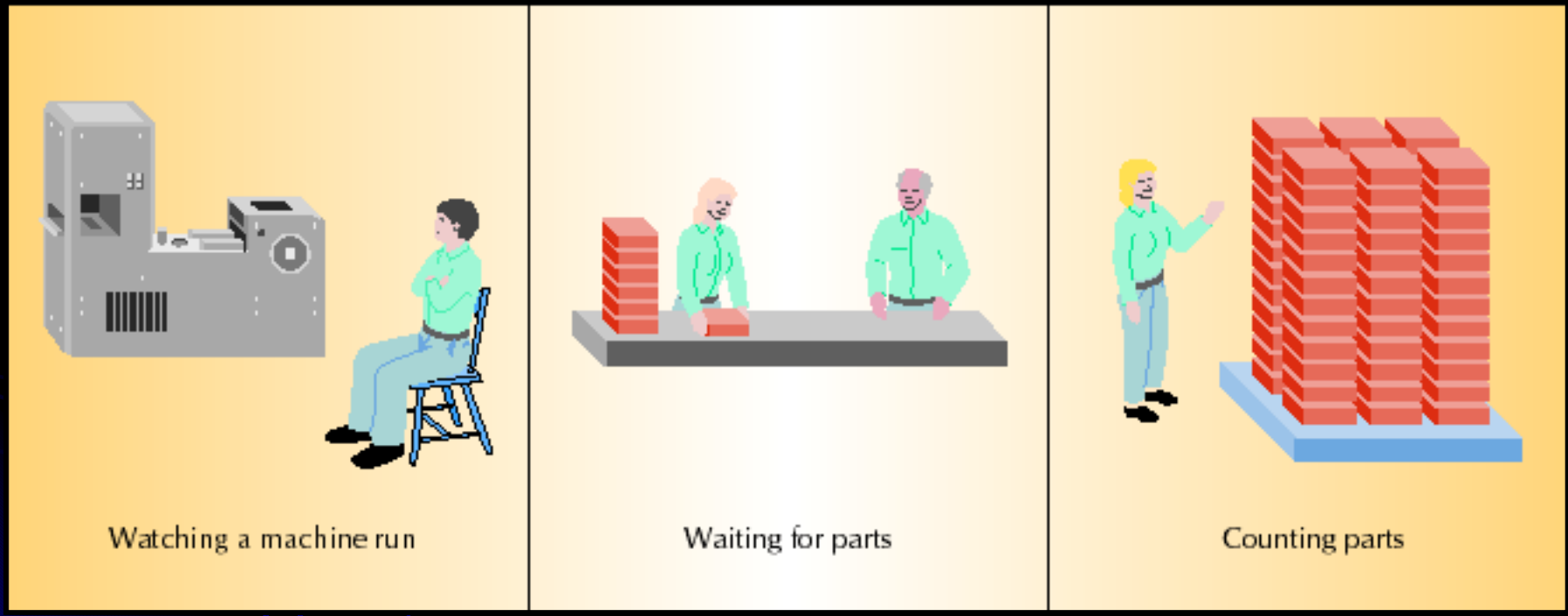
常見的資源浪費[1]

- 超額生產(overproduction)
- 等候時間(waiting time)
- 不必要的運送(unnecessary transporting)
- 存貨(inventory)
- 加工浪費(processing waste)
  - 不必要的生產步驟
  - 產出瑕疵品

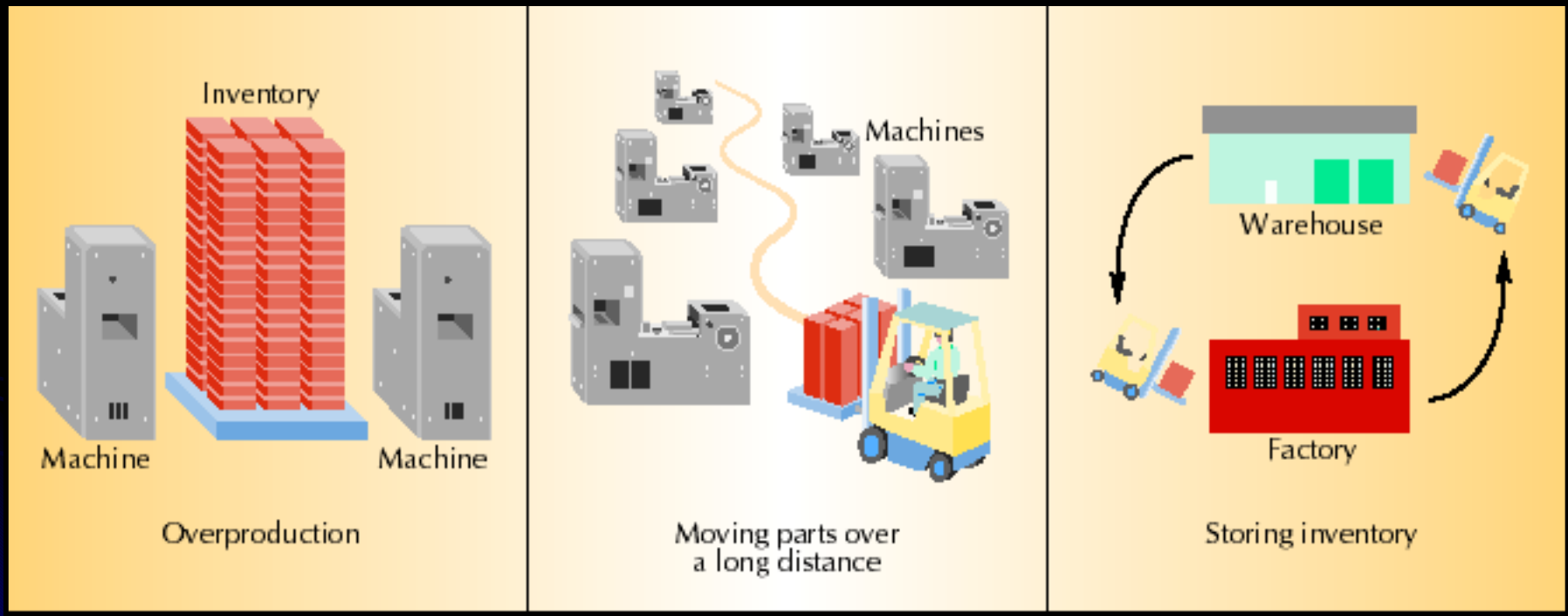
常見的資源浪費[2]

- 無效的工作方法**(inefficient work method)**
  - 不佳的佈置和物料搬運模式，增加在製品存貨
- 產品不良
  - 再製成本
  - 消費者不滿意造成銷售損失

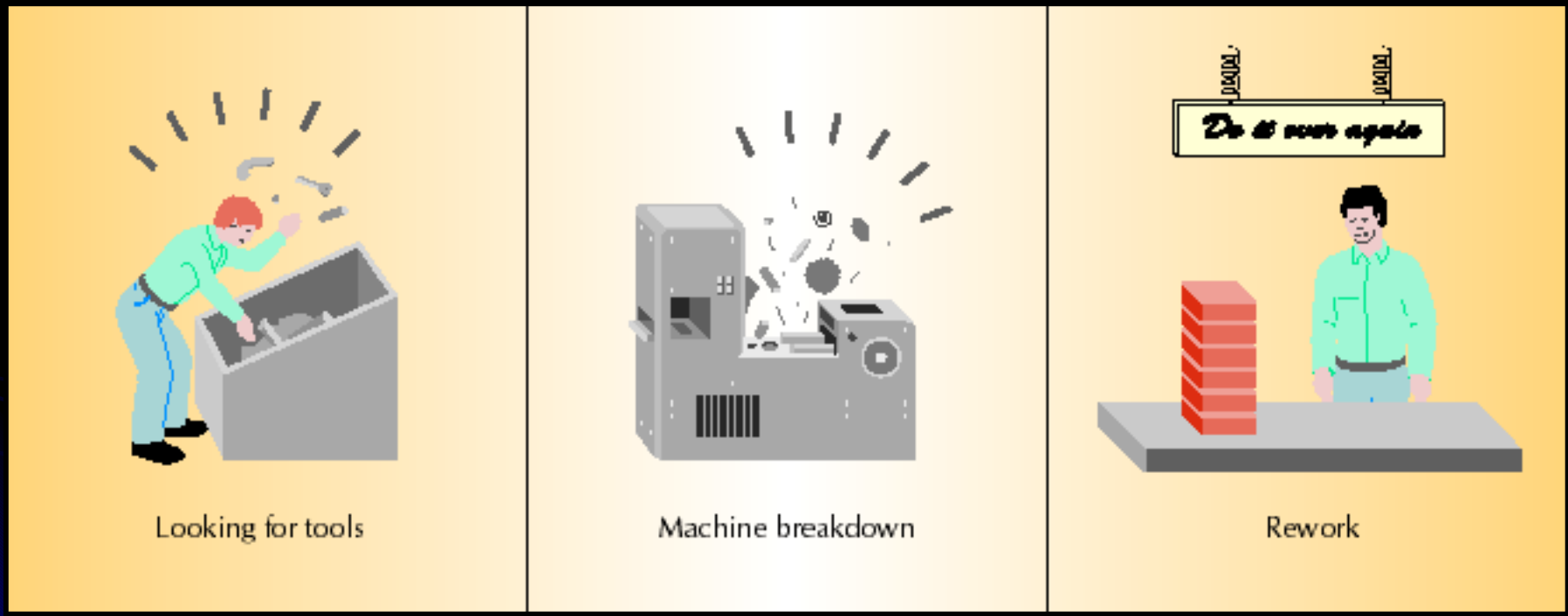
Waste in Operations



Waste in Operations



Waste in Operations



The Principles of the TOYOTA Production System (TPS)[1]

- **All work must be completely specified** as to content, sequence, timing, and outcome.
- Every **customer-supplier connection must be direct**, unambiguously **specifying the people involved**, the **form and quantity** of the services or goods to be provided, **the way the requests** are made by each customer, and the **expected time** in which the requests will be met.

The Principles of the TOYOTA Production System (TPS)[2]

- The **pathway** for every service and product **must be simple and direct**.
- Any improvement to the system must be made in accordance with the **scientific method**, under the guidance of a teacher, at the **lowest possible organizational level**.

Basic Elements of JIT

1. Cellular layouts
2. Pull production system
3. Flexible resources
4. Kanban production control
5. Small-lot production
6. Quick setups
7. Uniform production levels
8. Quality at the source
9. Total productive maintenance
10. Supplier networks

