New Systematic Layout and Information System Planning Method

SLIM

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This manual is owned by:

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This manual was compiled by Mr Shigehiro Nakamura of the Japan Management Association and translated by John Loftus.

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Section 1

Overview

The Significance of Utilising Layout Design Techniques, and their Position within a Company

Productivity Europe

The Aims of SLIM (New Systematic Layout and Information System Planning Method)

- To achieve the kind of production that positively impacts bottom-line results.

- Systematically, step-by-step, to build the 'factory of the future' – one that consistently and comprehensively achieves its quality, cost and delivery objectives.

- To proceed logically and rationally, with full employee commitment and involvement.

Difference between SLIM and Conventional Layout Design

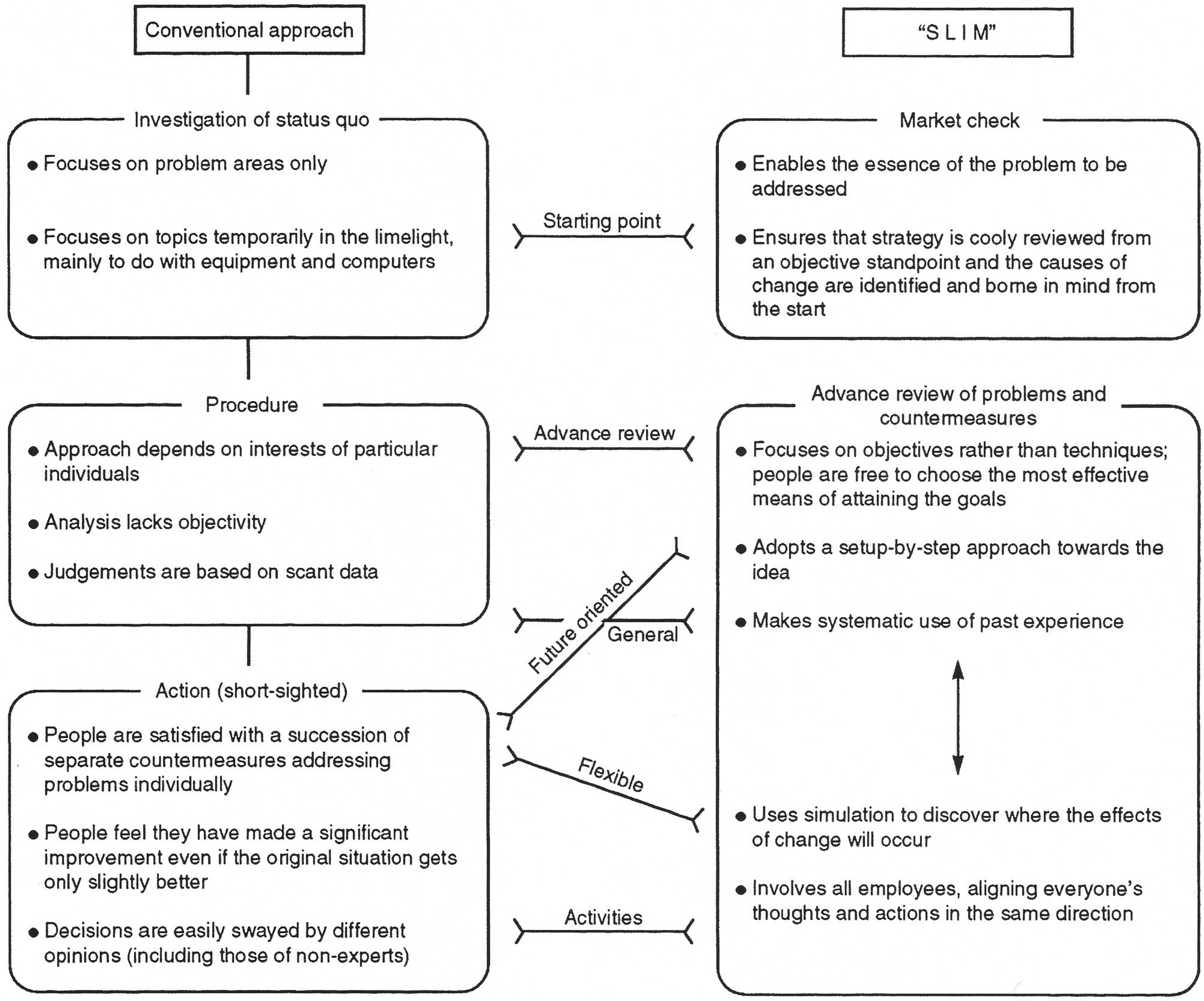

Figure 1-1

Comparison of SLIM with Systematic Layout Planning (SLP)
Richard Muther

No.	Item	SLIM	SLP
1	Product analysis strategy	Uses customer-oriented analytical techniques	Taken as read; not clearly identified
2	Objective-setting	Establishes policy based on management analysis	Concentrates on layout design techniques
3	Clarification of production technology	Clarifies key points	Taken as read; not clearly identified
4	Analysis of status quo	Utilises specific IE analysis techniques	Implements countermeasures by evaluating invisible elements
5	Product analysis	Involves no strategic analysis of products or line division (is aimed at mixed-model production)	Focuses mainly on line division (focuses on distinguishing volume production and non-volume production mathematically)
6	Materials flow analysis and load-capacity analysis	Applies step-by-step analytical procedure following movement of materials, equipment and people	Treats relationships between flow of materials and production activities at same level
7	Basic layout formulation	Compares three proposals based on a combination of basic SLP concepts with idea generation and selection techniques	Formulates alternative proposals (X, Y, Z)
8	Diagramming of conditions	Aims for comprehensive review, with nothing omitted	Focuses on selected layout
9	Simulation techniques	Designed to check layout in actual operation	No dynamic confirmation methods developed
10	Preparation of investment proposal	Prepared business plan summarising 1-9 above	No clear method used
11	Implementation and operation	Uses PERT in combination with risk analysis	No clear method used

Table 1-1

Basic SLP Procedure

(For reference)

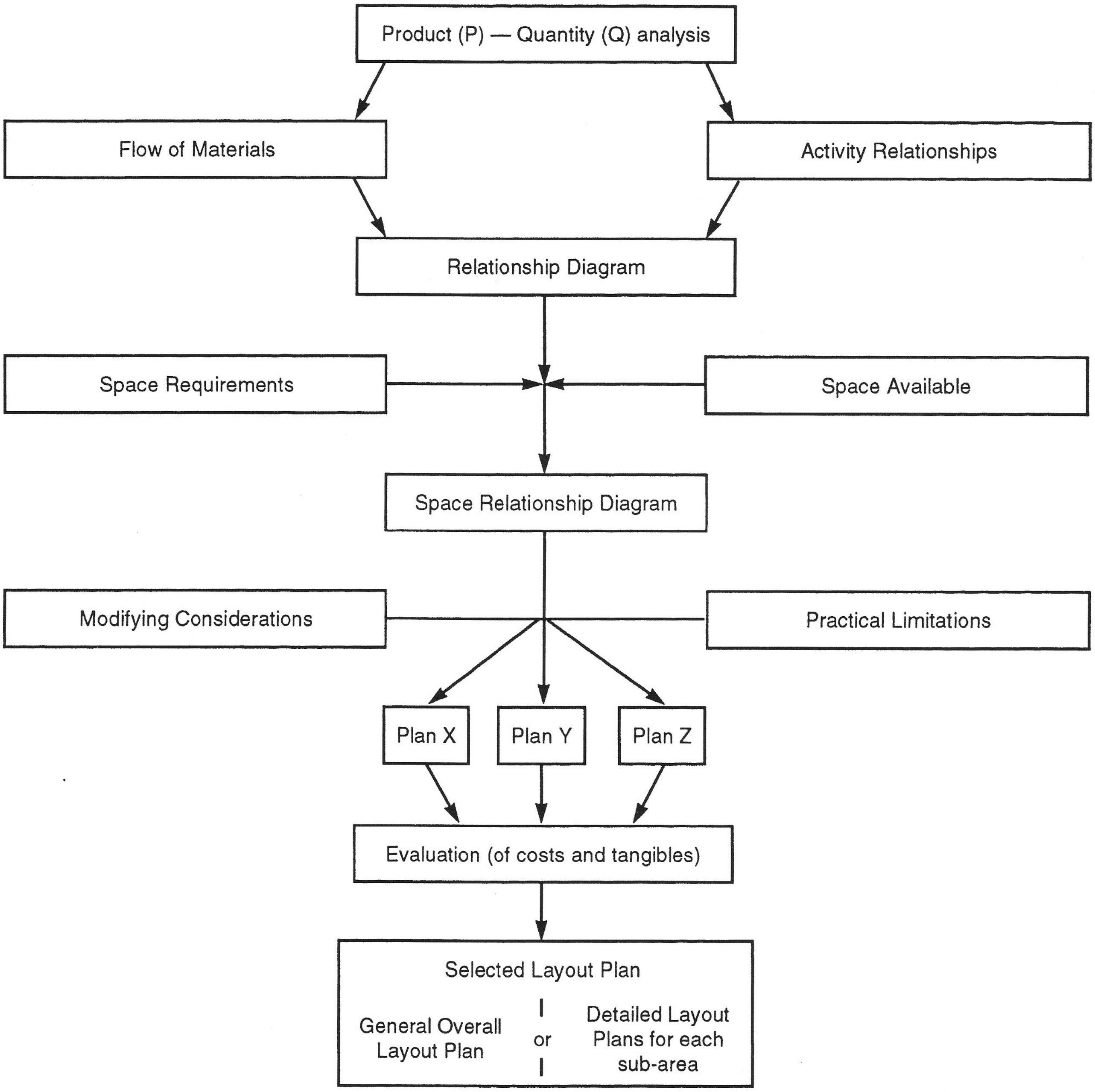

Figure 1-2

The Corporate Environment

1.	Diversification of corporate management, shift to high-variety/small-lot production, greater requirement for international transactions.
2.	Collaborations and mergers with companies in different industries possessing different technologies.
3.	Shortening of product life-cycles, greater product diversification, shorter production runs.
4.	Utilisation of advanced data-processing technologies.
5.	Increasing quantity and complexity of administrative work (need for more efficient decision-making and data processing as information volumes and transfer speeds increase).
6.	Heightening and diversification of individual demands; need to revitalise workplaces.
7.	Pursuit by developing countries, worsening international balance of payments positions of developed countries.
8.	Shift in consumer demand, from material affluence to spiritual fulfilment.
9.	Emergence of knowledge-based service industries.
10.	Increasing involvement of women in traditionally male-dominated areas of society; shortages of skilled labour; 'greying' of society; spiralling labour costs; young people's aversion to hard, dirty or dangerous work; demand for shorter working hours, etc.
11.	Development of new materials; products not previously rivals suddenly becoming competitors.
12.	Need to address environmental and welfare issues.

Table 1-2: Examples of Pressures for Change on Companies

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In layout design, thorough planning is the key to success.

1. Utilise accumulated knowhow fully in the preparatory stage.

2. Predict problems and plan preventive and emergency measures.

3. Unite the company in Q, C and D improvement activities.

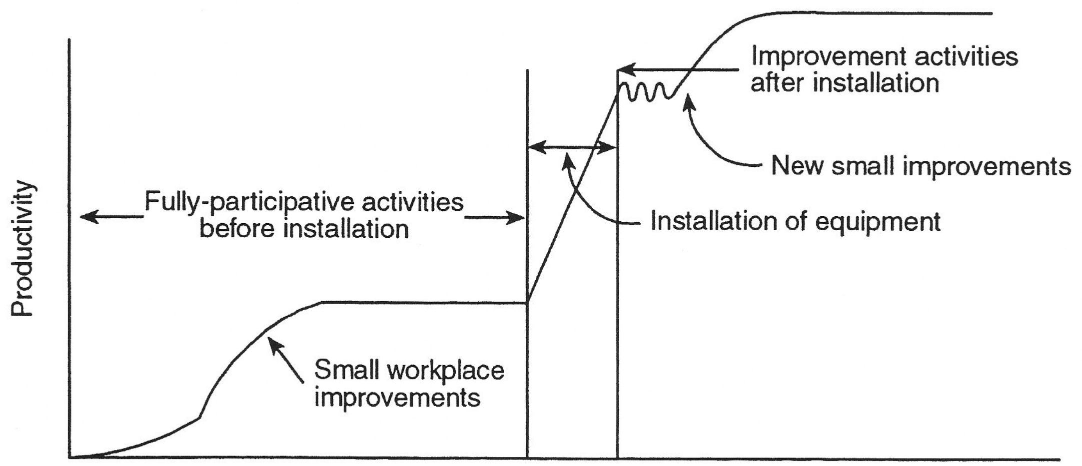

Figure 1-3: Factory Activities Before and After Establishment of New Layout (Ideal)

Efficiency-Boosting Measures Based on Fundamental Manufacturing Principles

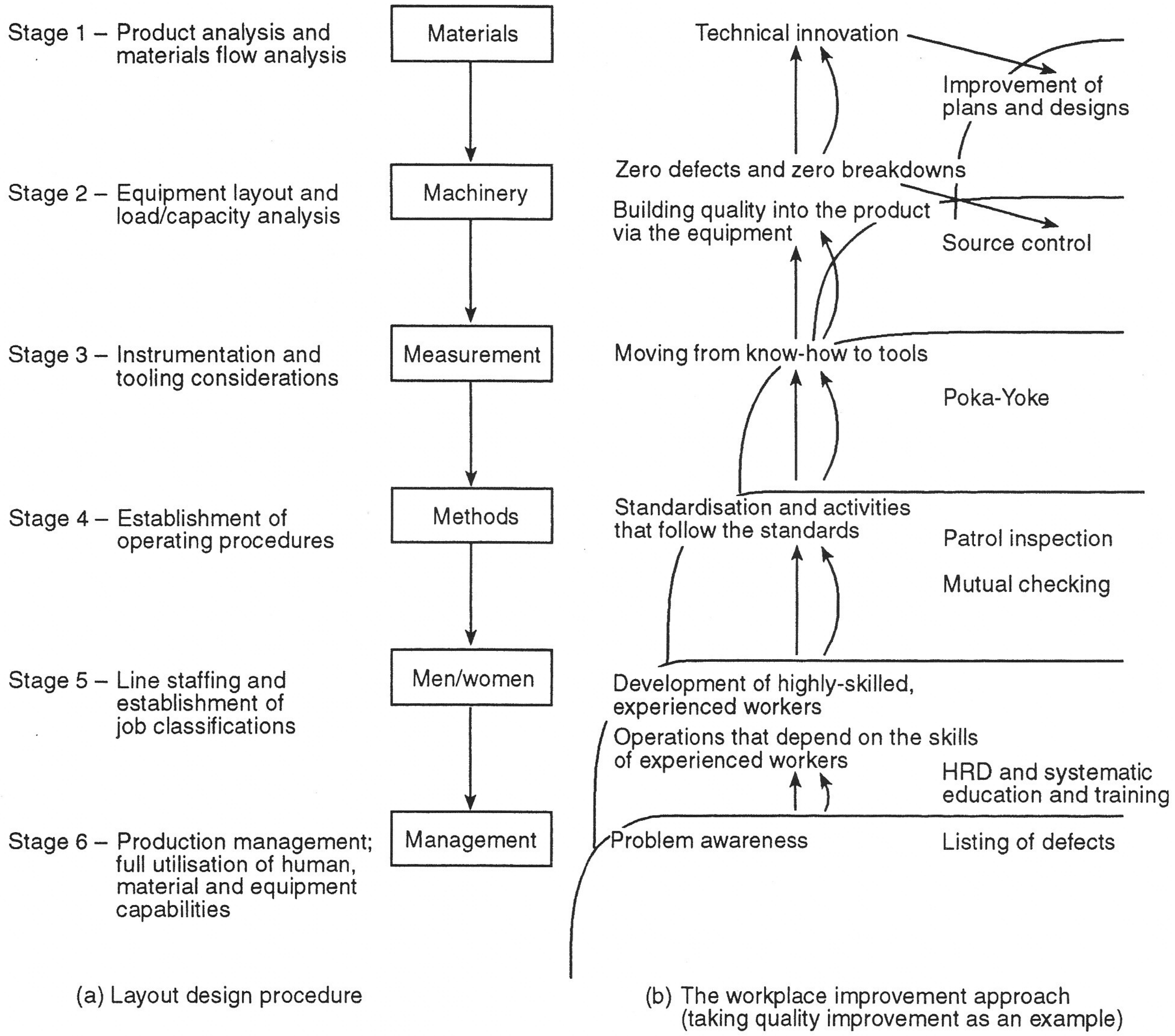

Figure 1-4: Relationship Between Layout Design and Workplace Improvement

Utilisation of Evaluation Formulae

1. Marvin E Mundel: In the 1960's Japanese companies' productivity was a quarter of that achieved by top American companies. It could be assessed by the following formula:

Japanese companies' productivity	=	methods productivity 65%	X	operating rate 70%	X	work rating 75%	x	line balance 70%

2.

Overall equipment effectiveness	=	availability	X	performance rate	X	quality rate

3. JIT: creating a system that produces zero defects and zero breakdowns.

Table for Evaluating Corporate Health

Item to be evaluated	System level		Low-level control and operation ——→	Moving towards unattended operation		Unattended operation level
1. Health and strength of system (operation control)	Manual production scheduling, instructions and follow-up	Partial mechanisation of manual procedures	Automation of routine tasks (on-line)	Automation of related systems (on-line)	Combination with equipment automation (data highway or hierarchy)	Fully-integrated on-line system from order receipt to production
2. Production regime	Production to order; problems addressed after they occur	Group technology applied to production flow; activities to detect and solve process problems	Systematic load-smoothing production; SMED	Small-lot production; changeovers accomplished within cycle time	Flexible, automated manufacturing (FMS)	·
3. Equipment automation	One operator per machine; processes controlled individually	Multi-machine and multi-process manning with abnormality monitoring	Multi-machine manning; quality control implemented; microprocessors installed	Unattended operation at night (with Poka-Yoke devices); multi-process computer control	All lines computer-controlled, linking CAD with CAM	CAD/CAM/CAT
4. Automation of control	Macro-control in units of tonnes	Load control using number of pieces and standard times	Automatic computer generation of process smoothing schedules	Integrated system controlled by central computer	·	·
5. Human tasks	Extensive use of manual labour	Problem-finding-type operation (small-group activities)	Pursuit of automation through study of workplace knowledge	Pursuit of zero failures	Pursuit of full automation	·
6. Factory constitution improvement campaigns	Problem-awareness and participation campaigns (plantwide initiatives)	Standardisation and systematic application of PDS cycle	Activities focusing on improvement; training of operators in productive maintenance skills	Elimination of wasteful working practices by means of improvement-team activities	Priority production technology development project and innovation activities	Staff activities for developing new products and new technologies
7. Equipment management	Operating rate totalisation by means of daily reports; breakdown maintenance	Operating rate control by means of operating-rate meters; preventive maintenance	Preventive maintenance and improvement with total employee involvement	Corrective maintenance	Corrective maintenance and equipment improvement through mastery of high skill levels by operators	Maintenance prevention
8. Quality control	Statistical analysis and discussion performed after the discovery of defects (post-mortem style)	Investigation of problems as they occur by means of small-group activities; use of 'soft' QC and ATS (analytical trouble shooting) techniques	Prompt solution of problems detected by in-line inspection; hardware devices (Poka-Yoke, etc.)	Zero-defect measures; complete elimination of rework	Production technology innovation for zero defects	Zero-defect, zero-breakdown unattended manufacturing
Factory initiative: 9. Workplace	Promotion of small-group activities	QC and PM circle activities	IE, Poka-Yoke, improvement activities	Multiskilling, multi-process handling, research activities	In-house fabrication of materials-handling robots	·
Factory initiative: 10. Office	Rationalisation of manual procedures and activities to reduce documentation (office automation, introduction of PCs)	Standardisation of production know-how	Introduction of computerised on-line POS (point of service) systems	Preemptive control	Strategic production management	Paperless systems; labour minimisation
11. Production control systems	Production by means of macro-scale production orders; monitoring by means of graphs	Load control for individual equipment items by means of daily scheduling	Systematic production ordering and monitoring for individual equipment units and time periods	Automatic production ordering and monitoring systems	On-line production ordering and monitoring systems	·
12. Abnormality (problem) detection systems	Manual data compilation and review	Problem display by use of QC techniques	Signal displays using electronic devices	Automatic advance abnormality detection; systematic feedback for immediate improvement	Abnormality prevention systems	Zero-defect, zero-breakdown, unattended operation
13. Production response	Reactive type; problem detection and follow-up	Immediate solution of problems in the workplace, with importance given to actual facts	Systematic solution of problems through management by objectives	Rapid and continuous measures to deal with idling, minor stoppages and other disturbances	Systematic pursuit of innovative production technologies	
14. Materials-handling technology	Transportation by means of pallets; manual loading and unloading	Loading/unloading and transportation using robots and auxiliary devices; improvement of materials handling	Materials flow control by automated transportation systems	Minimisation of materials handling by improvement of process links	Pursuit of production control and abnormality monitoring systems using process links and materials handling equipment	
15. Layout	Clustered type with independent shops	Rationalised materials handling with 2-3 linked processes per line	Efficient, integrated materials handling linking all lines	Smoothed lines with minimum WIP	One-piece-flow production pursuing ultimate in throughput speed	

Table 1-3

Section 2

Simplified Layout Design

Process Analysis and Improvement

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Process Analysis Symbols and Their Use

Figure 2-1 is a schematic diagram of what takes place when products are made in a factory. The factory has the function or role of converting materials into products. In order to do this, something called a process has to act on the materials. This 'process' can be defined as follows:

Process: An operation that applies a transformation in order to change principally the form or properties of materials (or information) and that attains this objective through the action of men/women, materials and machinery.

