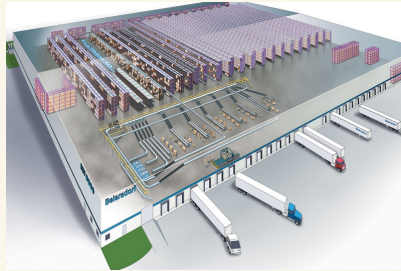


## Chapter 9 Warehouse Layout

Design is all about trade-offs. Between speed, travel distances, space utilization, handling, access, safety, risk and cost.



The most optimal design is one that fully meets today's operational requirements but ... being flexible, scalable and relatively inexpensive to adapt.



## Examples

某化妝品牌集團除現有實體通路外，決定進軍網路銷售，直接銷售給消費者，預期網路銷售在未來5至10年內將趕上實體通路。

Q: B2B與B2C的訂單內容差異大，至少需要擴建或改造揀貨區。

某外商直營之南科廠為眾多維修零件庫存所困擾，由於缺乏單一的大空間，庫存儲存於多個不同地點，部分舊器材則堆放於停車場。

Q: 如何減少庫存並重新規劃倉庫的佈署？

某半導體大廠計劃擴充生產基地，擬引進自動化倉儲系統以支援未來五年的生產需求。

Q: 分期擴建或一次到位？需要多大的空間？



## What Areas to Concentrate

gather as much data as possible and analyse it. 資料分析

imagine the business in 5–10 years' time and build in flexibility. 未來彈性

the cubic capacity of the building. 善用建築體積

ensure the design is sympathetic to the existing storage equipment and MHE. 適用現有設備

the health and safety of staff. 員工安全

reduce the amount of movement required. 減少移動

standardize the packaging both for movement and storage. 包裝標準化

the local building regulations and floor loading requirements. 當地法規

don't forget the outside of the building. 建築外部環境



## 1. Space Planning

影響主要動線

確定固定障礙的位置：樑柱、樓梯、升降梯、消防設施

決定進貨與出貨部門位置

考慮車輛進出交通、共用的優點與缺點  
影響主要動線

決定各部門的大小與位置

棧板儲貨區、揀貨區、加工區、冷藏、冷凍、管制品  
搬運設備停放區、耗材儲存區  
辦公室、餐廳、洗手間

決定主通道與次通道

通道寬度可會車或迴轉，編號與標示

決定各部門的內部規劃

料架排列方式、各類商品的儲存空間與位置

A類與超大超重商品

倉庫周遭的交通與空間需求



## Receipt and Despatch Areas

Q: 是否進出共用？是否同時進行？是否有進出貨排程？

- ❖ Getting the right balance between the number of doors, equipment and labour is difficult to achieve and requires the coordination of arrivals and departures with available resources.

$$A = \frac{\text{number of loads} \times \text{hours to load/unload}}{\text{time of shift}} \div \text{dock utilization}$$

- ❖ Space requirement for staging vehicles on arrival and departure:

$$B = A \times [\text{number of pallets per load} \times \text{space per pallet} + \text{allowance}]$$



## Pallet Storage Requirements

- ❖ 預測年出貨量/預定年存貨週轉次數=平均存貨量
- ❖ 平均存貨量/棧板平均存貨量=平均棧板數量
- ❖ 平均棧板儲存數量×**peak to average ratio**=尖峰棧板數量
  
- ❖ 尖峰棧板數量×尖峰存量比率=有效棧板儲存量
- ❖ 有效棧板儲存量/**預定儲位佔用率**=棧板儲位需求 (1)
  
- ❖ 棧板儲位需求/每排料架儲位數=料架排數 (依高度而定)
- ❖ 料架所佔面積+走道面積=棧板區樓板面積需求



## AS/RS儲位數計算



## Number of Pallets that Can be Stored

The number of pallets that can be stored is determined by the aisle width, type of racking and the size of pallet (**1.1×1.1**).