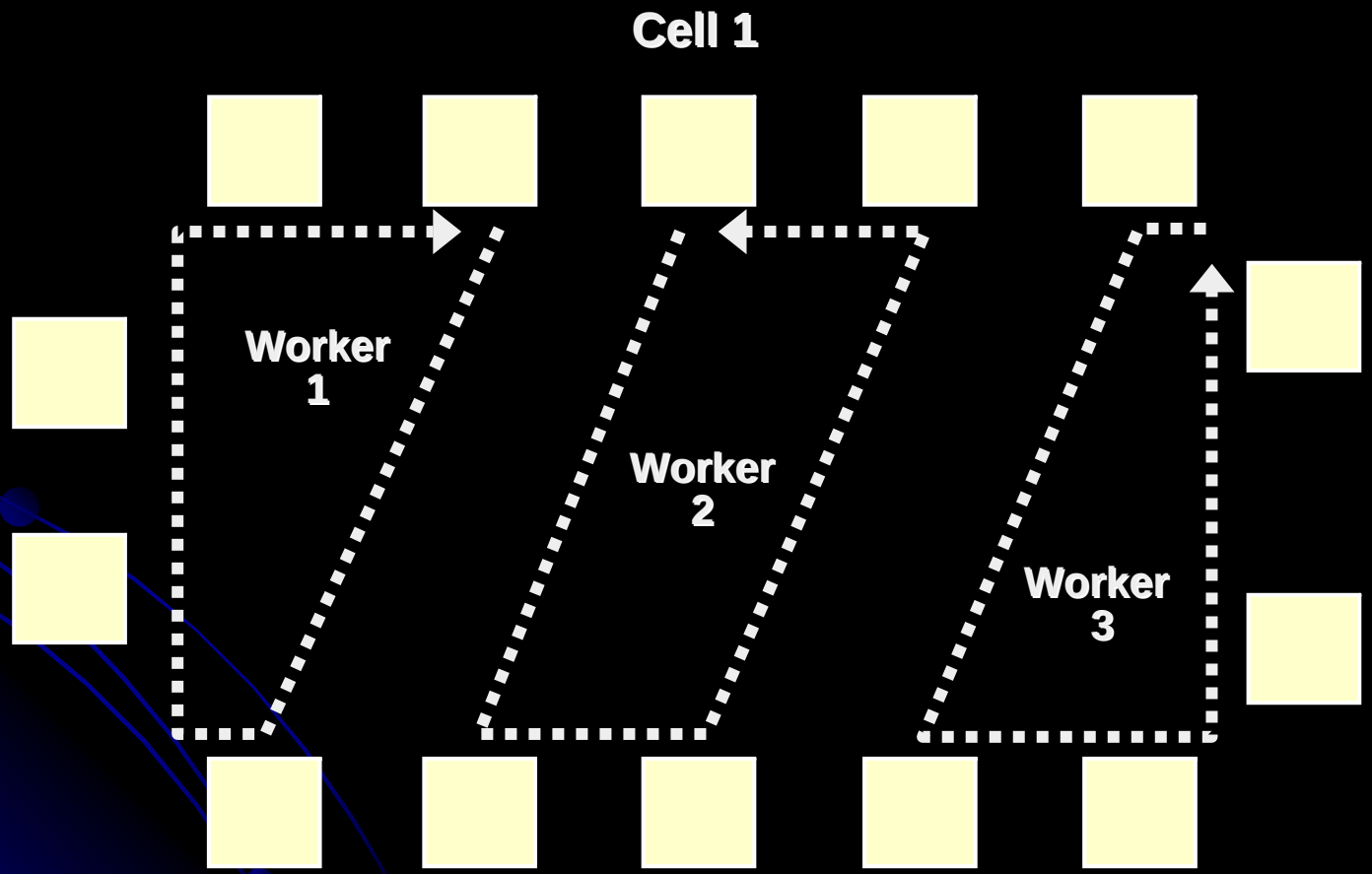
Flexible Resources

- ✓ ***Multifunctional workers (多能工)***
  - ✓ ***Perform more than one job***
- ✓ ***General purpose machines (通用設備)***
  - ✓ ***Perform several basic functions***
- ✓ ***Study operators & improve operations***

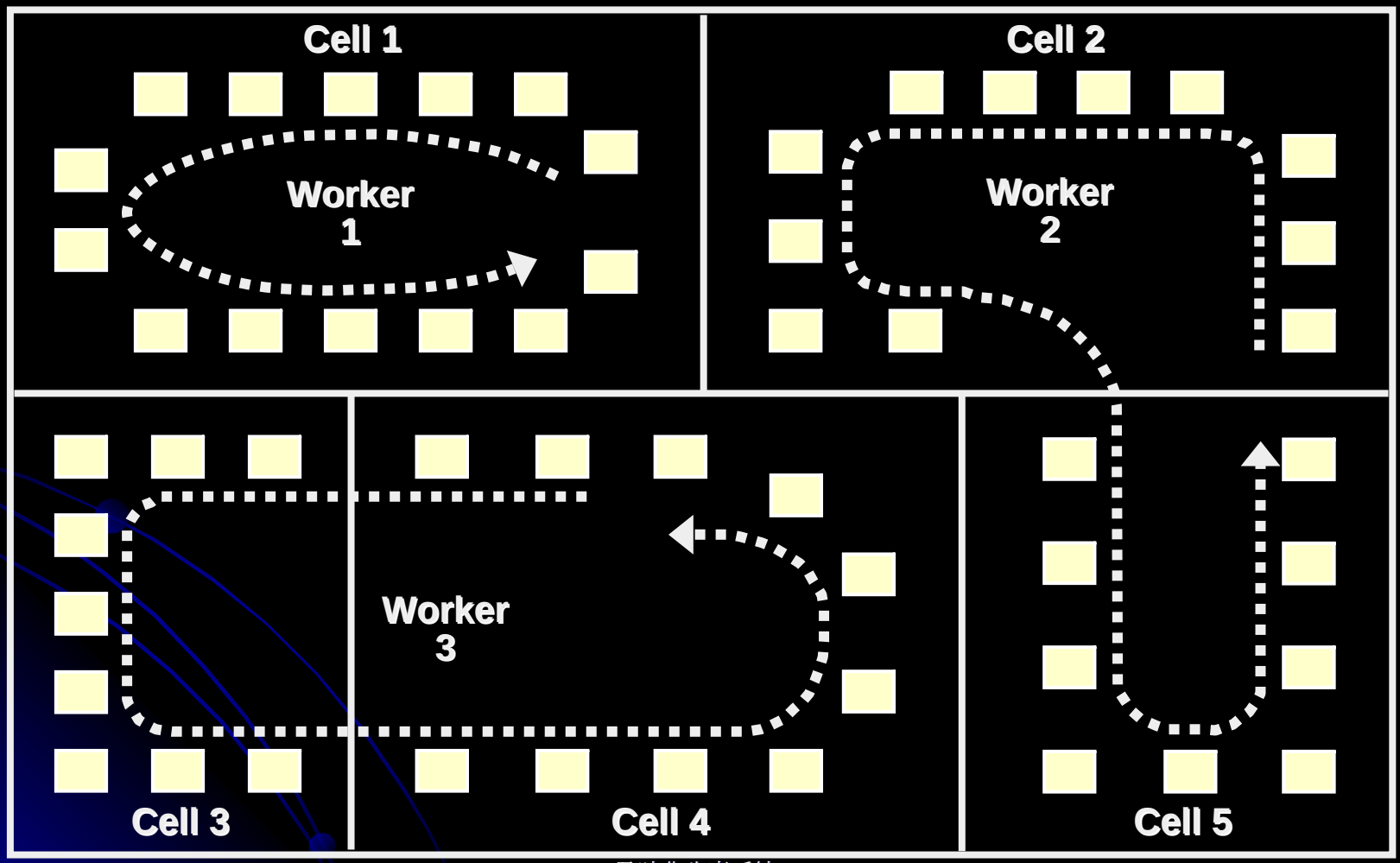
Cellular Layouts

- ✓ ***Group dissimilar machines in manufacturing cell to produce family of parts***
- ✓ ***Work flows in one direction through cell***
- ✓ ***Cycle time adjusted by changing worker paths***

Manufacturing Cell with Worker Routes



Worker Routes Lengthened as Volume Decreases



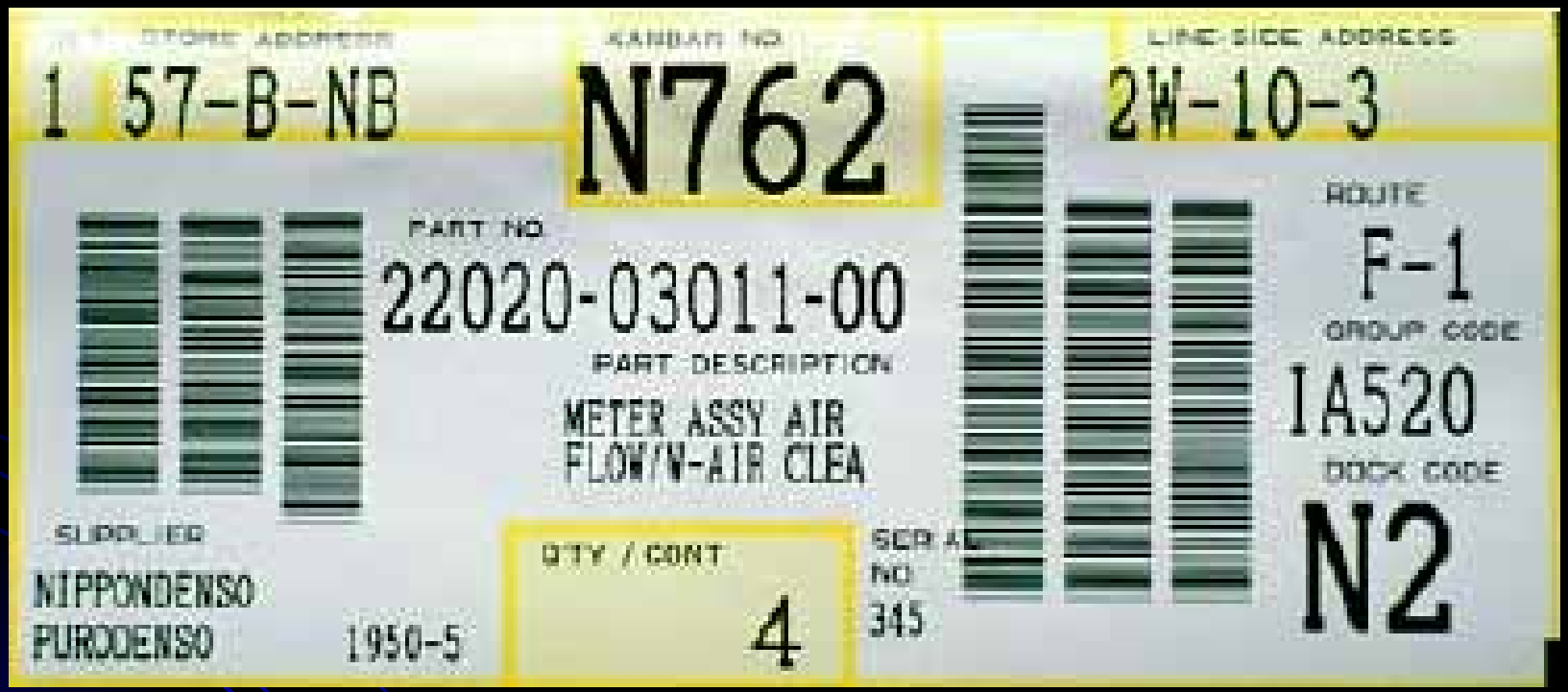
推式與拉式系統

- **推式系統(push system)(例如，MPR)**
  - 當工作在某工作站完成時，產出就被推往下一站。
- **拉式系統(pull system)(例如，JIT)**
  - 工作移動的控制落於下一站;每一工作站從前一站拉拔所需產出。

Kanban Production Control System (看板生產管制系統)

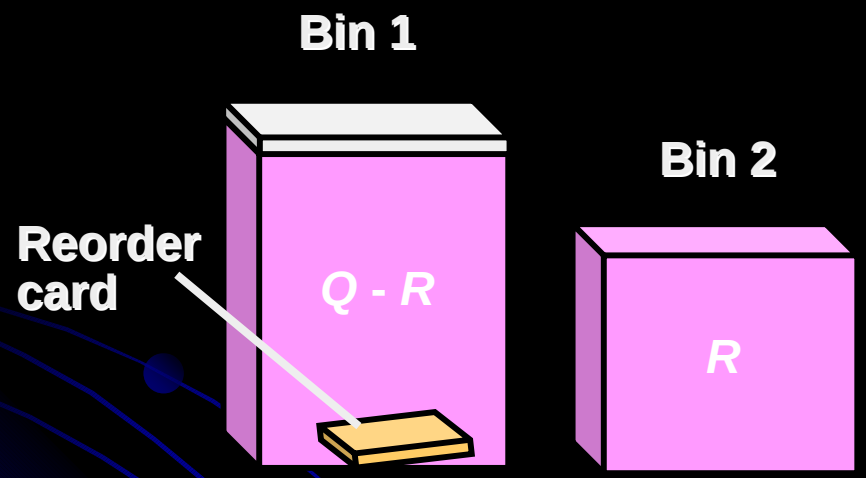
- ✓ *Kanban card indicates standard quantity of production*
- ✓ *Derived from two-bin inventory system(雙倉制)*
- ✓ *Kanban maintains discipline of pull production*
- ✓ *Production kanban(生產看板) authorizes production*
- ✓ *Withdrawal kanban(提領看板) authorizes movement of goods*