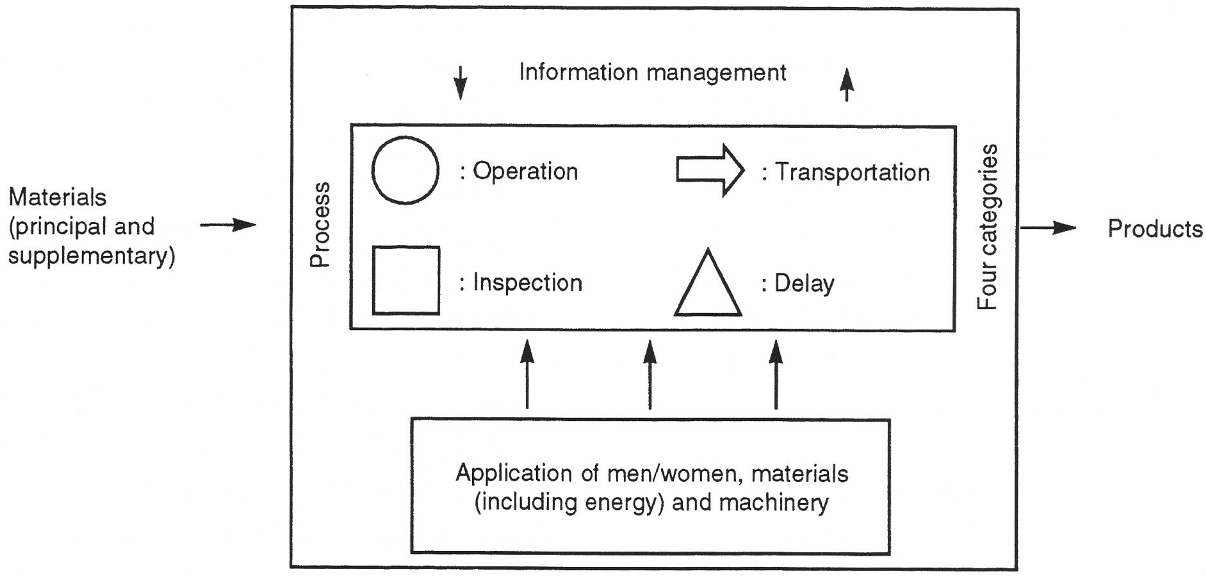


Figure 2-1: The Production Process and the Role of the Factory

Processes can be classified as operation, inspection, transportation or delay, defined as follows:

Operation ○ : an operation occurs when machining, heat-treatment, assembly or other processes essential for making the product take place.

Inspection □ : the process of examining and monitoring the quality of a product made in an operation. Since inspections do not add value if the factory's operations produce non-defective products, inspections should always be targeted for elimination.

Transportation ⇨ : a process whose objective is to transfer objects from one process to another ('transportation' is used for objects, 'movement' for people).
Transportation is unnecessary if processes are joined together. If transportation is unavoidable, efforts should be made to make the routes taken as short and 'wide' (as measured by the volume-distance product, i.e. the product of the distance moved and the volume of items transported simultaneously) as possible, since transportation does not add value.

Delay △ : delay occurs whenever something stops as a result of timing mismatches between processes. Delays arise as a result of the occurrence of defectives and rework, the breakdown of machinery and equipment, changeovers, and when operatives stand idle for personal reasons or reasons to do with the way in which the work is organised. Since WIP is money, any delay means that the flow of money has stopped, and countermeasures must be devised. In JIT production, reduction of WIP is employed as a technique for exposing hidden problems in the workplace.

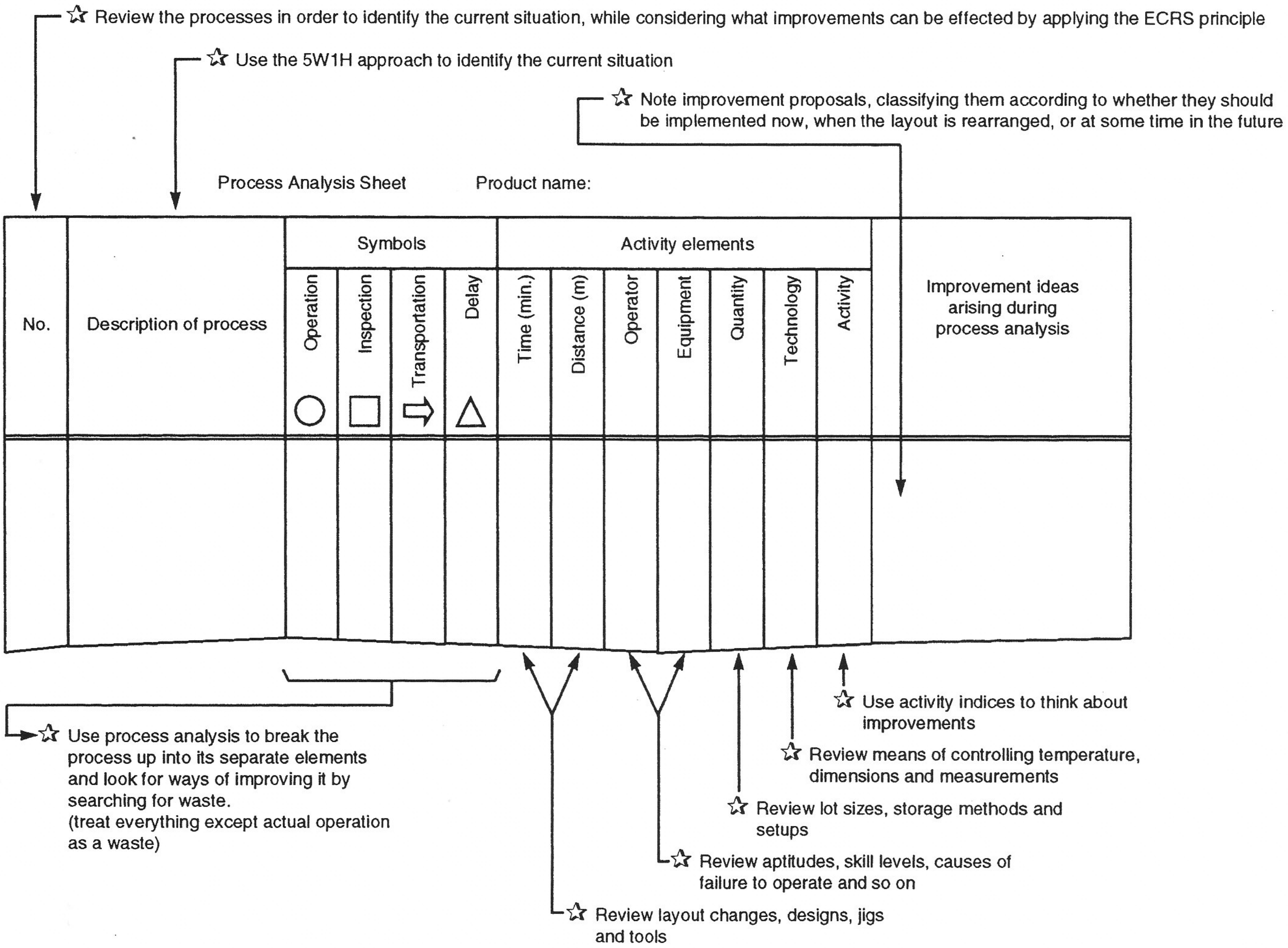
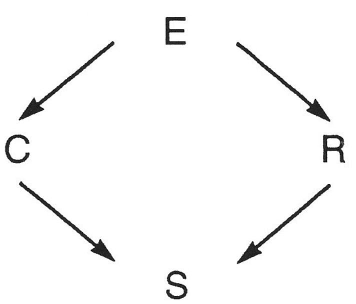


Figure 2-2 Process Analysis and its Application

Improvement sequence



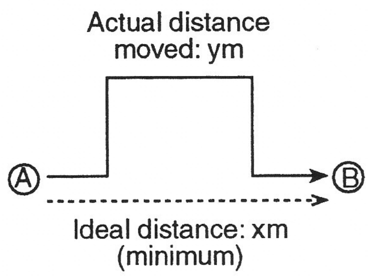
E : Eliminate
C : Combine
R : Rearrange
S : Simplify

Quantitative Methods of Assessing Waste in Process

1. Transportation distance ratio:

$$\frac{ym}{xm}$$

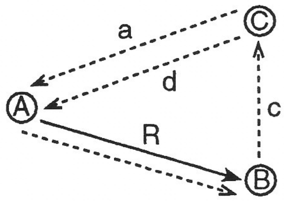
Ideal value: 1



2. Empty transportation ratio:

Objective: to move objects from A to B (distance R)

$$\frac{a + c + d}{R} \longrightarrow \text{Ideal value: } 0$$

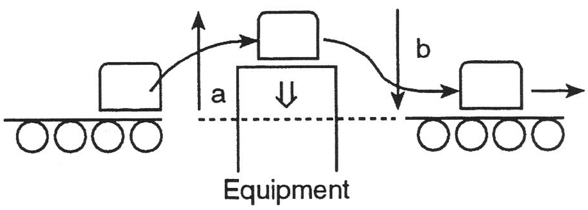


Movement of personnel:

a + R + c + d

Movement of objects: R

3. Vertical movement:



Ideal value: a + b = 0

4. Activity index

Activity Index

Status	Description	Handling operations required					Activity index
		Collect	Pick up	Lift	Move	Total	
Loose	Left lying loose on the floor	O	O	O	O	4	0
In containers or bundles without supporting blocks	The products are collected together in containers or bundles but must be picked up off the floor before they can be moved	X	O	O	O	3	1
On pallets or skids with supporting blocks	Ready for insertion of lifting gear such as the forks of a fork-lift truck, for immediate transportation	X	X	O	O	2	2
On trolleys or conveyors	Ready to be moved simply by pushing the trolley or starting the conveyor	X	X	X	O	1	3
On automatic conveyors or in chutes	Already moving; no action required	X	X	X	X	0	4

Table 2-1: Readiness for Transportation

Mini Layout Design

Procedure

Step 1 : Understand present situation
Use process analysis to find out how materials are moving.

Step 2 : Ask about workplace problems
To involve the people in the workplace, collect information on their opinions, problems, desires, constraining factors, etc.

Step 3 : Perform process and layout analysis, and consider possible improvements
Draw up a process analysis chart and diagram the problems.

Step 4 : Clarify problems and set improvement objectives
Identify waste quantitatively and set numerical improvement targets.

Step 5 : Formulate layout improvement proposals
Draw up three different proposals and compare their advantages and disadvantages.

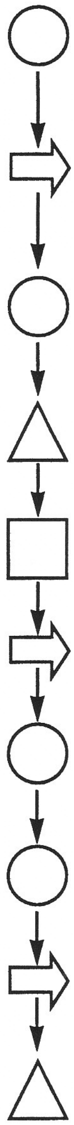
Step 6 : Select specific plan
Work out one or two concrete action plans based on the three original proposals.

Step 7 : Consider plans for future
Consider plans for the future and revise the selected action plan.

Simplified Example: Steps 1 and 2

Current situation

1. Load WIP in the inspection area onto a trolley
2. Wheel the trolley to the packing area
3. Unload the trolley
4. Select the items that need to be packed
5. Load these items on to a trolley and transport them to the packing table
6. Perform the packing operation
7. Load the packed items onto a fork-lift truck
8. Transport the packed items to the storage area and store ready for loading into trucks



Example of Improvement Ideas for Inspection and Packaging Process

No.	Process	E: Eliminate	C: Combine	R: Rearrange	S: Simplify
1. 2. 3.	Place on trolley Move trolley Remove from trolley	Combine inspection and packing processes	Place materials on trolley as they exit from the previous process	Place in packages	Connect by means of a conveyor
4. 5. 6.	Select the required items Move them to the packing station Pack	Inspect in conjunction with packing	Lengthen the conveyor and pass the materials along it in work sequence	Use stacker cranes to synchronise storage, transportation and sorting	Use computer control
7. 8.	Load by fork-lift truck Place in storage area	Place directly on truck beds Place in containers to be used for transportation	Redesign trolleys and synchronise storage and transportation	Store on conveyor after packing	

Table 2-2: Simplified Example of Step 3

Simplified Example of Steps 4, 5 and 6

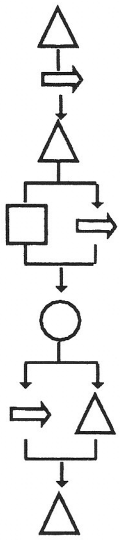
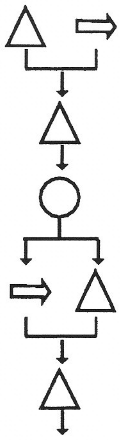
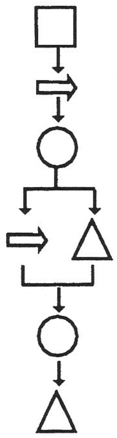
Stage	Process	Key Points
Example of Stage 1 improvement Trolley + conveyor	 Place on trolley and store Transport Store Select necessary items and transport Pack Store on conveyor (Waiting for loading onto truck)	• For each package type, contact previous process in advance and store on trolley • Install a sorting conveyor between the packing process and the delivery dock
Stage 2 improvement Direct connection by means of conveyors	 Sort on conveyor by package type in inspection process Store Pack and sort Store on conveyor (Waiting for loading onto truck) Load onto truck	• Install a sorting conveyor that sorts the items by package type and transports them directly from the inspection process to the packing station • Install a sorting conveyor at the packing process and create an automated line
Stage 3 improvement Link processes directly together	 Inspection Transportation Packing Sorting Container loading	• Connect the inspection and packing lines directly together • Install an automated sorting line after the packing process • Load directly into containers and leave products in containers while they wait to be loaded onto trucks

Table 2-3: Use of Process Analysis to Investigate Possible Improvements

Basic Layouts (Creating Efficient Combinations of Men/Women, Materials and Machinery)

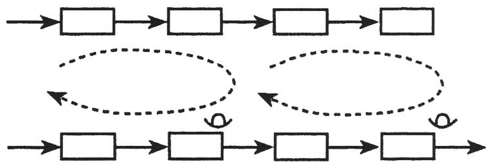
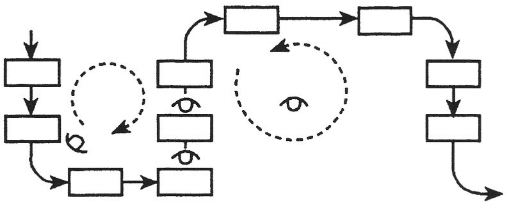
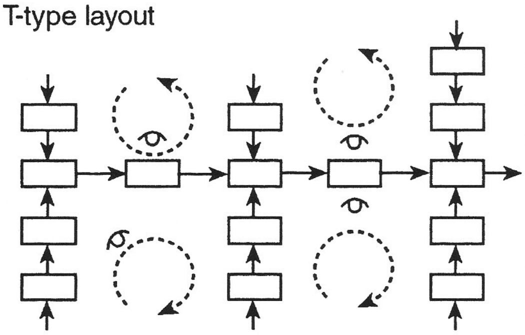
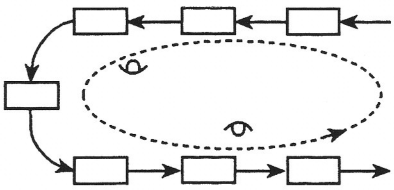
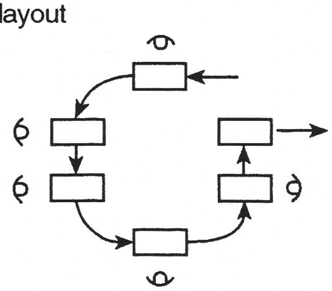
No.	Layout type	Features
1	I-type layout 	• Equipment is arranged in straight lines in line with flow of materials. • Usually expanded by adding further straight lines of equipment parallel to the existing ones. • Effective when returns and swarf are disposed of by conveyor.
2	S-type layout 	• Used when materials must be introduced from the lineside, e.g. when flows of different workpieces merge or when dies, etc. must be introduced or removed. • Effective for assembly lines, welding lines, etc. where assembly-type operations take place.
3	T-type layout 	• Basically, a modification of the L-type line. For space reasons, the main line is generally installed down the centre, and other materials flow into it from both sides. • Effective when large numbers of components need to be assembled.
4	U-type layout 	• Generally used for 'circuit-type' multi-process handling. Aligns the flow of materials with the movement of the operators. • Improves operational efficiency and clearly assigns responsibility for quality.
5	O-type layout 	• Used when operators must sit or stand in the same place. • The central space can be used for storing maintenance materials, jigs, tools, etc. • The turntable-type layout is a development of this.

Table 2-4: Basic Layouts and their Characteristics

Practice Exercise 1: Mini Layout Design

Example of mini layout improvement .... results of standard work analysis (mini layout Step 1).

To bring together the information in the previous section, we will perform a step-by-step analysis of how to effect a mini layout improvement utilising process analysis (focusing principally on layout improvement). As an example, we will take the process from packing to shipping of a certain component. Step 1 (understand present situation) has already been performed and the process is currently as described below.

Step 1 : Understand present situation ...... collect information by interviewing people

X Company makes 30 different kinds of electrical components, and packs them for delivery to its customers. The following information was collected by interviewing the people on the shop floor:

1. Five machines are used to produce the components, and they are processed in lots of approximately 1,000. After processing, each lot is placed in a bin, and the bins are stored temporarily in a storage area. Three operators work the five machines.
2. After temporary storage, the processed parts are taken out in accordance with instruction slips issued by the office, wheeled by trolley to a lift 6m away and taken up to the first floor on the trolley.
3. Since nobody is allowed to ride in the lift for safety reasons, operator T goes to some stairs 10m away, walks up to the first floor, pulls the trolley out of the lift, and pushes it to a temporary storage area near the washing unit where the components wait 30-60 minutes.
4. Because the components must be placed in the washer loose, they are removed from the bins and placed in a hopper. They then have to wait a further 30-60 minutes for the previous washing cycle to be completed. Once the previous lot of components has been washed, the hopper is switched over and the new lot of components is placed in the machine.

