



# **Just-in-Time and Lean Operations**

# What is JIT ?

- ✓ Producing only what is needed, when it is needed (not early, not late; not less, not more)
- ✓ Achieving high volume production using minimal inventories
- ✓ An integrated but simplified system
- ✓ JIT's mandate:  
Elimination of all waste in production effort



# Just-in-Time

*Just-in-time (JIT)*: A highly coordinated processing system in which goods move through the system, and services are performed, just as they are needed

- Supplies and components are 'pulled' through the system to arrive where they are needed when they are needed (just-in-time)
- A management philosophy of continuous and forced problem solving by attacking the root causes

# Lean Production

- JIT ↔ lean production
- Lean Production supplies customers with exactly what the customer wants, when the customer wants, without waste, through continuous improvement
- JIT operates with very little fat

# What Does Just-in-Time Do?

- Attacks waste (anything not adding value to the product)
- Achieves streamlined production by reducing inventory
- Exposes problems and bottlenecks caused by variability

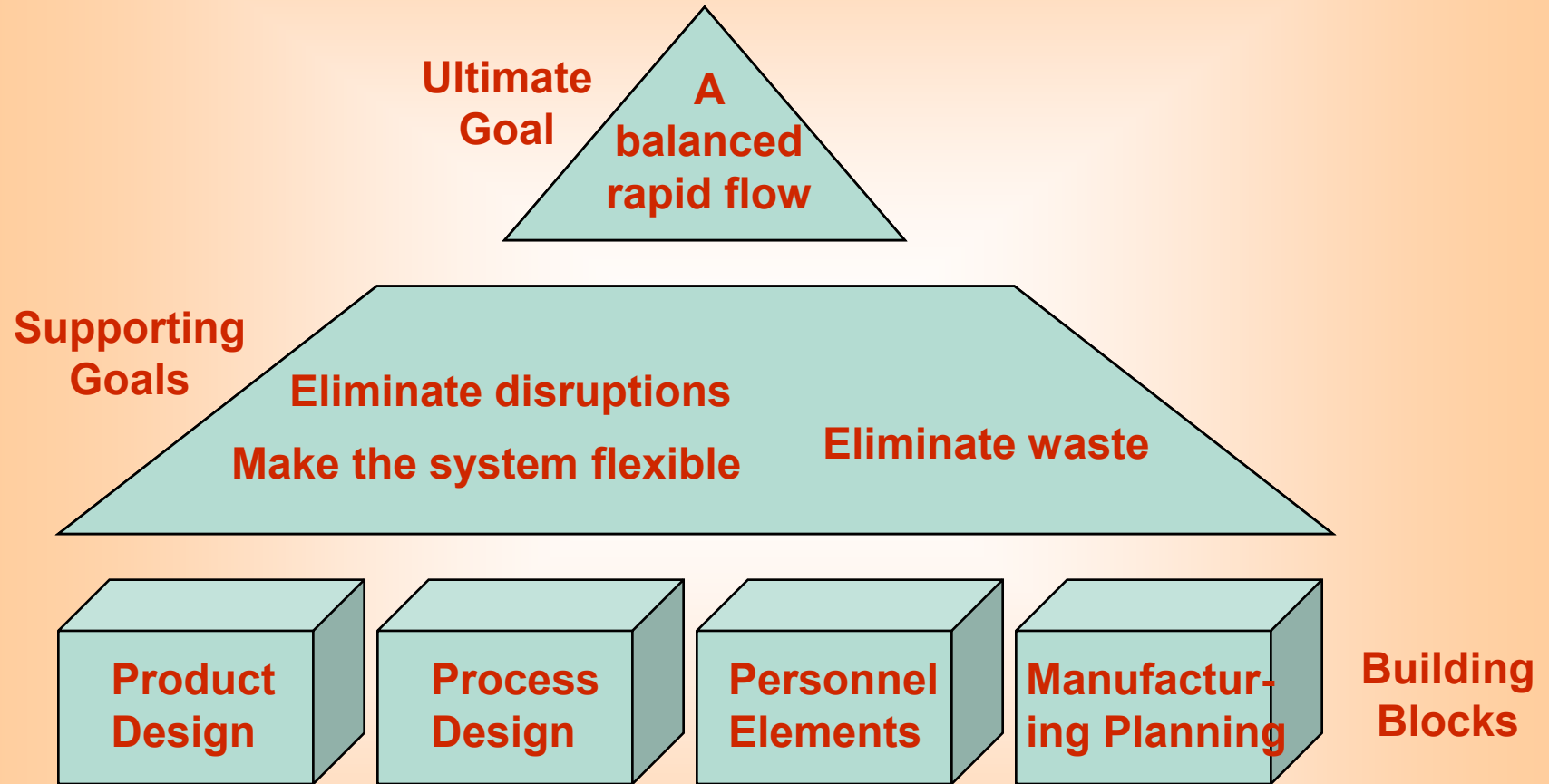
# Goal of JIT

The ultimate goal of JIT is a balanced system.  
(Achieves a smooth, rapid flow of materials through the system)

The supporting goals are:

- Eliminate disruptions
- Make the system flexible
- Eliminate waste, especially excess inventory

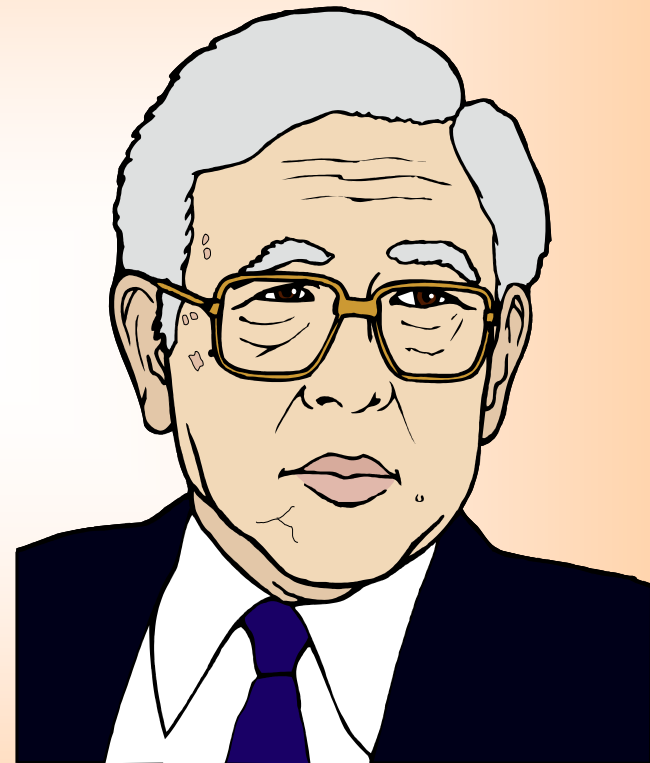
# Summary:JIT Goals and Building Blocks



# Quotation by Shoichiro Toyoda

*Waste* is 'anything other than the *minimum* amount of equipment, materials, parts, space, and worker's time, which are absolutely essential to *add value* to the product.'

— Shoichiro Toyoda  
President, Toyota

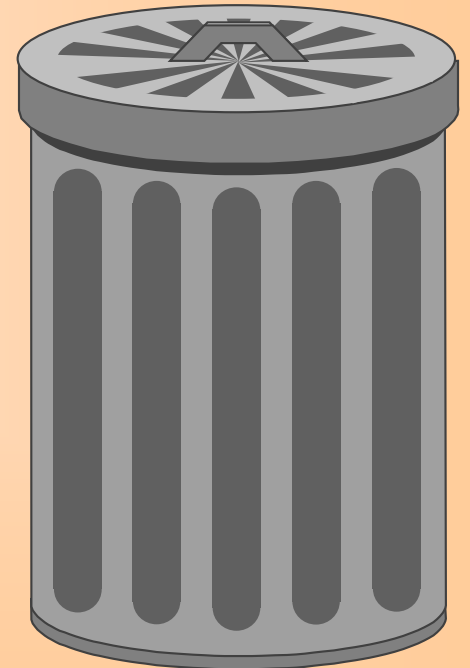


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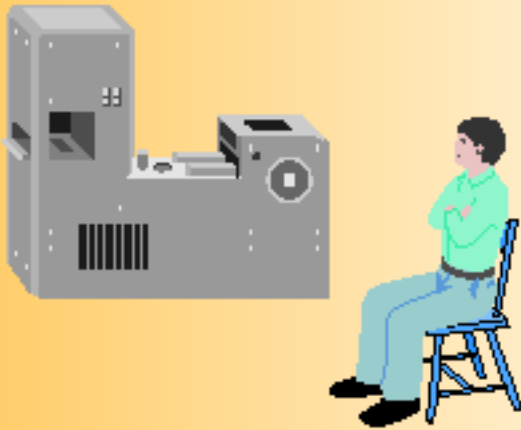


# Sources of Waste

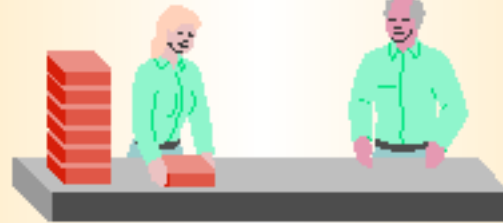
- **Overproduction**
- **Waiting**
- **Unnecessary transportation**
- **Inventory**
- **Inefficient work methods**
- **Inefficient processing**
- **Unnecessary motions**
- **Product defects**



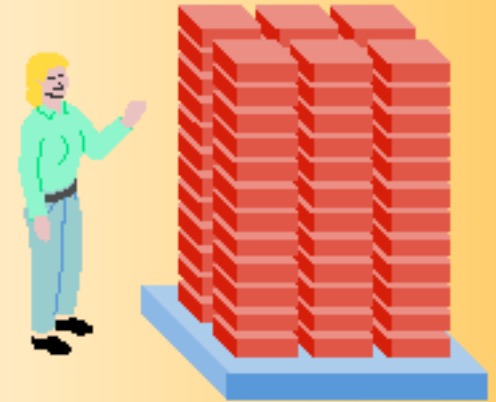
# Waste in Operations (1 of 3)



