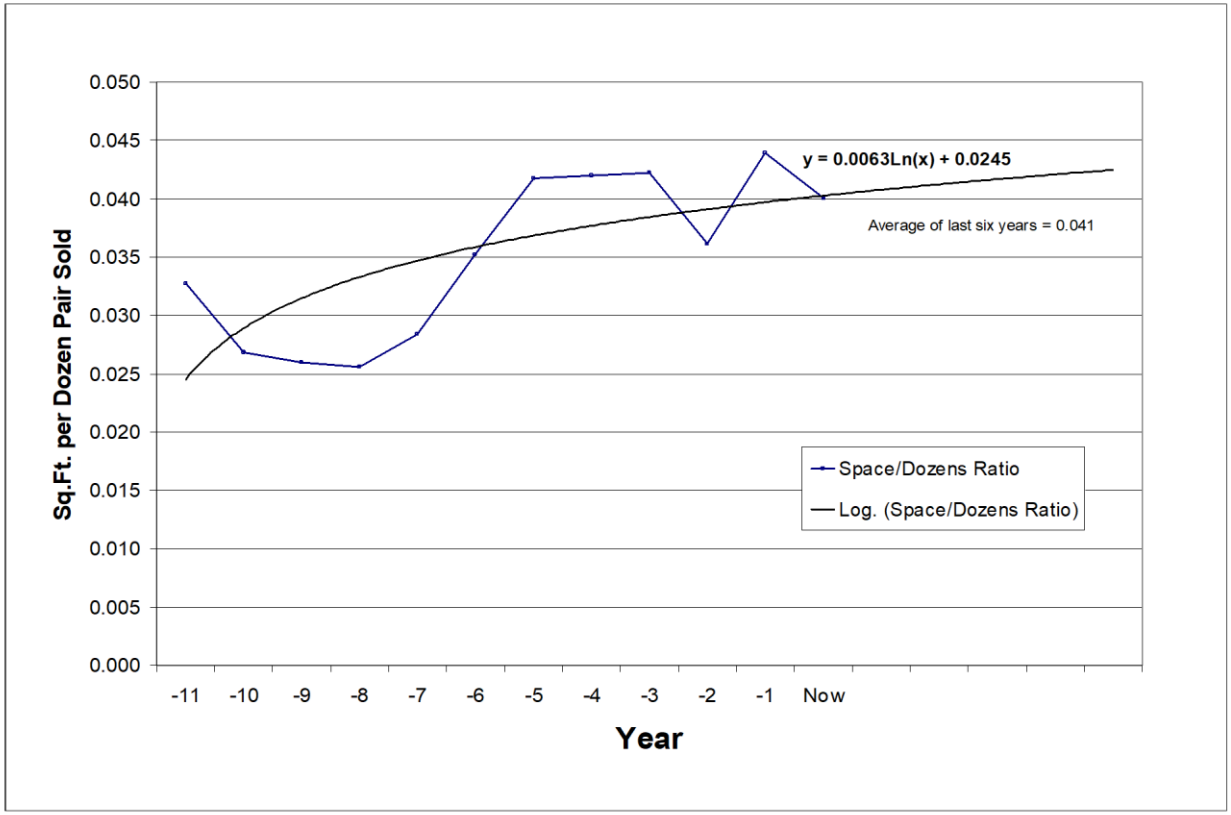
Notes

Main Points

1. Long-term trends in space per unit of output will be "up," "down," or "side-ways."
2. Here, the trend is up because this manufacturer of socks began outsourcing to Asia 7 years ago. Since then, the longer supply line has required more finished inventory, and thus more floor space.
3. New buildings were acquired 2 years ago and 6 years ago. These increased the ratio since the new facilities were sized for growth and were underutilized at first.
4. Now, the company is again out of space, suggesting the need for at least 0.04 square feet per dozen pairs of socks sold.
5. A curve can be fitted to the historical ratio data. In this case a logarithmic function is the best fit and provides a formula for projecting the ratio into the future.
6. This graph and formula were applied to a sales forecast to size a new facility and estimate the acreage required.

Trend in Space per Unit of Activity



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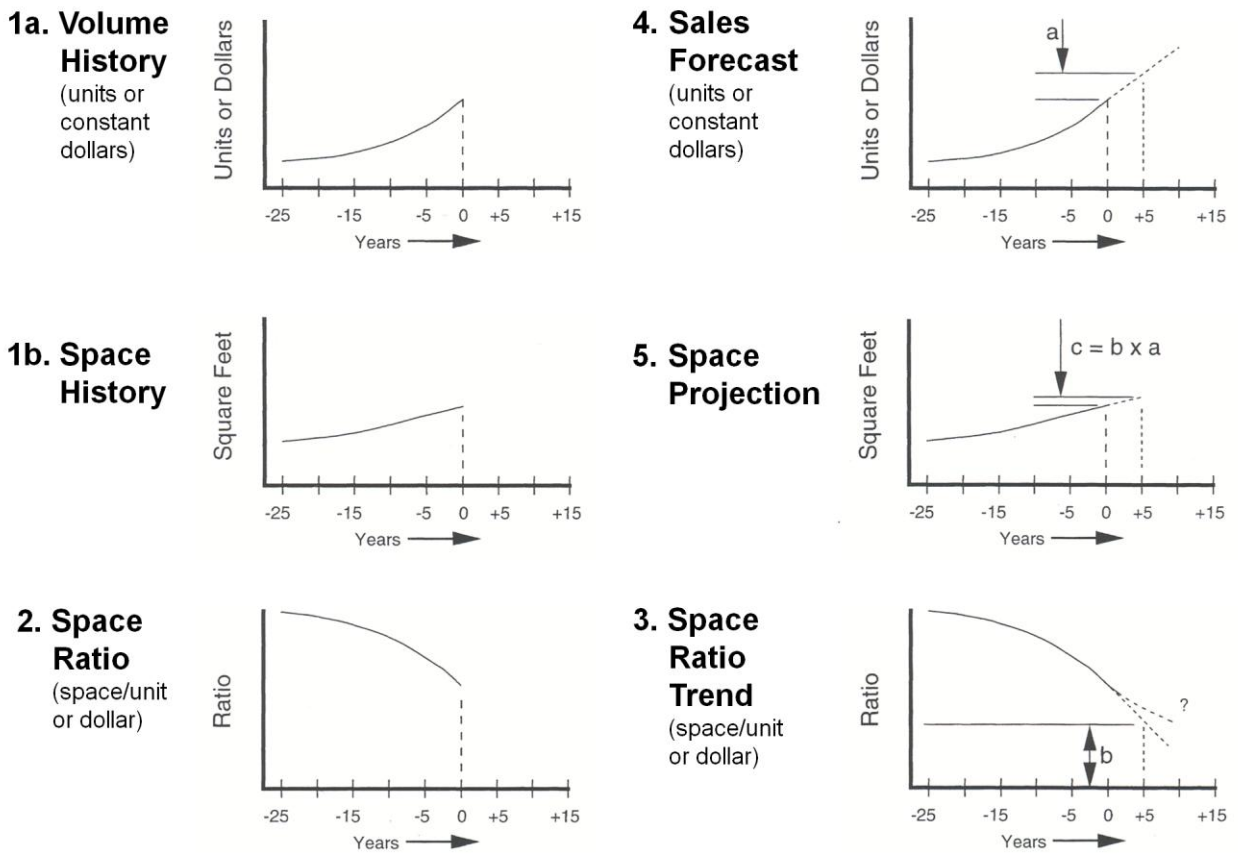
Notes