5. The hopper is fitted with a Poka-Yoke device that allows only correctly-dimensioned components to enter the washing machine and excludes any having the wrong dimensions. It also excludes components with burrs or fins on them, and these are reworked and included with the next lot. The operator at this station is operator H. The yield is approximately 97%. The machines takes approximately 25 minutes to wash 10 lots.
6. Once the washing operation is finished, operator H collects the components into lots. When he has collected 4 lots, he places these separately into a bin. He then wheels the components over to the rustproofing process on a trolley.
7. The components then wait for a short time before they are placed in the rustproofing unit. They are placed in the unit lot by lot in order to avoid mixing up different lots. The rustproofing unit consists of three separate items of equipment, each performing one of the three processes of degreasing, immersion in rustproofing liquid and drying. Each lot passes through these three processes in the order given. Operator Q is responsible for this. After the rustproofing operation has been completed, operator Q places the components one lot at a time into a bin, and, as before, uses a trolley to wheel groups of four lots over to the packing process. Items that cannot be packed immediately are left in a temporary storage area.
8. The packing process consists of placing the components ten at a time into PVC bags and placing these bags ten at a time into boxes. This process is performed by five female operators. Delivery advice notes are attached to the boxes in accordance with shipping orders issued by the office. Since the components are packed in accordance with the times of delivery requested by customers, a certain amount of WIP is kept on hand after the rustproofing process. Items that are scratched or otherwise defective in appearance are removed during the packing process. The defect rate is approximately 2% relative to the previous rustproofing process. The packing operatives are kept very busy and generally work 1-2 hours overtime per day.

9. In addition to the above, a changeover is required in the initial machining process each time a different type of component is machined. These changeovers consist mainly of exchanging jigs and tools, and the required tools are brought from the toolroom together with the necessary programme tapes. The present factory layout is as shown in Figure 2-3. Since there is a shortage of labour and it is difficult at the moment to increase the number of employees in the plant, the workplace is required to make the operation as efficient as possible. Top management also wants to reduce the number of workers by one and make an annual saving of around £14,000. They have asked the plant manager to work out an improvement plan. All the equipment can easily be moved and can be rearranged at little cost in any way desired.

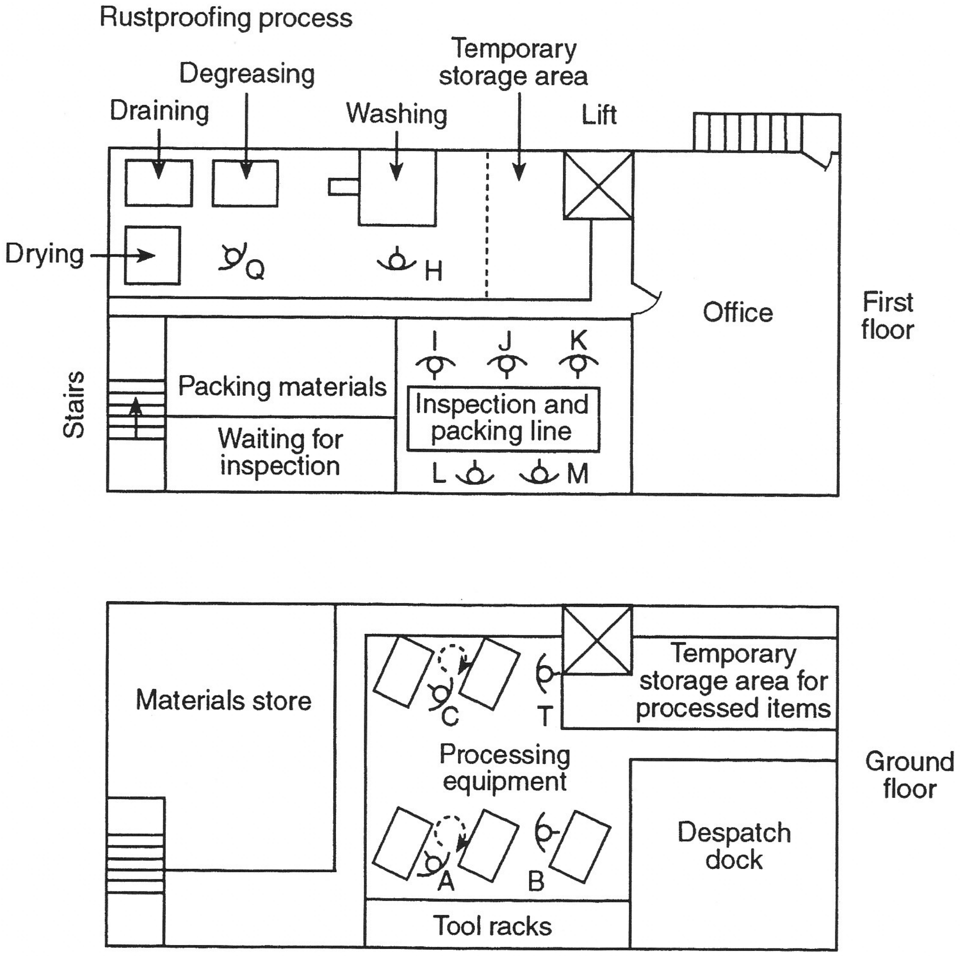


Figure 2-3 Present Layout

Line Balancing

Output cycle time (OCT)

$$\text{OCT} = \frac{\text{Number of hours factory operates in a day}}{\text{Number of products produced in a day}}$$

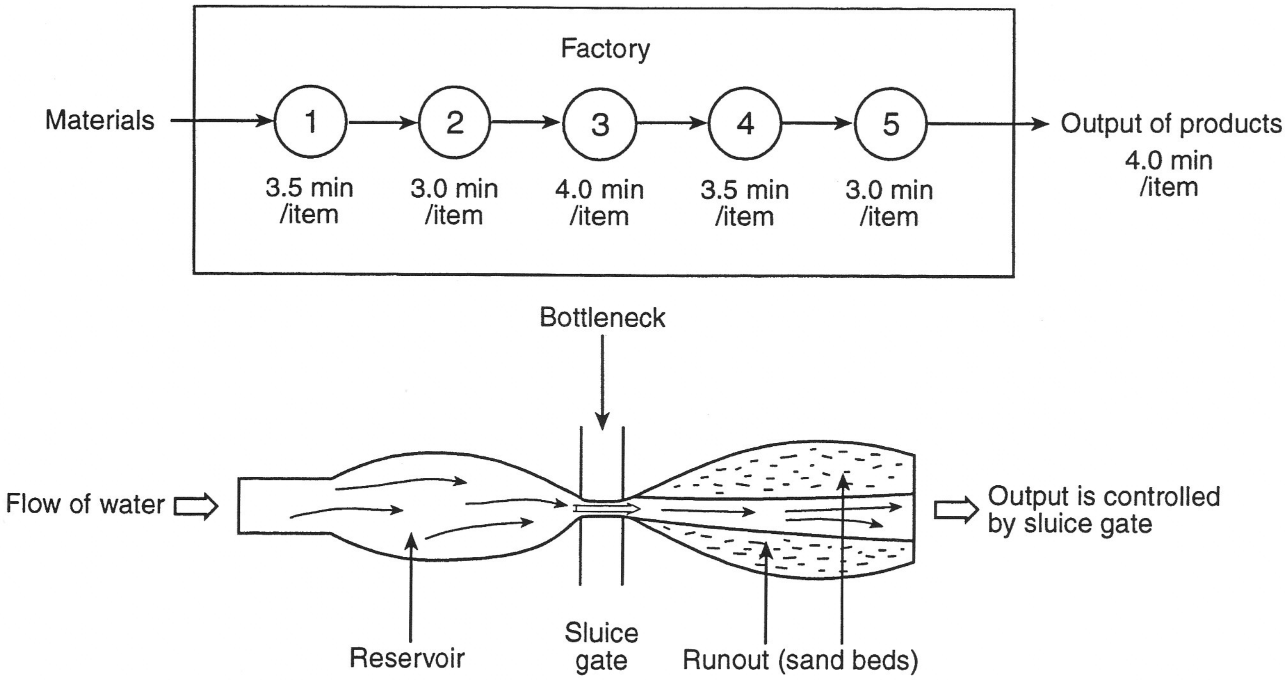


Figure 2-4: Concept of Output Cycle Time Controlling Flow

Practice Exercise

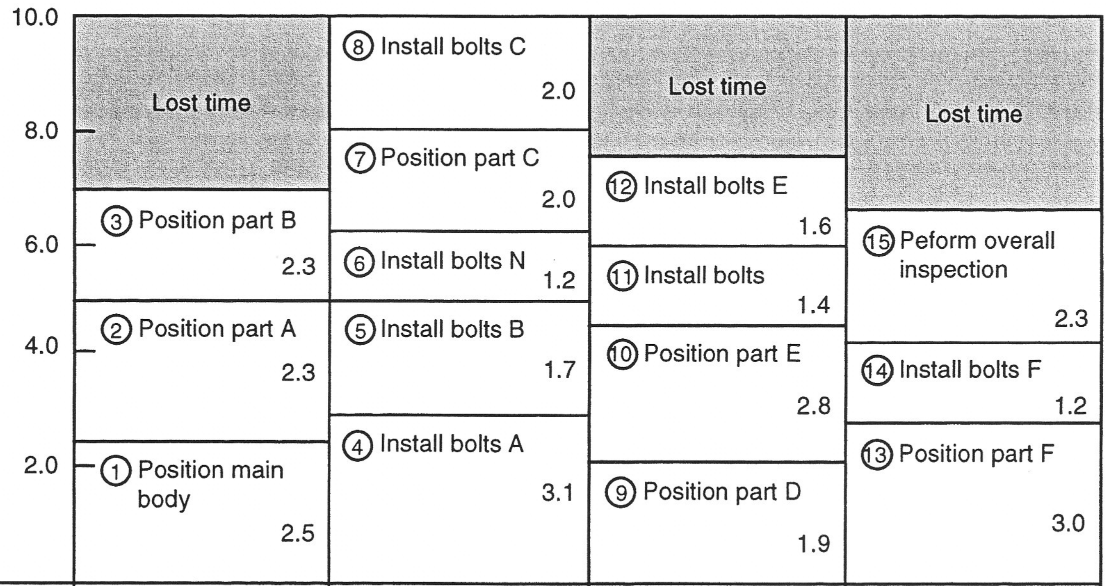
Calculate the OCT for the following operation:

1. Production volume : 15,000 items/month (product A only)
2. Factory operation : 25 days x 2 shifts/month, 1 shift = 7.5 h, overtime = 20 h/month
3. Operating rate : 90%

Calculation of Process Balance Ratio

$$\text{Process balance ratio} = \frac{\text{total of time values for each process}}{\text{time for bottleneck process x number of processes or complement}} \times 100\%$$

Calculate the process balance ratio for the operation shown in Figure 2-5



Process	1	2	3	4
OCT	7.10	10.00	7.70	6.50
Balance loss	2.90	0.00	2.30	3.50

Figure 2-5: Work Arrangement Before Improvement, with Balance Losses

Process balance ratio = --------------------------------- x 100% =

Practice exercise 2: Draw the above diagram after improvement

Method of Improving Process Balance Ratio

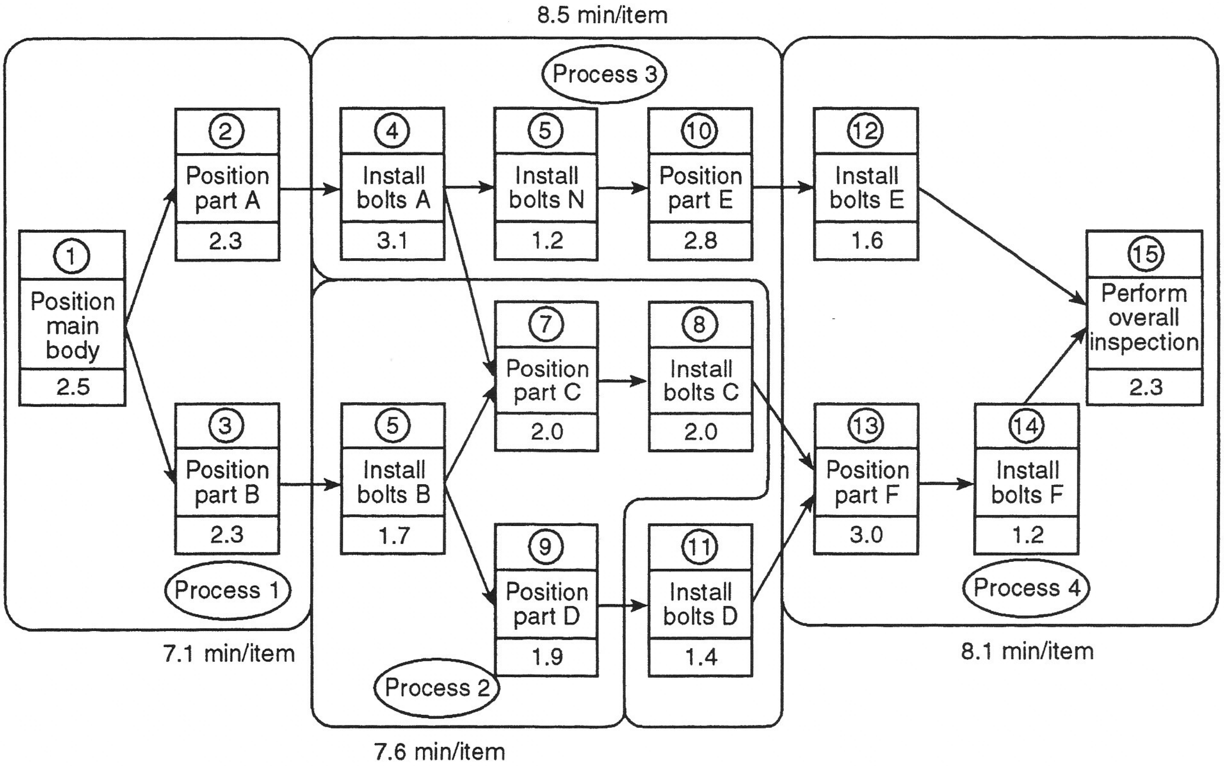


Figure 2-6: PERT Diagram for Reducing Balance Losses

Evaluating and Improving Process Links

No.	Evaluation formula	Explanation
1	(Linkage waste index) $= \dfrac{\text{(transportation + manual handling + waiting)}}{\text{(processing + inspection)}}$	• Identify tasks that do not add value, and assess them in terms of frequency and time taken. • Use this formula after analysing transportation processes. • Do not include automated tasks in the numerator; identify the problems to do with manual work and set improvement targets.
2	(Linkage automation ratio) $= \dfrac{\text{(automated transportation, handling and waiting)}}{\text{(all transportation, handling and waiting)}}$	• Perform this evaluation in order to set objectives for the automation of process linkage operations. Use frequency or labour-hours for this evaluation. • Assess manual linkage work in terms of return on investment and ease of automation to determine whether automation is worthwhile, and set targets for promoting automation.
3	(Linkage labour-hours ratio) $= \dfrac{\text{(number of labour-hours required for linkage work)}}{\text{(total labour-hours)}}$	• Use work sampling techniques to find out what proportion of the total amount of work done in the workplace is occupied by linkage work (in terms of labour-hours), or use motion study to analyse the procedure in terms of frequencies. Use the findings for promoting improvement and automation.

Table 2-5: Example of Formulae for Evaluating Inter-Process Links and Automation

The basis of improving process links (ECRS):

1. Apply E, C, and R to the flow of materials.
2. When (1) is impossible, save labour by means of S.
3. Use motion study to improve process linkage work step-by-step.

Table 2-6 gives some hints for improving process linkage work.

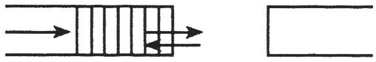
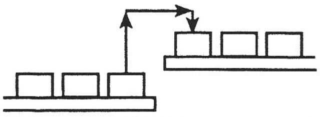
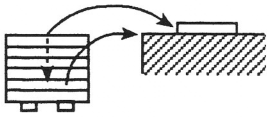
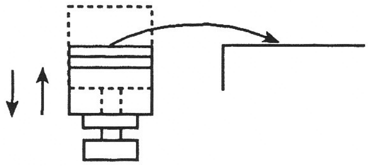
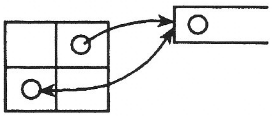
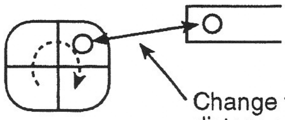
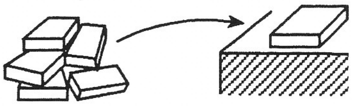
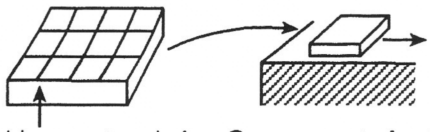
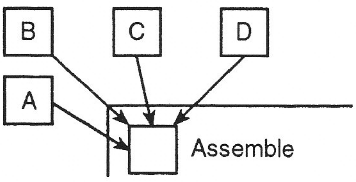
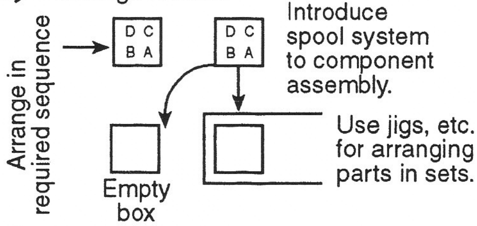
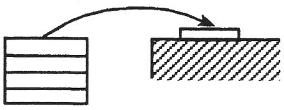
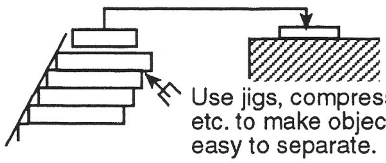
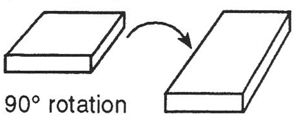
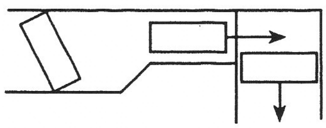
No.	Type of work	Example of problem	Example of improvement approach
1	Transportation Hints: • Lines of movement should be short and wide. • Reduce losses due to weight.	(1) Items are transported manually between processes. 	Use dedicated carts or shuttles.  (Examples: shuttle cart, automated guided vehicle (AGV), direct conveyor connection, etc.)
		(2) Items are moved up or down. 	Arrange at same level. 
		(3) Work point varies. 	Use lifting mechanism. 
		(4) Work distance varies. 	Use smaller lots, introduce turntables, etc. 
2	Grasping and moving Hints: • Utilise objects' shapes and stable surfaces. • Avoid complex movements. • Set up in previous process (prepare in advance).	(1) Randomly-placed items must be lined up. 	Place in designated container.  Line up at end of previous process. Or use a parts feeder or similar mechanism to line up automatically.
		(2) Parts must be selected.  	Arrange in sets. 
		(3) Awkward objects must be picked up. 	Use suction plates or magnets. 
		(4) Items must be placed in a particular position.  	Change orientation to facilitate handling. 