Watching a machine run

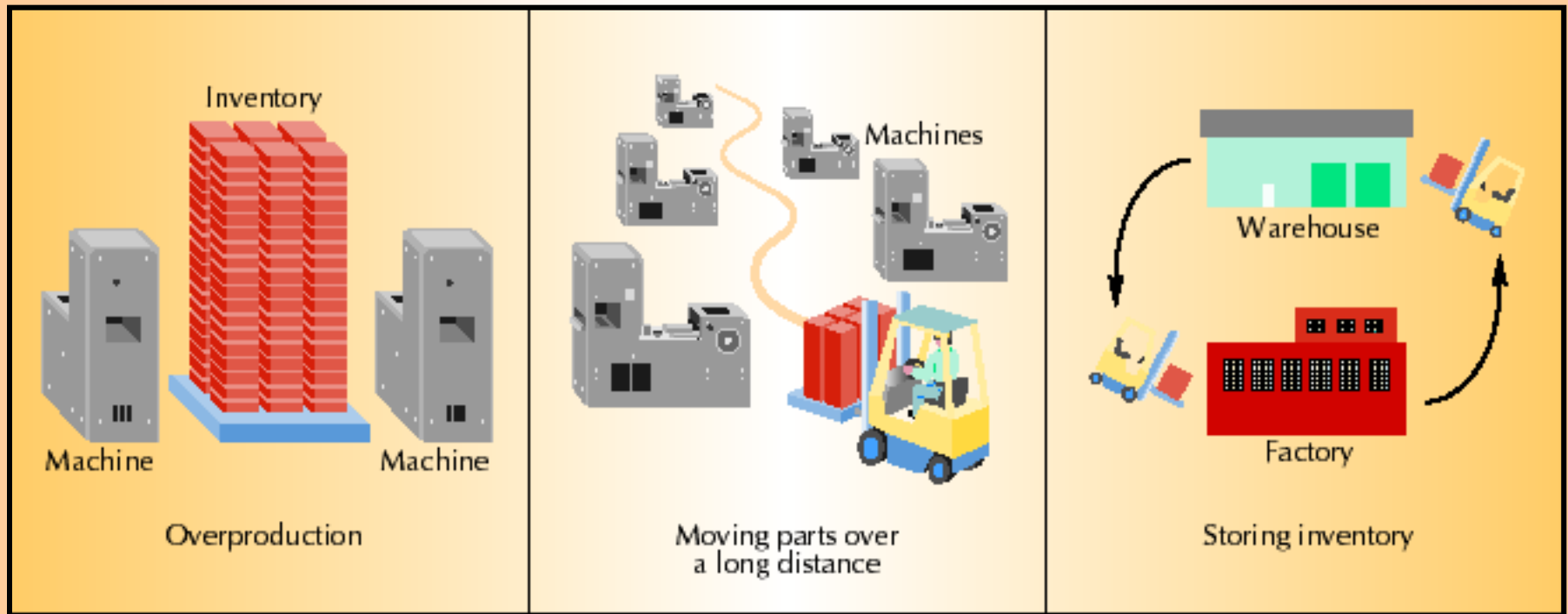


Waiting for parts



Counting parts

# Waste in Operations (2 of 3)



# Waste in Operations (3 of 3)



Looking for tools

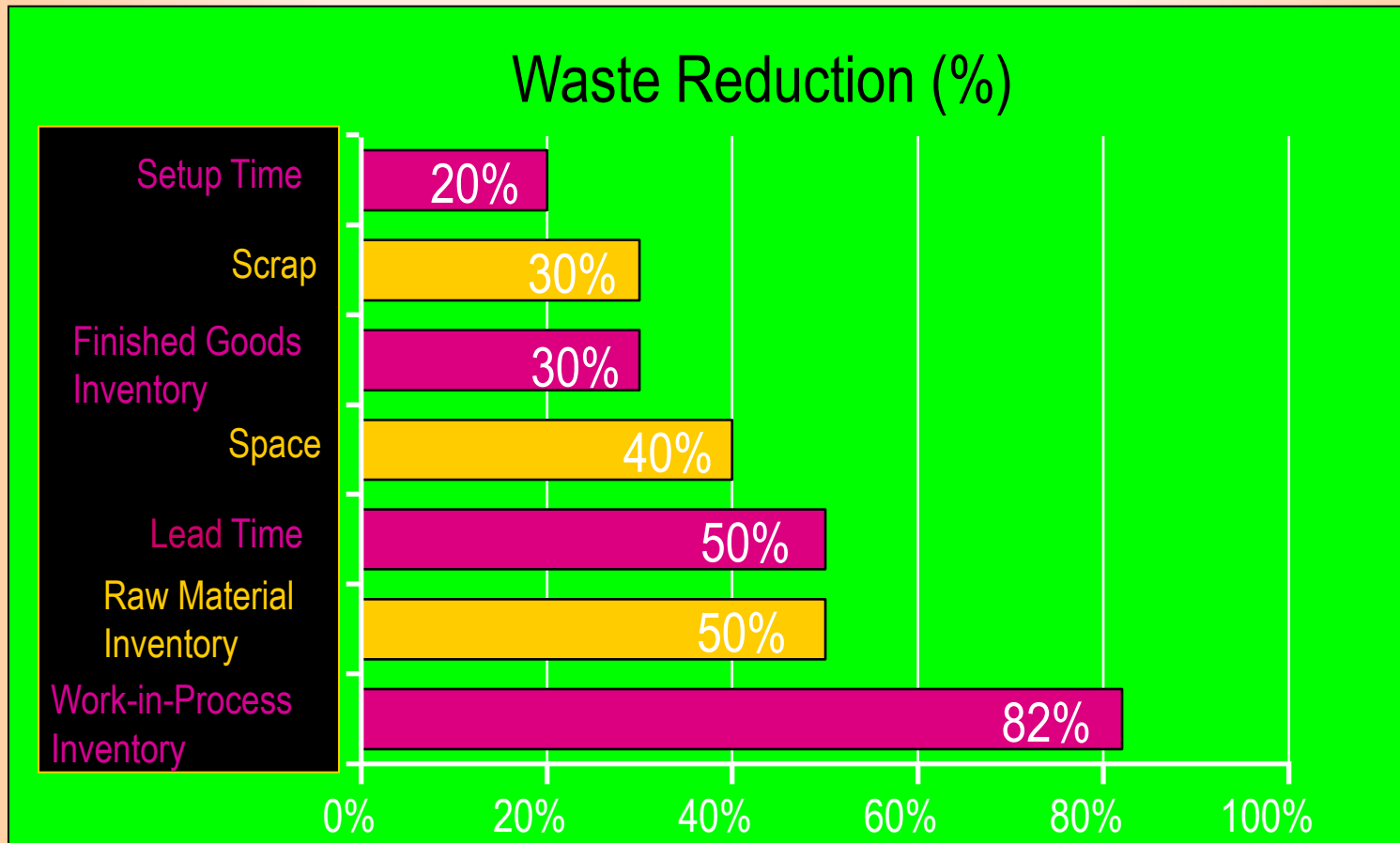


Machine breakdown



Rework

# JIT Reduced Waste at Hewlett-Packard



# Kaizen Philosophy (1 of 3)

- ✓ Continuous improvement
- ✓ Requires total employee 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

# Kaizen Philosophy (2 of 3)

- Waste is the enemy
- Improvement should be done gradually and continuously
- Everyone should be involved
- Built on a cheap strategy
- Can be applied anywhere

# Kaizen Philosophy (3 of 3)

- Supported by a visual system
- Focuses attention where value is created
- Process oriented
- Stresses main effort of improvement should come from new thinking and work style
- The essence of organizational learning is to learn while doing



# Big vs. Little JIT

- Big JIT – broad focus
  - Vendor relations
  - Human relations
  - Technology management
  - Materials and inventory management
- Little JIT – narrow focus
  - Scheduling materials
  - Scheduling services for production

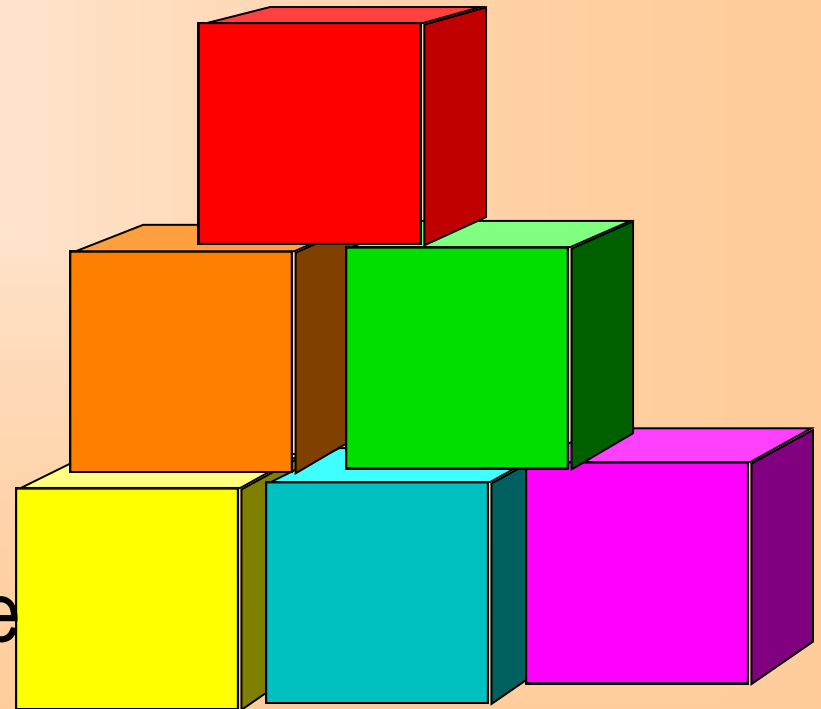
# JIT Building Blocks

In order to achieve competitive advantage through JIT, the necessary building blocks should be installed

The building blocks can also be regarded as JIT success factors or the basic elements of JIT

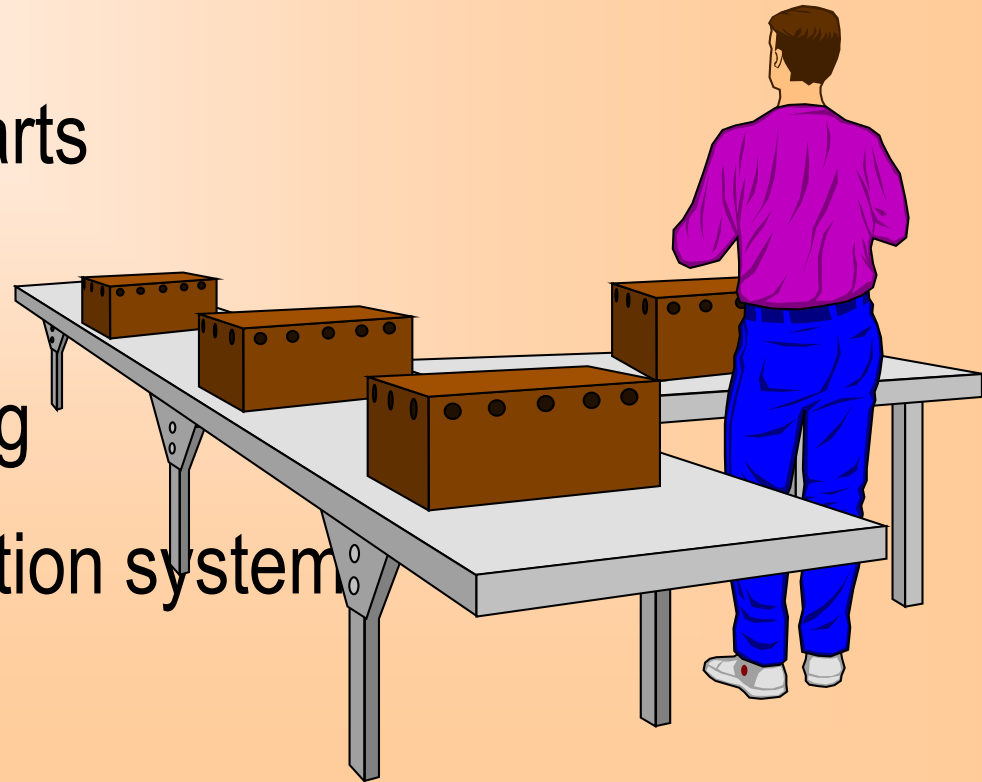
# JIT Building Blocks

1. Product design
2. Process design
3. Personnel/organizational elements
4. Manufacturing planning and control
5. Supplier relationships (supplier networks)
6. Preventive maintenance