Main Points

1. The ratio-trend and projection method is limited to total or general space requirements. It cannot be applied to individual activity-areas.
2. It is perhaps the least accurate of the five methods for determining space requirements. Still, for long-range planning, especially for warehouses and distribution centers, it may be fully adequate.
3. Ratio-trend and projection establishes a ratio of space used to some other factor, such as business volume or inventory level. (See steps 1a., 1b., and 2)
4. By comparing ratios for past periods, one establishes a trend for the ratio and projects into the future what the ratio is likely to be. (See step 3)
5. From this projection and a projection of the companion portion of the ratio, the space to meet that projection can be derived. (Steps 4 and 5)
6. Space per physical unit of volume is perhaps the best ratio to use. In distribution, this could be orders, lines picked, case volume, etc.
7. Other potentially useful ratios include: space per dollar of inventory investment; space per labor hour worked; space per active stock keeping unit; space per customer served…

Ratio-Trend & Projection



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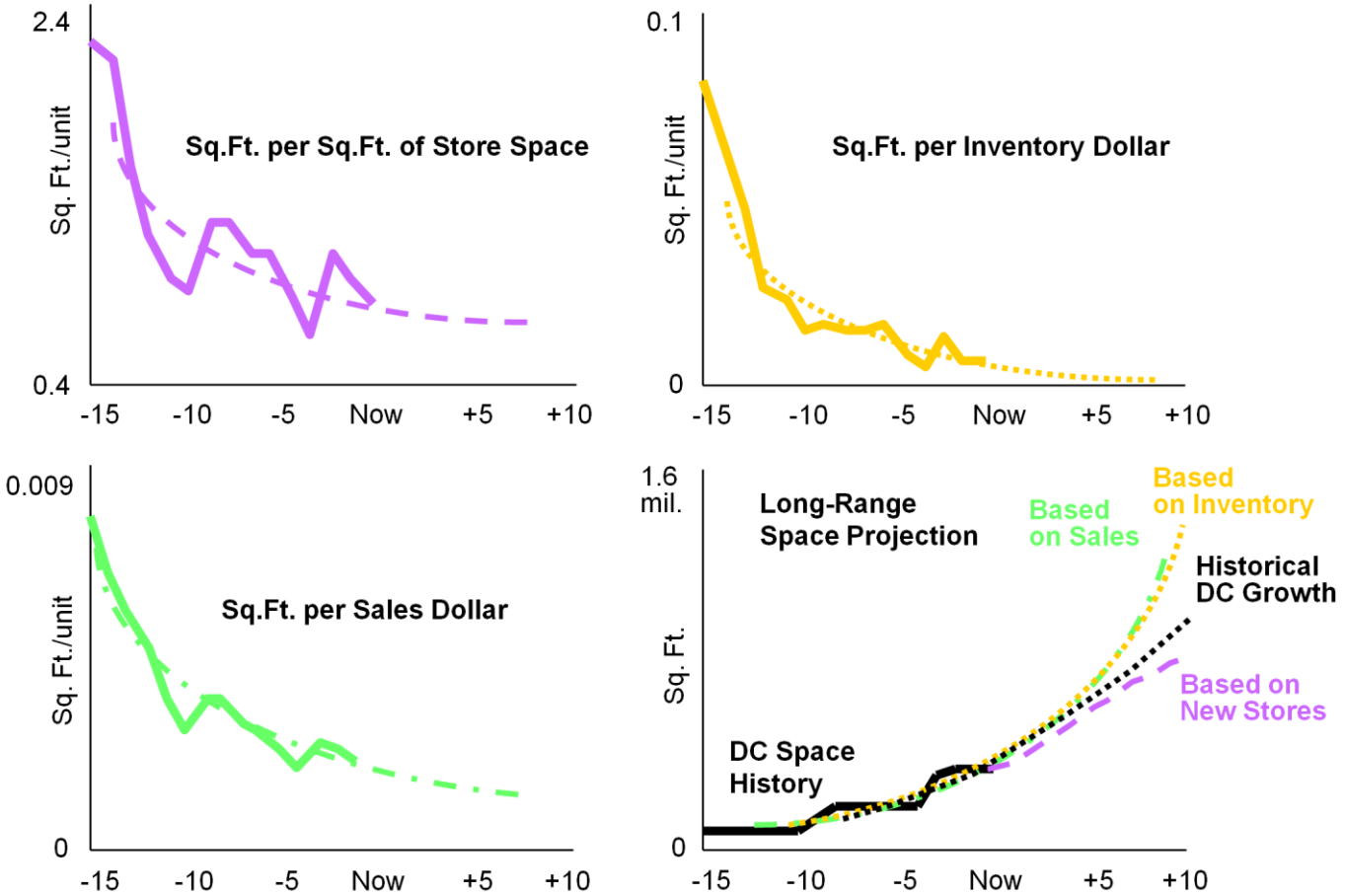
Notes