Module width = (aisle width) + 2 pallet lengths + clearance between back-to-back pallets =  $2 \times 1.1 + 0.1 = 2.3$

Module length = width of upright + 3 × clearance + 2 pallets =  $0.15 + 3 \times 0.1 + 2 \times 1.1 = 2.65$

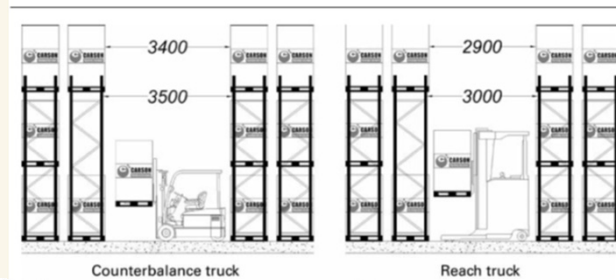
Module height = height of pallet + clearance above pallet + racking beam height =  $(0.15 + 1.2) + 0.15 + 0.15 = 1.65$



## Aisle Width

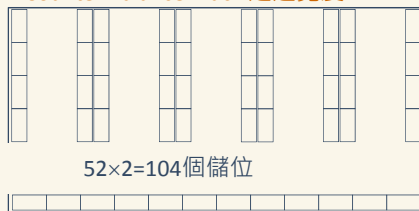
- ❖ The aisle width is determined by the turning circle of the forklift truck and the size of pallet being carried.
- ❖ Aisle width decisions need to achieve the best combination of productivity, space utilization, flexibility, safety and equipment costs.

**FIGURE 9.2&9.3** Aisle widths (courtesy of Carson Racking Systems Limited)



## Forklift Truck vs. Aisle Width

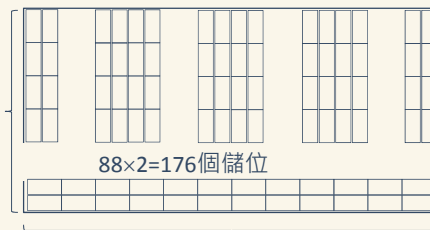
Counter Balance Truck 走道寬度4 m



52×2=104個儲位

$$\text{Width} = 0.1 + 2.65 \times 4 + 2.9 + 2.3 + 0.1 = 16.0$$

Reach Truck 走道寬度2.9m



88×2=176個儲位

$$\text{Length} = 0.1 + 2.65 \times 12 + 0.1 = 32.0$$



## 棧板存取設備選擇

- ❖ 預測年出貨量/營運天數=平均日出貨量
- ❖ 平均日出貨量×peak to average ratio=尖峰日出貨量 (2)
- ❖ 尖峰日出貨量/每棧板平均出貨量=尖峰日出貨棧板數
- ❖ (尖峰日出貨棧板數×2)/設備每日存取能力=存取設備需求

	每小時存取數	料架高度	走道寬度
人工拖板車	8 (6)	地面層	2m
電動拖板車	12 (10)	地面層	3m
電動堆高機	15 (12)	五層	4m
直達式堆高機	15 (12)	五層	3m
側載式堆高機	12 (10)	五層	2m
自動倉儲存取機	30 (25)	十五層	2m



## 棧板儲存區整體成本計算

1. 首先決定儲位需求 (1)
2. 其次決定每日存取棧板數 (2)
3. 選擇棧板料架類型(3.1) · 決定儲存高度(3.2)與走道寬度 (3.3)
4. 根據儲位需求(1)、料架類型(3.1) · 計算料架數量(4.1)與成本(4.2)
5. 根據料架數量(4.1)與走道寬度(3.3) · 計算儲存空間需求與成本(5)
6. 根據每日存取棧板數(2)、料架類型(3.1)與走道寬度(3.3) · 決定存取設備的數量與成本(6)
7. 計算棧板儲存區整體成本=(4.2)+(5)+(6)