# JIT Building Blocks: 1. Product Design

- Process design with product design
- Standard product configuration and standard parts
- Reduced number of parts
- Modular design
- Concurrent engineering
- Highly capable production system



# JIT Building Blocks: 2. Process Design

- Small lot sizes
- Setup time reduction
- Cellular layout (Manufacturing cells)
- Reduced Inventories (Limited WIP)
- Continuous quality improvement
- Production flexibility (multifunctional workers, general purpose machines)
- Balanced system
- Fail-safe methods



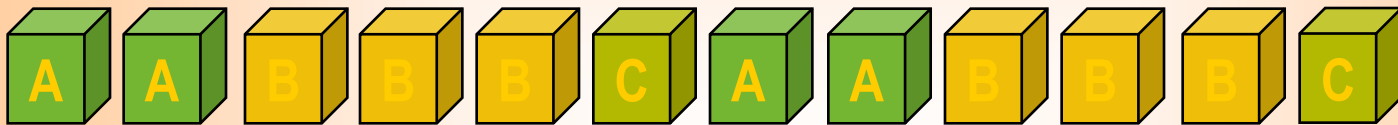
# Small-Lot Production

- ✓ Requires less space & capital investment
- ✓ Moves processes closer together
- ✓ Makes quality problems easier to detect
- ✓ Makes processes more dependent on each other

# Small versus Large Lots

JIT produces same amount  
in same time if setup times  
are lowered

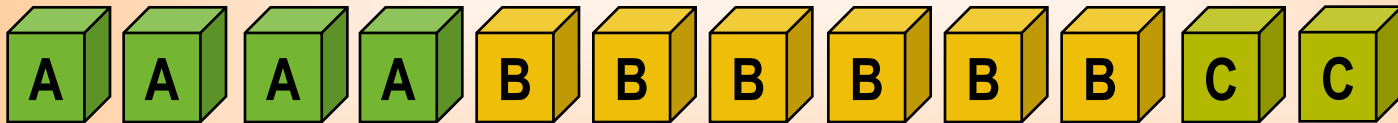
## JIT Small Lots



Time

Small lots also increase flexibility to meet  
customer demands

## Large-Lot Approach



Time

# Comparison of Level and Large Lot Material-use Approaches

## JIT Level Material-Use Approach



## Large-Lot Approach



Time →



# Benefits of Small Lot Sizes

- ✓ Reduces inventory
  - ✓ Less rework
    - ✓ Less storage space
  - ✓ Problems are more apparent
- ✓ Increases flexibility
  - ✓ Easier to balance operations

# Single-Minute Exchange

- Single-minute exchange of die (SMED): A system for reducing changeover time
- Categorize changeover activities
  - Internal – activities that can only be done while machine is stopped
  - External – activities that do not require stopping the machine

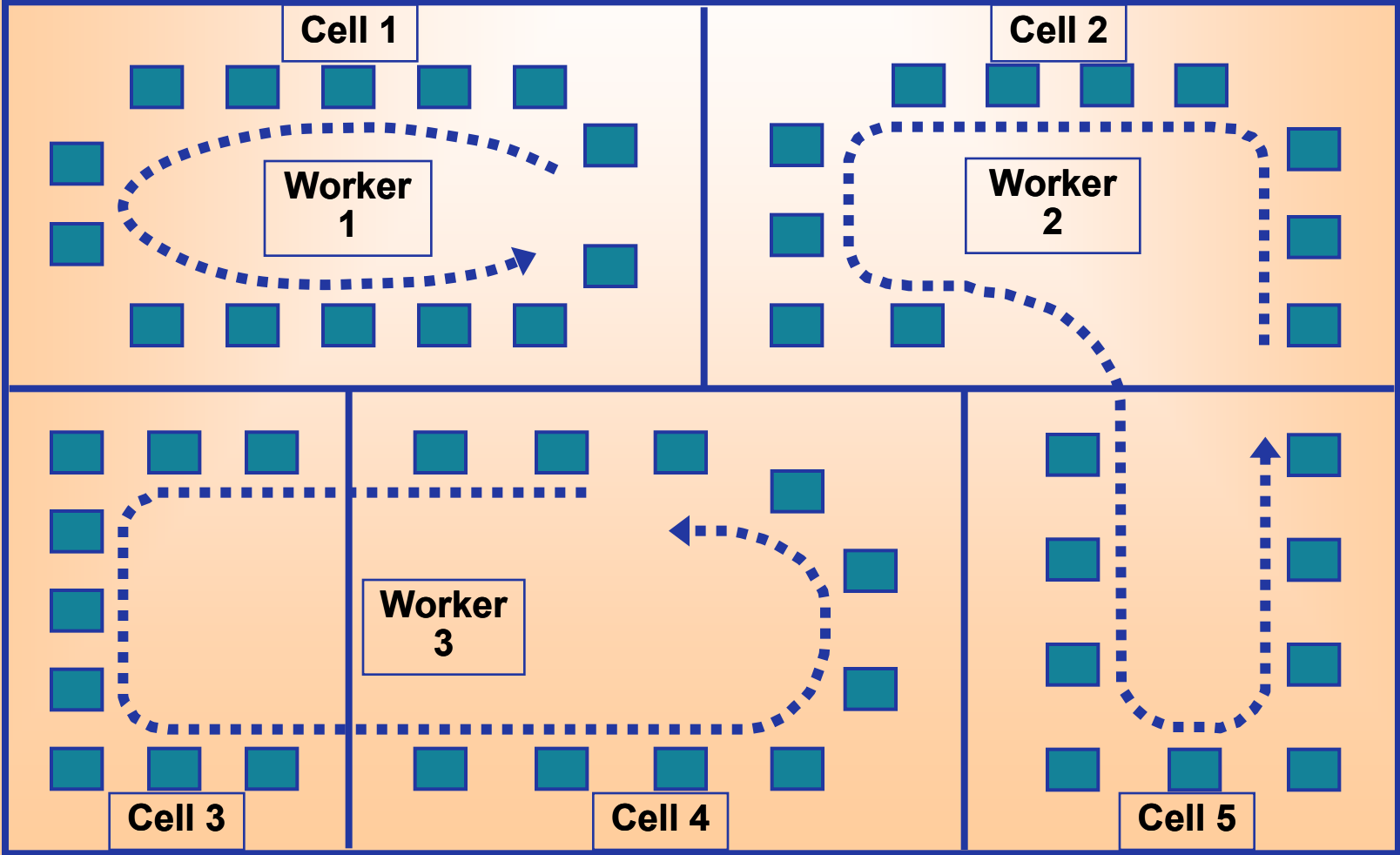
# Layout

- JIT objective: Reduce movement of people and material
  - Movement is waste!
  - JIT requires work-cells for product families (group technology)
    - movable, changeable, flexible machinery
    - short distances
    - high level of workplace organization and neatness
    - reduced space for inventory
    - delivery directly to work areas
    - balanced workstation capacities

# 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
- ✓ Decreasing set-up times

# Worker Routes Lengthened as Volume Decreases



# Layout Tactics

- Build work cells for families of products
- Minimize distance
- Design little space for inventory
- Improve employee communication
- Use poka-yoke devices
- Build flexible or movable equipment
- Cross train workers to add flexibility to layout

# Quality Improvement (1 of 4)

- JIT exposes quality problems by reducing inventory
- JIT eliminates number defects with small lots
- JIT requires quality by suppliers
- Team approach and continuous improvement are important for ensuring quality
- Quality is maintained by the following procedure:

**Find the root cause of the problem, solve permanently and use team approach in solving the problems**

# Quality Improvement (2 of 4)

- JIT requires TQM
  - Statistical process control
  - Continuous improvement
  - Worker involvement & empowered employees
    - Inspect own work
    - Quality circles
  - Immediate feedback
  - Failsafe methods such as poka-yoke (prevents defectives)
  - Quality at the source



# Quality Improvement (3 of 4)

**JIT requires**

**1) Quality within the firm**

- **Autonomation (jidoka): automatic detection of defects during production**

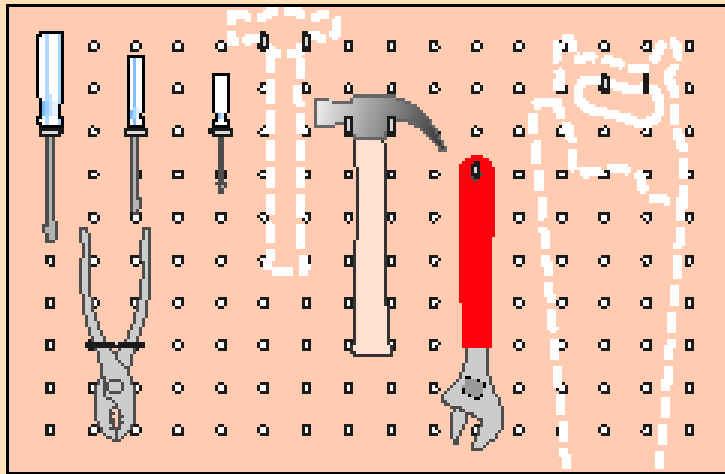
**2) Quality by suppliers**

# Quality Improvement (4 of 4)

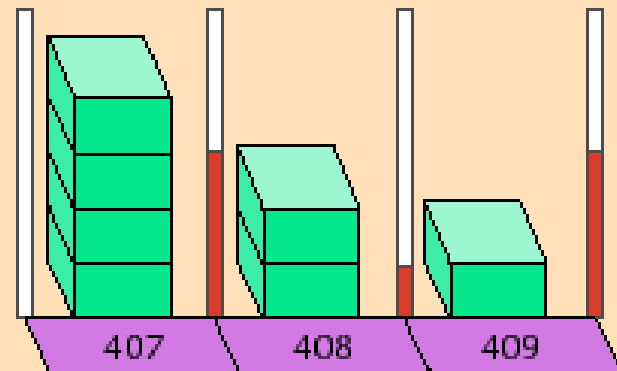
- ✓ Jidoka assures quality at the source
- ✓ Andon lights signal quality problems
- ✓ Visual control makes problems visible