Table 2-6: Key Points for Discovering Problems with Inter-Process Links, and Examples of Improvement Ideas

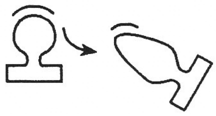
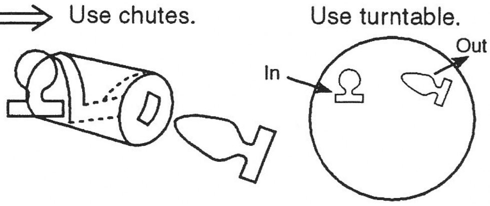
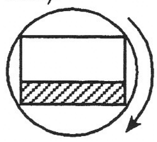
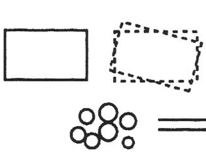
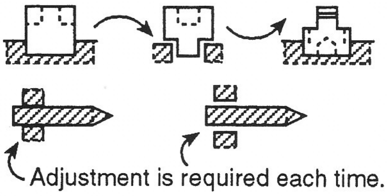
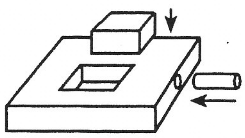
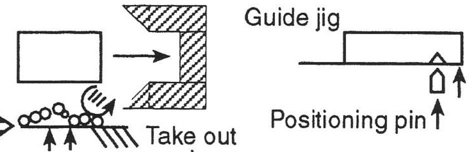
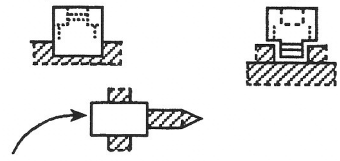
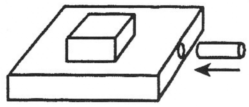
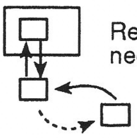
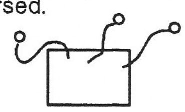
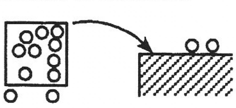
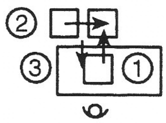
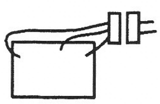
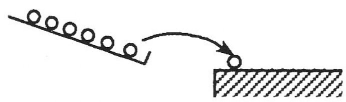
No.	Type of work	Example of problem	Example of improvement approach
3	Prepositioning Hints: ● Utilise natural forces. ● Utilise shapes. ● Use simple tools as part of transport-ation process.	(1) Orientation varies.  (2) Items turn upside down. 	Use chutes. Use turntable.  In Out Use inverting mechanism (180°, 90° etc.). 
4	Assembly Hints: ● Utilise shapes. ● Utilise guide jigs, positioning. ● Use grouped processing to reduce number of assembly operations.	(1) Positioning is required. Adjustment is needed  (2) Item must be repeatedly inverted between processing steps. Step 1 Step 2 Step 3  Adjustment is required each time. (3) A large number of parts is handled. 	Use positioning jigs, stoppers, etc. Guide jig  Take out one by one. Positioning pin Group processing steps together. Steps 1 + 3 Step 2  Use dedicated jig. Change design Integrate; employ monolithic casting, shrink-fitting , etc. 
5	Assembly Hints: ● Group together or disperse.	(1) Items interfere with work position.  Repositioning is necessary. (2) Connection positions, equipment inspection points, etc. are dispersed.  (3) Items are transported and processed in batches. 	Use empty space on opposite side of workstation.  Avoid setups, interference with work position, etc. (dispersion). Group together at one point, introduce one-touch connectors, use bundled wiring/piping, or use point (grouping).  Introduce in processing sequence. 

Table 2-6: Key Points for Discovering Problems with Inter-Process Links, and Examples of Improvement Ideas (continued)

Section 3

Specific Procedure for SLIM-I

(Optimum Arrangement of Men/Women, Materials and Machinery)

Productivity Europe

The SLIM Concept

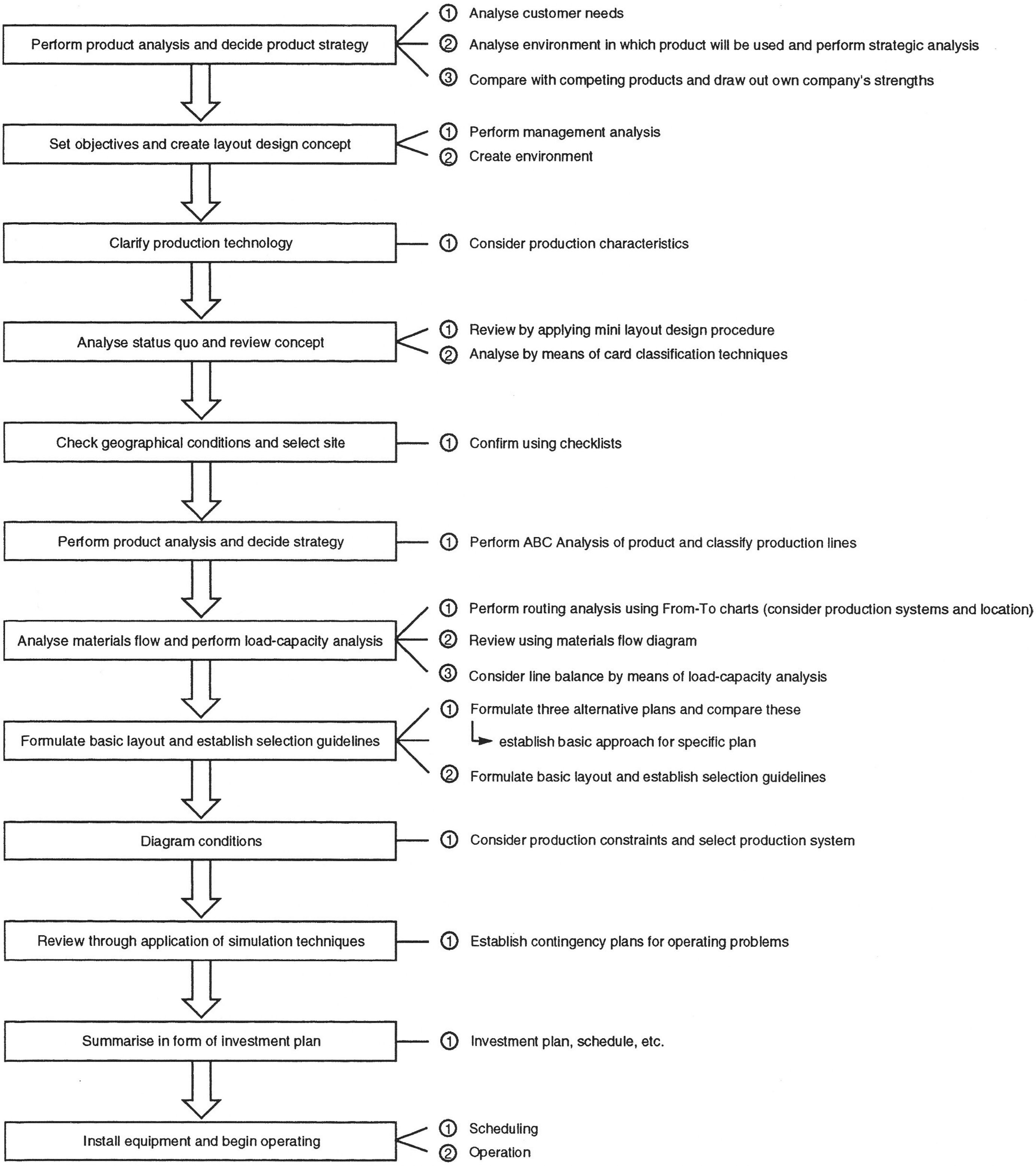


Figure 3-1: SLIM Layout Design Procedure

Product Strategy Analysis and Design

SLIM is a tool for achieving management reform. It is therefore necessary to analyse the market environment carefully, find out what competitors are doing, and consider the characteristics, marketing strategies and production systems of the products to be manufactured.

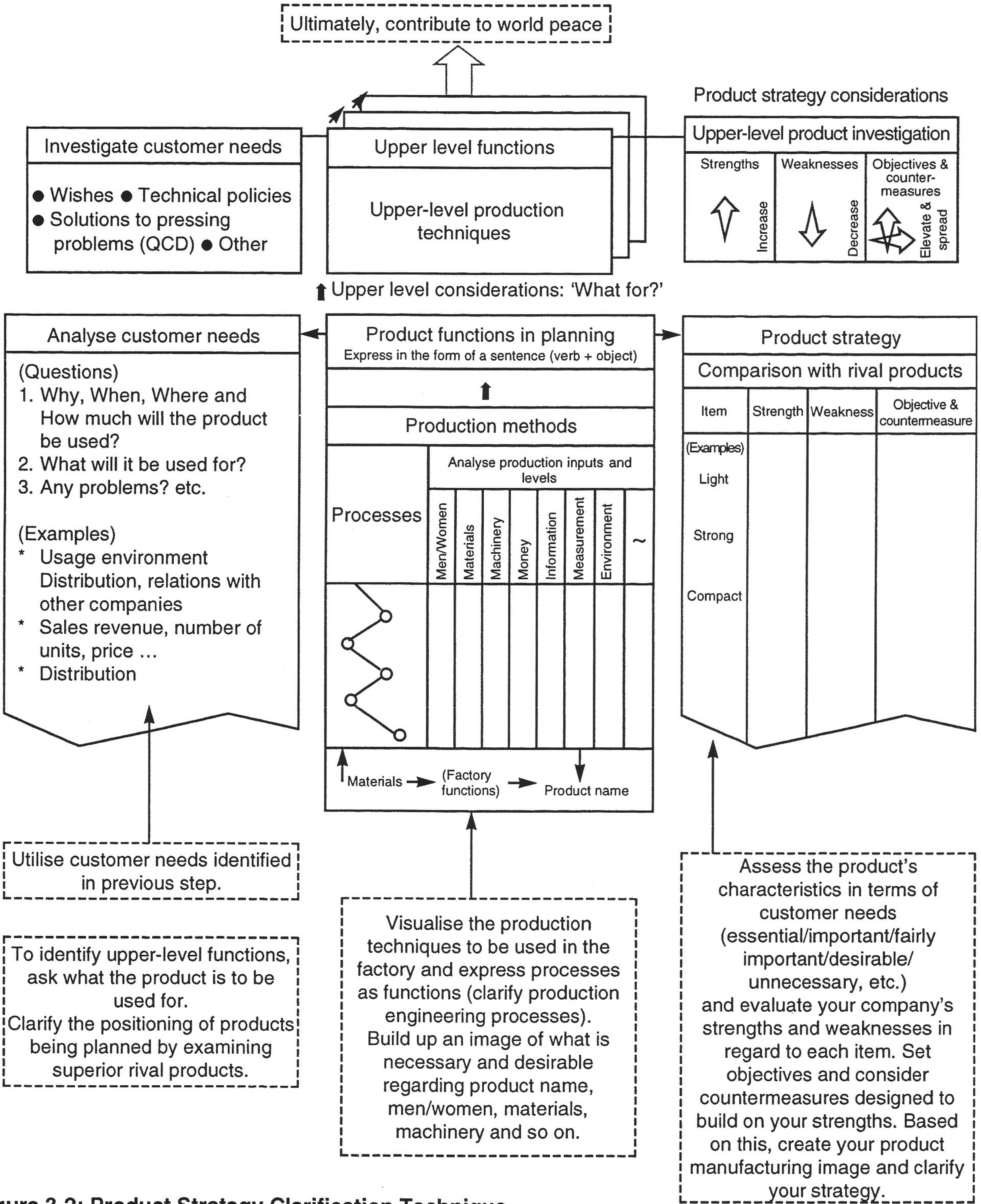


Figure 3-2: Product Strategy Clarification Technique

Converting to a Customer-Focused Product Strategy

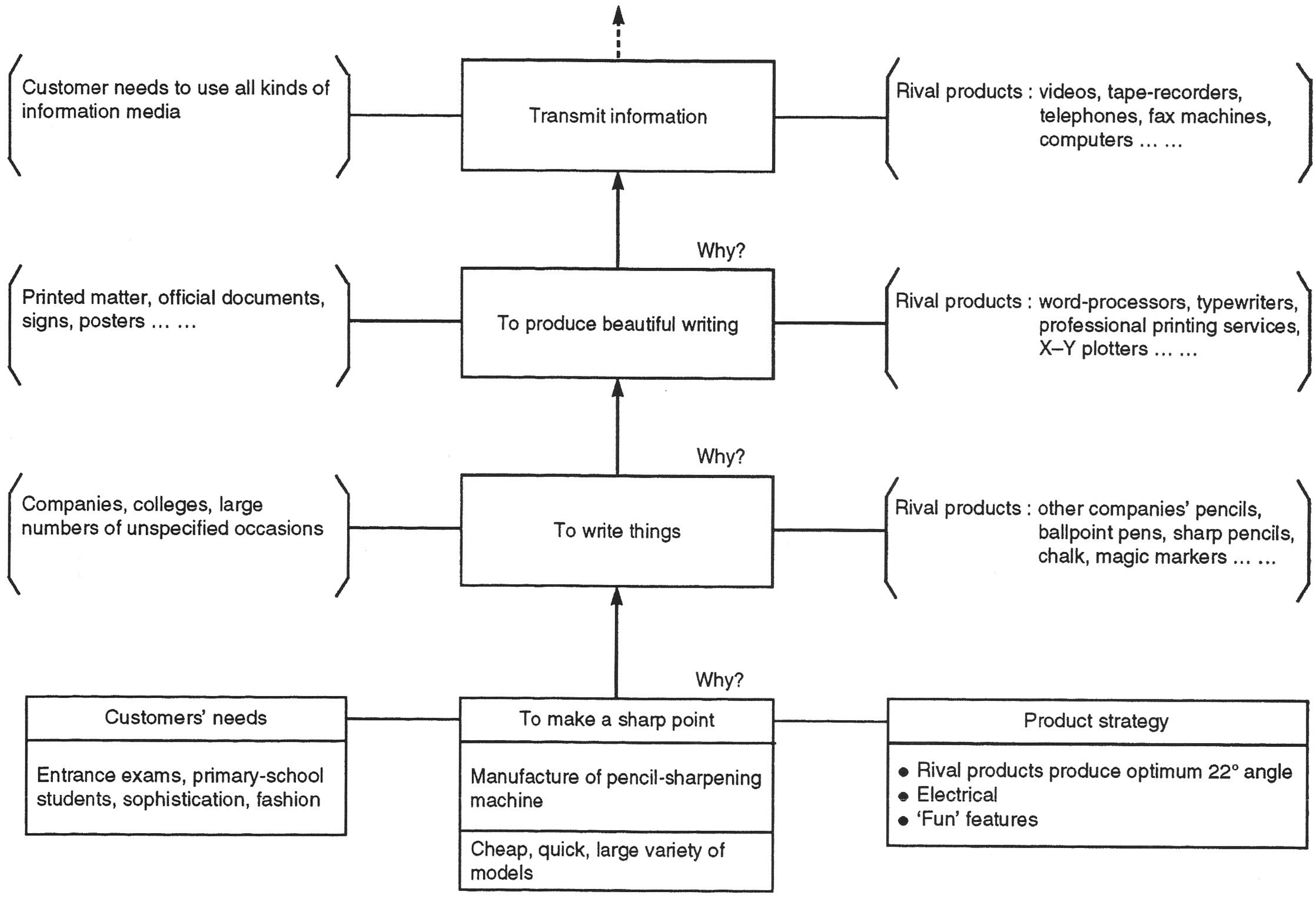


Figure 3-3: Example of Functional Analysis (Pencil-Sharpening Machine)

MQC evaluation index = (expectation of product) + (degree of satisfaction in use)

$$= \frac{\text{selling price}}{\text{price level hoped for by market}} + \frac{\text{actual functions and performances}}{\text{market function and performance level}} + \frac{\text{possible delivery conditions}}{\text{delivery levels and reliability promised to market (including co-ordination with customer's new product development and marketing plans)}} + \frac{\text{actual product attractiveness index}}{\text{market attractiveness index (colour, shape, size etc.)}}$$

$$= \frac{\text{actual usability index}}{\text{market usability index (by standard-value assessment; user's policy on installability, operability, applicability/developability, exchangeability, maintainability, remodelability, etc.)}} + \frac{\text{product's image index}}{\text{image index at time of use (technical reputation, reliability, sales figures, safety, etc.)}} + \text{other (e.g. quantity)}$$

Expectations towards product

$$+ \frac{\text{new running costs}}{\text{old running costs}} + \frac{\text{new serviceability}}{\text{old serviceability (MTBF, after-sales service, future outlook when model changes are introduced)}} + \frac{\text{new life expectancy}}{\text{old life expectancy and durability}} + \text{other}$$

Degree of satisfaction in use

Table 3-1: Market-Oriented QC (MQC) Evaluation Index

Techniques for Analysing Potential Problems to do with Product Manufacture and Marketing

Key Points

1. Devise and implement measures to prevent problems from occurring in the first place.
2. Work out strategies for action to be taken if problems occur anyway.

Topic: ← (Who is to do what by when; include target values)

Predicted problems	Seriousness	Causes	Suggested countermeasures	Schedule and person/ group responsible
Hold a brainstorming session and list at random. Use ABC ranking to show impact of problem on project. Examples: A : Extremely serious B : Serious, should be considered C : No need to consider at present		(Why might the predicted problem occur; list using product development steps and checkpoints).	List suggested countermeasures and their effects; classify in terms of whether: 1. They should be implemented immediately. 2. The situation should be monitored, and they should be put into effect when signs of trouble occur (clearly state the checkpoints to be used in this case). 3. Measures prepared in advance should be put into effect when trouble actually occurs.	Use the 5W1H technique to break down the scheduled action items and the people responsible, and establish a follow-up schedule.

Table 3-2: Example of Contingency Planning Table for Addressing Potential Problems

Examples of Potential Problems

1. Drop in price
2. Competitors' more effective marketing strategy or greater advertising power.
3. Entry of companies from other industries
4. Delay or mistiming in launch of new product
5. Loss of customer confidence owing to problems with product
6. Insufficient capacity
7. Lack of technical confidence on part of customers
8. No clear prospects for solving various technical problems
9. Insufficient consideration of customers' needs as a consequence of focusing on specific customers
10. Labour shortages, reluctance of young workers to engage in dirty, difficult or demanding tasks
11. Insufficient financial strength on part of manufacturer
12. Model changes by purchasers; changes in product environment
13. Changes in users' preferences and usage environments

Production Technology Analysis and Design

Handling production technologies

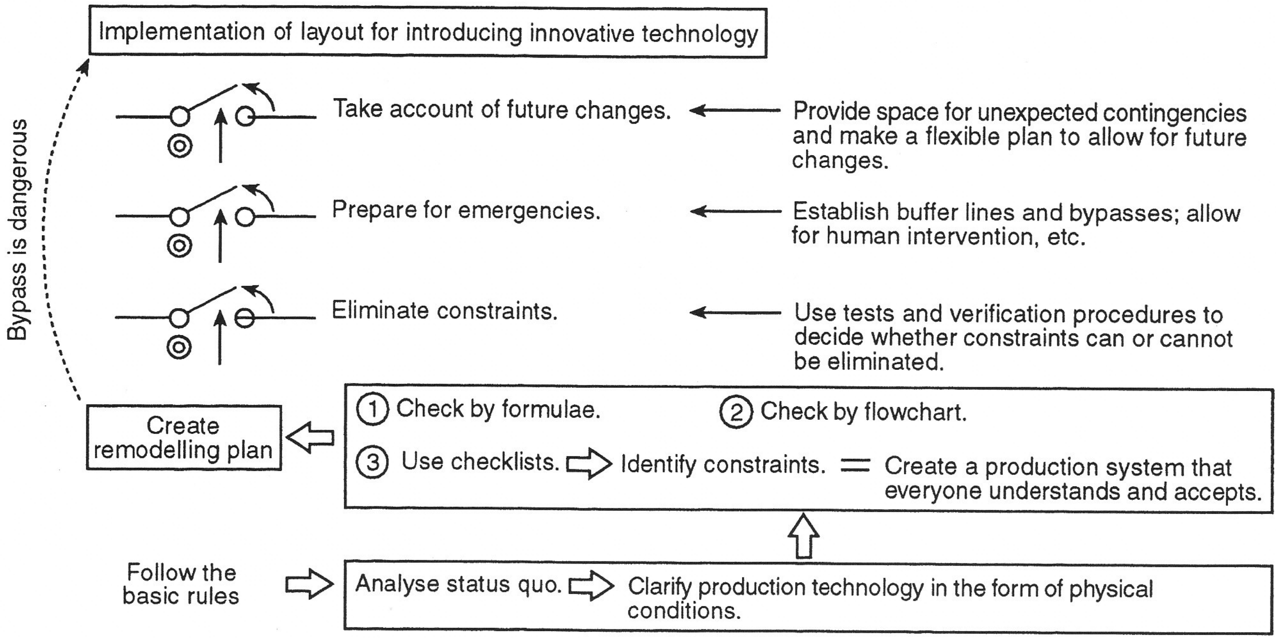


Figure 3-4: How to Deal with the Production Technology that Needs to be Considered when Designing a Layout