Retailer DC Ratio Trends & Projections

Main Points

1. In this example, three different space ratios have been established and projected. These relate total distribution center (DC) space to:
   - Retail store space that the DC supports
   - Inventory dollars stored
   - Sales made
2. The space history of the DC is established from records and memory of long-time employees.
3. Forecasts are obtained for number of stores and store size, inventory levels, and sales.
4. By applying the projected space ratios to the forecasts, three estimates of DC space are determined.
5. These are compared to a projection of historical DC space itself.
6. Strategic plans are built around the average, the mid-point of the estimates, or some other judgmentally-selected estimate of long-range requirements.



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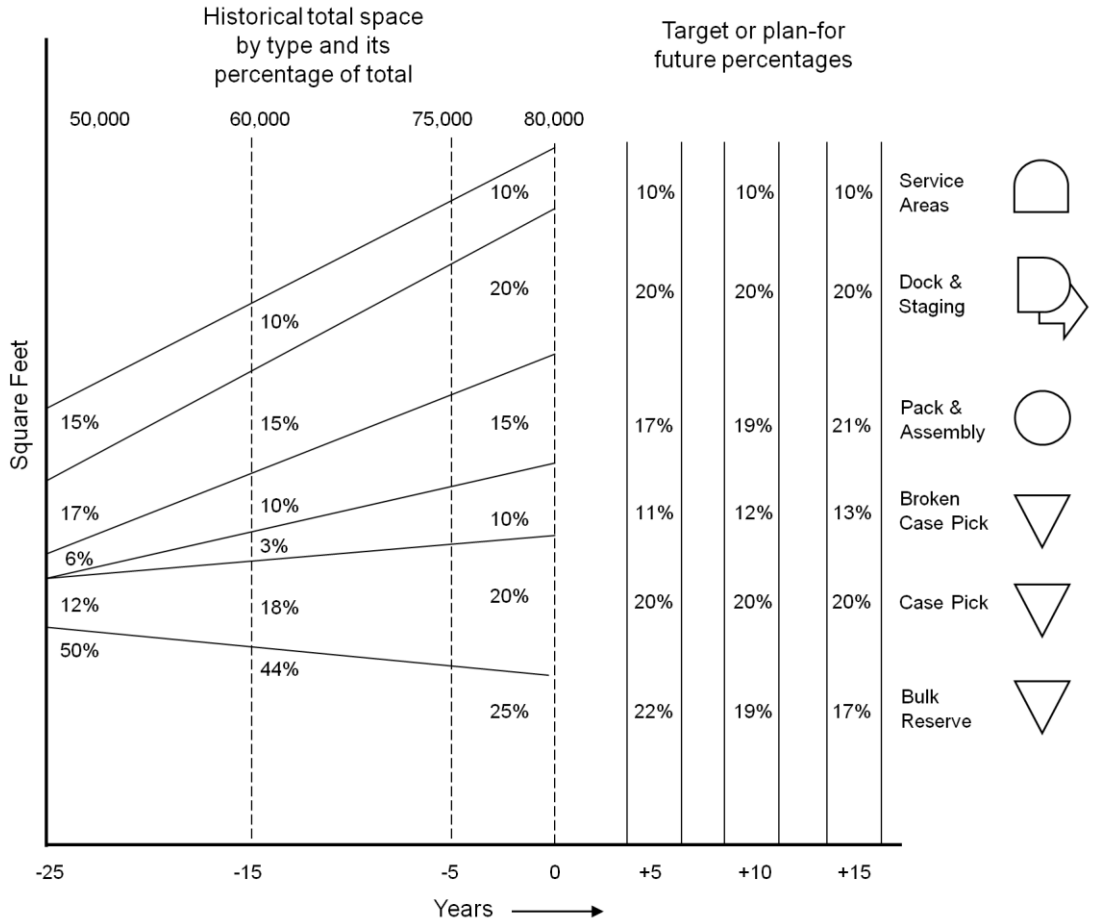
Notes

Warehouse Class of Space Proportions and Projection

Main Points

1. When making estimates for 5, 10 or more years into the future, methods that rely on estimates for specific equipment or activity-areas are of questionable validity.
2. Changes in products, processes, and organizational structures tend to invalidate estimates for precisely-defined activity areas. For this reason, the Calculation, Conversion, and Rough Layout methods tend to be of less value for long-range projections.
3. However, by combining similar areas or departments into several classes of space, the aggregate space in each class can be estimated, long-term, using Ratio Trend and Projection.
4. Projecting the percentages of under-roof space by class of occupancy is not difficult so long as we realize that long-range projections need not be precise.
5. Whenever the basic character of a business changes, the percentages change. Percentages also reflect improvements in operations.
6. Historical records of space by class are often difficult to obtain. Old photographs, memories of senior and retired employees, old drawings, and insurance records may be useful.