# Visual Control (1 of 3)

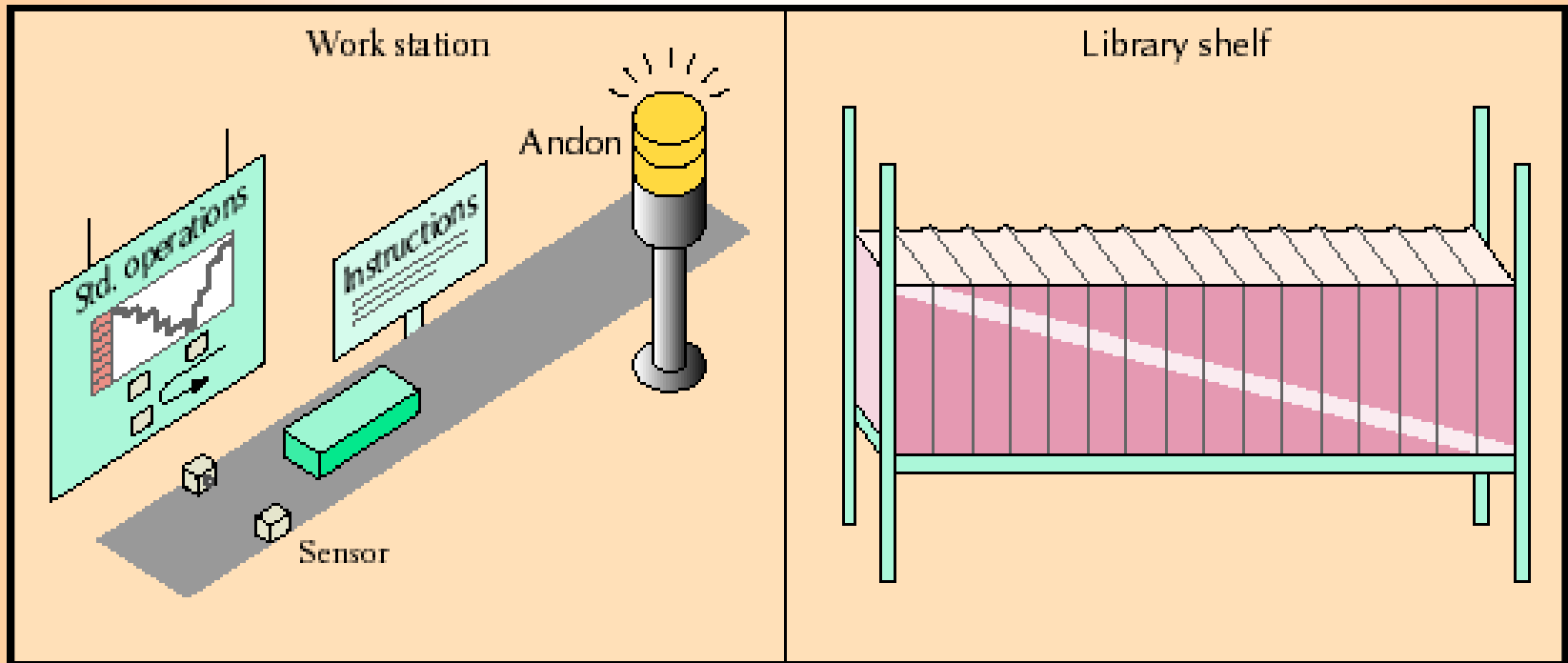
Tool board



Visual kanbans



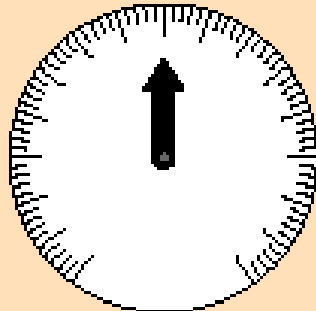
# Visual Control (2 of 3)



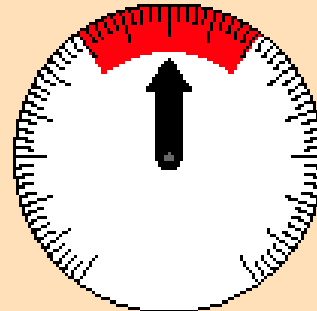
# Visual Control (3 of 3)

Machine controls

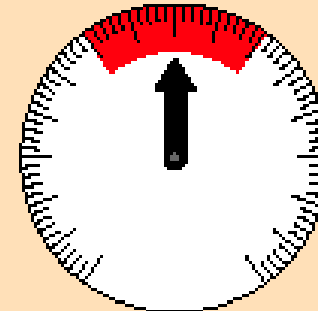
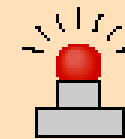
30-50



Good



Better



Best  
(Poka-Yoke)

# Production Flexibility

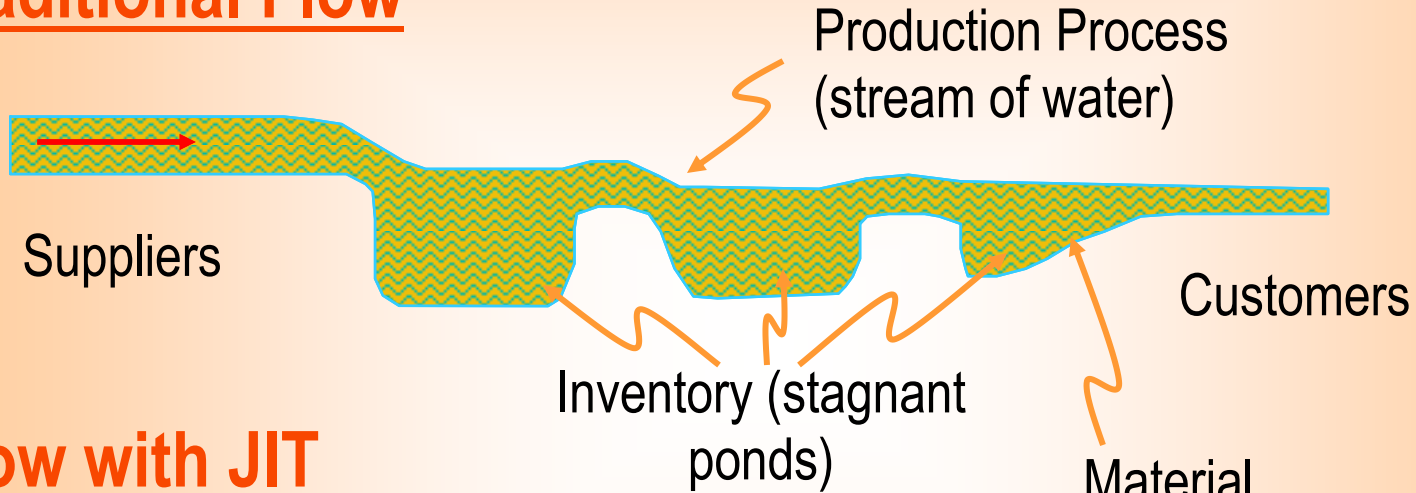
- Overall objective is to achieve the ability to process a mix of products in a smooth flow.
- Eliminate bottlenecks
  - **Reduce downtime by reducing changeover time**
  - **Use preventive maintenance to reduce breakdowns**
  - **Cross-train workers to help clear bottlenecks**
  - **Use many small units of capacity**
  - **Use off-line buffers**
  - **Reserve capacity for important customers**

# A Balanced System

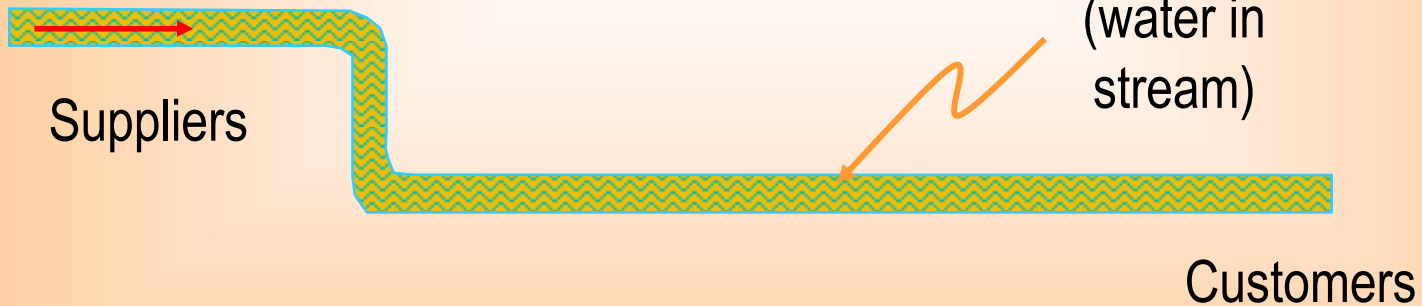
- Balanced system: Distributing the workload evenly among work stations
- Work assigned to each work station must be less than or equal to the cycle time
- Cycle time is set equal to the takt time
- Takt time is the cycle time needed to match the pace of production to customer demand for final product

# Streamlined Production

## Traditional Flow



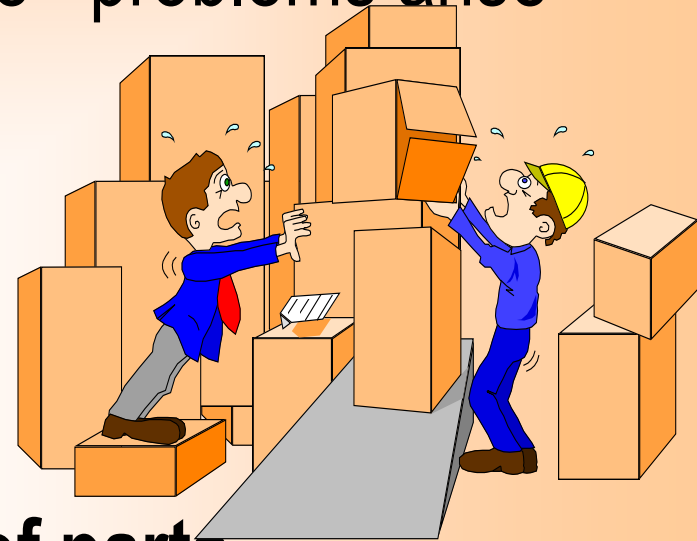
## Flow with JIT





# Inventories

- Traditional: inventory exists in case problems arise
- JIT objective: eliminate inventory
- JIT requires
  - **Small lot sizes**
  - **Low setup time**
  - **Containers for fixed number of parts**
- JIT inventory: Minimum inventory (raw material, WIP and finished goods) to keep the system running
- **Specialized bins for holding previously set number of parts**