Example: Heat-treatment of steel

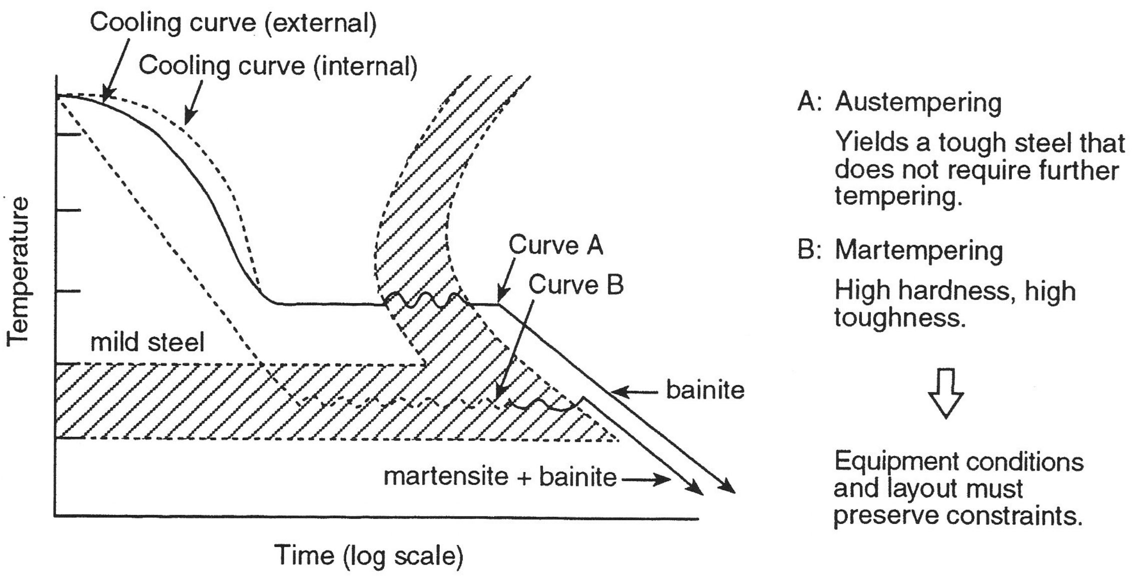


Figure 3-5: Quenching Curve (S Curve)

		Market strategy	Important tactics	Specific actions	
Strategy items	Aims	1. Increase market share 2. Develop distribution and marketing routes 3. Initiate joint development projects 4. Diversify and globalise 5. Secure established customers	1. Reduce costs 2. Raise sales price by increasing value added 3. Reduce distribution and transportation costs 4. Improve quality and yield 5. Reduce delivery times, WIP, etc.	1. Introduce high-variety, small-lot production and mixed-model lines 2. increase per-capita productivity 3. Improve ability to introduce new products and models 4. Help to reduce customers' labour-hours 5. Save energy and resources 6. Create model workshops	7. Reduce noise, pollution, vibration, etc. 8. Eliminate hard physical labour and improve working environment 9. Introduce automation, robots and FA systems 10. Increase proportion of product manufactured in-house
	Objectives	1. Sales (£K/month) 2. Price (£/item) 3. Market share (x% → y)% 4. Export ratio (%) 5. Sales outlets (x → y) 6. Reliability improvement 7. Delivery compliance rate improvement, etc.	1. Profitability (%) 2. Total costs (% reduction) 3. Per-capita productivity (% increase) Labour reduction (headcount) 4. Yield (% increase) 5. Inventory turnover rate 6. Lead time (days)	1. Labour cost reduction and ratio (%) 2. Outsourcing cost reduction and ratio (%) 3. Defect rate (%) 4. Number of complaints (%) 5. Energy and materials consumption per product unit 6. Distribution and transportation costs and ratio (%) 6. Distribution and transportation costs 7. In-plant stock reduction (days' stock)	8. Attendance rate improvement 9. Leaving rate 10. Environmental pollution indicators 11. Number of patents 12. Length of research period ⋮
Items that should be treated as special features in implementing layouts	Technical innovation items	'Hard' technology		'Soft' technology	
		1. Mechanisation, labour-saving, automation, simplification 2. Unattended operation, multi-machine handling, multi-process handling 3. Automation of materials flow, packing and transportation (including materials handling) 4. Automated measurement and control, Poka-Yoke 5. Equipment speed increase 6. Introduction of new technology ⋮		1. Process integration, process-eliminating designs 2. Information network rationalisation (CAD, CAM, CIM, etc.) 3. Production streamlining, JIT 4. Centralised processing, group technology 5. Re-use of scrap materials, environmental protection measures ⋮	
	Scope of application	1. Rationalisation of model workshops 2. Individual machining, assembly and inspection processes 3. Initial process → final process (inspection, packing) 4. All processes + control system		5. Factory + product warehouse + control system 6. Design + factory + product warehouse + control system 7. Development + sales + factory + product warehouse + control system ⋮	
	Total employee involvement (TEI) strategies	Improvement of control and service	Improve operating rates	Enhance support systems	
		1. Speedier customer response 2. Better administrative accuracy and efficiency 3. Improved process control 4. Prompt provision of specifications and estimates 5. More efficient handling of non-routine situations ⋮	1. Eliminate waste time in work processes 2. Reduce setup times 3. Introduce TQC, TPM, 5Ss 4. Improve space utilisation 5. Improve transportation and materials handling efficiency 6. Increase equipment speed and reduce downtime ⋮	1. Raise morale 2. Conduct thorough training 3. Practise management by objectives 4. Run plantwide campaigns 5. Develop a multi-skilled workforce 6. Introduce visual controls 7. Increase number of suggestions ⋮	

Table 3-3: Example of Strategy and Objective Setting Checksheet for Use in Layout Design (Plan XX)

Establishing Concepts and Building a TEI Culture (TEI: Total Employee Involvement)

Management objectives and layout-setting (clarification of relationships)

a. Table 3-3: examples of strategy, target-setting and checksheet for XX Plan when designing layouts.
   Organise on target-setting checksheet.
b. Table 3-4: equipment investment plan at the concept stage.
   Organise project and adjust as each step is taken.

Clarify layout design concept and ideal.
Organise ideas systematically as shown in Tables 3-5 and 3-6.

Aims:

1. To create an ideal or concept that will secure everybody's participation and unify their actions.
2. Create a dream or vision for employees that focuses on satisfying the customer.
3. Create a robust system that improves progressively in a balanced fashion and has continuity and a form direction.

Use of diagnostic techniques for analysing and assessing the status quo and evaluating the present level.

Assess the current situation using the kind of table shown in Table 1-3. Then list the problems and work out exactly what level of improvement is required.

As Figure 3-6 shows, combine the top-down and bottom-up approaches and try to solve problems as part of the process of designing the layout.

Equipment Investment Planning

Proposal Year Month Day

Title of topic		Total investment amount	Implementation date (Year / Month / Day)	Submitted by:	Site	Sales manager	Production manager

1. Reason for proposal (background, purpose, new-product marketing strategy, etc.)
   (1) Background
   Example: Increased orders are forecast and a new product is being developed, mainly for company X
   (2) Purpose
   Example:
   - Increase market share from 0% to X%
   - Establish sales of £Y,000/month

   (3) Strategy
   Example
   - Enter electronics field, focusing on material A
   - Establish a quality differentiation in aspect A, featuring B of technology C

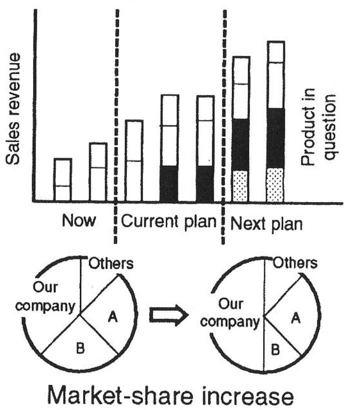
2. Objectives (strategies: technology, equipment, personnel, yield, delivery, etc.)
   (1) Strategies

Item	Outline	Benefit	Technical level
1. ....Rationalisation 2. ....Yield improvement 3. ....Lead-time reduction	Labour-saving: reduce headcount by X (present ➧ planned)		

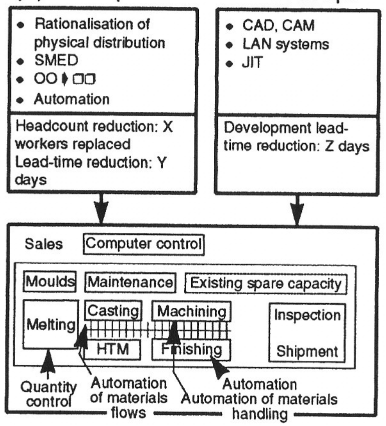
(2) Principal equipment

Item	Specification (supplier)	No. of units	Price	Target
Conveying device X : :	......24-hr unattended conveying : :	1 set : :	£X,000	Replace 4 workers : :
—	Total			

3. Equipment planning framework
   (1) Sales plan

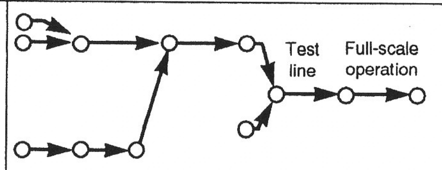


(2) Example: FMS line concept



4. Profit plans
   Product A: sales revenue = unit price x quantity Sales – cost of sales = gross profit
   Return on investment = x % Payback period = x years

5. Schedule

Item	Person responsible	Schedule	Notes
1. Move X 2. Bring in automatic device Y ... : : : N. Make official application	....		....

6. Notes: titles of appended documents
   ....

Table 3-4: Example of Organisation at Concept Stage

Step	Explanation	Application Example
1. Strategy	Think in terms of the product's characteristics, technology, marketability, sales volume and international acceptability, and the company's philosophy. Incorporate the customer-focused approach.	• Improve quality of life • Contribute to a better environment • Support basic technology • Reduce customers' labour-hours, etc.
2. Product characteristics	Write down specific product names and features. Identify key points of production technology. Specifying the target values gives the product a clear quality image.	• Large-volume storage freshness • Compactness, lightness (passport-size) • XX grams, energy-saving type, quadruple-strength materials
3. Factory mission ↓ factory objectives	Review from quality, delivery, cost and after-sales service aspects, and publicise factory's manufacturing approach.	• Factory lead-time: 2 days Flexible JIT production • Build in quality via the equipment, making full use of innovative technology
4. Scope	Identify the range to be covered, from identifying customer needs (market surveys) through research, prototype development, marketing, production, sales and distribution.	• Integrated production line from intake of raw materials to despatch of finished product • From order breakdown to installation
5. Methods	Explain the features of the new layout in terms of the factory's strategies and a comparison with other companies. Describing the present technical state of the art is effective.	• FA lines, CIM • Non-polluting, labour-saving factory • World-class factory in terms of component precision, assemblability, etc.
6. Philosophy	Excite the enthusiasm of all the factory's employees and challenge them to provide excellent quality, delivery and service to customers. Describe the basic activities that everyone in the factory will be undertaking as a united team.	• Focused on unattended operation • A manufacturing facility that makes full use of hand-made devices • Improving the environment through XX technology

Table 3-5: Checksheet for Layout Design and Concept Creation

Step	Company A	Company B	Company C	Company D
1. Strategy	Improve accuracy, offer lightweight materials	Introduce JIT, build product families, offer radical cost reductions	Manufacture small lots of products meeting customers' needs	Offer high-quality, full-sized household electrical products that double as items of furniture
2. Product characteristics	10 years' trouble-free operation at X,000 rpm	Manufacture of lighter, thinner products with new materials	Thin-walled products with dimensional variety in small lots	High variety, small-lot production, custom built
3. Factory mission	Non-mass-production, automation, CAD/CAM	SMED, systematic daily management	Width dimension control in response to orders (timely production)	Volume production using one-piece-flow, mixed-model lines
4. Scope	Materials processing lines	Integrated production line from casting to inspection and packing	Slitting – inspection – packing – shipping	Parts setting + assembly + inspection + packing
5. Methods	Standardisation of direct numerical control machining knowledge	Transportation automation, computer-controlled production management	Automatic warehousing system for automated picking and packing	Advanced design system for individual products, improved assemblability
6. Philosophy	Pursue automation of worlds'-best veteran skills	A waste-free factory with no dirty, dangerous or physically demanding work	Creation of a system for accumulating intangible productivity know-how	A highly-efficient JIT assembly plant that respects humanity
Products	Aircraft parts	Automobile parts	Electronics materials	Household electrical goods

Table 3-6: Example of Concept Creation

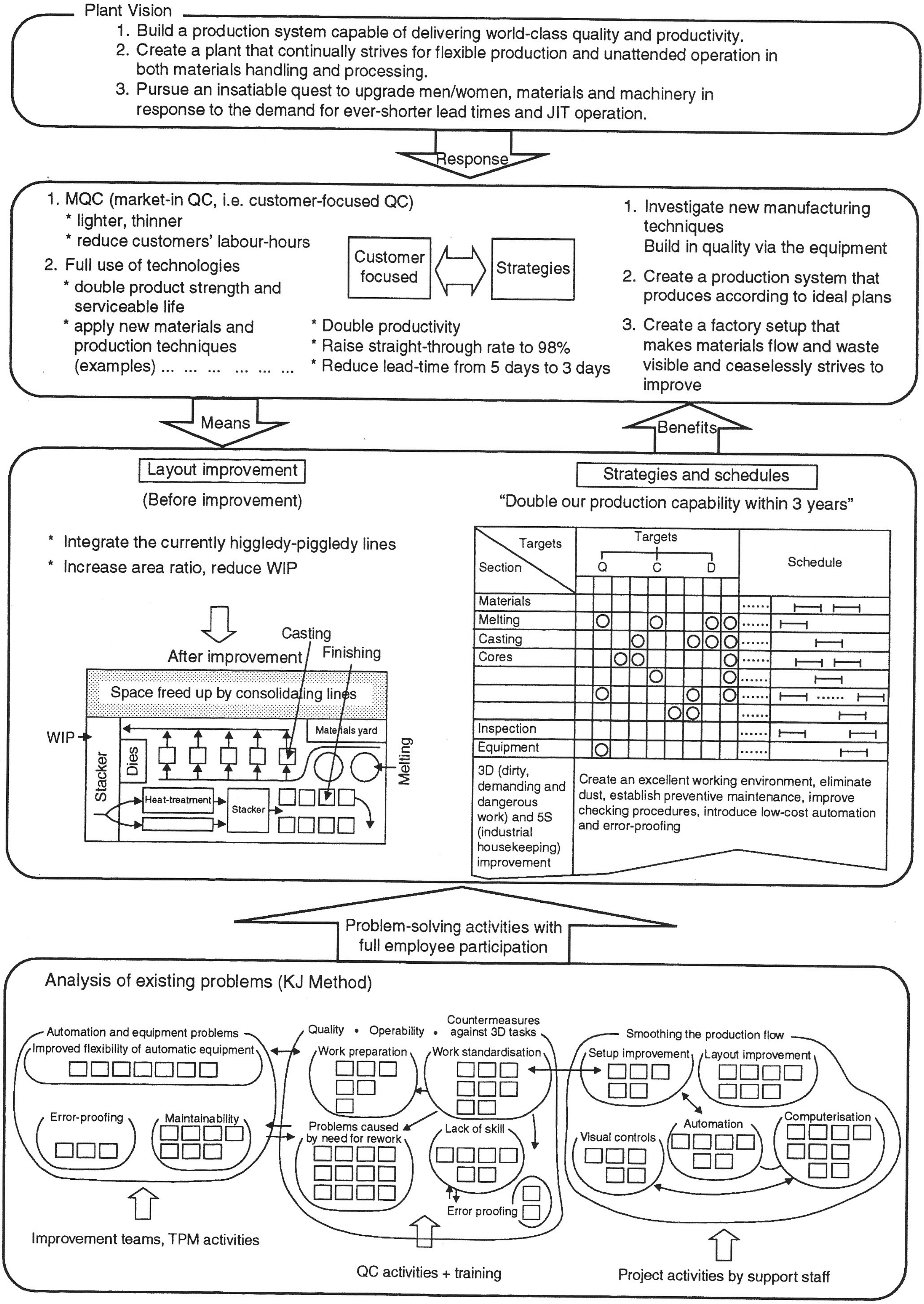


Figure 3-6: Relation between Layout Design Concept and Workplace Improvement in an Integrated Casting Plant

Confirming Installation Conditions for New Layout

Approach When Designing New Layouts

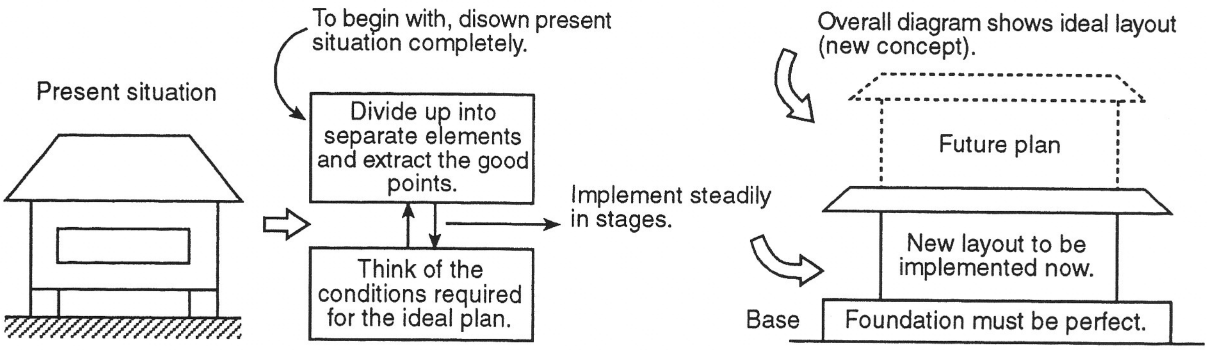


Figure 3-7: Basic Approach to Layout Design

Items to be considered when designing factory layouts:

1. Does it conform to the factory design concept or policy?
2. Comprehensively review all the conditions, and establish the theoretical basis for why this particular plan has been chosen (show clearly how the various possible plans were evaluated).
3. Ensure that the plan includes guidelines indicating how future concerns are to be dealt with (ensure that the plan incorporates a story explaining how problematic technology will be improved in the future).

To satisfy the above conditions, we formulate a plan for the future, working out a current plan as the first step in moving towards this. Although the current plan is based on existing technology and conditions and is therefore highly practical, it is also important to break out of the current paradigm and move in the direction of the future plan.

To achieve this, we perform a review using items of the kind listed in Table 3-7 and utilising information such as the existing layout (Table 3-7 shows a list of in-plant evaluation items; it does not include checkpoints to be used when selecting factory sites).