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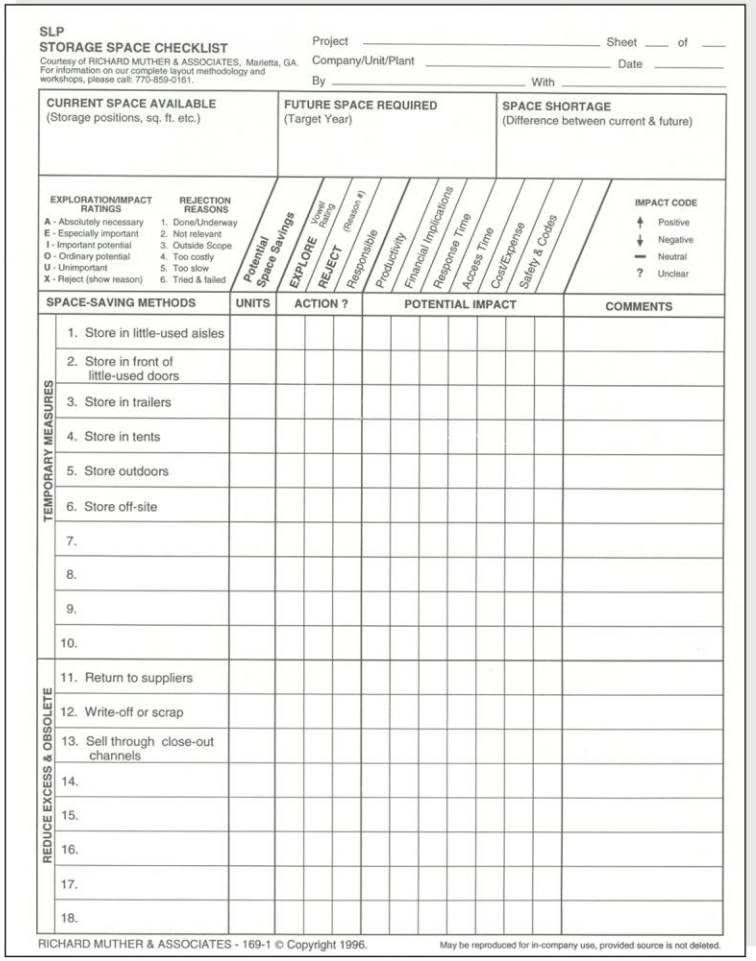
Notes

Main Points

1. In Systematic Layout Planning (SLP), the Storage Space Checklist is used to resolve space shortages.
2. Sheet 6 is photocopied for use on a specific project. The planner reviews Sheets 1 – 5 for relevant space-saving methods.
3. The checklist includes many measures that may be beyond the control of the warehouse manager or facilities planner. Yet these are often the best solutions.
4. Most shortages require the application of several methods. At the same time, only a few methods will apply to any specific project and shortage.
5. Since most space-saving methods have some negative impact on the operations, the alternative of providing more space should always be considered.
6. The specific procedure for balancing space required and space available is:
   - Estimate future needs.
   - Identify relevant space saving methods and calculate the space they would save.
   - Estimate each method's investment cost or expense.
   - Assess or rate the impact of relevant methods on operational effectiveness.
   - Evaluate and decide.



SLP
STORAGE SPACE CHECKLIST
Courtesy of RICHARD MUTHER & ASSOCIATES, Marietta, GA. For information on our complete layout methodology and workshops, please call: 770-859-0161.

Project _____ Sheet ___ of ___
Company/Unit/Plant _____ Date _____
By _____ With _____

CURRENT SPACE AVAILABLE (Storage positions, sq. ft. etc.)	FUTURE SPACE REQUIRED (Target Year)	SPACE SHORTAGE (Difference between current & future)

EXPLORATION/IMPACT RATINGS
A - Absolutely necessary
E - Especially important
I - Important potential
O - Ordinary potential
U - Unimportant
X - Reject (show reason)

REJECTION REASONS
1. Done/Underway
2. Not relevant
3. Outside Scope
4. Too costly
5. Too slow
6. Tried & failed

IMPACT CODE
↑ Positive
↓ Negative
— Neutral
? Unclear

	SPACE-SAVING METHODS	UNITS	Potential Space Savings	ACTION ? EXPLORE	Level Rating	REJECT (Reason #)	POTENTIAL IMPACT Responsible	Productivity	Financial Implications	Response Time	Access Time	Cost/Expense	Safety & Codes	COMMENTS
TEMPORARY MEASURES	1. Store in little-used aisles													
	2. Store in front of little-used doors													
	3. Store in trailers													
	4. Store in tents													
	5. Store outdoors													
	6. Store off-site													
	7.													
	8.													
	9.													
	10.													
REDUCE EXCESS & OBSOLETE	11. Return to suppliers													
	12. Write-off or scrap													
	13. Sell through close-out channels													
	14.													
	15.													
	16.													
	17.													
	18.													