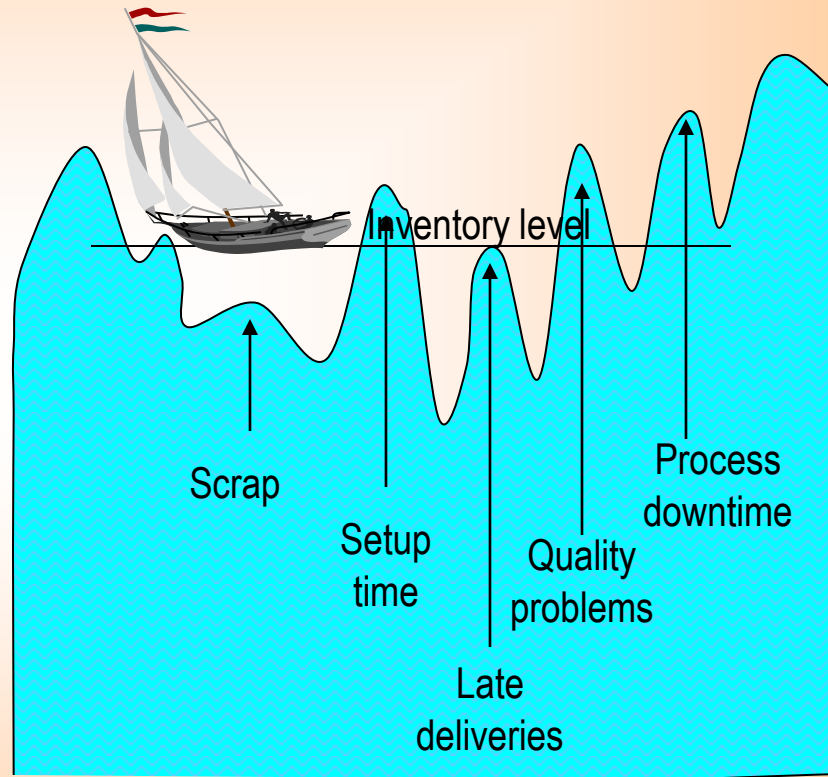
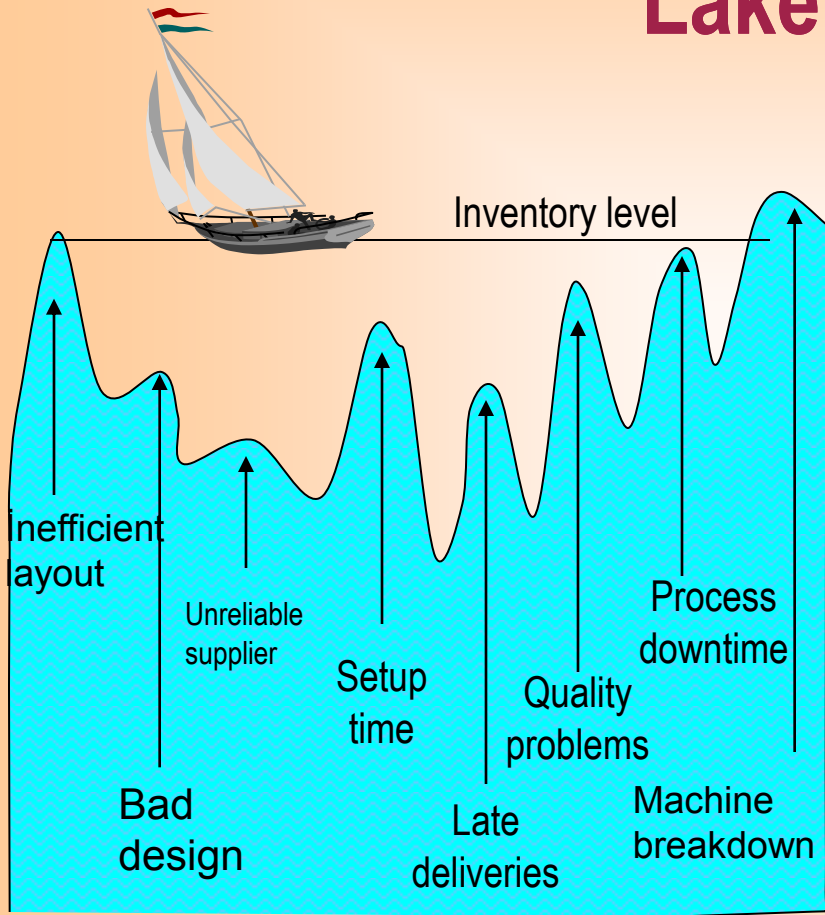
# JIT Inventory Tactics

- Use a pull system to move inventory
- Reduce lot size
- Reduce setup time
- Develop **Just-in-Time** delivery systems with suppliers
- Deliver directly to point of use
- Perform-to-schedule
- Use group technology

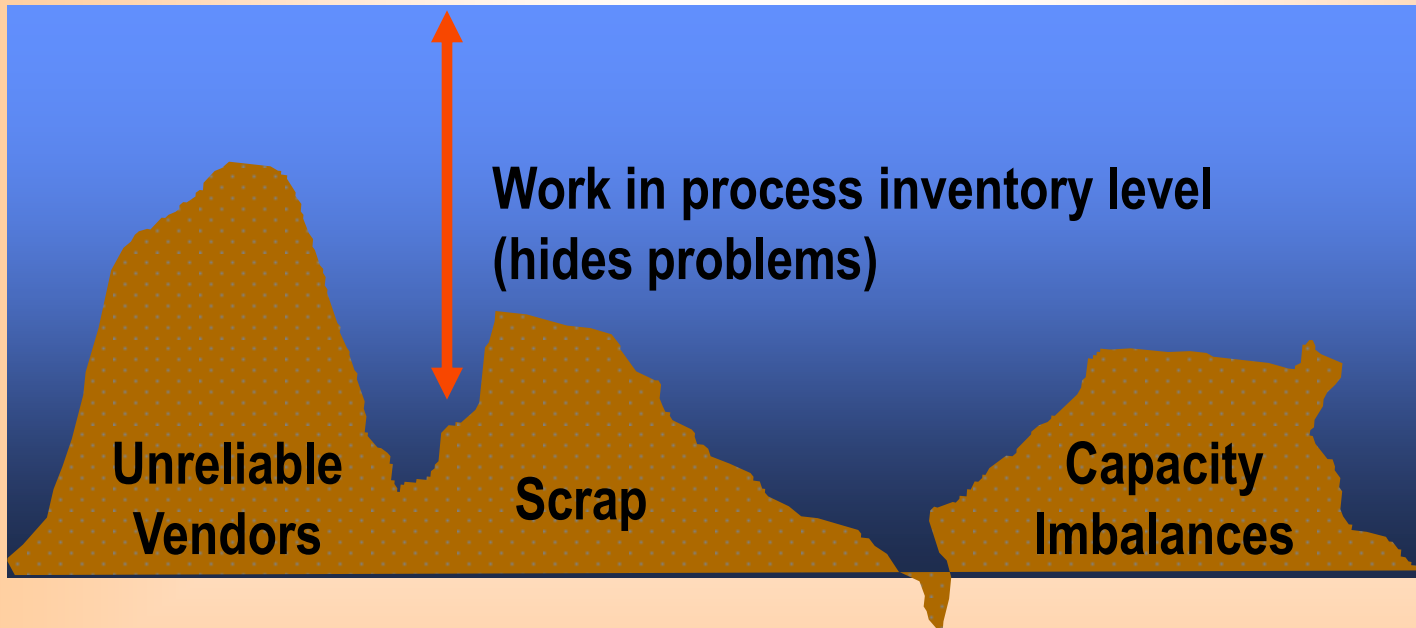
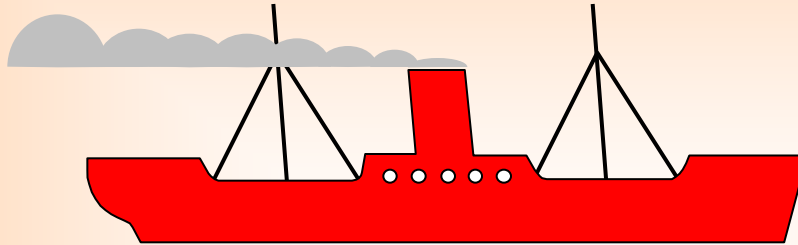
# Limited Work in Process

- Benefits
  - Lower carrying costs
  - Less space
  - Increased flexibility
  - Aids scheduling
  - Saves cost of rework and scrap
- Two general approaches
  - Kanban – focuses on individual work stations
  - Constant work in process (CONWIP) – focuses on the system as a whole

# Inventory Hides Problems Just as Water in a Lake Hides Rocks



# Lowering Inventory Reduces Waste



**Unreliable  
Vendors**

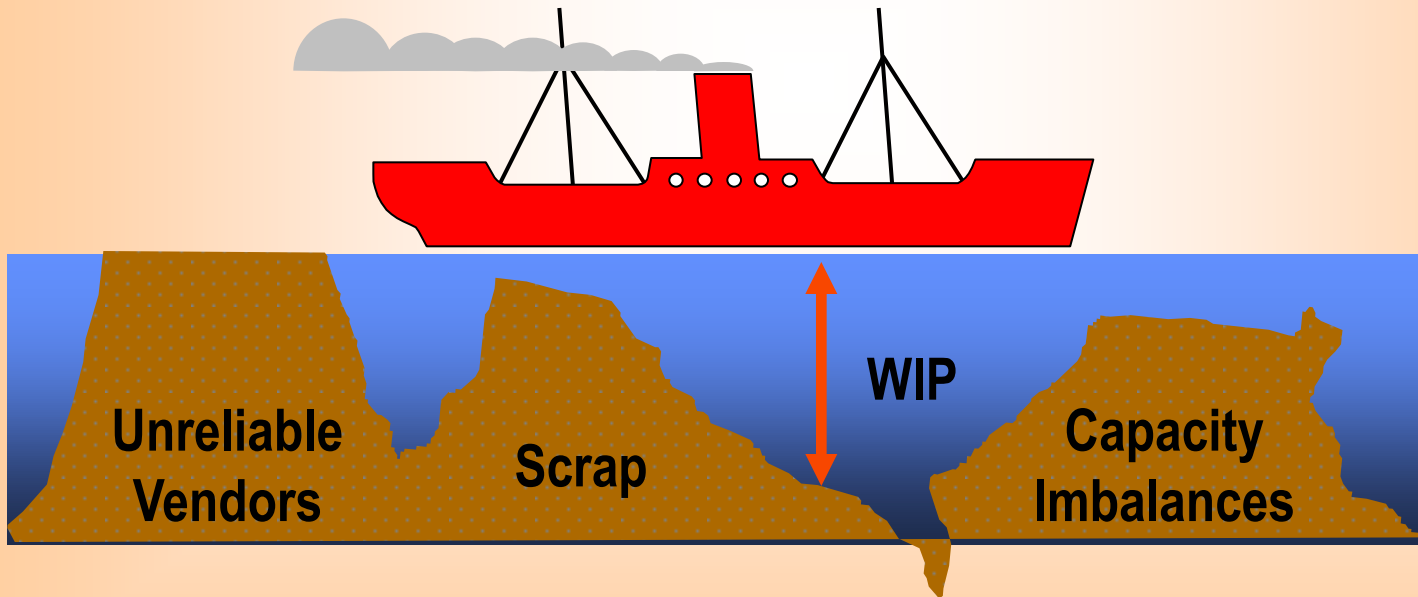
**Work in process inventory level  
(hides problems)**