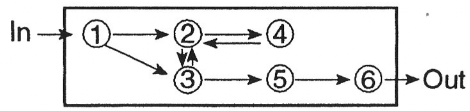
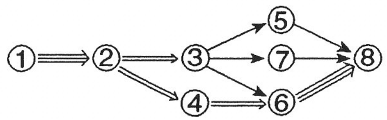
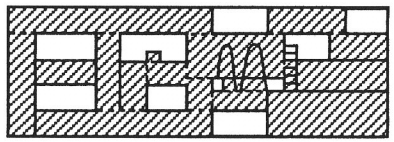
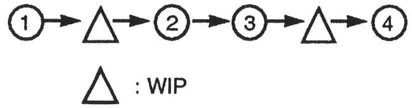
No.	Evaluation item	Example and formula
1	Forward-flow ratio	• In the process illustrated here, steps 1 - 2, 2 - 3, 2 - 4, etc. are forward steps, while steps 3 - 2 and 4 - 2 are backward steps. Estimate the forward flow as a proportion of the total flow, and try to increase this proportion. • Examples of possible strategies: 1. Develop technology that obviates the need for backtracking. 2. Group sub-processes 2, 3 and 4 together at a single piece of equipment. 3. Instead of returning the work to the previous process, peform the operation in the current process.  Forward-flow ratio = $\frac{\text{number of forward steps}}{\text{total number of steps (distance x number of movements)}}$
2	Flowline proximity ratio	• This diagram uses single, double and triple lines to represent the flow of materials in terms of number of items. Classify the sub-processes according to whether they are directly linked (separated by 1 metre or less) or not, and review the layout from the closeness aspect. • Examples of strategies: 1. Combine sub-processes 1 and 2. 2. Bring processes closer together than 1 metre. 3. Introduce improvements to eliminate work involving small quantities such as shown by the arrows leading to and from sub-process 5. 4. Raise the capacity of certain sub-processes in order to eliminate flowlines arising from under-capacity.  Flowline proximity ratio = $\frac{\text{number of flowlines connecting directly-linked processes}}{\text{total number of flowlines (distance x number)}}$
3	Building utilisation ratio	• Evaluate the height of the building in terms of area. When space above or below the production floor can be used (e.g. mezzanines) include it in the calculation as available space. • Include area occupied by equipment, offices, toolrooms, etc. in production-related area. Also include area of WIP storage, despatch-dock inventory, etc. as necessary. (Include all items regarded as eligible for improvement).  Space utilisation ratio = $\frac{\text{area used for production}}{\text{total area}}$
4	Process synchronisation ratio	• When materials flow through a production process as shown in the diagram, WIP will always build up between sub-processes as a result of lack of synchronisation between sub-processes, the need to wait for products to build up into lots of a certain quantity before a changeover can take place and the next sub-process can start, equipment problems, quality problems and so on. • Devise separate countermeasures to suit each type of cause.  WIP time = $\frac{\text{(number of WIP items) x (time taken for subsequent process)}}{\text{monthly production}}$ WIP area ratio = $\frac{\text{WIP area}}{\text{(total area – area used for production)}}$

Table 3-7: Layout Evaluation Items and Formulae

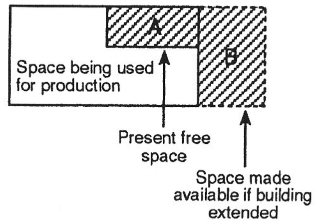
No.	Evaluation item	Example and formula
5	Future available space ratios	• The future available space ratio can be worked out in terms of either the space available within the existing building or the space available if the existing building were extended, as a proportion of the existing total floor space, by the following formulae:  Future available space ratio $= \frac{A}{A+S}, \frac{A+B}{A+S}$, etc. • This ratio can be increased by reducing the floor space presently occupied by equipment. This can be done by introducing new technology to make the equipment more compact, raising machine capacity to reduce the number of machines needed, etc.
6	Production area reduction ratio	• Calculate this with reference to a past point in time or using a competitor as a model (compare with a production operation of the same scale over a particular time period). • The 'production multiple' term in the formula is the factor by which production has been increased as a result of productivity improvements. • Strategy examples: increase the performance, efficiency or speed of individual processes, make equipment more compact or integrate vertically, eliminate processes, etc. Production area reduction ratio $= \frac{\text{planned area (or current area)}}{\text{standard production area x production multiple}}$
7	Control simplicity ratio	• Use the number of contacts as the base for the calculation (do not count as a contact if a worker only has to walk one or two steps to obtain or convey the necessary information). • Examples of contacts: reporting equipment failures, communicating about jigs, tools and setups, informing and reporting or work volumes, liaising about essential quality items, etc. Think how these can be simplified. • Methods: increase contact with office by improving aisles and visibility and positioning communications devices such as notice boards, telephones and loudspeakers more effectively. Control simplicity ratio $= \frac{\text{number of simple control points}}{\text{total number of control points}}$ Number of people involved x number of essential information items
8	Rearrangeability	• Count the number of items of equipment that can be rearranged cheaply (at less than a certain specified cost) in about a day including rewiring, repiping and auxiliary equipment. • Leave enough space for easy rearrangement of those items for which the need is predicted, while identifying and taking special care over immovable facilities such as pits, cranes, heavy equipment, etc. Rearrangeability ratio $= \frac{\text{number of equipment items that can be moved within the laid-down criteria}}{\text{total number of equipment items}}$ Immobility ratio $= \frac{\text{number of items of equipment that cannot be moved}}{\text{total number of equipment items}}$ • In assessing the rearrangeability of a layout, it is necessary to clarify the constraints that make it impossible to rearrange certain items.

Table 3-7: Layout Evaluation Items and Formulae (continued)

No.	Evaluation item	Example and formula
9	Workplace safety	1. Visibility along aisles, height of WIP storage areas. 2. Danger anticipation, evenness of aisle floors. 3. Safety racks, safety instructions, designation of managers responsible for safety, labelling of dangerous articles, signposting of dangerous areas: assess in terms of number of safety directions given.
10	5 Ss	1. Placement and classification of materials 2. Handling of jigs, tools, dies, etc. 3. Ease of cleaning, inspection and maintenance 4. Countermeasures against sources of dust, etc. Evaluate on a 5-step scale
11	Work environment	1. Ventilation, refreshment rate 2. Ease of installation of coolers, fans, etc. and ability to increase the number of these 3. Isolation from noise, heat, odours, etc.
12	Maintainability	1. Ease of finding and handling parts, reliability of storage management 2. Ease of operation when servicing and repairing equipment (including interference with various conditions) 3. Ease of installation and operation of abnormality alarms
13	Employee welfare	1. Ease of discussion for small groups, etc. 2. Closeness of cafeteria and toilets, availability of drinks, snacks, etc. 3. Factory environment (sports ground, relaxation areas, etc.)
14	Environmental friendliness	1. Measures to comply with various regulations relating to environmental standards 2. Maintainability of pollution-prevention equipment
15	Energy reduction	1. Energy reduction measures 2. Ease of reuse of waste heat
16	Handling of recycled materials and waste products	1. Ease of transportation, storage and control of recycled materials 2. Ease of storage, extraction and control of waste materials, etc.

Table 3-7: Layout Evaluation Items and Formulae (continued)

Product Analysis and Production System (Application of SLP)

SLP: Systematic Layout Planning – Richard Muther

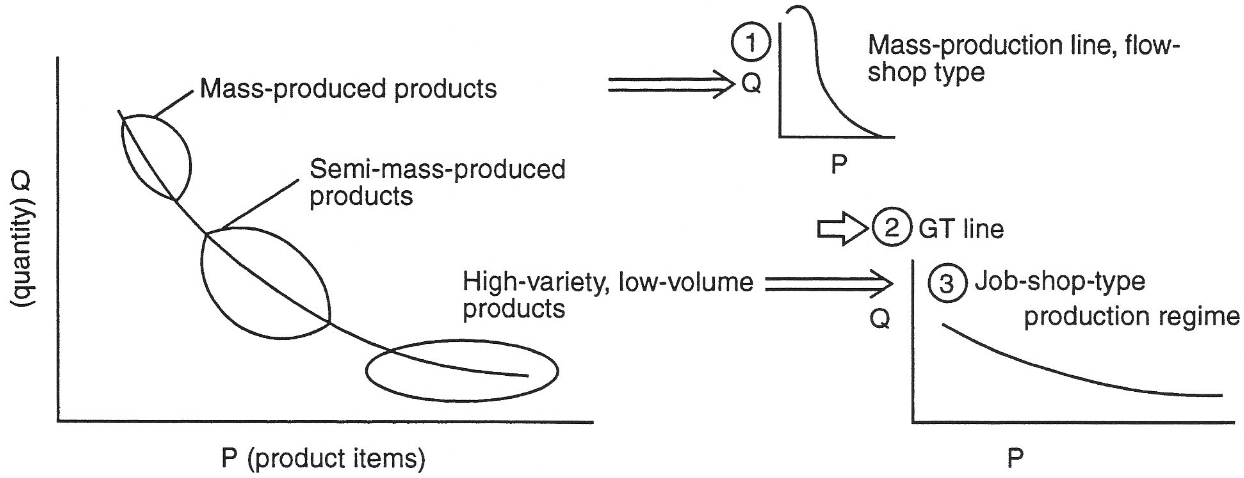


Figure 3-8: Method of Classifying Production Lines by P-Q Analysis (from SLP Technique)

Application using SLIM ... Strategic application method

1. Assess product life cycle (perform P-Q analysis + life cycle analysis).
2. Group together and stratify similar products
   (Examples: switch to in-house fabrication, rearrange lines, consolidate, etc.).
3. Instigate cost countermeasures using cost x production volume
   (identify priority strategies).
4. Indicate problematical products
   (Examples: establish separate lines, bypass, etc.)
5. To save time and effort during the calculation, take the top 95% for this procedure and continue.

Materials Flow and Load/Capacity Analysis

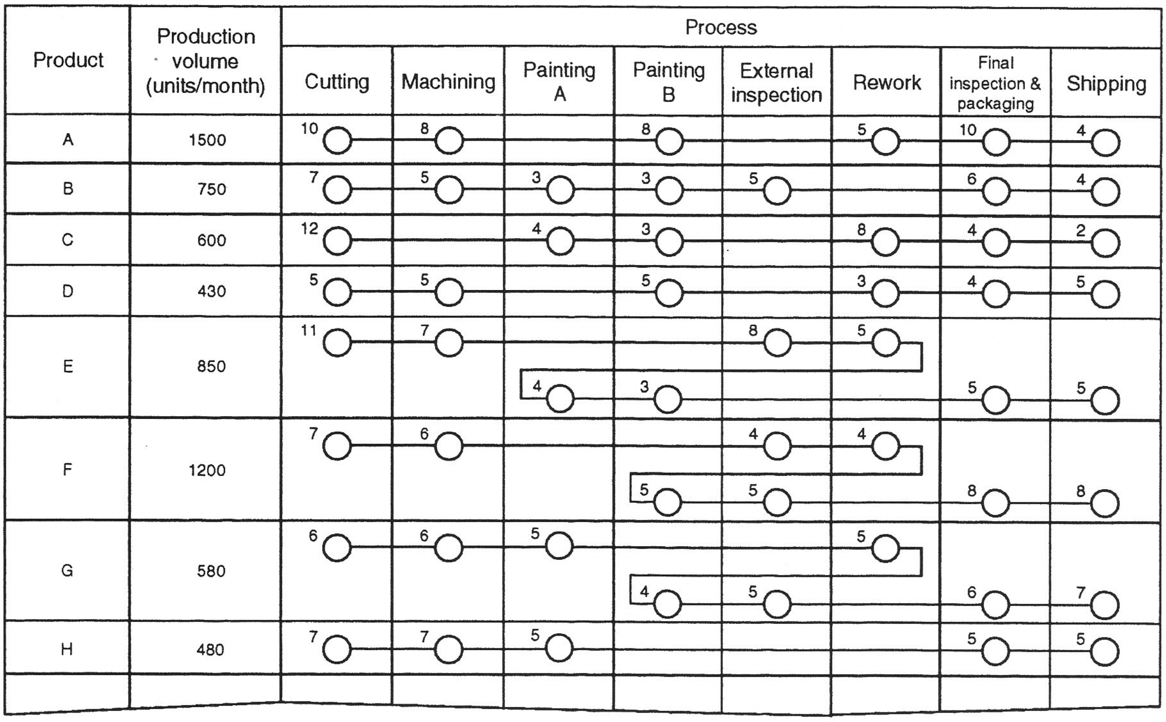
Materials flow analysis

Procedure

1. Use a routing analysis such as that shown in Figure 3-9

2. Circles show processes through which the product flows – lines represent routes taken

3. Note in the circles the time taken to manufacture each item (ST or CT)



Items to consider:
1. Process and routing improvement (ECRS)
2. Grouping of similar processes
(e.g., painting processes A and B could be combined into a single process by carrying them out on the same equipment with the addition of a changeover)

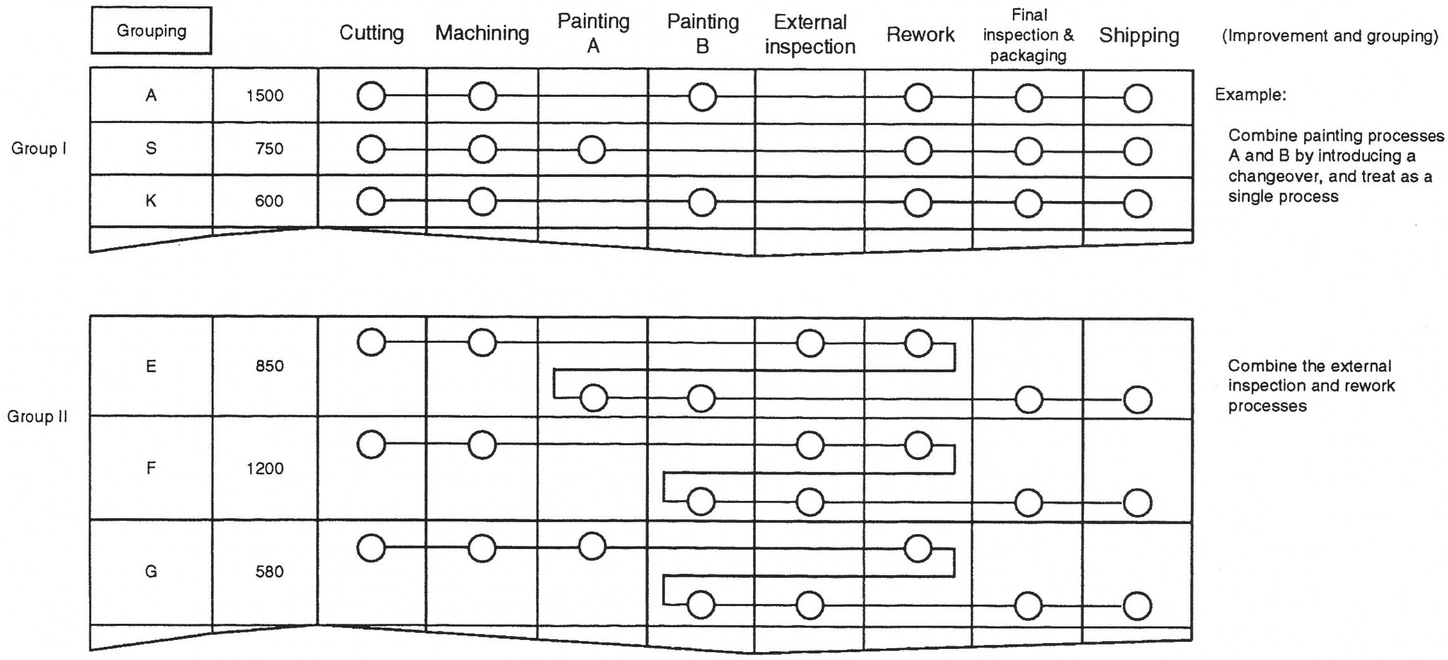


Figure 3-9: Example of Multi-Product Process (Routing) Analysis (Processing of Worked Material)

GT Codes and Standardisation

Examples of standardisation

1. GT codes showing the flow of materials (placing into similar groups)
2. Clarification of production standards
3. Labour-hours standards (ST, CT)
4. Standardisation of parts and machining techniques

(Items 1–4:) Use as is for computer control

Example of use of materials flow GT

Example of GT coding system (store on computer as a reference)

Initial process		Heat-treatment process		Painting process	
GT Code	Process pattern	GT Code	Process pattern	GT Code	Process pattern
0	None	0	None	A	None
1	Cutting	1	Tempering	B	Oiling
2	Cutting – rework	2	Quenching – tempering	C	Degreasing – painting A
3	Cutting – machining – rework	3	Salt bath	D	Degreasing – painting B
4	Cutting – machining – welding			E	Degreasing – painting A – painting B
5	Cutting – machining – welding			F	Degreasing – special painting
	Hand finishing			G	Degreasing – hand painting

Example of GT code registration for individual make-to-order items (store as file)

Assignment of parameters for make-to-order items

Customer name: MMC   Material: stainless steel

Specification : welded, quenched, tempered, machined

GT code | 4 | 2 | C | 1 | Average lead time: 5.5 days

Automatic setting of process pattern and lead time

Process pattern →	Cutting	Machining	Welding	Quenching	Tempering	Degreasing	Painting A	Packing	Shipping
Lead time (days) →	0.5	0.5	0.5	1.0	1.0	0.5	0.5	0.5	0.5
GT code →		4		2		C		1	

Note: for lead times, the number of days registered against the GT code is used. In some cases, a standard yield is also appended to the GT code.

Figure 3-10: Example of a GT Coding System and its Application

From-To Analysis:
Preparation of Materials Flow Relationship Diagrams

From-To analysis

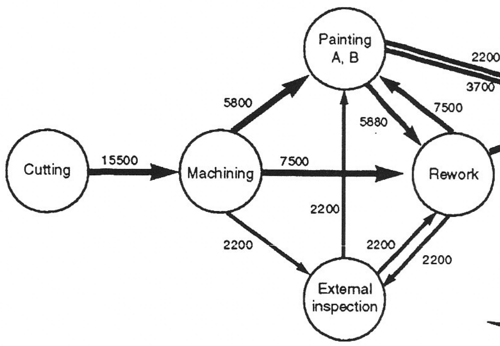
From \ To	Cutting	Machining	Painting A, B	External inspection	Rework	Final inspection & packing	Shipping
Cutting		7,500 2,200 5,800 (100A) ≡					
Machining			5,800 (37D) =	2,200 (16E) –	7,500 (46D) =		
Painting A, B					5,800 (37D) =	2,200 7,500 (63C) ≡	
External inspection			2,200 (14E) –		2,500 (16E) –		
Rework			7,500 (48D) =	2,00 (14E) –		5,800 (37D) =	
Final inspection & packing							7,500 5,000 2,200 (100A) ≡
Shipping							

100 - 85 : Class A, red
84 - 65 : Class B, orange
65 - 50 : Class C, yellow
50 - 20 : Class D, green
20 - 10 : Class E, blue
10 or below : Class F, colourless

Forward-flow section

Reverse-flow section

Preparation of materials flow relationship diagram



Improvement

Example: when the external inspection process is performed after the rework process but before the painting processes

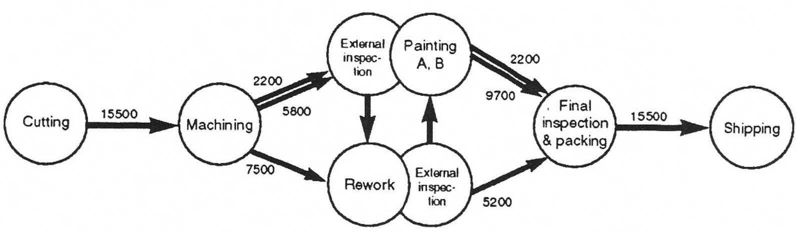


Figure 3-11: Example of Materials Flow Analysis

Load/Capacity Analysis and Equipment Capacity Considerations

Calculation of Load

Loading time for each process = $\sum$ (number of items in each process) x (ST for each item)

5 min/item x 1,500 items/month = 7,500 min/month

Product	Production volume (items/month)	Cutting	Machining	Painting (including external inspection)	Rework (including external inspection)	Final inspection and packing	Shipping	Remarks
A	1,500	15,000	12,000	12,000	7,500	15,000	6,000	• Processes after improvement shown in Figure 3-9
S	750	7,500	6,000	6,000	4,000	8,200	7,500	
K	600	3,000	6,000	8,900	6,540	4,500	3,200	• For items that pass through painting processes A and B, use (ST(A) + ST(B)) x number of items
E	850	9,350	5,100	8,500	4,250	6,800	6,800	
F	1,200	8,400	7,200	6,000	4,800	9,600	9,600	
G	580	3,480	3,480	5,220	2,900	3,480	4,060	
1. Total	100,000 items/month	1,848 h/month	1,470 h/month	1,000 h/month	1,477 h/month	1,800 h/month	1,300 h/month	Deal with overload in shipping process by merging final inspection, packing and shipping teams: 3,100 h/month) ÷ 3,226 h/month ≅ 96%
2. Equipment or human capacities in h/month		7 machines (2,053)	5 machines (1,466)	4 machines (1,173)	5 people (1,466)	7 people (2,053)	4 people (1,173)	
3. Loading ratio = 1 ÷ 2		90%	100%	85%	101%	87%	111%	

Processes remaining as bottlenecks (Machining 100%, Rework 101%) — Overload (Shipping 111%)

Table 3-8: Example of Review of Process Balance through Comparison of Load and Capacity Values

Countermeasures and items for consideration

1. Reduce the number of bottleneck processes.
2. The flow of materials down the line becomes smoother when the loading rates for downstream processes are lower than those for upstream processes.
3. Try to improve processes with high loading rates.