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Notes

_____

_____

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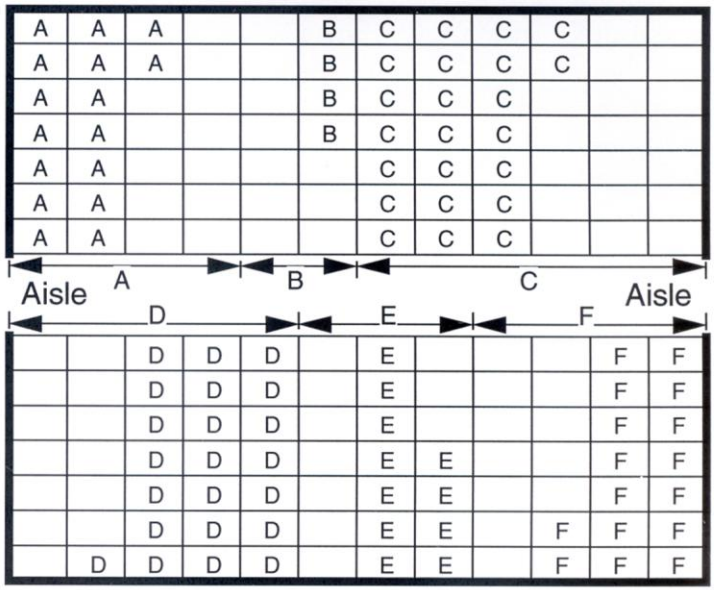
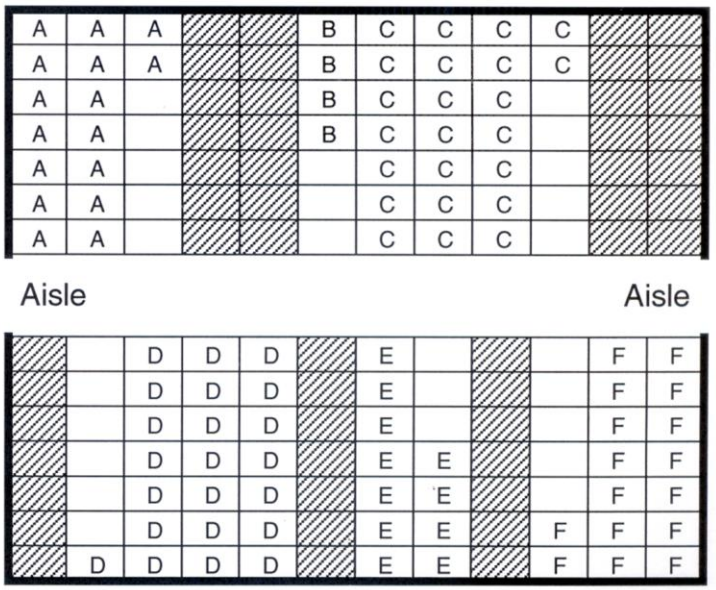
Fixed or Random Stock Locations





Fixed Stock Locations

With fixed locations, the number of slots (or spots or rack openings) is determined by the maximum or planned target inventory.

In this illustration, none of the vacant slots are available for other products.

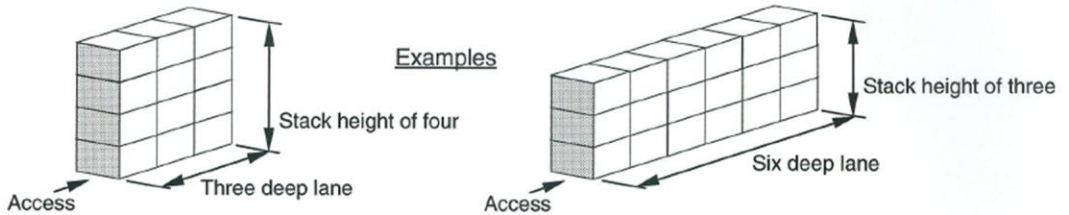
Fixed locations makes finding materials (items) easy and engineers the ideal location relative to flow, but requires more space than random storage – sometimes significantly more.

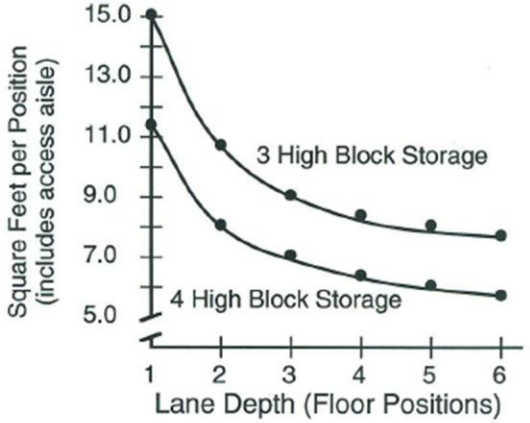
Random Stock Locations

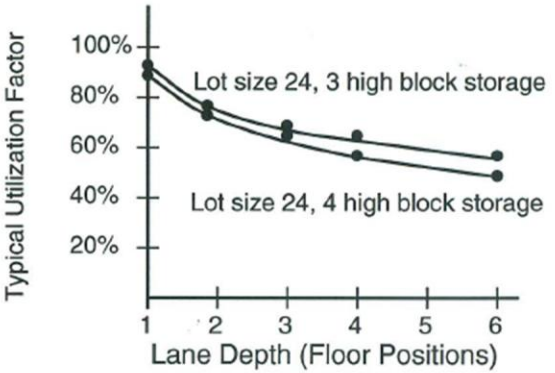
Storage in random locations makes good use of space (high density) but requires an accurate stock locator system. In this example, random storage provides an additional 49 positions or 29% of all available space for storage of any item.

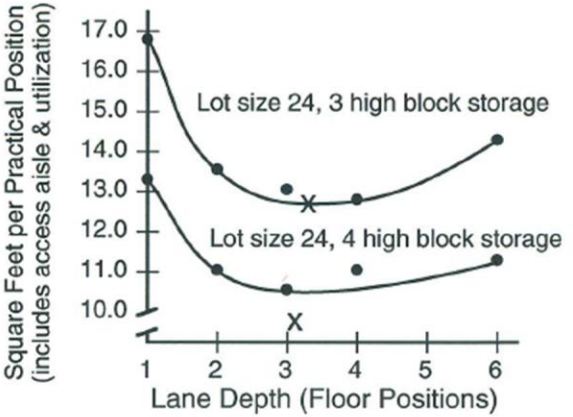
Random location storage makes it feasible to plan for average rather than maximum inventory. However, it may sacrifice the productivity benefits of order-picking from fixed locations. For this reason, reserve may be random, while order-picking locations are fixed.

Floor Storage: Lane Depth and Stack Height









Increasing lane depth increases *theoretical* capacity.

Greater lane depth reduces access space and thus **decreases** the floor space required for each position.

Always stack as high as safely possible to minimize floor space requirements.

Increasing lane depth tends to lower utilization.

Greater lane depth also reduces utilization (causes honeycomb) which tends to **decrease** practical or observed capacity.

Increase lane depth until saved access space is offset by lower utilization of recovered storage space.

Select lane depths that minimize floor space per practical load position.