**Scrap**

**Capacity  
Imbalances**

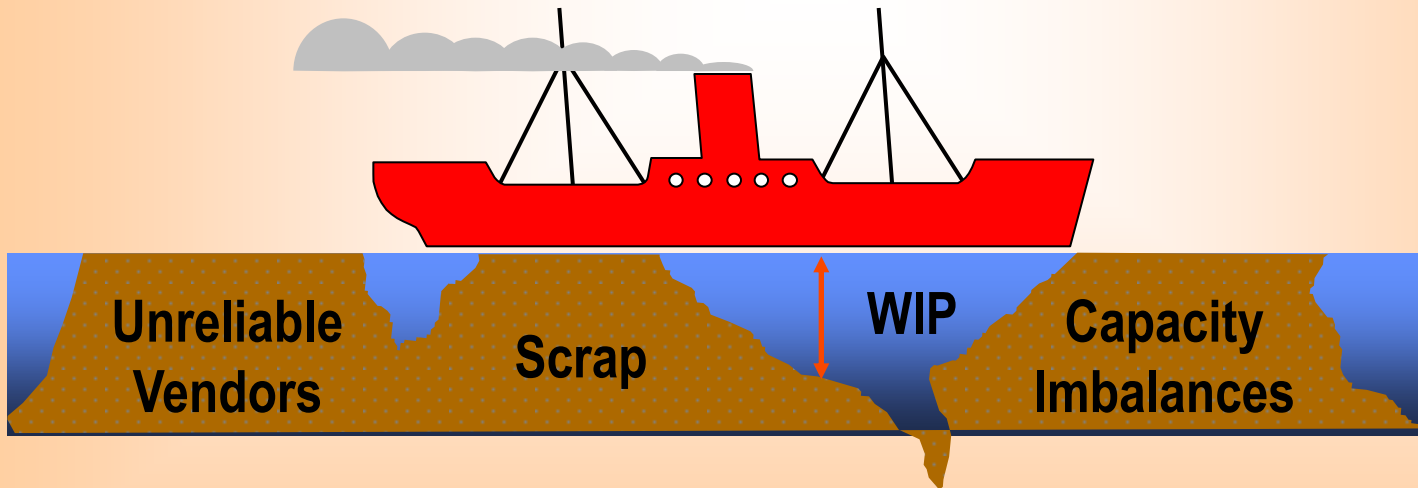
# Lowering Inventory Reduces Waste

Reducing inventory exposes  
problems so they can be solved.



# Lowering Inventory Reduces Waste

Reducing inventory reveals  
problems so they can be solved.



# JIT Building Blocks:

## 3. Personnel/Organizational Elements

- Workers as assets
- Cross-trained workers
- Employee empowerment
- Continuous improvement
- Cost accounting
- Leadership/project management
- Commitment





# Employee Empowerment

## Employee empowerment

- Empowered and cross-trained employees (to help clear bottlenecks)
- Get employees involved in product & process (employees know the job best!)
- Few job classifications to ensure flexibility of employees
- Training support

# Bottom-round Management Style & Commitment

## Commitment

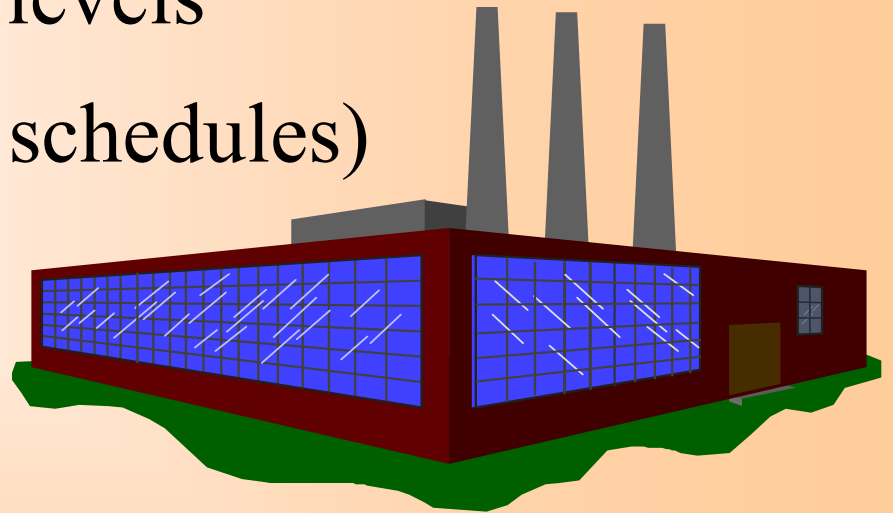
- Support of management, employees and suppliers

Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organization (Toyota Production System's work rule)

# JIT Building Blocks:

## 4. Manufacturing Planning and Control

- Uniform production levels
- Level loading (level schedules)
- Pull systems
- Visual systems
- Reduced transaction processing



# Uniform Production

- ✓ Results from smoothing production requirements
- ✓ Kanban systems can handle +/- 10% demand changes
- ✓ Smooths demand across planning horizon
- ✓ Mixed-model assembly steadies component production

# Level Schedules

- Reduce ripple effect of small variations in schedules (e.g., final assembly)
- Production quantities evenly distributed over time (e.g., 7/day)
- Build same mix of products *every* day
  - **Results in many small lots**
  - | <u>Item</u> | <u>Monthly Quantity</u> | <u>Daily Quantity</u> |
|-------------|-------------------------|-----------------------|
| A           | 40                      | 2                     |
| B           | 60                      | 3                     |

# Mixed-Model Sequencing



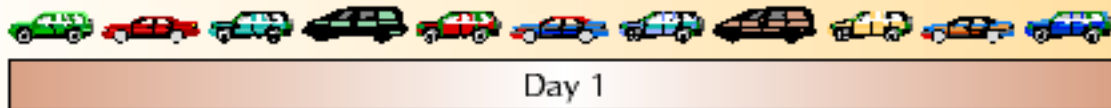
September Sales Forecast



Daily Breakdown



Daily Sequence—Batched



Daily Sequence—Mixed

# JIT Scheduling Tactics

Involves timing of operations

Scheduling in JIT requires

- Level loading (level schedules)
- Zero deviation from schedules (performing to schedules)
- Suppliers informed about schedules
- Small lots (seeking one-piece-make and one-piece move)
- Making each operation produce a perfect part
- Kanban techniques

# Pull/Push Systems

➤ Pull system: System for moving work where a workstation pulls output from the preceding station just as it is needed. (e.g. Kanban)

VS.

➤ Push system: System for moving work where output is pushed to the next station as it is completed



# The Pull System

- ✓ Material is pulled through the system when needed
- ✓ Reversal of traditional push system where material is pushed according to a schedule
- ✓ Forces cooperation
- ✓ Prevent over and underproduction

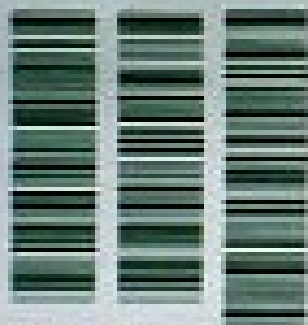
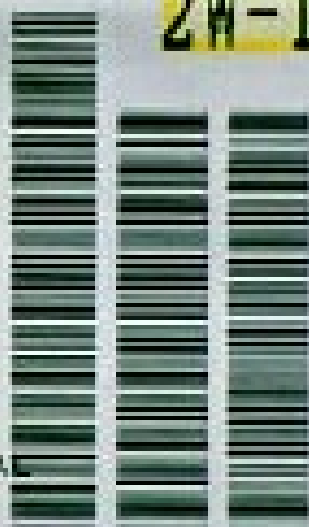
# Kanban Production Control System (1 of 2)

- ✓ Kanban: Card or other device that communicates demand for work or materials from the preceding station
- ✓ Japanese word meaning “signal” or “visible record” may be a card, or may be a flag, ball etc.
- ✓ Paperless production control system
- ✓ Kanban card indicates standard quantity of production
- ✓ Used often with fixed sized container

# Kanban Production Control System (2 of 2)

- ✓ The kanban cards provide direct control (limit) on the amount of work-in-process between cells.
- ✓ Derived from two-bin inventory system
- ✓ Maintains discipline of pull production
- ✓ Signifies an authority to pull or produce which comes from a downstream process
- ✓ Production kanban authorizes production
- ✓ Withdrawal kanban authorizes movement of goods

# A Sample Kanban

GET STORE ADDRESS		KANBAN NO		LINE-SIDE ADDRESS	
1 57-B-NB		N762		2W-10-3	
		PART NO. 22020-03011-00			
PART DESCRIPTION METER ASSY AIR FLOW/W-AIR CLEA		ROUTE F-1		GROUP CODE IA520	
SUPPLIER NIPPONDENSO PURDENSEO		DITY / CONT 4		DOCK CODE N2	
1950-5		SERIAL NO 345			

# Determination of the Number of Kanbans Needed

- Setting up a kanban system requires determining the number of kanbans (or containers) needed.
- Each container represents the minimum production lot size
- An accurate estimate of lead time required to produce a container is key to determining how many kanbans are required