Practice Exercise

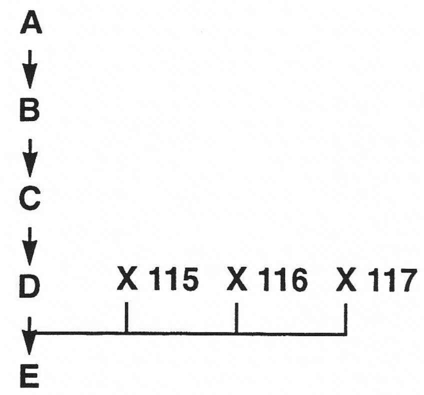
Calculate the loading rates for the processes shown in Table 3-9.

4. Manual simulation is also effective.

Practice Exercise 3

How many people should be assigned to each process when the processes shown below are used in production?

PROCESS



Assume mutual assistance between processes is not possible.

Process	Production volume per month	Production volume per day	Cycle time: min. per piece	Load	Percentage Loading	Staffing Requirements
A	23,000	920	0.501			
B	23,000	920	0.825			
C	22,000	880	0.624			
D	22,000	880	0.400			
E	20,000	800	0.384			
X115	20,000	800	0.476			
X116	20,000	800	0.923			
X117	20,000	800	0.816			

Conditions:

1. There are 25 work days per month
2. Cycle times
3. Capacity: 378 minutes per day = 7 hr x 60 min x 0.9 (availability rate)

Questions:

1. Calculate load and percent loading
2. Assign needed staffing. How did you arrive at this number?
3. Which processes are bottlenecks? How can these be straightened out?

Be specific, and record all countermeasures you see as being possible.

Table 3-9: Load Capacity Analysis and Bottleneck Process Countermeasures

Planning the Basic Layout and Comparing Alternative Proposals

Items to be considered when comparing three alternative proposals:

See Table 3-10 for a practical example

1. Cost considerations (initial cost, additional costs, cost of changes, running costs)
2. Equipment considerations (ease of changeover, maintainability, safety, environmental considerations, constraints on construction of pillars, pits, etc., constraints on removal of swarf, etc.)
3. Materials flow considerations (flow path intersections, disposal of returns, return of empty pallets, ease of unattended operation)
4. Human considerations (operability, mutual supportability, HRD)
5. Control considerations (communications, discussion, computerisation, visual controls)
6. Space utilisation (effective utilisation, accessibility)

Use a ranking scheme such as the following to perform the evaluation:

A : essential
B : important
C : desirable

Select or combine the proposals to create the one or two best options.

List the advantages of the selected proposal(s) and work out ways of dealing with these.

Examples:
1. Insufficient flexibility to accommodate changes in items being produced.
2. Insufficient flexibility to accommodate changes in production methods.
3. Few bypass routes available in case of breakdown.
4. No room for extra workers to intervene when rework is required.
5. Workplace incapable of mastering level of technology required.

Table 3-11 shows a practical example.

Objective: Formulate alternative plans, select the best, minimise its disadvantages, and diagram it.

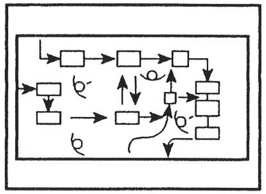
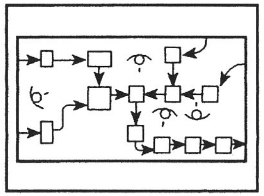
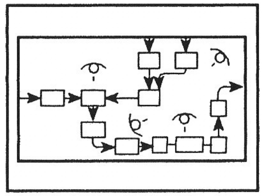
	Evaluation items / Plan (key points only)	Plan P	Plan Q	Plan D
		 Features … … …	 Features … … …	 Features … … …
A items	1. Investment £1M or less	◎A £0.9M	(A) £1.10M	△A £1.05M
	2. Return on investment 25% or more	(A) 26%	◎A 30%	(A) 27%
	3. Time limit for layout change: 10 days	◎A 10 days	△A 12 days	◎A 9 days
B items	1. Compatible with policy	◎B Emphasises productivity	◎B Emphasises quality feedback	◎B Highly suitable for JIT
	2. Space available for future expansion	△B Little free space available	◎B Room to add new line	(B) Expandable for this product only
	3. Personnel required	(B) 4 people	(B) 4 people	◎B 3.5 people
	4. Accessibility	◎B Accessible from outside	◎B Accessible from outside	(B) Some problems: crane required
	5. Equipment mobility	(B) Relatively good	△B Machine X must be changed	△B Machine X must be changed
	6. Maintainability	(B) Work required on machine A	◎B Accessible from outside or work side	◎B Same as Plan Q
C items	1. Workplace controllability	(C) 2 sections	△C 3 sections	(C) 2 sections
	2. Visual control and ease of mutual support by operators	△C Multiskilling required	◎C Similar items grouped together	◎C Easy for 3 of the operators
	Final selection	A : 5 points B : 7 points C : 1 point Cheap and easily changed, but poor future potential	A : 3 points B : 9 points C : 1 point Takes more time and money, but future potential good: adopt	A : 3 points B : 8 points C : 3 point Best for JIT applicability

Table 3-10: Example of Evaluation Table for Selecting Optimum Layout Plan

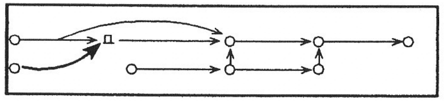
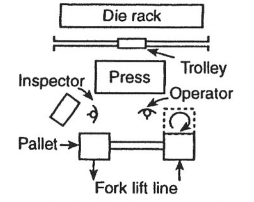
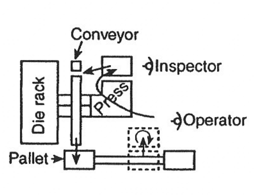
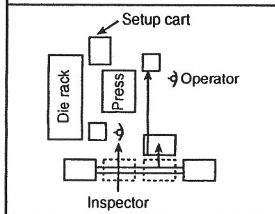
Defect items → objective selection	Defect element analysis	Defect countermeasure and benefit
1. Equipment cost: £1.10M ≡– ↓ Objective: reduce from £1.10M to £1.00M or less Ⓐ → Ⓑ	1. Machine A: £250K Machine B: £350K ⋮ Total: £750K 2. Installation cost: £250K Breakdown: ≡≡	1. Buy machines A and B without accessories (purchase them early and fit hand-made accessories) £75K 2. Cover part of installation by holiday work £25K
2. Installation time: 12 days ↓ Reduce from 12 days to 10 days and complete during shutdown period △A → Ⓐ	1. Schedule  → critical path 2. The items manufactured include some important ones and there is concern that delivery dates might be missed	1. To shorten the critical path, move machine N into place temporarily and construct pits, etc. before the installation 2. Work on Path M 24 hours per day 3. Revise the production plans and stockpile part L
3. Workplaces are separated ↓ △A → Ⓐ Devise a communication system	1. Support during setups 2. Multiskilling has not been accomplished	1. Install intercoms to enable operators to converse 2. Start multiskill training today

Table 3-11: Example of Use of Defect Elimination Techniques for Realising Basic Layout

Designing Working Conditions for Individual Processes (Work Standardisation)

Building the Best Processes for Men/Women, Materials and Machinery for each Process Unit

Proposed unit layout		Evaluation points			Rating
Structure	Features	Financial aspects	Operability	Technical level	
	• Dies are brought in from the back • Pallets are pulled in to the operators' positions and rotated through 360°	• Cost of change: £50K • 360° turntable required ○	• Good communication with inspection personnel • Work space restricted △	• No problems ○	×
	• Install a conveyor and automatically place materials on pallets after inspection • Move materials out to rear of press and transport to inspection table	• 2 conveyors, 360° turntable needed: £75K △	• Good operability • Effective use of space ○	• Possible ○	○
	• Move materials to small pallets and press (hanging type) • Use setup cart as inspection table	• Little change from existing situation • Accomplished through small improvements: £25K ○	• Some problems, but possible if operators help one another ○	• No problems ○	Adopted ◎

⇩ Standardisation

Examples of evaluation points

1. Investment amount
2. Technical level and ease of achieving technology
3. Ease of change from present situation
4. Constraints
5. Ease of die changeover
6. Maintainability (daily checking and dealing with breakdowns)
7. Equipment reliability, absence of breakdowns

Table 3-12: Unit Processes and Example of Application of Evaluation Techniques (Press)

Computer Simulation

Objectives

1. To identify in advance the problems likely to occur during operation, and take steps to prevent them.
2. To pinpoint the bottleneck processes and check any particular concerns.
   ——► Use for automation and process control.
3. To identify WIP, operating rates and improvement targets for each process.

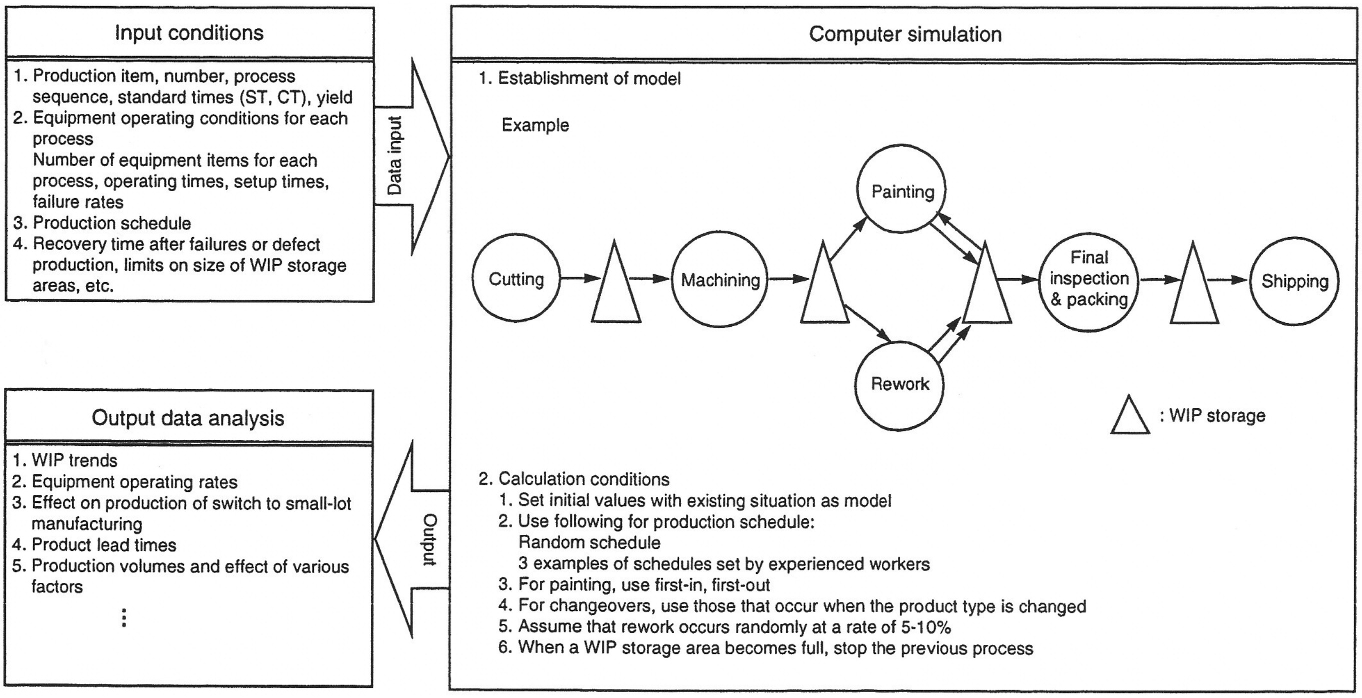


Figure 3-12: Example of Structure of Simulation Calculation Input, Processing and Output

Effective Techniques

1. Simulation Language for Alternative Modelling (SLAM II)
2. General Purpose Simulation System (GPSS)

Preparing an Equipment Investment Plan

After collating the results obtained in the previous steps, prepare an equipment investment plan and submit it for approval and implementation.

No.	Process	Present level	Improvement	Benefit
1	Cutting	3 shifts x 2 operators = 6 operators	• Setup improvement: 1 person operates 2 machines 3 shifts x 1 operator = 3 operators	Headcount reduction of 3
2	Machining	1. 3 shifts x 2 operators = 6 operators 2. Yield: 78% Breakdown of losses: Surface damage 5% Wrong dimensions 3% Setup losses 3% (total 22%) . . 3. Equipment operating rate: 68% Idling and minor stops: 20% Setup losses: 10% (total 32%) . .	• Improve equipment operating rate from 57.1% to 80% • Cope with 50% increase in loading ratio 1. Move some of the products to NC machine 1.5 → 1.15 2. Improve product yield from 78% to 85.5% $1.15 \times \frac{78\%}{85\%} = 1.055$ 3. Improve equipment operating rate from 68% to 85% $1.005 \times \frac{68\%}{85\%} = 84\%$	Increases yield by 7% with same staffing level
	Total benefits	1. Number of operators: 65 → 2. Overall yield: 45% → 3. WIP: 2,500 pcs 4. Outsourcing cost: £25K/month . .	47 47% 800 pcs £15K/month	Headcount reduction of 18 2% increase Reduced by 1,700 pcs £10K/month saving

↓

Prepare a broad-brush, see-at-a-glance table — Example: "Objectives" section of Table 3-4

↓

Examples of items to include in equipment investment plan

- Heading information: title of plan, cost, completion date, names of proposer and people responsible
- Plan objectives: reasons, background, main aims
- Outline of plan: items to be implemented, with their benefits: profit plan
- Detailed supporting data: drawings, equipment lists, names of vendors, depreciation schedules, etc.
- Contigency plans for serious potential problems
- Simulation results, detailed installation schedule, etc.

Table 3-13: Table of Improvement Benefits (Example of Detailed Analysis)

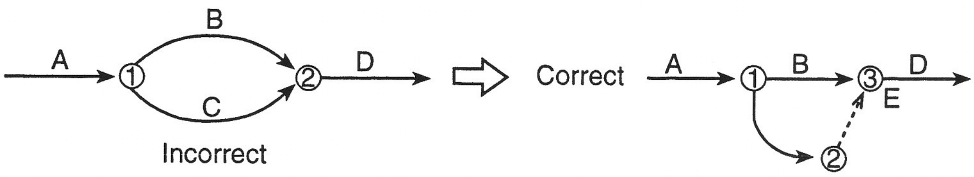
Installation Planning (PERT)

Features of PERT

1. Clarifies the relationships among tasks.
2. Facilitates control of priority tasks.
3. Permits comprehensive schedule control (including calculations).

PERT symbols and rules

1. ———► (activity) : indicates a task. The length of the arrow can be regarded as indicating the period available to complete the task.
2. ---------► (dummy) : indicates a hypothetical task. Although there is no actual work or time involved, dummy arrows are used to indicate logical connections between tasks.
3. ○ (node) : indicates a point in time where a task begins or ends. The date or time is usually inscribed in the circle.
4. Prohibition 1 : two tasks must not end at the same node.



Use a dummy (E) to show that task C must be completed before task D can be started.

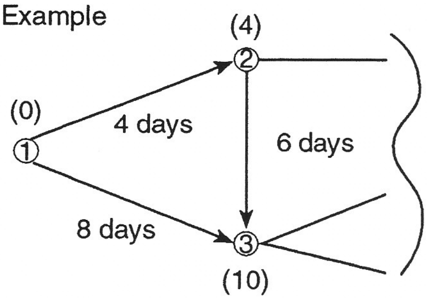
5. Prohibition 2 : never introduce a loop

Incorrect

Schedule calculation using PERT

1. The earliest time at which a particular activity can be started is called the earliest start time, or EST.
   EST = maximum value of (time of previous node + time taken for tasks on all paths entering the node in question).

Example



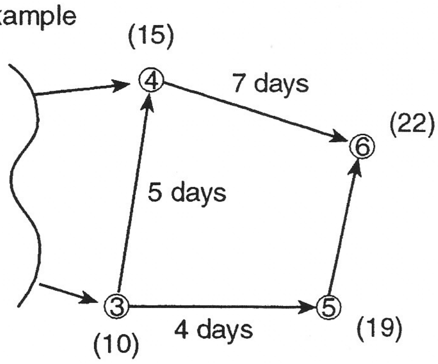
Calculation for node 3: figures in brackets represent ESTs.

Path ①→③ : (0) + 8 = Day 8
Path ②→③ : (4) + 6 = Day 10

Since we take the larger of the two values, the EST for node 3 is Day 10.

2. The latest time by which an activity can be finished is called the latest finish time, or LFT.
   The LFT for a particular node = the minimum of (the date of the subsequent node + the time taken for all activities proceeding from the node in question).

Example

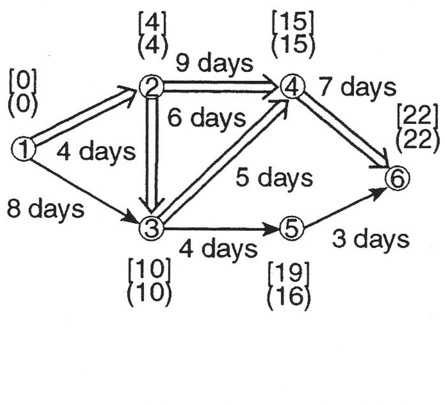


Calculation of LFT for node 3: figures in brackets represent LFTs.

Path ③→④ : (15) - 5 = Day 10
Path ③→⑤ : (19) - 4 = Day 15

Since we select the smallest of the two values, the LFT for node 3 is Day 10.

3. By performing the above calculations, we can work out the critical path through the network of activities (the critical path is the route along which there is no slack, or room for delay, in any of the tasks).



( ) : EST
[ ] : LFT
⇨ : Critical path

It is calculated that this project will take 22 days to complete. By entering the number of people and days required for each task, we can work out the daily loads.