Depletion (picking) patterns, incoming lot sizes, and typical on-hand quantities are the primary factors to assess in planning lane depths.

NOTE: This analysis assumes steady depletion of inventory. The analysis may not apply to produce-and-ship, seasonal builds, or long term storage applications.

Main Points

1. In this example, main aisle space is called out on a separate line as Activity 10.
2. This approach makes clear how much of total space is assigned to main aisles.
3. Areas 1 – 9 are thus net of main aisle space.
4. Here, main aisles have been estimated by adding 20% to the sum of the net areas.
5. The resulting space amounts to 17% of total area, including main aisles.
6. Most industrial facilities have between 15% and 20% in main aisles.
7. Some variation in percentage depends upon whether a main aisle is included between rack storage and adjacent receiving or shipping areas.
8. 18.5% is a rule of thumb in the absence of an actual layout to be measured.
9. The larger the objects moved, the higher the aisle space percentage. Conversely, less is typically needed when moving very small items.

ACTIVITIES AREA & FEATURES SHEET

Plant: Oil Products Ltd.
Project: Finished Goods Storage
By: KH With: RM
Date: 8/11 Page: 1 of 1

Activity — Physical Features Required

No.	Name	Area in Sq. Ft.	O'Head Clearance	Max. Overhead Supported Load	Max. Floor Loading	Min. Column Spacing	Water & Drains	Steam	Compressed Air	Foundations - or Pits	Fire or Explosion Hazard	Special Ventilation	Special Electrification	Requirements for Shape or Configuration of Area (Space)
		Total: 14,600	Enter Unit and Required Amount under each				Relative Importance of Features: A - Absolutely Necessary; E - Especially Important; I - Important; O - Ordinary Importance; - Not Required							Enter Requirements for Shape or Configuration and Reasons therefore
			feet											
1. (1)	Drums, Bulk Storage	2,100	20	--	--	--	--	--	--	--	--	--	--	
2. (2)	Drums, Pallet Racks	2,400	20	--	--	--	--	--	--	--	--	--	--	
3. (3)	Cartons, Bulk Storage	4,300	20	--	--	--	--	--	--	--	--	--	--	
4. (4)	Cartons, Order-Picking	1,500	20	--	--	--	--	--	--	--	--	--	--	
5. (5)	Packaging	200	12	--	--	--	O	--	I	--	--	--	--	
6. (6)	Staging Area	800	12	--	--	--	--	--	--	--	--	--	--	
7. (7)	Office	500	9	--	--	--	O	--	--	--	--	--	--	
8. (8)	Personnel Facilities	200	9	--	--	--	I	--	--	--	--	--	--	
9. (9)	Truck Station	100	9	--	--	--	--	--	--	--	I	I	I	
10. (10)	Main Aisles (a)	2,500	--	--	--	--	--	--	--	--	--	--	--	
11. (11)	(Loading Dock)		--	--	--	--	--	--	--	--	--	--	--	
12.														
13.														
14.														
15.														

Sub-Activities or Areas

Notation References:
a 20% added for main aisles
b
c

No. ____ Activity ____ Sheet ____ of ____

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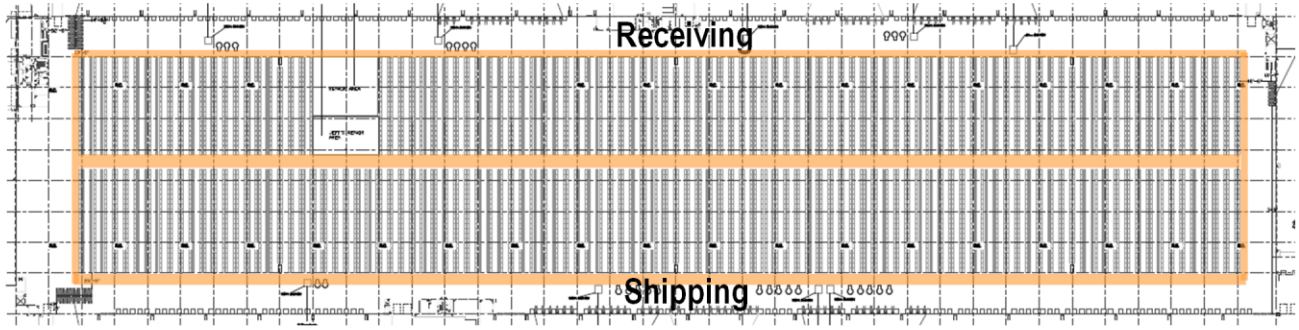
Notes

Main Points

1. Storage aisles are included in space requirements for each storage area. These are aisles floor storage lanes, pallet racks and shelves.
2. Local aisles between order assembly stations and packing are also typically included in the requirements for each area.
3. Main and cross aisles are those used to across the facility and between storage and other activity areas.
4. This type of aisle space typically ranges from 10% to 20% of total area underroof.
5. In layout planning, main aisle space can be allocated to the activity areas on each side, or it can be measured as a separate category or type of space.
6. In smaller layouts, storage aisles often double as main or cross aisles. So some judgment is required when allocating their space or tracking it separately as aisle space.
7. In receiving and shipping areas that may consist of open space between racks and exterior walls, there may be no marked aisle for lateral movement. Here, the planner must decide to ignore the unmarked aisle, or to declare it and reduce the space allocated to dock activities.

Accounting for main & cross aisles



Large industrial supply DC

- Center main aisle is 20' wide, so that through traffic does not conflict with local travel between storage aisles.
- 20' aisle also doubles as overnight staging for put away.
- Aisles across Receiving and Shipping are not marked but real.
- Aisles total about 10% of total area.

Small, crowded produce DC

- Un-marked cross-aisle within Receiving & Shipping is blocked at times. <10% of total area.
- Should have second aisle at rear.