# Determination of the Number of Kanbans- Kanban Formula

$$N = \frac{DT(1+X)}{C}$$

**N = Total number of containers**

**D = Planned usage rate of using work center**

**T = Average waiting time for replenishment of parts  
plus average production time for a  
container of parts**

**X = Policy variable set by management  
- possible inefficiency in the system**

**C = Capacity of a standard container**

# JIT Demand-Pull Logic

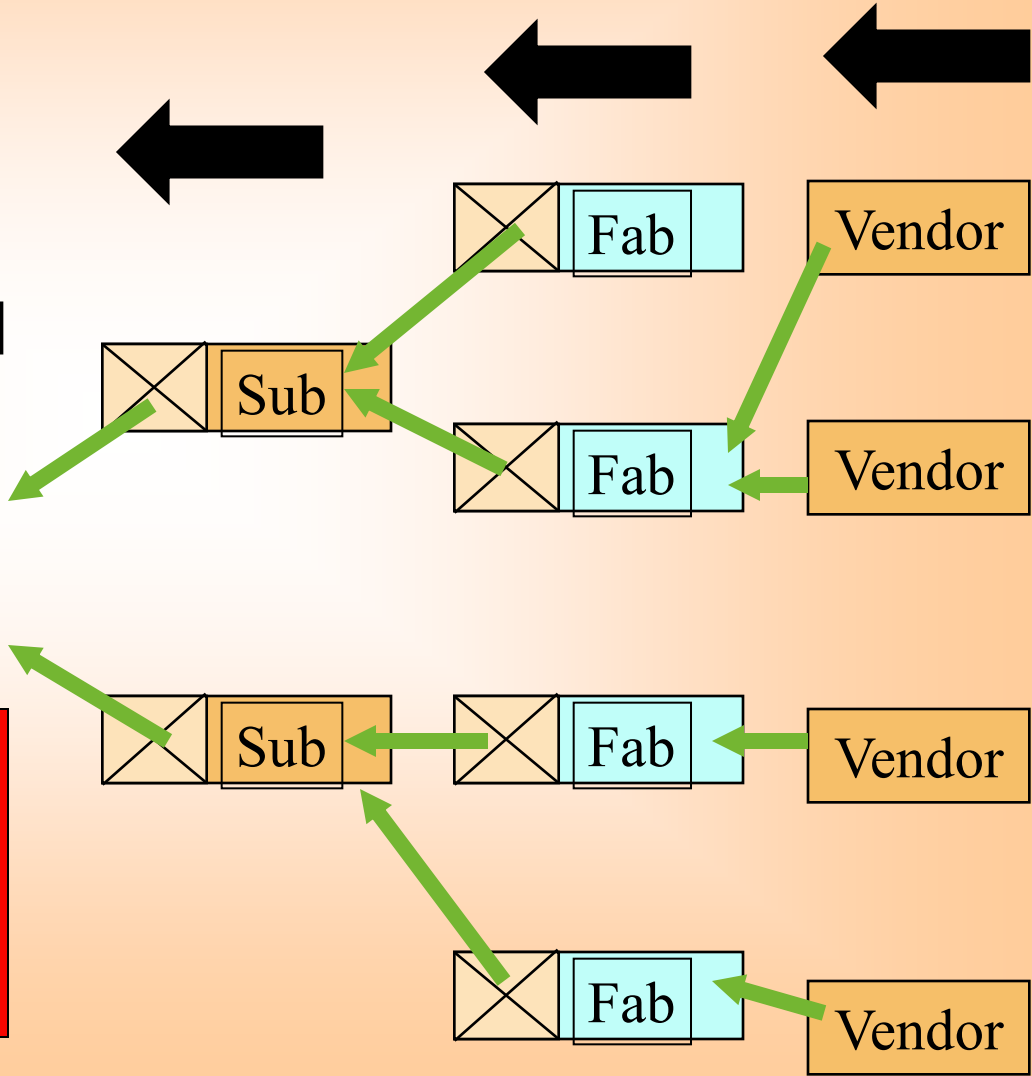
Here the customer starts the process, pulling an inventory item from Final Assembly...

Then sub-assembly work is pulled forward by that demand...

Customers

Final Assembly

The process continues throughout the entire production process and supply chain

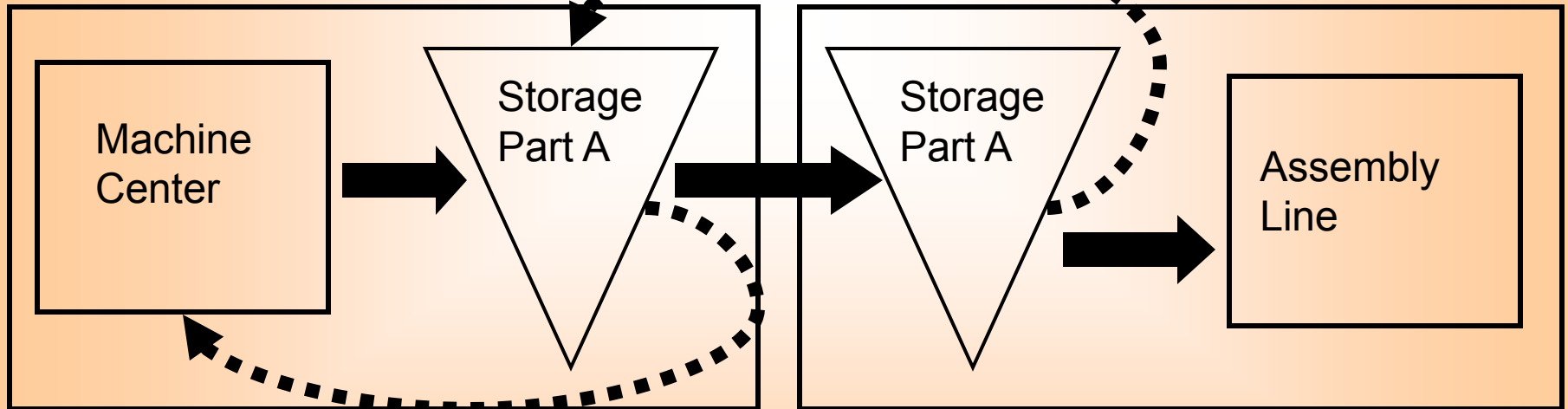


# Kanban Signals “Pull” Material Through the Process

Once the Production kanban is received, the Machine Center produces a unit to replace the one taken by the Assembly Line people in the first place

Withdrawal kanban

This puts the system back where it was before the item was pulled



Production kanban

The process begins by the Assembly Line people pulling Part A from Storage

➡ Material Flow  
⋯➡ Card (signal) Flow



# JIT Building Blocks:

## 5. Supplier Relationships

- Reduced number of vendors
- Supportive supplier relationships
- Quality deliveries on time
- Frequent deliveries in small lot quantities
- Reduced lead times
- Reduced transaction processing
- Certified vendors

# Suppliers

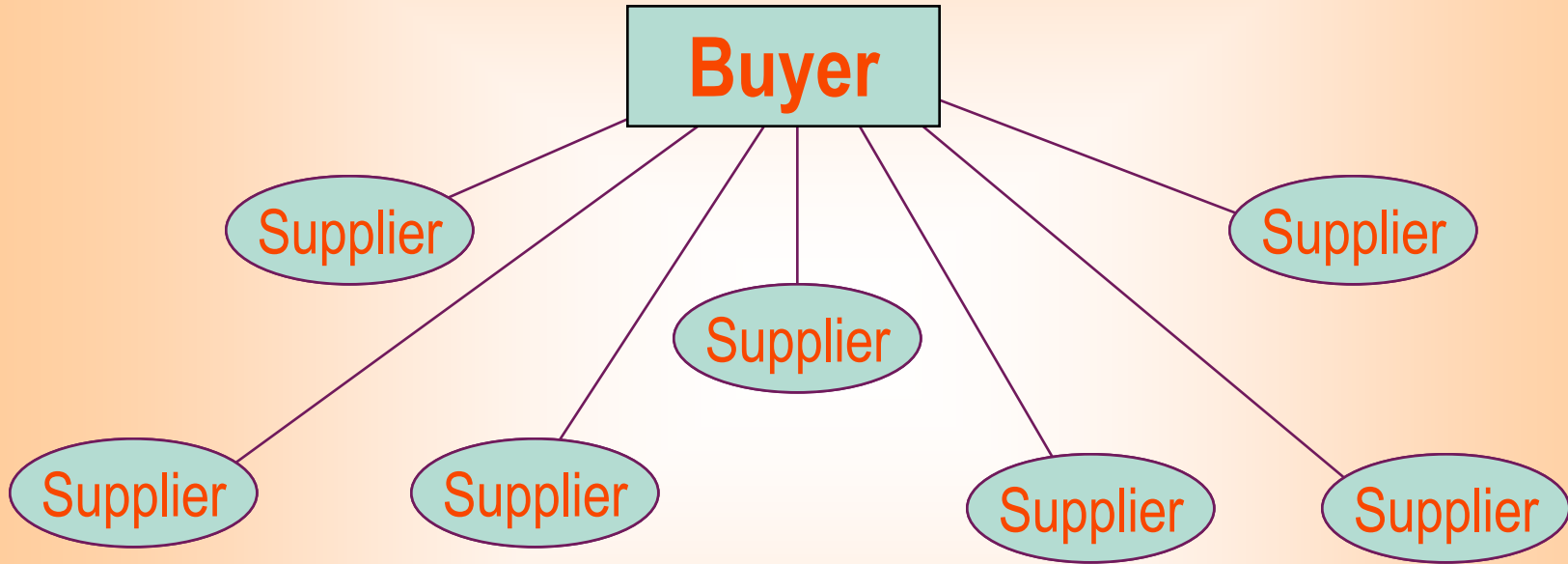
- JIT partnerships are formed
- JIT partnerships eliminate:
  - Some unnecessary activities
  - In-plant inventory
  - In-transit inventory
  - Poor suppliers



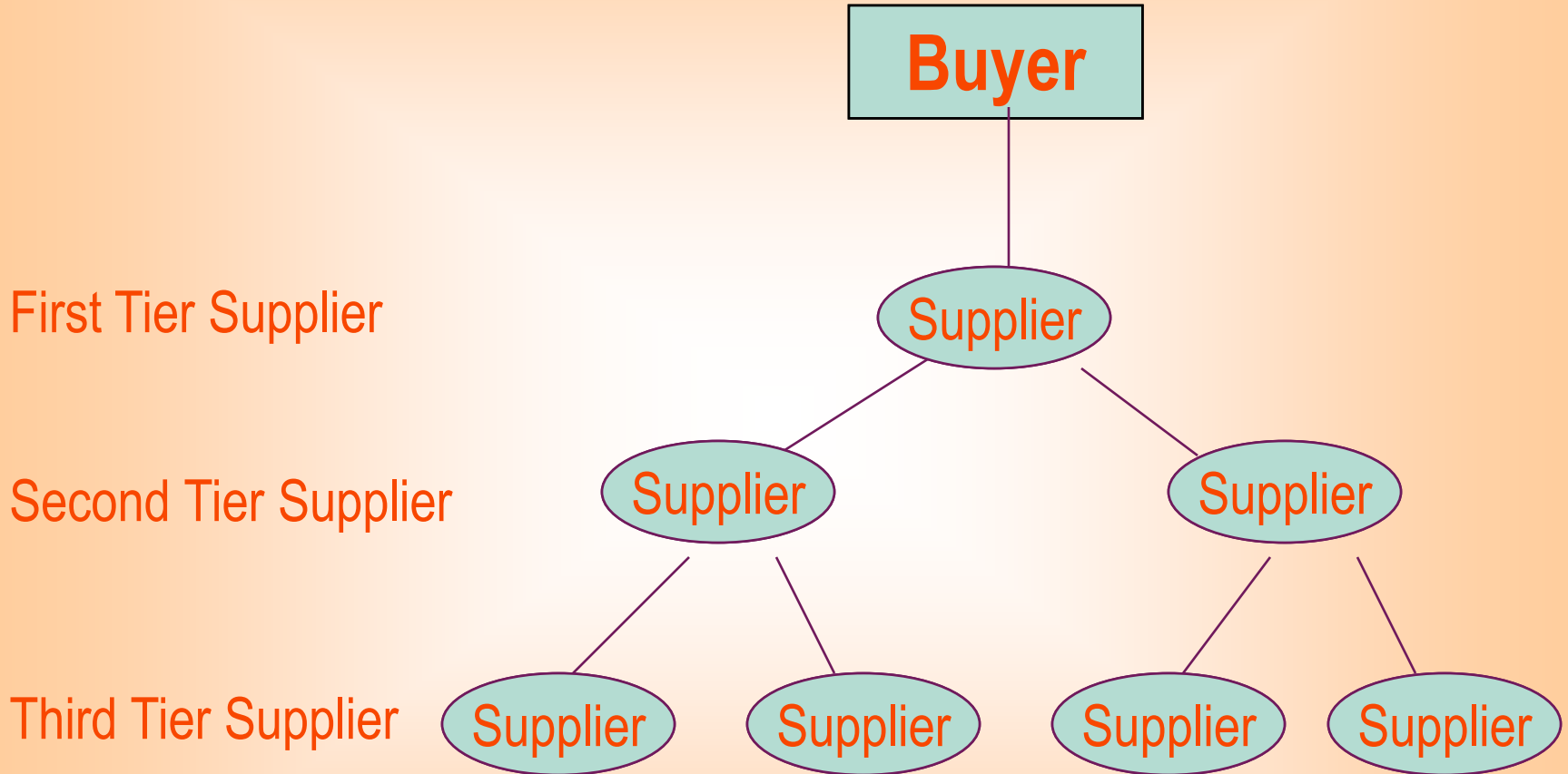
# Characteristics of JIT Partnerships *Suppliers*