A Sample Kanban

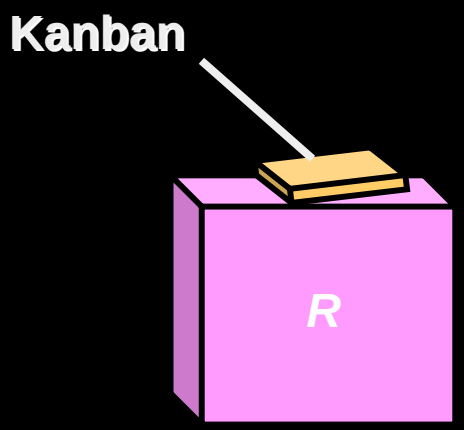


The Origin of Kanban

a) Two-bin inventory system



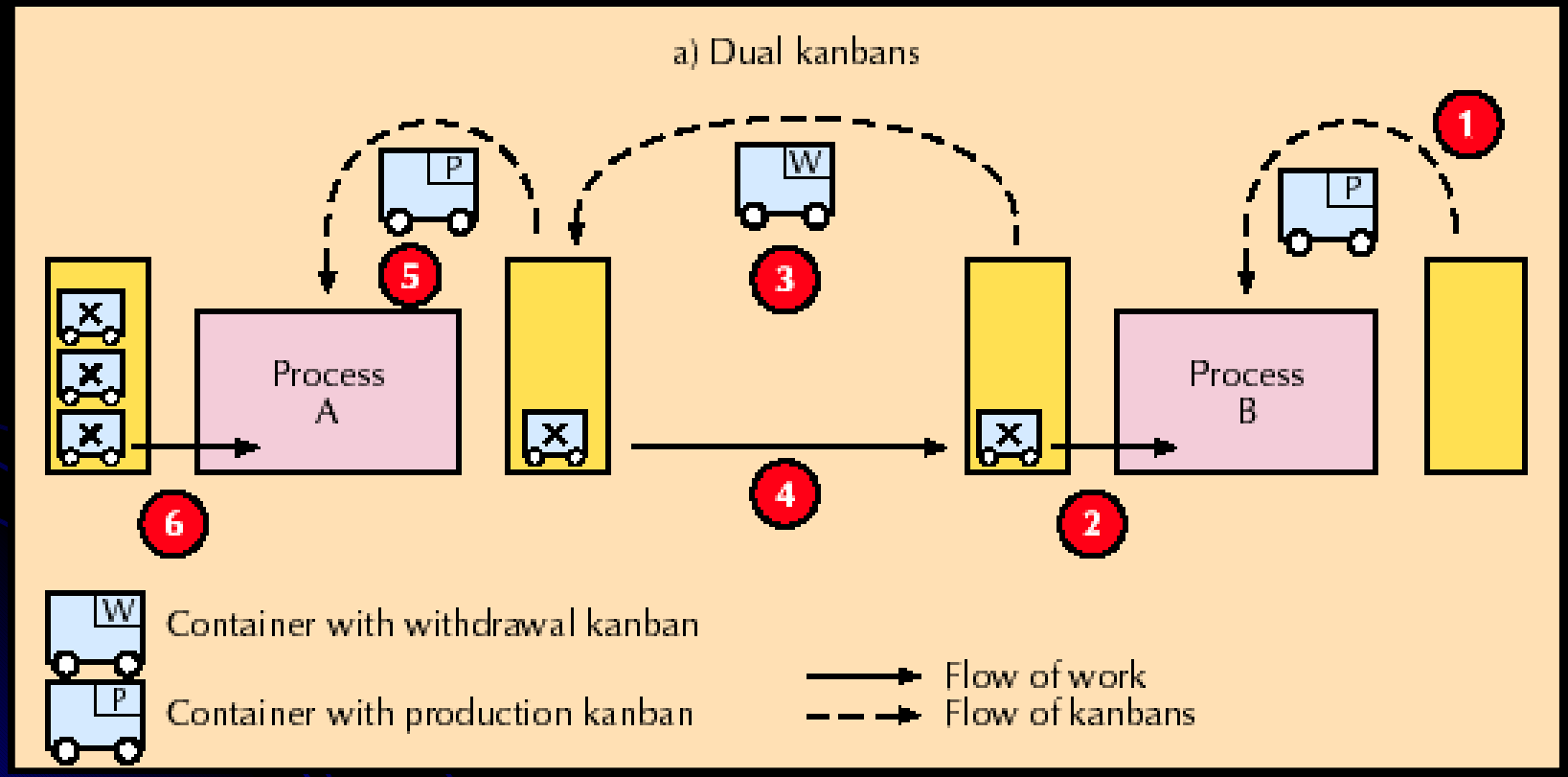
b) Kanban inventory system



Q = order quantity

R = reorder point - demand during lead time

Types of Kanbans — Dual kanbans



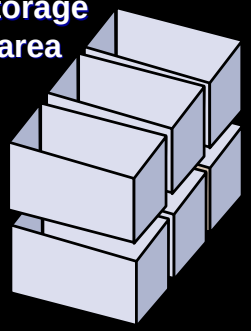
Single-Card Kanban System

Receiving post

Kanban card for product 1

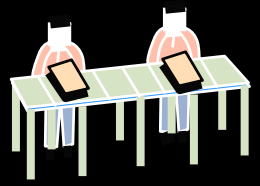
Kanban card for product 2

Storage area