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Notes

ACTIVITIES AREA & FEATURES SHEET

Plant *Homart Distributors*
Project *Rearrangement*
By *HK* With *RMA*
Date *4/21* Page *1* of *1*

Activity

Physical Features Required

No.	Name	Area in ____ Total: Sq. Meters 3,550	O'Head Clearance (mtrs)	Max. Overhead Supported Load	Max. Floor Loading (Kg/m2)	Min. Column Spacing		Water & Drains	Steam	Compressed Air	Foundations - or Pits	Fire or Explosion Hazard	Special Ventilation	Special Electrification		Requirements for Shape or Configuration of Area (Space)
			Enter Unit and Required Amount under each					Relative Importance of Features: A - Absolutely Necessary; E - Especially Important; I - Important; O - Ordinary Importance; — - Not Required								Enter Requirements for Shape or Configuration and Reasons therefore
1.	*Receive*	*75*	*4*	*Any conveyors floor supported.*	*1220*	*10 x 10 meters throughout warehouse space*		--	--	--	--	--	--	*A*		*Minimum width 10 meters*
2.	*Check-In*	*75*	*4*		*1220*			--	--	--	--	--	--	*A*		
3.	*Returned Goods*	*50*	*4*		*1000*			--	--	--	--	--	--	*A*	(a)	
4.	*Home Goods*	*500*	*6*		*1220*			--	--	--	--	--	--	--		
5.	*Apparel*	*800*	*6*		*1220*			--	--	--	--	--	--	--		
6.	*Footware*	*900*	*6*		*1220*			--	--	--	--	--	--	--		
7.	*Direct Ship*	*200*	*4*		*1000*			--	--	--	--	--	--	--		
8.	*Sales Display*	*50*	*4*		*1220*			--	--	--	--	--	--	--		
9.	*Order Assembly & Pack*	*300*	*4*		*1220*			*A* (b)	--	*A*	--	--	--	*A*		
10.	*Stage*	*100*	*4*		*1220*			--	--	*E*	--	--	--	--		
11.	*Ship*	*150*	*4*	*Normal building roof load only.*	*1220*			--	--	*E*	--	*A*	--	*A*		*Minimum width 10 meters*
12.	*Packing Materials*	*100*	*4*		*1220*			--	--	--	--	--	--	--		
13.	*Office*	*150*	*3*		*750*			*A*	--	--	--	*A*	--	--		*Must stay at front (windows & entrance)*
14.	*Rest Rooms*	*50*	*3*		*750*			*A*	--	--	--	*A*	--	--		
15.	*Supplies & Maintenance*	*50*	*3*		*750*			*A*	--	--	--	*A*	--	--		

Sub-Activities or Areas

Notation References
a *May need fence*
b *Eyewash station next to battery charger*
c

No. ____ Activity ____ Sheet ____ of ____

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Filled-in – 7139-14a-ppt

Here's What I Know

Question	Which Answer Is (Most) Correct	Got It
1. Which of these is not a way to determine space requirements in SLP?	A. Calculation. B. Conversion. C. Computer simulation. D. Rough Layout. E. Space Standards.	
2. Ratio-trend and projection determines long-range aggregate space requirements.	A. True. B. False.	
3. Before determining future needs, current space should be checked for over- or under-utilization.	A. True. B. False.	
4. When space requirements exceed space available, management decisions will likely be needed to resolve the shortage.	A. True. B. False.	
5. In addition to amounts of space, we should also determine the physical features required and any mandatory shape or minimum dimensions.	A. True. B. False.	
6. The total space needed for a layout must include an allowance for main aisles.	A. True. B. False.	

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STORAGE SPACE CHECKLIST

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Project _____ Sheet ___ of ___
Company/Unit/Plant _____ Date _____
By _____ With _____

CURRENT SPACE AVAILABLE (Storage positions, sq. ft. etc.)	FUTURE SPACE REQUIRED (Target Year)	SPACE SHORTAGE (Difference between current & future)

EXPLORATION/IMPACT RATINGS
- **A** - Absolutely necessary
- **E** - Especially important
- **I** - Important potential
- **O** - Ordinary potential
- **U** - Unimportant
- **X** - Reject (show reason)

REJECTION REASONS
1. Done/Underway
2. Not relevant
3. Outside Scope
4. Too costly
5. Too slow
6. Tried & failed

IMPACT CODE
- ↑ Positive
- ↓ Negative
- — Neutral
- ? Unclear

	SPACE-SAVING METHODS	UNITS	ACTION ?			POTENTIAL IMPACT							COMMENTS
		Potential Space Savings	EXPLORE (Vowel Rating)	REJECT (Reason #)	Responsible	Productivity	Financial Implications	Response Time	Access Time	Cost/Expense	Safety & Codes		
TEMPORARY MEASURES	1. Store in little-used aisles												
	2. Store in front of little-used doors												
	3. Store in trailers												
	4. Store in tents												
	5. Store outdoors												
	6. Store off-site												
	7.												
	8.												
	9.												
	10.												
REDUCE EXCESS & OBSOLETE	11. Return to suppliers												
	12. Write-off or scrap												
	13. Sell through close-out channels												
	14.												
	15.												
	16.												
	17.												
	18.												