## 棧板料架設備成本

- ❖ 單倍深料架 每儲位 2K
- ❖ 雙倍深料架 每儲位 2.5K
- ❖ 三倍深後推式料架 每儲位 5K
- ❖ 五倍深流動式料架 每儲位 10K
  
- ❖ 拖板車 10K(手動), 100K(電動)
- ❖ 電動堆高機CBLT 600K
- ❖ 直達式堆高機 1M
- ❖ 側載式堆高機 2M
- ❖ 自動倉儲 每走道(不含料架) 8M



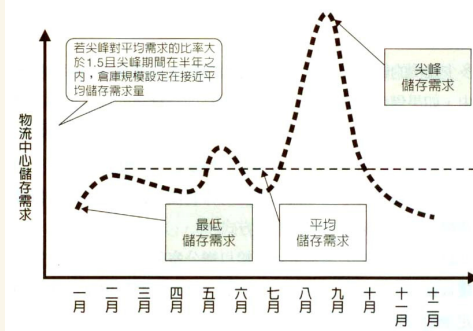
## Deal with Peaks, Do not Rely on Averages

The question is whether we plan for and accommodate peaks in business, whether we design for the average activity or somewhere in between.

若尖峰儲存期不長而且尖峰儲存量顯著高於平均儲存量，

1. 以平均需求為設計目標
2. 尖峰時可使用外部倉庫或是拖車等暫存空間

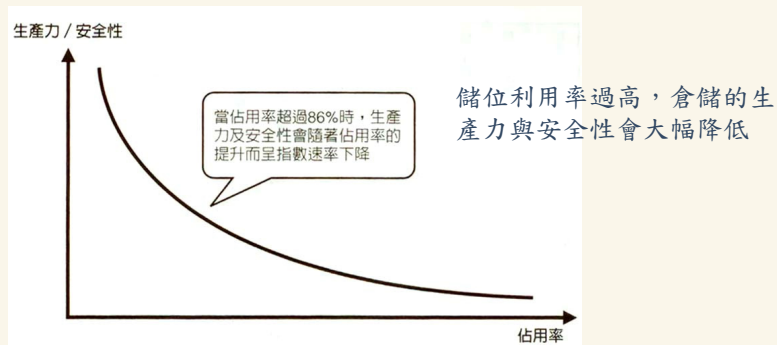
圖 10-1 某時期的儲存容量需求——高尖峰對平均需求比率



## Productivity vs. Storage Utilization

Q: 如何規劃儲位佔用率以決定儲位需求？

- ❖ 非即時運作的倉儲，儲位佔用率不應超過85%
- ❖ 即時運作的倉儲中，儲位佔用率不應超過90%



## Other Space Requirements

- ❖ The amount of space set aside for packing, value-adding services and returns processing ... staff and the type of equipment required. 包裝、增值服務、回收處理
- ❖ The area needed to store, recharge and change batteries for forklifts, a parking area for equipment when not in use, an area for storing empty pallets and ... 器具充電或停放
- ❖ Office and restroom space will be determined by the number of employees required within the warehouse. 辦公室與洗手間
- ❖ 預留部門之間的走道空間需求 (全部空間的20%)
- ❖ Outside the building: truck traffic, staff parking, waste storage ... 進出動線、員工停車、垃圾處理