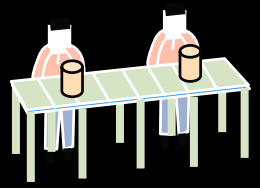


Empty containers

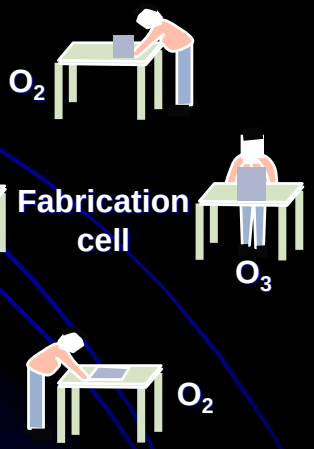
Full containers



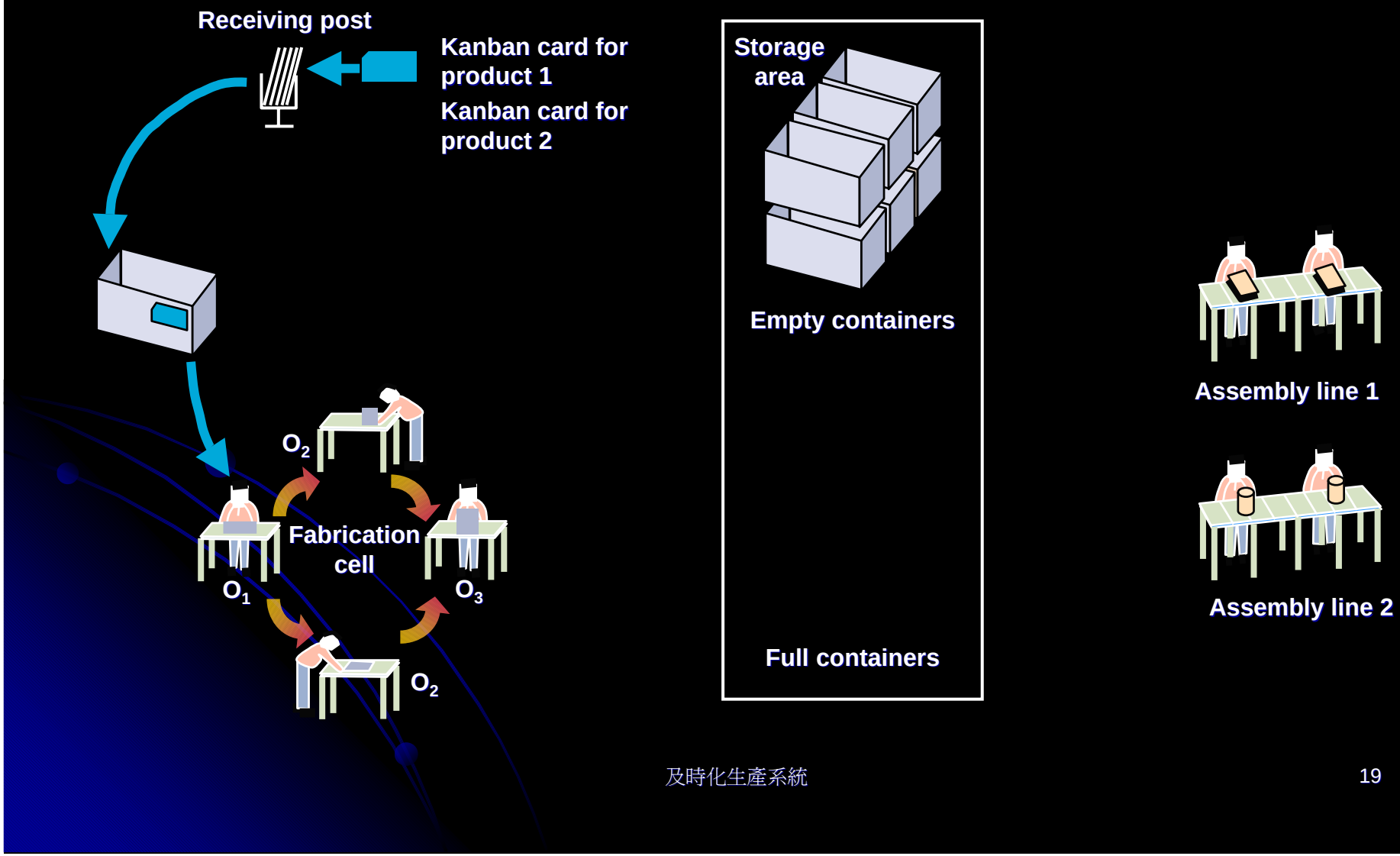
Assembly line 1



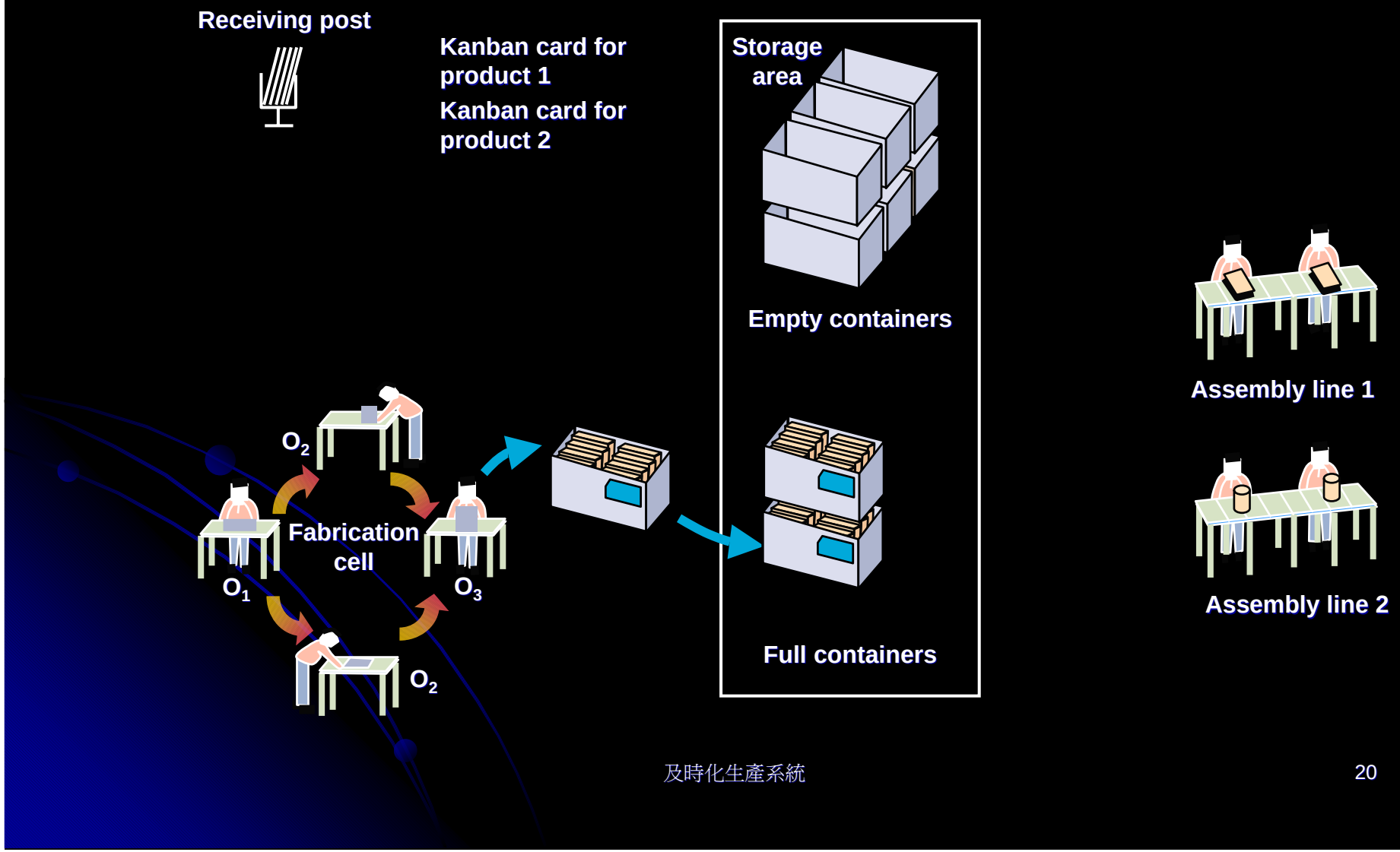
Assembly line 2



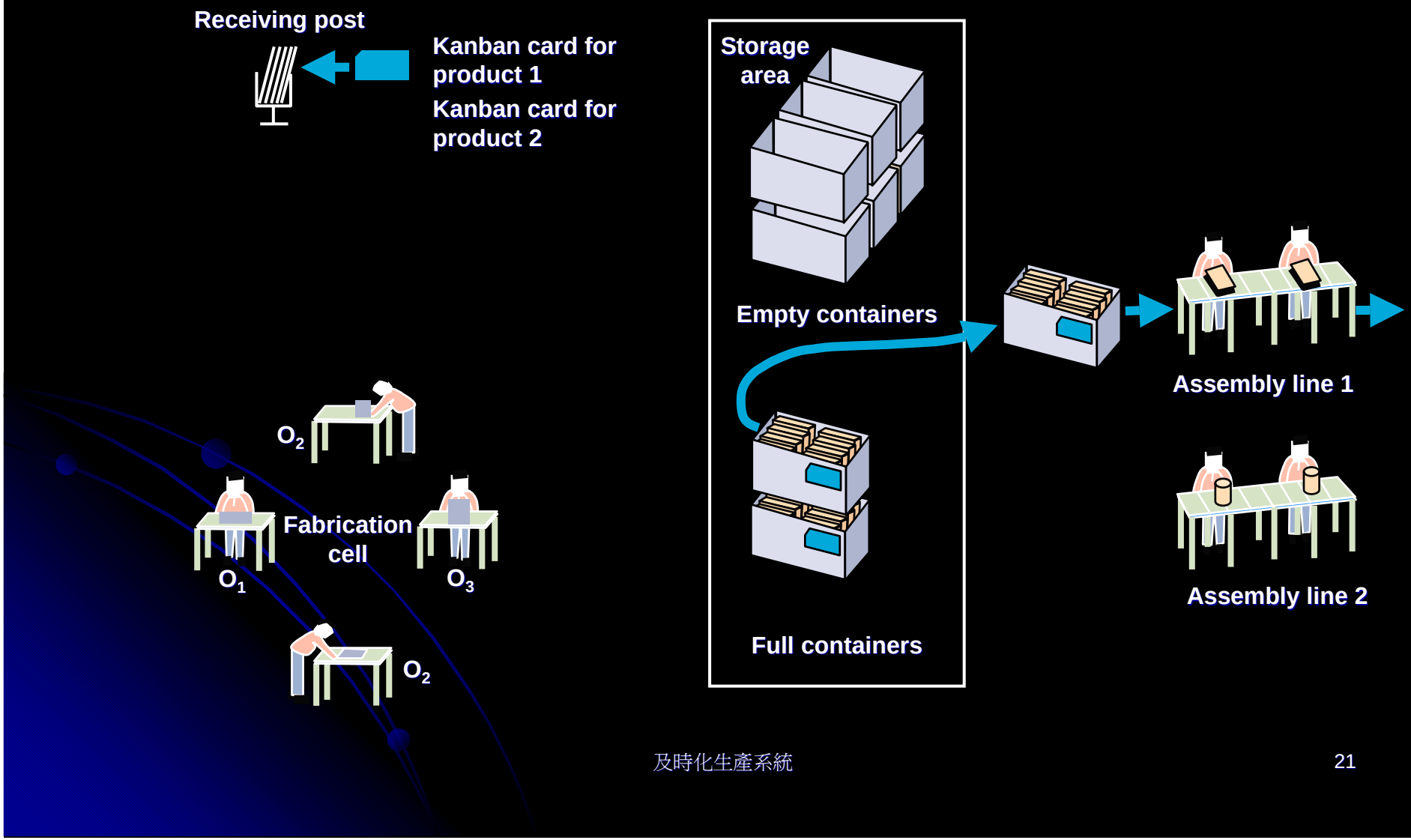
Single-Card Kanban System



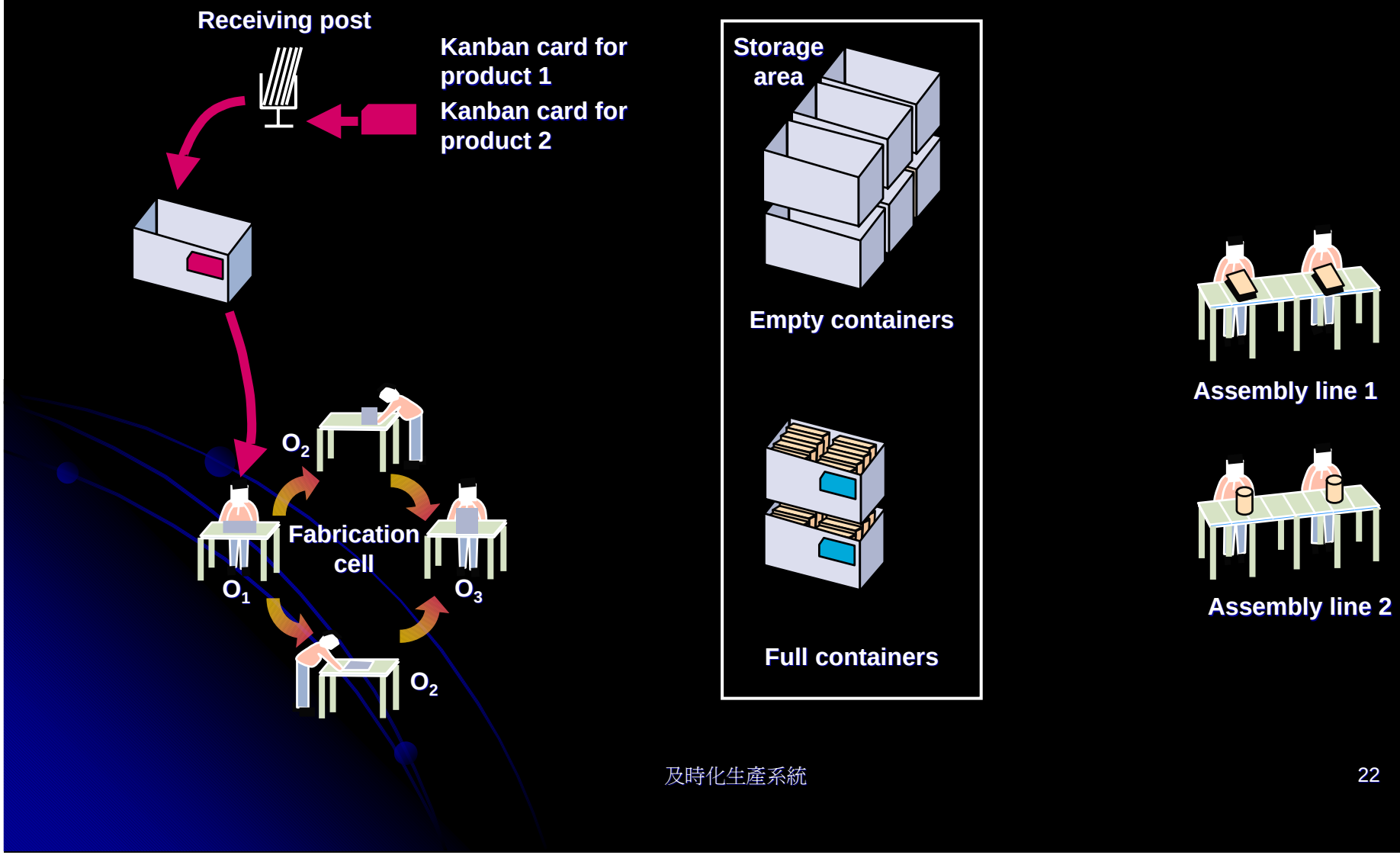
Single-Card Kanban System



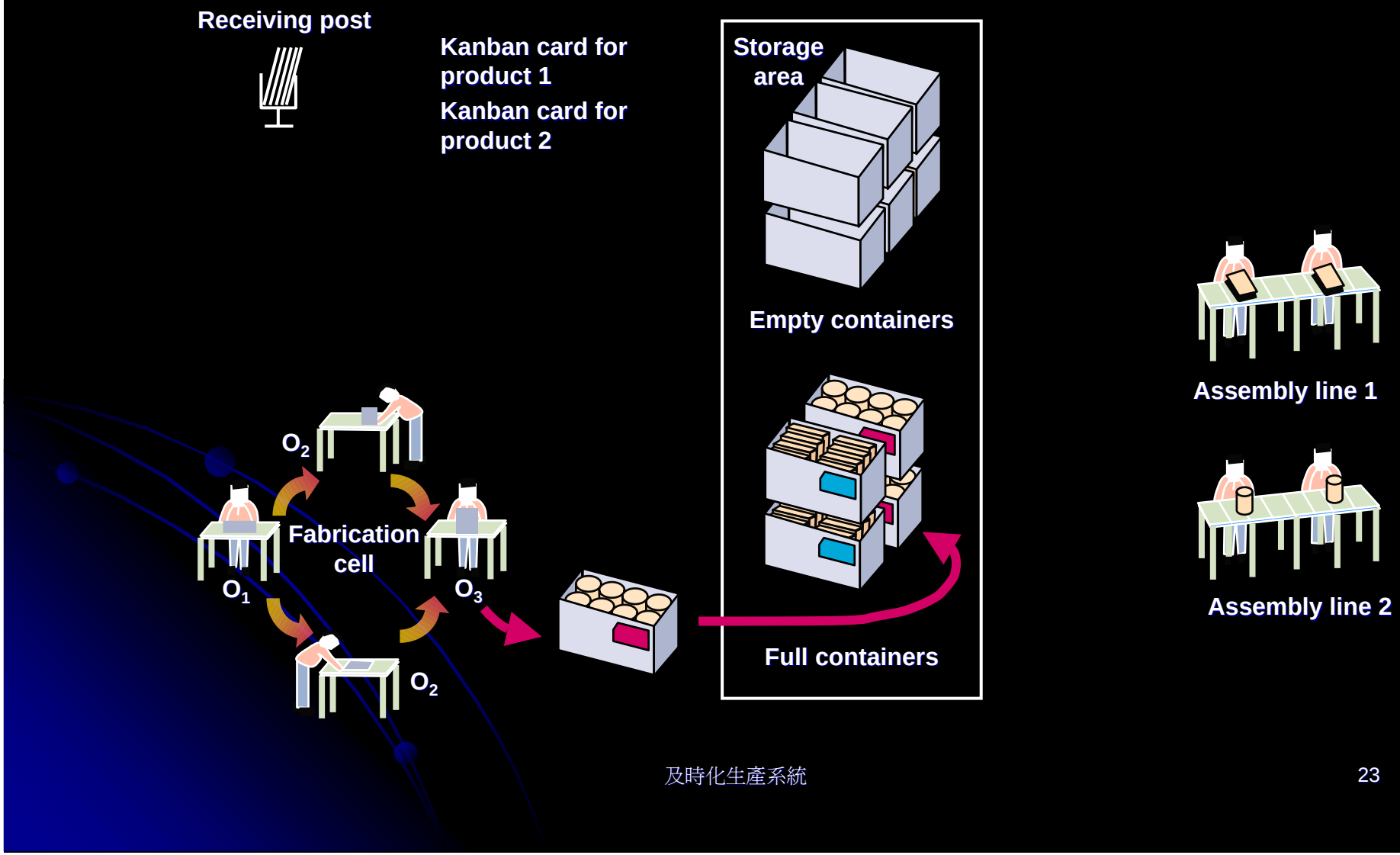
Single-Card Kanban System



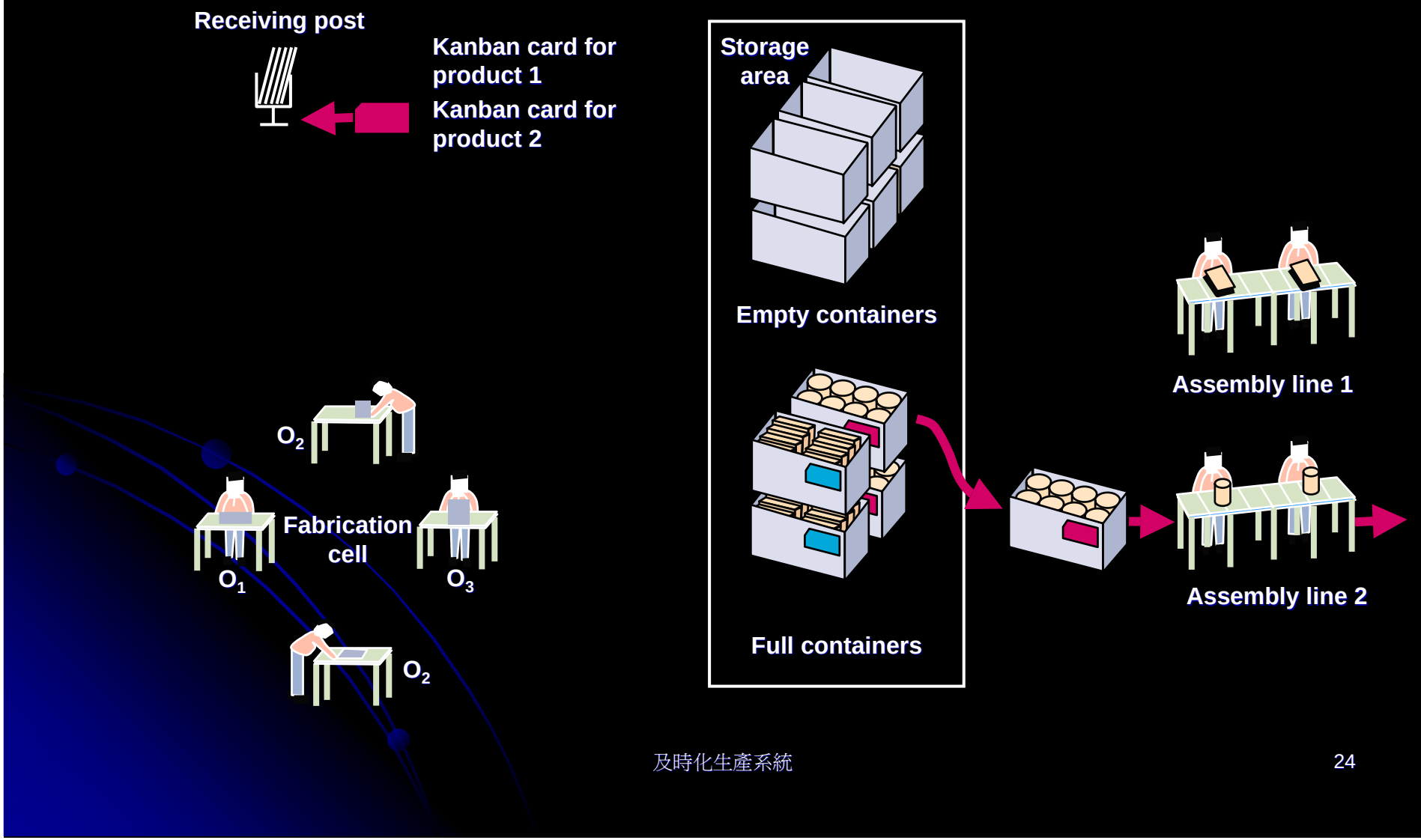