- Few
- Nearby
- Long-term relationships
- Analysis and support to enable desirable suppliers to become or stay price competitive
- Buyer resists vertical integration and subsequent wipeout of supplier business
- Suppliers encouraged to extend JIT to their suppliers (2<sup>nd</sup> and 3<sup>rd</sup> tier suppliers)

# Traditional Supplier Network



# Tiered Supplier Network



# JIT Building Blocks:

## 6. Preventive Maintenance

- All activities involved in keeping equipment in working order
- Maintaining equipment in good condition and replacing parts that have a tendency to fail before they actually fail
- Done to *prevent* failure
- JIT requires
  - Scheduled & daily PM
  - Operator involvement in PM
    - Knows machines
    - Responsible for product quality

# 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



# Housekeeping

Housekeeping: Maintaining a workplace that is clean and free of unnecessary materials.

Housekeeping 5 S's

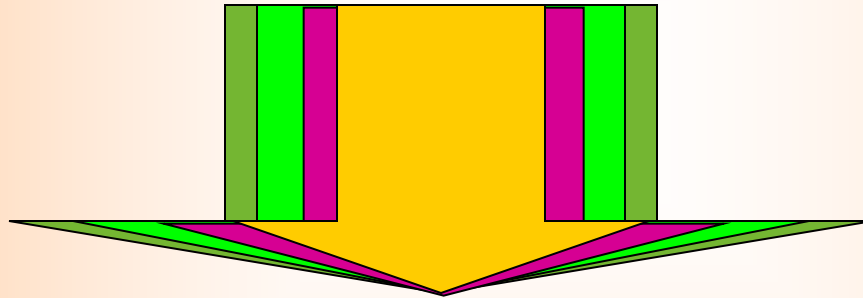
- Sort
- Straighten
- Sweep
- Standardize
- Self-discipline

# Results

- Queue and delay reduction, speedier throughput, freed assets, and winning orders
- Quality improvement, reduces waste and wins orders
- Cost reduction increases margin or reduces selling price
- Variability reductions in the workplace reduces waste and wins orders
- Rework reduction, reduces waste and wins orders

# Yielding

Faster response to the customer at lower cost  
and higher quality



**A competitive advantage!**

# Summary: Just-In-Time Production

## WHAT IT IS

- Management philosophy
- “Pull” system through the plant

## WHAT IT DOES

- Attacks waste
- Exposes problems and bottlenecks
- Achieves streamlined production

## WHAT IT REQUIRES

- Employee participation
- Industrial engineering/basics
- Continuing improvement
- Total quality control
- Small lot sizes

## WHAT IT ASSUMES

- Stable environment

# Comparison of JIT and Traditional Systems

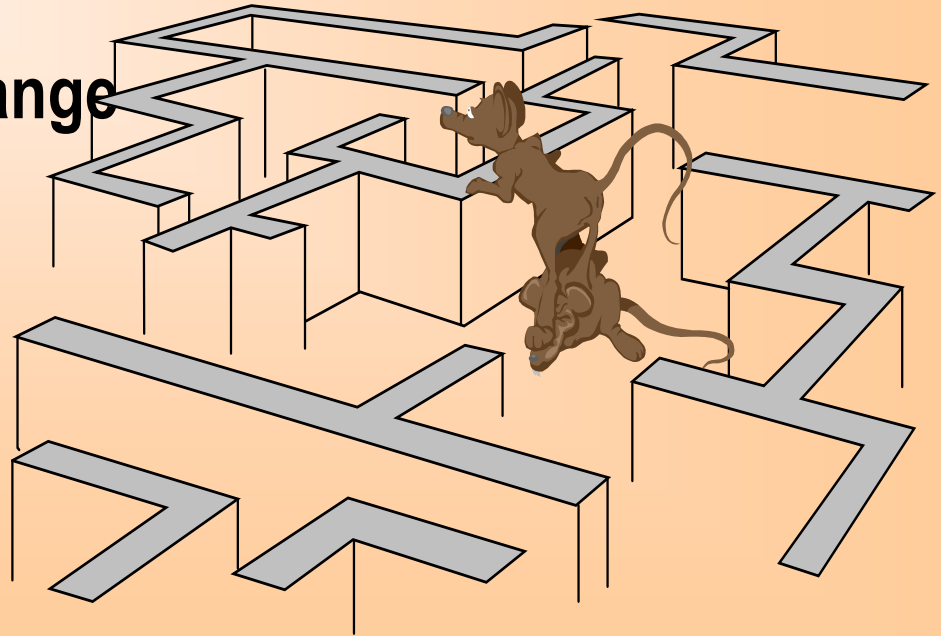
<b>Factor</b>	<b>Traditional</b>	<b>JIT</b>
<b>Inventory</b>	Much to offset forecast errors, late deliveries	Minimal necessary to operate
<b>Deliveries</b>	Few, large	Many, small
<b>Lot sizes</b>	Large	Small
<b>Setup; runs</b>	Few, long runs	Many, short runs
<b>Vendors</b>	Long-term relationships are unusual	Partners
<b>Workers</b>	Necessary to do the work	Assets

# Transitioning to a JIT System

- Get top management commitment
- Decide which parts need most effort
- Obtain support of workers
- Start by trying to reduce setup times
- Gradually convert operations
- Convert suppliers to JIT
- Prepare for obstacles

# Obstacles to Conversion

- **Management may not be committed**
- **Workers/management may not be cooperative**
- **May be difficult to change company culture**
- **Suppliers may resist**
  - **Why?**



# Suppliers May Resist JIT

- Unwilling to commit resources
- Uneasy about long-term commitments
- Frequent, small deliveries may be difficult
- Burden of quality control shifts to supplier
- Frequent engineering changes may cause JIT changes



# Benefits of JIT

1. Reduced inventory
2. Improved quality
3. Lower costs
4. Reduced space requirements
5. Reduced lead times
6. Increased productivity
7. Greater flexibility
8. Reduced scrap and rework
8. Better relations with suppliers
9. Simplified scheduling and control activities
10. Increased capacity
11. Increased equipment utilization
12. Better use of human resources
13. More product variety
14. Reduced need for indirect labor

# JIT in Services (1 of 3)

The basic goal of the demand flow technology in the service organization is to provide optimum response to the customer with the highest quality service and lowest possible cost.

# JIT in Services (2 of 3)

All the techniques used in manufacturing are used in services

- Level the facility load & eliminate disruptions and unnecessary activities
- Reorganize physical configuration
- Introduce demand-pull scheduling
- Develop supplier networks
- Minimize WIP

# JIT in Services (3 of 3)

All the techniques used in manufacturing are used in services

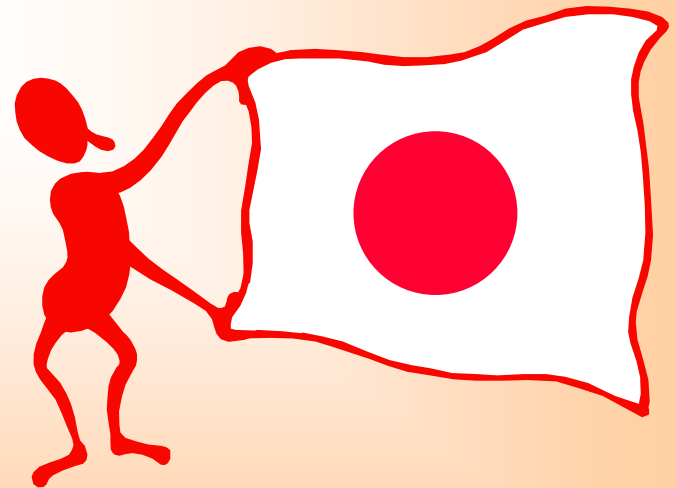
- Make the system flexible
- Reduce setup and lead times
- Eliminate waste
- Simplify the process
- Organize problem solving groups
- Upgrade quality

# JIT II

JIT II: a supplier representative works right in the company's plant, making sure there is an appropriate supply on hand.

# JIT Implementation

- ✓ Use JIT to finely tune an operating system
- ✓ Somewhat different in USA than Japan
- ✓ JIT is still evolving
- ✓ JIT isn't for everyone



# Elements of JIT (1 of 2)

- Smooth flow of work (the ultimate goal)
- Elimination of waste
- Continuous improvement
- Eliminating anything that does not add value
- Simple systems that are easy to manage
- Use of product layouts to minimize moving materials and parts
- Quality at the source

## Elements of JIT (2 of 2)

- Poka-yoke – fail safe tools and methods
- Preventative maintenance
- Good housekeeping
- Set-up time reduction
- Cross-trained employees
- A pull system



# Attributes of Lean Producers - They

- use JIT to eliminate virtually all inventory
- build systems to help employees produce a perfect part every time
- reduce space requirements
- develop close relationships with suppliers
- educate suppliers

# Attributes of Lean Producers - They

- eliminate all but value-added activities
- develop the workforce
- make jobs more challenging
- reduce the number of job classes and build worker flexibility