## 2. Warehouse Layout Examples

動線應配合作業需求，降低物料搬運的距離與時間

- ❖ U型動線

為其他動線設計的標竿，其他設計都應該要與U型動線進行功能與效率上的比較，如果在某些方面優於U型動線，才值得考慮

- ❖ 穿越式動線

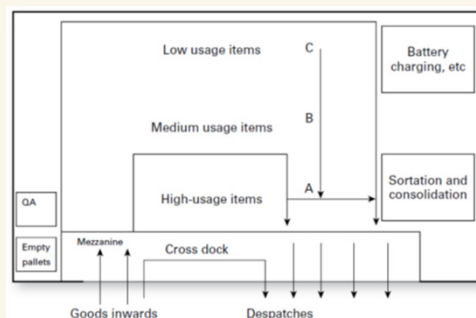
- ❖ 模組化主幹動線

- ❖ 多樓層倉儲動線

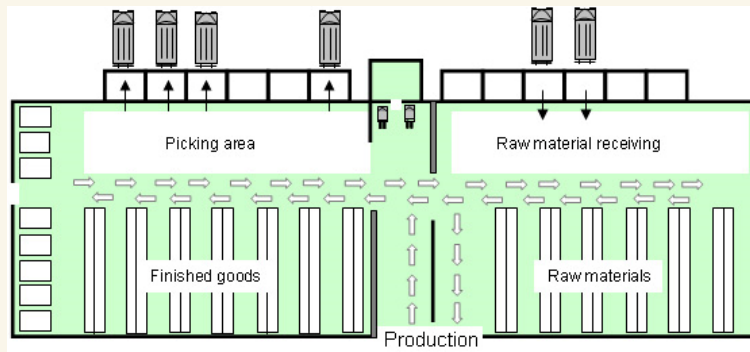


### U-Shaped Flow

- ❖ Receiving and despatch are on the same side ... facilitating cross docking. But can result in congestion if both areas are busy at the same time.
- ❖ Fastest-moving items are closest to the despatch bay, thus ensuring minimum travel and the opportunity to combine put-away and retrieval.
- ❖ 可以往三個方向進行空間的擴張
- ❖ 進出貨都在建築物的單邊進行，安全性較高



## Manufacturing Warehouse Layout

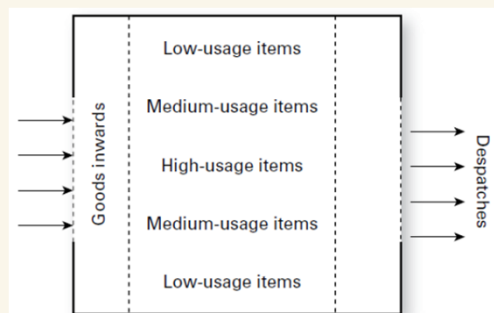


- 須配合生產線需求，進出貨動線不同
- 原料與成品的儲存與揀貨方式不同



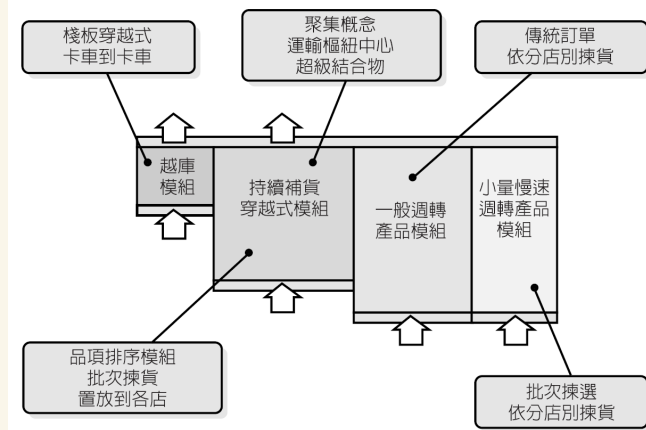
## Straight-Thru Flow

- ❖ 適合純越庫作業，或是應付進出貨尖峰時間同時發生的情況
- ❖ 缺點是無法獲得ABC分類儲存的效益
- ❖ There are no issues with congestion but travel distances are increased and ... increased security and access