Single-Card Kanban System



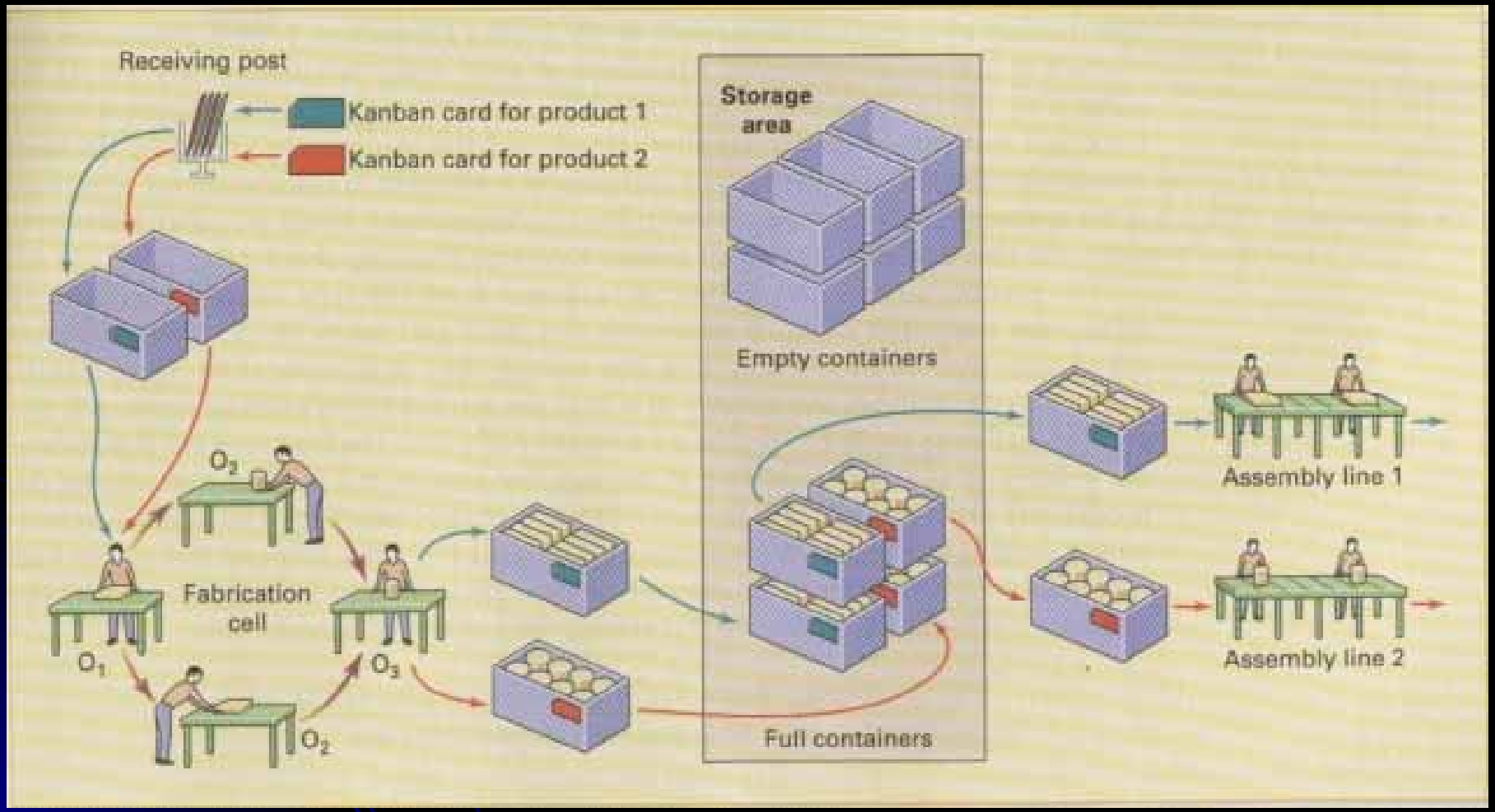
Single-Card Kanban System



Single-Card Kanban System



看板系統 — single kanban



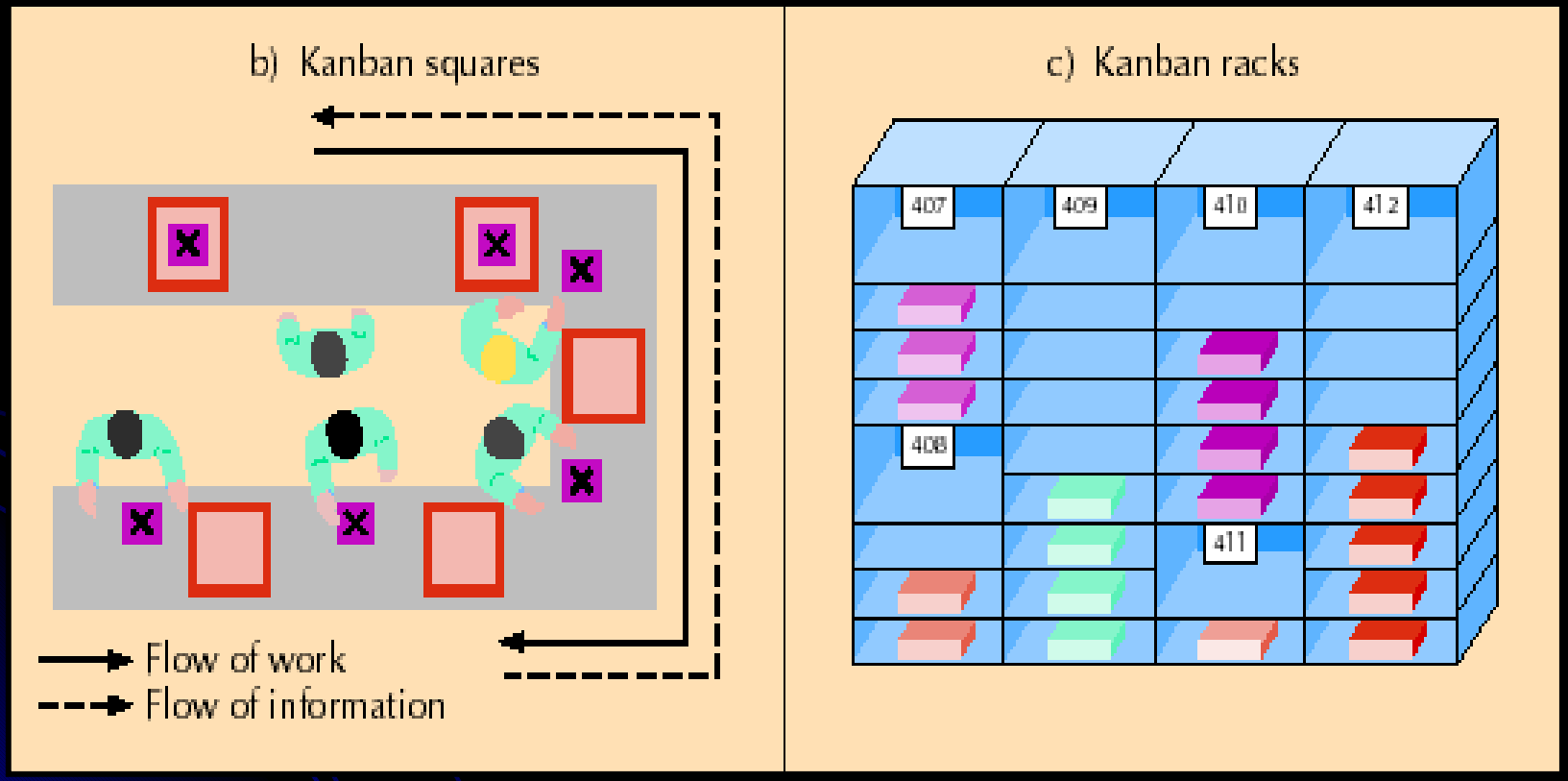
Dual kanban vs. single kanban

- **Dual kanban**
  - Is used when material is not necessarily moving between two consecutive processes, or when there is more than one input to a process and the inputs are dispersed throughout the facility.
- **Single kanban**
  - Is used when the processes are tightly linked.