SLP
STORAGE SPACE CHECKLIST

Project _____ Date _____
By _____ With _____

EXPLORATION/IMPACT RATINGS
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IMPACT CODE
- ↑ Positive
- ↓ Negative
- — Neutral
- ? Unclear

	SPACE-SAVING METHODS	UNITS	ACTION ?			POTENTIAL IMPACT							COMMENTS
		Potential Space Savings	EXPLORE Vowel Rating	REJECT (Reason #)	Responsible	Productivity	Financial Implications	Response Time	Access Time	Cost/Expense	Safety & Codes		
REDUCE ACTIVE STOCK	19. Reorder smaller lots and receive more often												
	20. Let suppliers manage their stocks												
	21. Deliver raw materials just in time												
	22. Deliver packaging just in time												
	23. Store purchased items on the production floor												
	24. Link/improve production to reduce WIP												
	25. Make smaller lots more often												
	26. Cross dock instead of storing												
	27. Drop ship instead of receiving												
	28. Reduce active stock-keeping units (SKUs)												
	29.												
	30.												
REDUCE STAGING REQUIREMENTS	31. Load directly into vans without staging												
	32. Combine checking & loading areas												
	33. Combine checking & picking operations												
	34. Combine checking & packing operations												
	35. Putaway from vans directly into storage												
	36. Eliminate/ reduce incoming staging												
	37. Smooth/tighten delivery schedules												
	38. Receive & ship on different shifts												
	39. Putaway & pick on different shifts												

SLP
STORAGE SPACE CHECKLIST

Project _____ Date _____

By _____ With _____

EXPLORATION/IMPACT RATINGS
- **A** - Absolutely necessary
- **E** - Especially important
- **I** - Important potential
- **O** - Ordinary potential
- **U** - Unimportant
- **X** - Reject (show reason)

REJECTION REASONS
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IMPACT CODE
- ↑ Positive
- ↓ Negative
- — Neutral
- ? Unclear

	SPACE-SAVING METHODS	UNITS	ACTION ?			POTENTIAL IMPACT							COMMENTS
		Potential Space Savings	EXPLORE Vowel Rating	REJECT (Reason #)	Responsible	Productivity	Financial Implications	Response Time	Access Time	Cost/Expense	Safety & Codes		
REDUCE STAGING	40. Stage in racks												
	41. Stage in horizontal carousels												
	42.												
	43.												
	44.												
CHANGE PACKAGING & CONTAINERS	45. Redesign to reduce package/container size												
	46. Change package dimensions												
	47. Change pallet stacking configurations												
	48. Change pallet dimensions												
	49. Change pallet style or design												
	50. Change bin or tote style or design												
	51. Use smaller bins/totes												
	52. Strengthen packages for higher stacking												
	53.												
	54.												
CHANGE STORAGE METHODS	55. Use random storage locations												
	56. Store multiple items per storage position												
	57. Use floor or bulk stack												
	58. Use stacking frames to stack higher												
	59. Increase/decrease lane or key depths												
	60. Deck & hand load pallet racks												

SLP
STORAGE SPACE CHECKLIST

Project _____ Date _____
By _____ With _____

EXPLORATION/IMPACT RATINGS
- **A** - Absolutely necessary
- **E** - Especially important
- **I** - Important potential
- **O** - Ordinary potential
- **U** - Unimportant
- **X** - Reject (show reason)

REJECTION REASONS
1. Done/Underway
2. Not relevant
3. Outside Scope
4. Too costly
5. Too slow
6. Tried & failed

IMPACT CODE
- ↑ Positive
- ↓ Negative
- — Neutral
- ? Unclear

	SPACE-SAVING METHODS	UNITS	ACTION ?			POTENTIAL IMPACT							COMMENTS
		Potential Space Savings	EXPLORE Vowel Rating	REJECT (Reason #)	Responsible	Productivity	Financial Implications	Response Time	Access Time	Cost/Expense	Safety & Codes		
CHANGE STORAGE METHODS	61. Use racks instead of shelves												
	62. Use shelves instead of racks												
	63. Vary rack opening heights												
	64. Vary shelf opening heights												
	65. Shorten/lengthen cross-beams												
	66. Extend rack uprights and/or add crossbeams												
	67. Use drawers												
	68. Install more spacers & inserts in drawers												
	69. Install mezzanines												
	70. Use vertical carousels												
	71. Use horizontal carousels												
	72. Use mobile (compactor) shelving												
	73. Use cantilever racks												
	74. Use double-deep racks												
	75. Use push-back racks												
	76. Use pallet flow rack												
	77. Use high-bay racks												
	78. Use mobile (compactor) racks												
	79. Dead-end storage aisles												
	80. Install bridges above cross-aisles												
	81. Install racks above entrances & exits												

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	SPACE-SAVING METHODS	UNITS	ACTION ?			POTENTIAL IMPACT							COMMENTS
		Potential Space Savings	EXPLORE (Vowel Rating)	REJECT (Reason #)	Responsible	Productivity	Financial Implications	Response Time	Access Time	Cost/Expense	Safety & Codes		
STORAGE METHODS	82. Store above floor conveyors												
	83.												
	84.												
	85.												
CHANGE HANDLING & PICKING METHODS	86. Pick from storage; eliminate pick areas												
	87. Use reach trucks												
	88. Use side-loading trucks												
	89. Use turret or swing-mast trucks												
	90. Use narrow-aisle trucks												
	91. Use rail or wire-guided trucks												
	92. Use overhead conveyors												
	93. Use stacker cranes												
	94.												
	95.												
	96. Fill-in enclosed docks; move docks outside												
	97. Use battery-charging racks												
	98. Put offices & support on mezzanine												
	99. Change distribution to bulk (eliminate picking)												
	100.												
	101.												
	102.												

SLP
STORAGE SPACE CHECKLIST

Courtesy of RICHARD MUTHER & ASSOCIATES, Marietta, GA.
For information on our complete layout methodology and workshops, please call: 770-859-0161.

Project ______________________ Sheet ____ of ____
Company/Unit/Plant ______________________ Date ________
By ______________________ With ______________________

CURRENT SPACE AVAILABLE (Storage positions, sq. ft. etc.)	**FUTURE SPACE REQUIRED** (Target Year)	**SPACE SHORTAGE** (Difference between current & future)

EXPLORATION/IMPACT RATINGS

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		Potential Space Savings	**EXPLORE** Vowel Rating	**REJECT** (Reason #)	Responsible	Productivity	Financial Implications	Response Time	Access Time	Cost/Expense	Safety & Codes		
	SPACE-SAVING METHODS	**UNITS**	**ACTION ?**			**POTENTIAL IMPACT**							**COMMENTS**