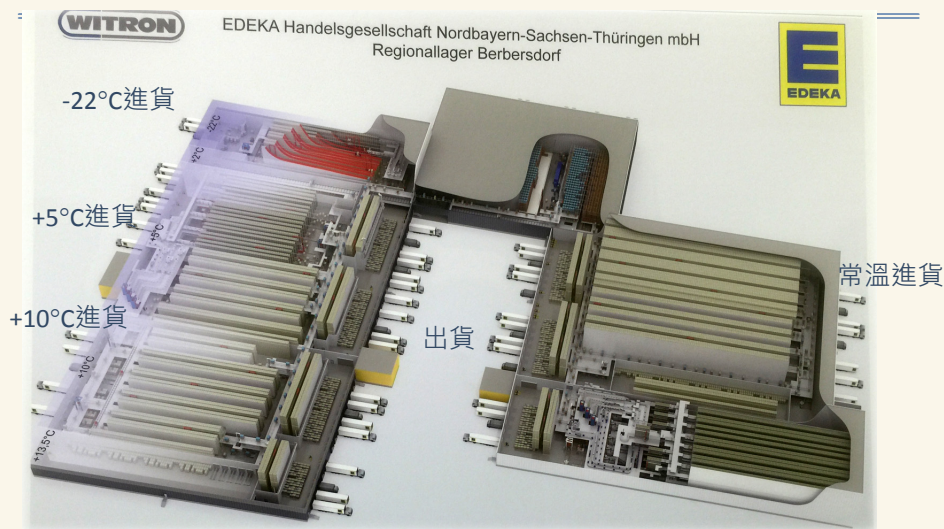


## Modular-Spine Design

適合大規模的營運，個別程序規模大到需要專屬的作業場所

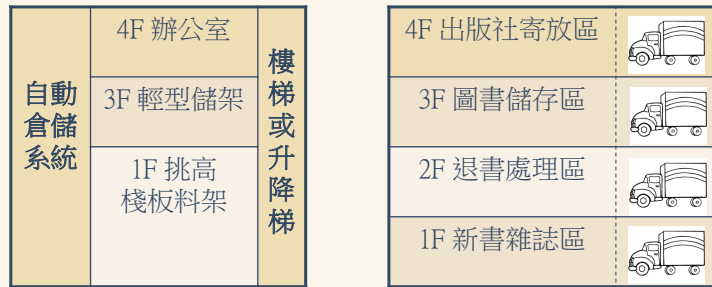


## 多溫層物流中心模組化設計



## Multistory Layouts

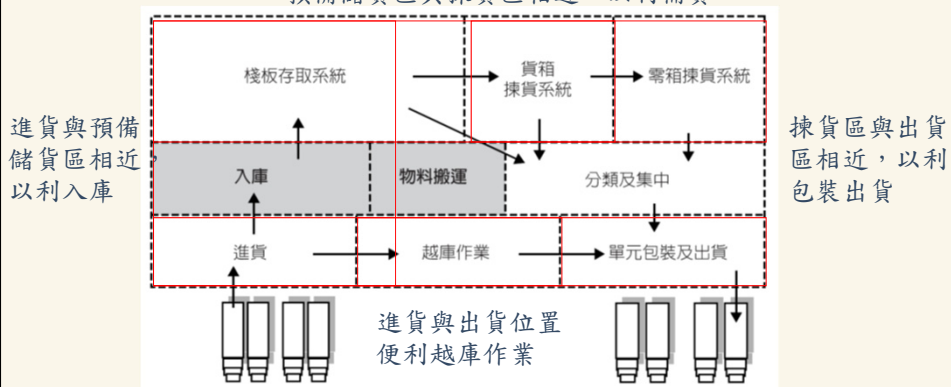
- ❖ 樓層間的物料移動將造成搬運困難以及動線的瓶頸
- ❖ 適合土地昂貴的地區