Types of Kanbans

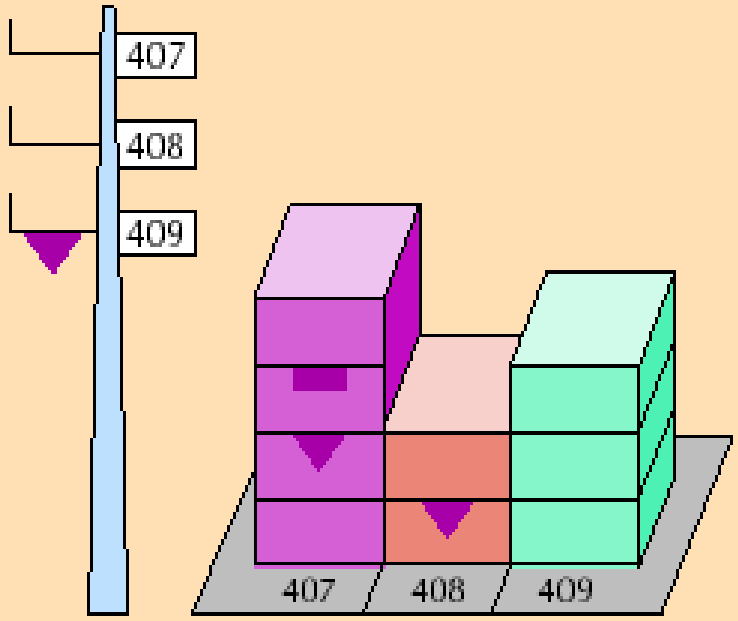
- ✓ ***Kanban Square***
  - ✓ *Marked area designed to hold items*
- ✓ ***Signal Kanban***
  - ✓ *Triangular kanban used to signal production at the previous workstation*
- ✓ ***Material Kanban***
  - ✓ *Used to order material in advance of a process*
- ✓ ***Supplier Kanbans***
  - ✓ *Rotate between the factory and suppliers*

Types of Kanbans — kanban square and kanban racks



Types of Kanbans — signal kanbans

d) Signal kanban



e) Kanban post office

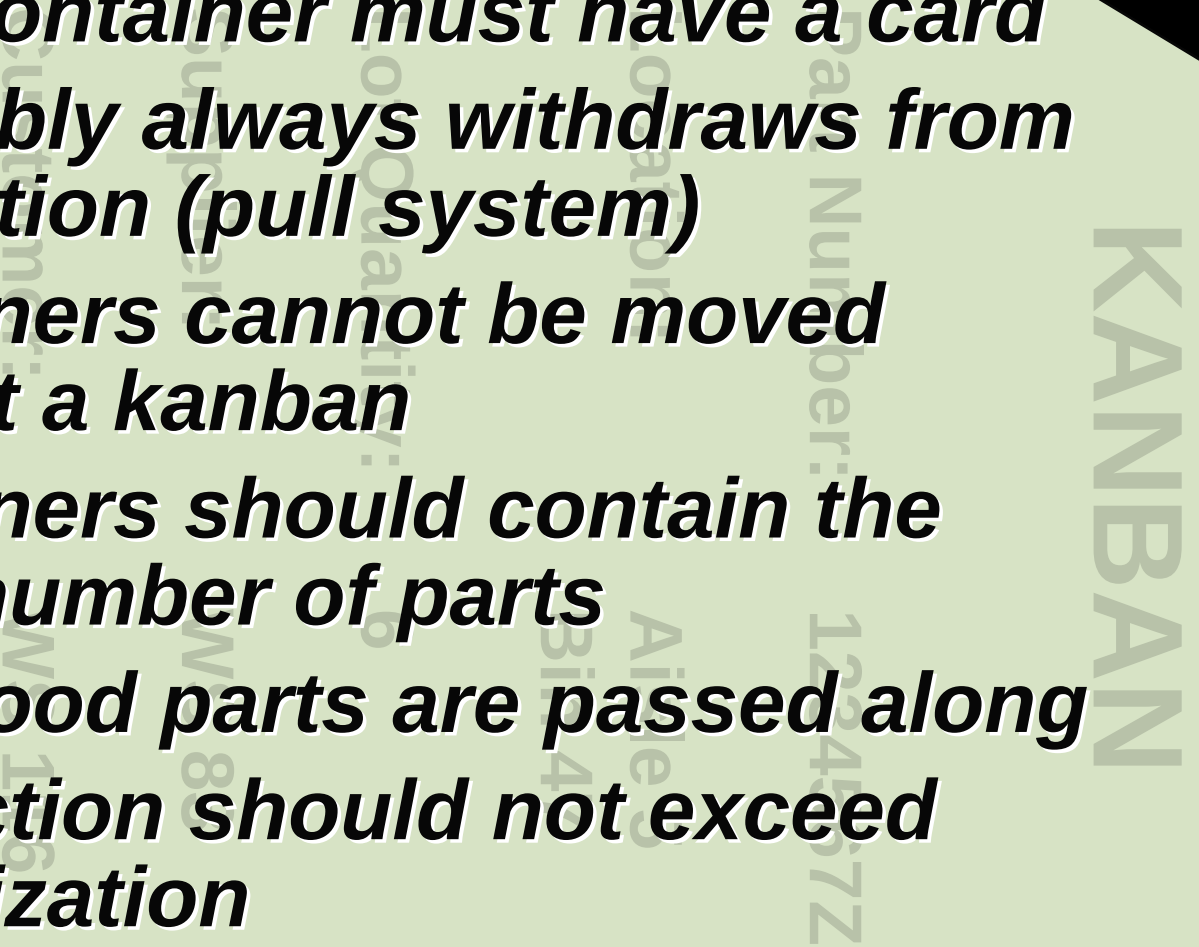
65	66	67	68	69	70	71
72	73	74	75	76	77	78
79	80	81	82	83	84	85
86	87	88	89	90	91	92
93	94	95	96	97	98	99
100	101	102	103	104	105	106
107	108	109	110	111	112	113
114	115	116	117	118	119	120

看板管理系統之規則

- 不要把不良品交給後製程。
- 由後製程到前製程來領取零件。
- 前製程僅生產將被後製程領用去的數量。
- 生產必須平衡。
- 看板只做爲微調整的手段，其張數必須減到最少。
- 製程必須安定化、合理化。

Single-Card Kanban System

- ✓ *Each container must have a card*
- ✓ *Assembly always withdraws from fabrication (pull system)*
- ✓ *Containers cannot be moved without a kanban*
- ✓ *Containers should contain the same number of parts*
- ✓ *Only good parts are passed along*
- ✓ *Production should not exceed authorization*



看板(容器)數量之決定[1]

- K=容器數量。
- d=工作中心之計劃使用率(預期每日需求)。
- p=每箱容器零件之平均加工時間。
- W=在生產過程中之平均等候時間，加上每箱物料的搬運時間。
- C=標準容器之零件容量。
- X=政策變數。反應生產系統的效率(10%以內)

看板(容器)數量之決定[2]

$$k = \frac{\text{在前置時間期間的平均需求+安全庫存}}{\text{每箱內的單位數量}}$$

$$= \frac{d(w+p)(1+x)}{c}$$

看板(容器)數量之決定[3]

$$\text{No. of Kanbans} = \frac{\text{average demand during lead time + safety stock}}{\text{container size}}$$

$$N = \frac{dL + S}{C}$$

where

N = number of kanbans or containers
d = average demand over some time period
L = lead time to replenish an order
S = safety stock
C = container size

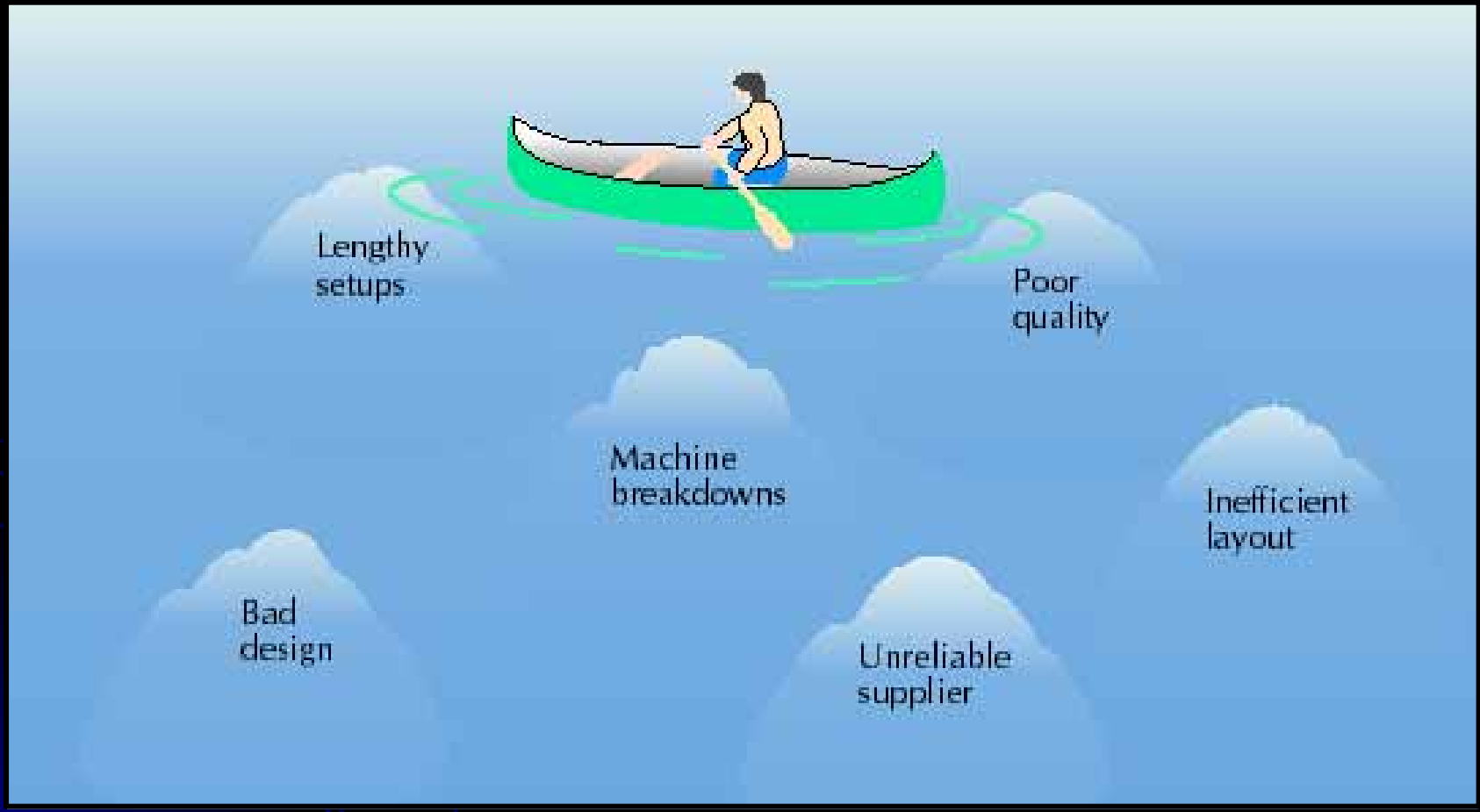
容器數量決定一範例

- 某汽車零件公司生產4輪傳動車的方向盤及暫停系統中的搖桿手臂組合。一般1箱零件在製造週期中需要0.02天的加工及0.08天的物料處理和等候時間。零件每日的需求爲2000個單位。管理部門認爲搖桿手臂組合的需求不確定，所以其安全庫存爲需求量的10%。
- 若每箱內各有22個零件，則應授權的箱子數量爲多少。