## 3. Adjacency Planning

有高度鄰近需求的程序應該被置放在鄰近區域

預備儲貨區與揀貨區相近，以利補貨



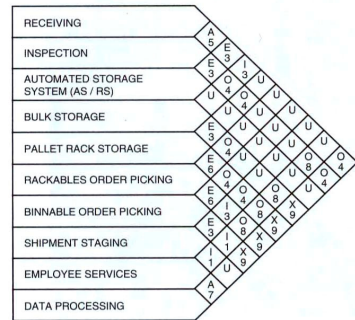
自然形成U形動線



## Activity Relationship

**FIGURE 10-11 Warehouse activity relationship chart.**

Source: Naval Supply Systems Command



**REASONS FOR IMPORTANCE**

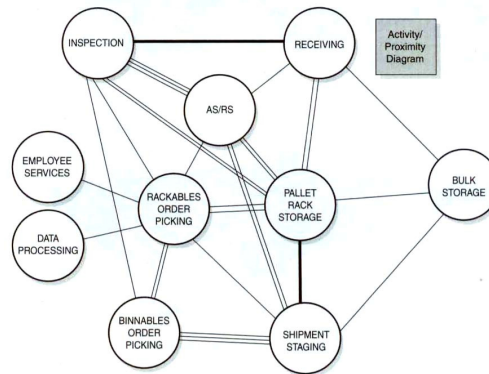
1. Supervision
2. Safety
3. Material flow
4. Work flow
5. Material control
6. Equipment proximity
7. Shared spaced
8. Employee health and safety
9. Security

**PROXIMITY IMPORTANCE**

- A. Absolutely necessary  
 E. Especially important  
 I. Important  
 O. Ordinary closeness  
 U. Unimportant  
 X. Undesirable

**FIGURE 10-12 Activity relationship diagram (heavy lines indicate high adjacency requirements).**

Source: Naval Supply Systems Command



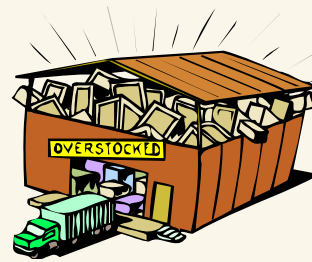
## Process Location

- ❖ 樓高較高的區域應優先用於儲存需求。
- ❖ 勞動力密集的流程應使用樓高較低的區域，如進貨、零箱揀貨、客製化、退貨處理等。
- ❖ 考慮儲存需求後，如果還有樓高較高的區域，可以興建夾層 (mezzanine)，增加空間利用。
- ❖ 辦公區域應與倉儲區域適當分隔，可設在角落或mezzanine
- ❖ 動線與流程位置的安排應考慮高流通品項或大型物品的搬運，減少運輸距離與困難。
- ❖ 高流通性品項的流程應在同一樓層進行。



## 4. Finding additional space

- 事先考量倉庫規模擴充或縮小的策略
- 可考慮租借或使用開放空間暫存
- 從現有設施找出額外的倉儲空間
  - Reduce inventory levels
  - Identify slow and non-moving stock
  - Change the type of storage medium: single-deep to double-deep racks
  - Consolidation of stock.
  - Temporary storage in the yard.



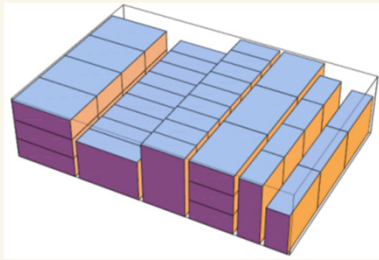
## 擠出更多儲存空間

- 從倉庫的四面內牆開始佈置料架，與建築物長軸平行
- Moving from fixed locations to random locations. 隨機儲位指派
- 使用走道上方或是碼頭上方的空間
- Reducing beam heights or adjustable heights 降低儲位高度或是可調整高度



## 提高儲存密度

- 拆除外包裝
- 不同儲放方向，增加儲放數量
- 共用儲位或允許不同規格的品項堆疊



## Summary and Conclusion

- ❖ An efficient warehouse layout should reduce the amount of travel and labour touch points.
- ❖ It needs to avoid bottlenecks and cross traffic where feasible ...
- ❖ The whole cube of the building should be utilized and not just the floor space.
- ❖ The idea is to design for the future whilst building for today.

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