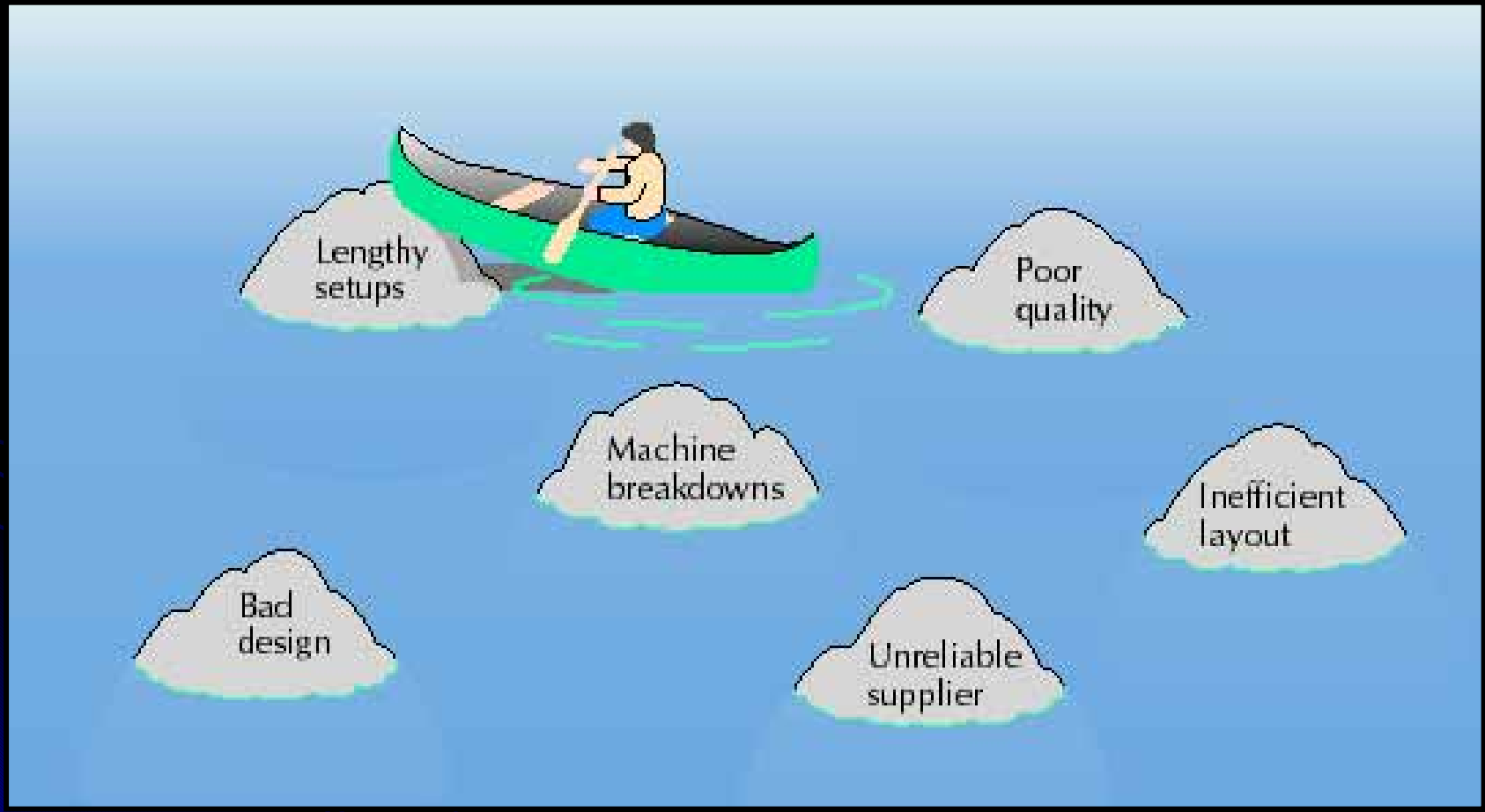
小批量 (Small-lot production) 的效益

- 降低在製品存貨
- 減少因品質發生問題時所產生的檢驗和重加工成本
- 減少儲存空間
- 問題更容易顯現
- 增加生產彈性
- 易於進行作業平衡

Inventory Hides Problems



Lower Levels of Inventory Expose Problems



Components of Lead Time (前置時間的元素)

- ✓ ***Processing time***
  - ✓ ***Reduce number of items or improve efficiency***
- ✓ ***Move time***
  - ✓ ***Reduce distances, simplify movements, standardize routings***
- ✓ ***Waiting time***
  - ✓ ***Better scheduling, sufficient capacity***
- ✓ ***Setup time***
  - ✓ ***Generally the biggest bottleneck***

快速籌置 (Quick setups)

- **Single-digit setup**
  - **The goal of having a setup time of less than 10 minutes.**
- **快速換模又稱一分鐘換模術 (single-minute exchange of dies, SMED)**

快速籌置的實施步驟

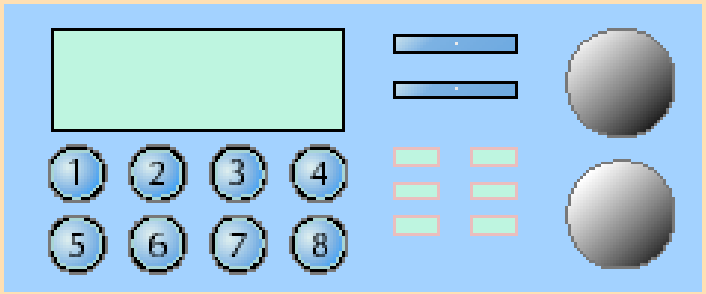
1. 將換模作業流程劃分外部整備作業與內部整備作業。
2. 儘可能把內部整備作業改變成外部整備作業。
3. 消除內部整備所需的調整作業。
4. 外部整備作業的標準化。
5. 推動平行作業。
6. 利用機械提高換模效率。
7. 其他管理部門的充分配合。

問題討論—教學成效之提昇

- 內整備：基楚觀念之講解(例如，品質管理課之統計概念...)
- 外整備：課前預習課後復習...

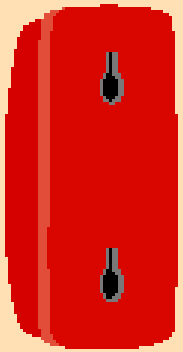
Common Techniques for Reducing Setup Time[1]

Preset desired settings



. . . like the stations on your car radio.

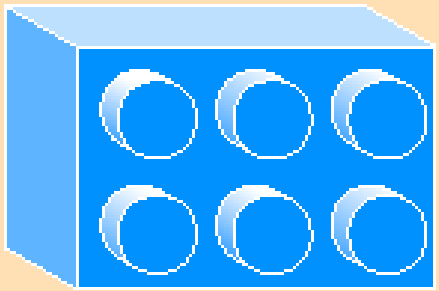
Use quick fasteners



. . . like the pear-shaped holes in the back of your wall phone.

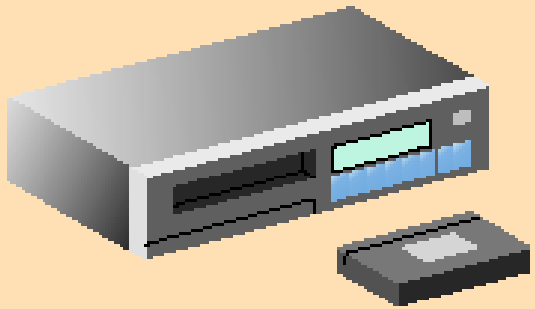
Common Techniques for Reducing Setup Time[2]

Use locator pins



. . . like Lego blocks

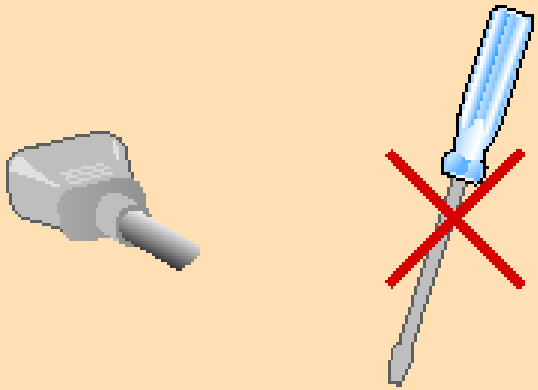
Prevent misalignment



. . . like the cassette tape for your VCR.

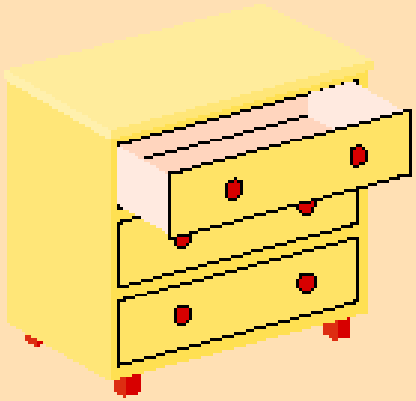
Common Techniques for Reducing Setup Time[3]

Eliminate tools



. . . like power cords for computers.

Make movements easier



. . . like exchanging the drawers in your dresser.

平準化生產 (Uniform Production)

- ✓ ***Results from smoothing production requirements***
- ✓ ***Kanban systems can handle +/- 10% demand changes***
- ✓ ***The way to reduce variability in production***
  - ✓***Smooths demand across planning horizon***
  - ✓***Mixed-model assembly steadies component production***

平準化—範例[1]

- The APP of TOYOTA: 4500 vehicles per week.
- Two full shifts, five days per week → 450 per shift (480 minutes)
- Three models are produced: Camry (C), Avalon (A), and Sienna (S).
- 200 Camry, 150 Avalons, and 100 Siennas per shift
- Cycle time: 480/450=1.067 (min)

平準化—範例2

- First
  - 200 C's → 150 A's → 100S's
  - High average cycle inventory level
  - Lumpy requirements
- Second
  - 4 C's → 3 A's → 2S's
  - The cycle =9(1.067)=9.60 (50 times per shift)

平準化—範例3

- Third
  - C → S → C → A → C → A → C → S → A
  - The setup times must be very short.
  - Component requirements is steady
  - Capacity requirements are smoothed

Quality at the Source[1]

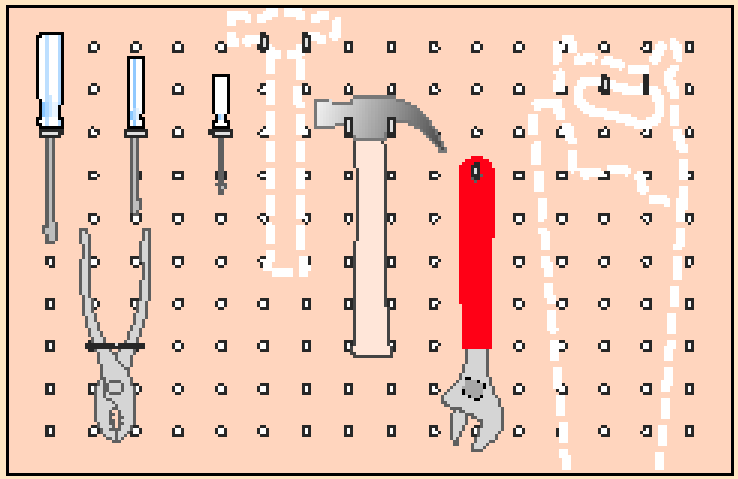
- ✓ **Jidoka (自働化)**
  - ✓ 在生產過程中自動偵測缺點
- ✓ **Andon (安童)**
  - ✓在每個工作站裝置燈號系統，以指示問題及落後狀態。
- ✓ **Undercapacity scheduling allows for planning, problem solving & maintenance**

Quality at the Source[2]

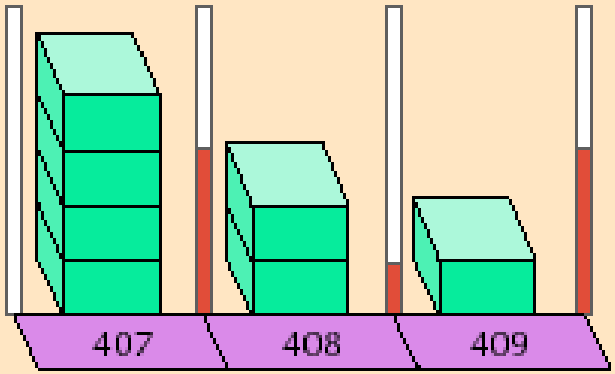
- 防呆裝置日文發音爲**POKAYOKE** ，是指在模具，工具，機器設備上設計防止錯誤(不良)發生的裝置，一旦作業員做錯或需要作業上的警示時，防呆裝置可以預防或使機器停下來，確保不產生不良品。
- **目視管理系統 (visual control)**： 係透過顯示板之顯示得以快速且明顯地發現異常、浪費、故障、斷料等現場不順暢之情形，而達到能速謀對策的一種管理系統。

Visual Control

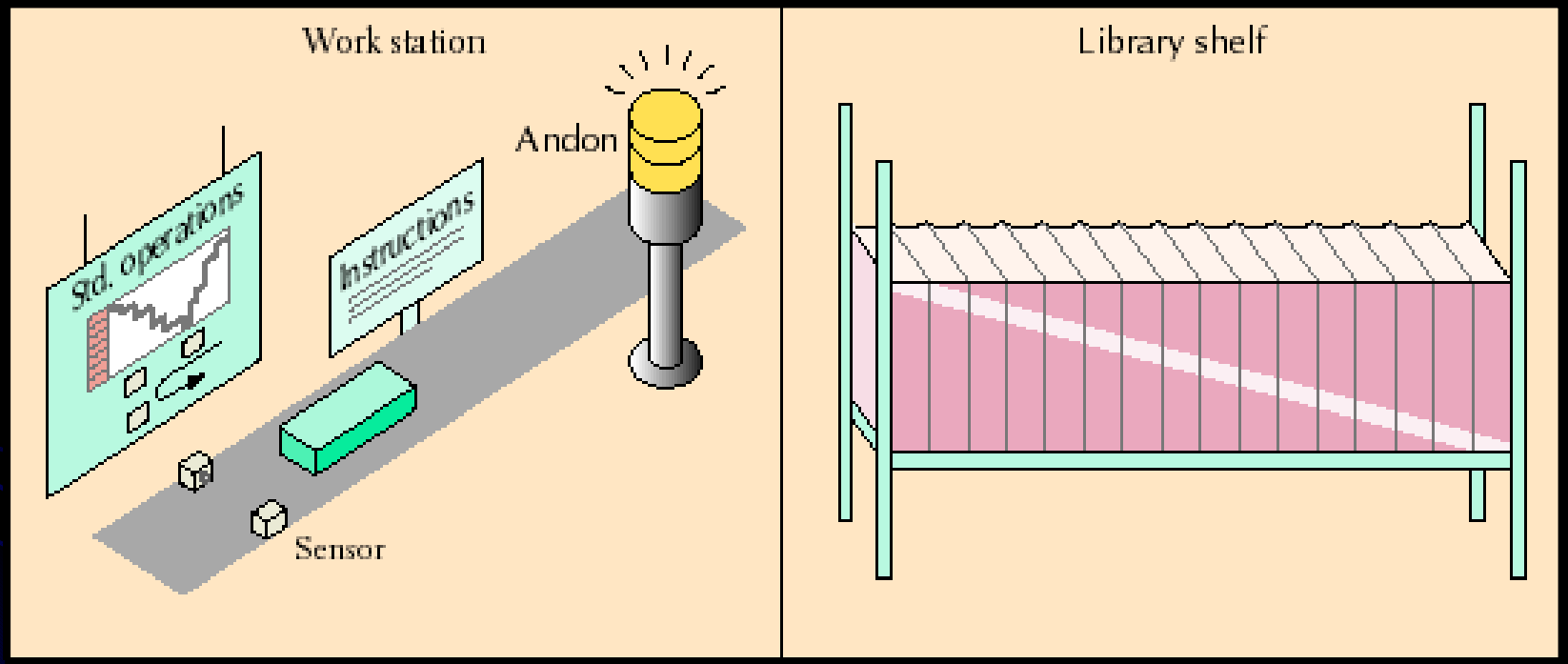
Tool board



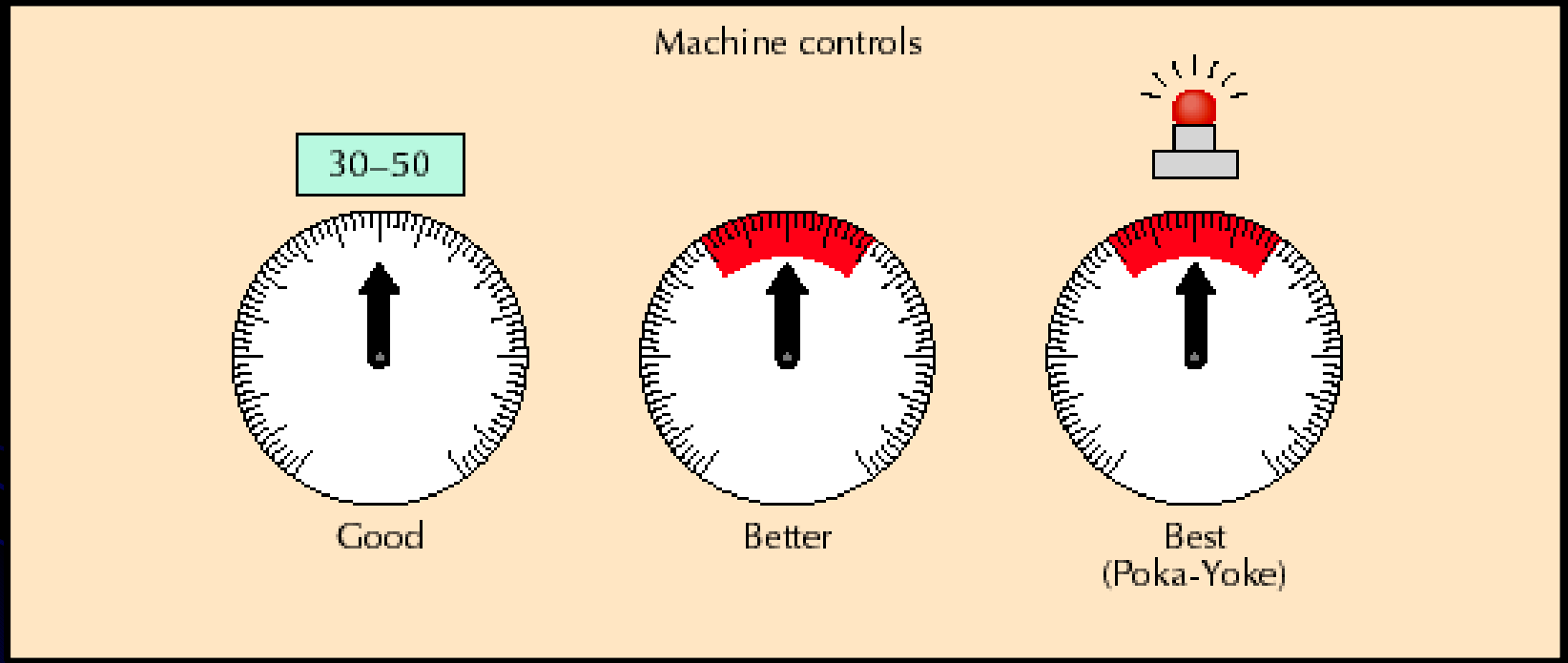
Visual kanbans



Visual Control



Visual Control



Kaizen (改善)

- ✓ ***Continuous improvement***
- ✓ ***Requires total employment involvement***
- ✓ ***Essence of JIT is willingness of workers to***
  - ✓ ***Spot quality problems***
  - ✓ ***Halt production when necessary***
  - ✓ ***Generate ideas for improvement***
  - ✓ ***Analyze problems***
  - ✓ ***Perform different functions***

Total Productive Maintenance (TPM)

- ✓ ***Breakdown maintenance***
  - ✓ ***Repairs to make failed machine operational***
- ✓ ***Preventive maintenance***
  - ✓ ***System of periodic inspection & maintenance to keep machines operating***
- ✓ ***TPM combines preventive maintenance & total quality concepts***

TPM Requires Management to:

- ✓ Design products that can be easily produced on existing machines
- ✓ Design machines for easier operation, changeover, maintenance
- ✓ Train & retrain workers to operate machines
- ✓ Purchase machines that maximize productive potential
- ✓ Design preventive maintenance plan spanning life of machine

導入JIT的基礎—5S運動

	定義	功能
整理 **(seiri, organization)**	把東西分成必要與不必要，將不必要的東西撤走。	排除資源空的浪費。
整頓 **(seiton, tidiness)**	需要的東西排放整齊以便取用。	排除尋找，縮短作業或產品線切換、準備時間。
清掃 **(seiso, cleanliness)**	把工作場所掃除清潔，去除雜物及灰塵。	提升效率，排除隱藏的工業災害與品質不良。
清潔 (seiketsu, maintenance)	保持整理、整頓、清掃所建立之成果。	確保作業安全，延長設備壽命，提升產品品質。
修養 **(shitsuke, discipline)**	對於規定的事項確實遵守並養成習慣。	加強小團體之自主性活動。

Supplier Policies[1]

1. *Locate near to the customer*
2. *Use small, side loaded trucks and ship mixed loads*
3. *Consider establishing small warehouses near to the customer or consolidating warehouses with other suppliers*

Supplier Policies[2]

4. *Use **standardized containers** and make deliveries according to a **precise delivery schedule***
5. *Become a **certified supplier** and accept payment at regular intervals rather than upon delivery*

及時生產系統Ⅱ

- 供應商進入工廠，成爲客戶採購部門的積極成員，駐廠代表取代採購人員、銷售人員，甚至物料規劃人員。

推行JIT之先決條件[1]

- 正確之**銷售預測**可有效縮短製造前置時間。
- 生產部門依訂單及長、短期預測，**規劃生產水準**。
- 訂購零件與**供應商密切合作**。
- **供應商**依公司之需求預測作**長期生產規劃**。
- 依需求變動及生產變動更新需求。

推行JIT之先決條件[2]

- 採購部門將設計變更及未來新零件的需求告知供應商。
- 供應商調整其生產、運送計劃以滿足公司之更新排程。
- 供應商將零件以少量多批方式送至公司。
- 進貨零件皆應有高品質而不需檢驗。

JIT系統的效益[1]

- 降低存貨水準
- 降低需求空間
- 改進生產品質
- 減少前置時間
- 增加生產彈性

JIT系統的效益[2]

- 使生產流程更爲順暢
- 增加生產水準
- 工人參與解決問題
- 促進與協力廠商的良好關係
- 降低間接勞力的需求

服務業的精實系統

- 維持一致的高品質
- 設施負荷均勻
- 標準化工作方法
- 緊密的供應商關係
- 彈性勞動力
- 自動化
- 預防維修
- 拉式物料流程
- 生產線流程

JIT實行的議題[1]

- 組織考慮
  - **JIT**系統的員工成本
    - **Problem-solving**
    - **Lost some autonomy (little or no safety stocks)**
  - 合作與信任
    - **Scheduling, expediting and improving productivity → lower-level personnel**
  - 薪資系統與員工分類
    - **JIT vs. Production volume**
    - **Management's flexibility vs. Union**

實行的議題[2]

- 程序考慮
  - **Cellular design → costly**
- 存貨和排程
  - 主生產排程穩定性
  - 生產整備
    - **Small lot sizes vs. large number of setups**
  - 採購與物流
    - **Small shipments of purchased items vs. geographic dispersion of suppliers**