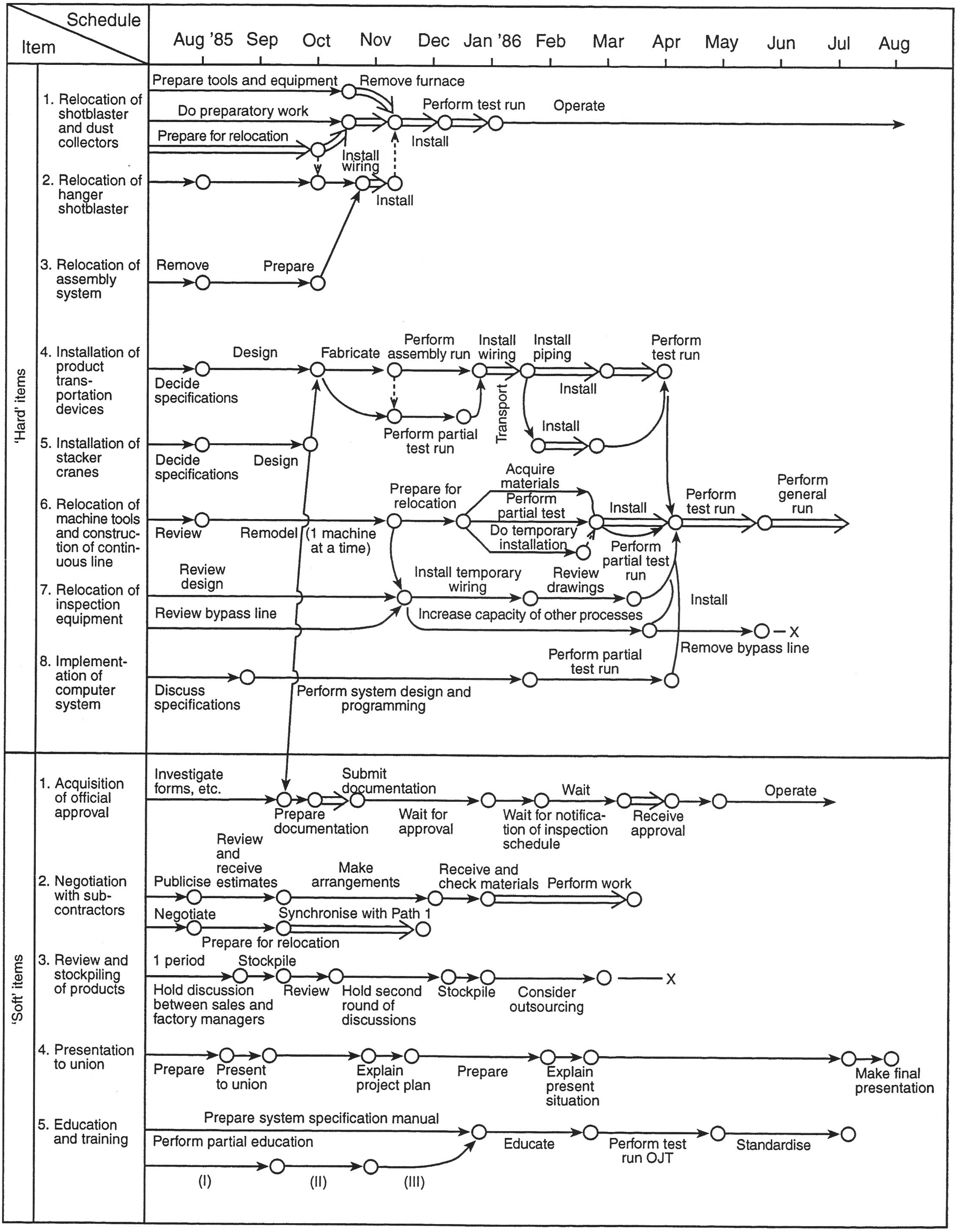


Table 3-14: Example of PERT Work Plan for Installation of FA Line

Appendix 1

Specific Procedure for SLIM-II

(Information Layout Design)

Productivity Europe

Analysing Information Processes
(The Correct Way to View Information Handling)

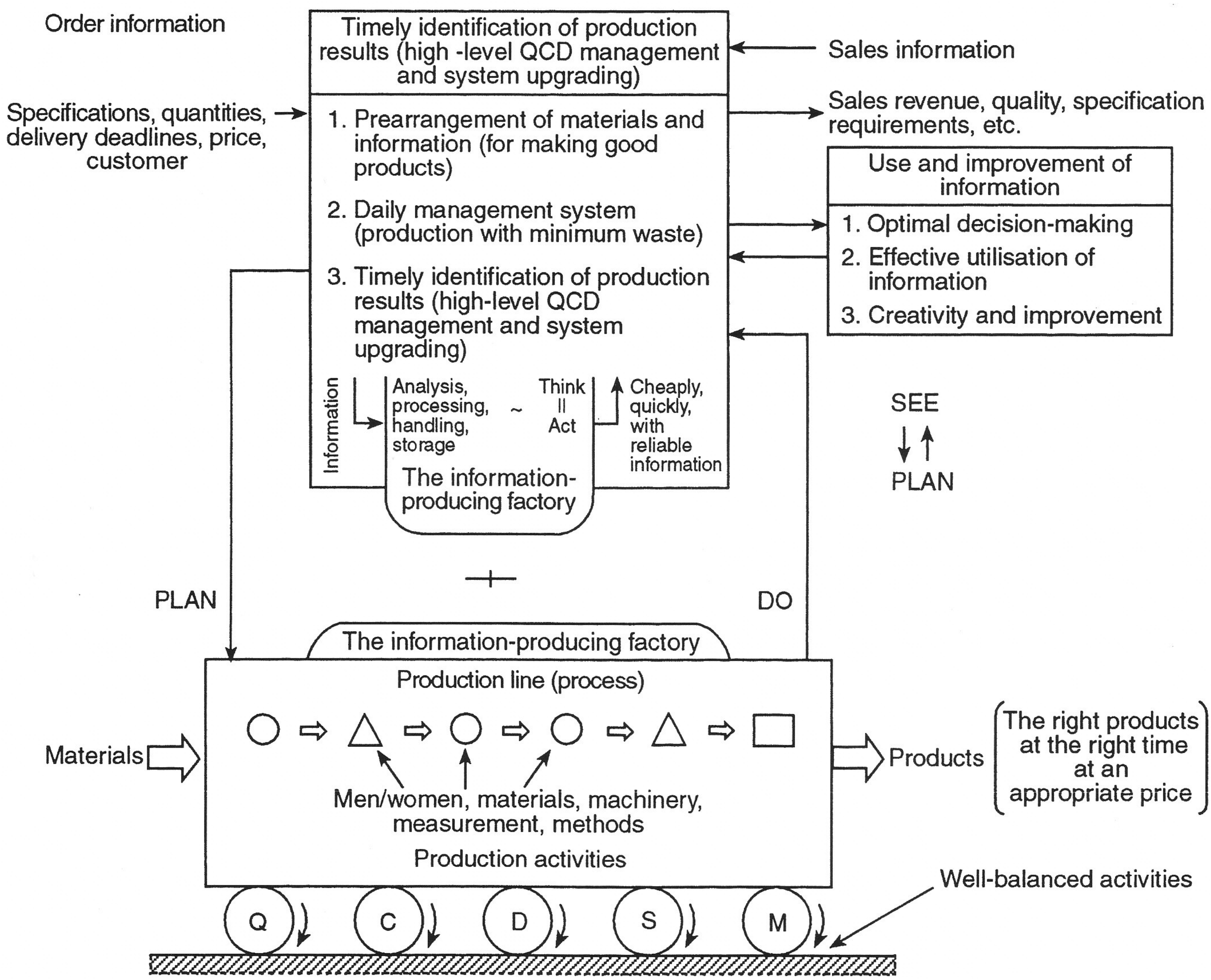


Figure 4-1: The Positioning and Role of Production Management at Manufacturing Plants

SLIM-II Design Procedure

The basic steps on the SLIM-II information layout design procedure, given below, are very similar to those used in SLIM-0 and SLIM-I:

Step 1 : Understand present situation.

Step 2 : Ask about workplace problems.

Step 3 : Perform information process and layout analysis, and consider possible improvements.

Step 4 : Clarify problems and set improvement objectives.

Step 5 : Formulate information layout improvement proposals.

Step 6 : Select specific plan (taking ECRS and line balancing into account).

Step 7 : Consider plans for future (perform function analysis and devise automation plans).
(Treat computerisation as a means of implementing these plans).

ECRS / Process analysis	E (Eliminate)	C (Combine)	R (Rearrange)	S (Simplify)
○ Information processing	● Eliminate non-functional work ● Use pre-processing to eliminate post-processing	● Combine similar tasks performed at different locations ● Centralise information handling	● Convert general guidelines to specific instructions ● Decide times and split up tasks (use night hours, etc.)	● Use computers, word processors, etc., for repetitive tasks ● Standardise and document
◇ Inspection (comparison)	● Establish systems that enable inspection to be carried out in the course of processing ● Use alarm functions ● Eliminate items	● Concentrate inspection at one location (review system of responsibilities) ● Only inspect priority control items	● Distribute to individual processes and clarify responsibilities ● Divide up in daily management style	● Create alarm systems and communicate by means of lists, etc.
⇨ Transmission (transportation)	● Eliminate wasteful routes ● Use visual management to eliminate documents	● Review and combine transmission routes ● Perform mass transmission at specified times	● Convert dispersed distribution and transmission into simultaneous parallel transmission ● Formulate rules for processing abnormal situations and exercise priority control	● Use on-line transmission systems such as LANs (local area networks) and POP (point of production) systems
△ Storage (filing)	● Eliminate paper ● Install counters and eliminate infrequently-used items	● Combine and integrate files ● Also integrate information on subcontractors, sales and related companies	● Only file information in the areas where it is needed ● Distribute search and retrieval techniques	● Use floppy disks, microfilms, etc.

Table 4-1: Process Analysis/ECRS Matrix-Type Improvement Checklist

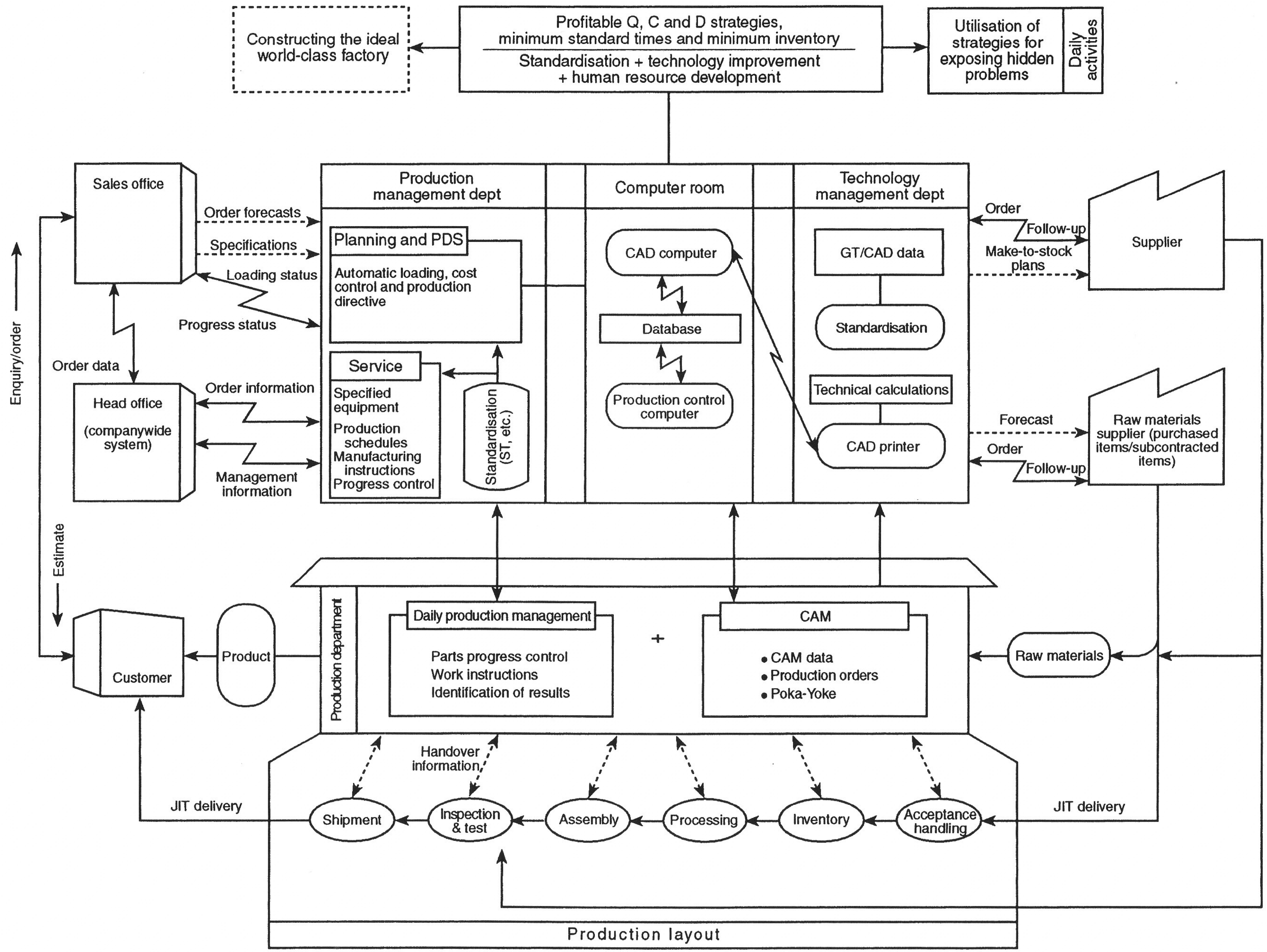


Figure 4-4: Example of Structure Diagram for Mechanisation of Information Layout

Appendix 2

SLIM-III

(Operating the Layout and Improving its Efficiency)

Productivity Europe

Techniques for Ensuring Smooth Startup (Make Full Use of Well-Known Improvement Techniques)

1. QC techniques : fact analysis, 5-Why? technique, Pareto analysis, $\overline{X}$-R control charts
2. IE techniques : time study, charts showing breakdown of idle time, production volume trend graphs
3. VE techniques : function analysis, VE improvement techniques

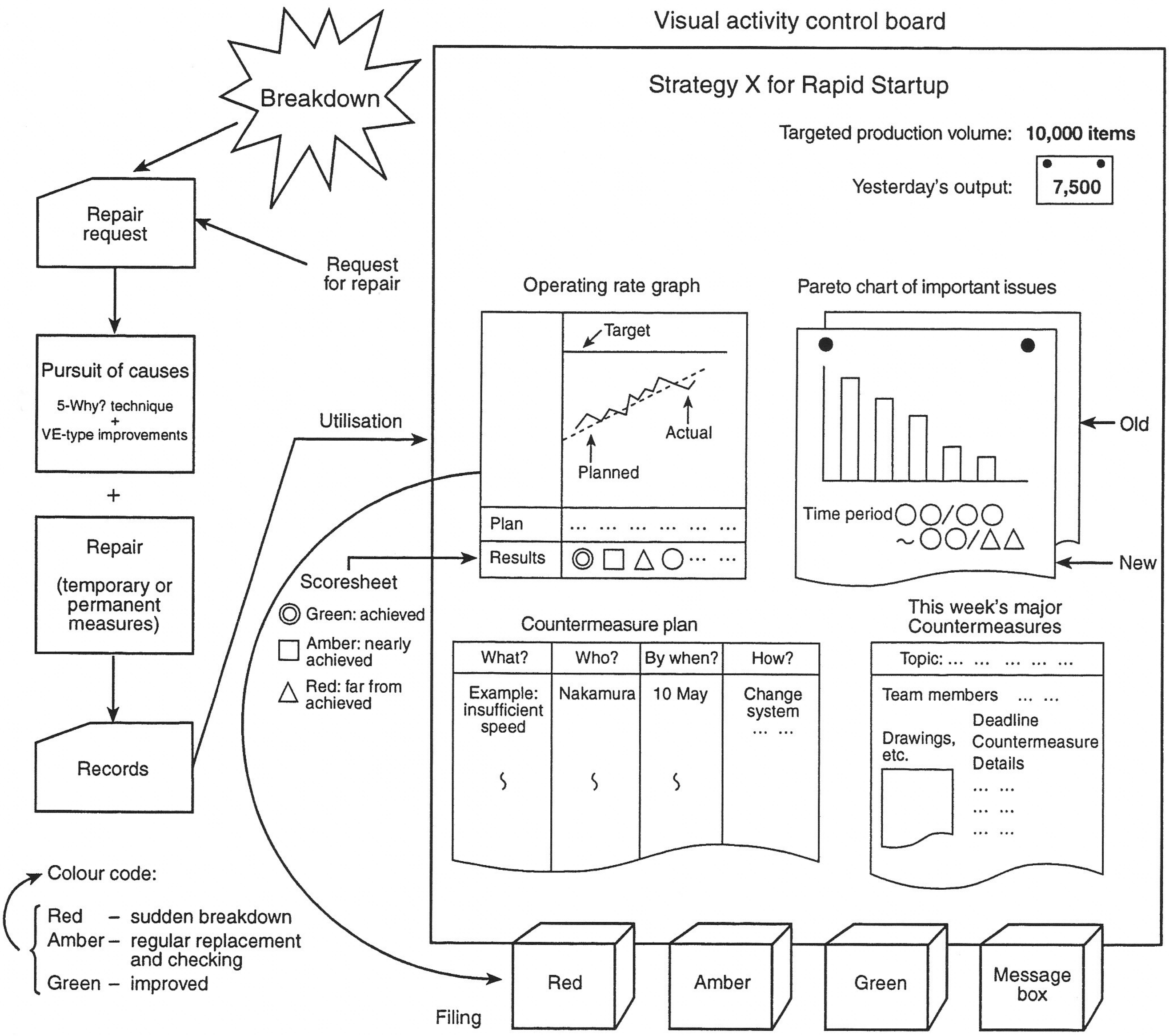
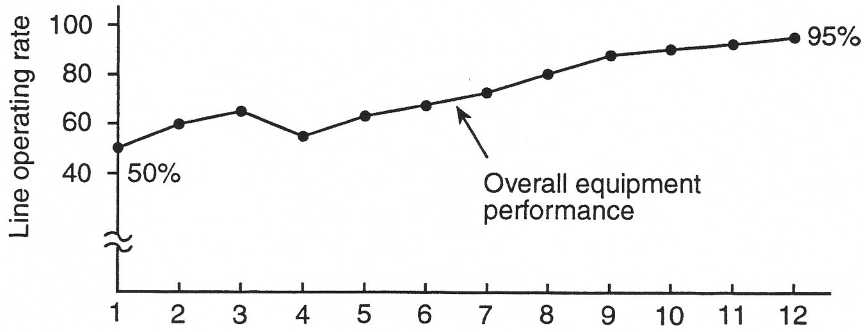


Figure 5-1: Example of Visual Activity Control Board for Fast Equipment Startup

Efficiency Improvement Through the Application of PAC (Performance Analysis and Control)

(a technique proposed by Mr Kadota of JMA Consulting)

1. For each division of responsibility
2. Collect and evaluate problems and numbers daily
3. Improve on a daily basis



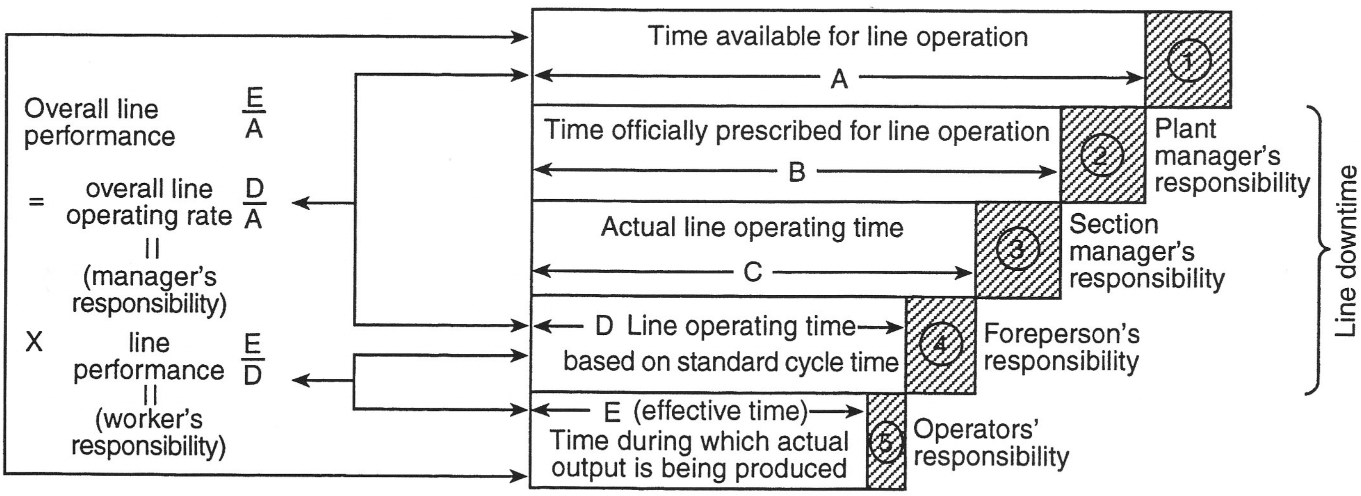


Figure 5-3: Division of Responsibility and Evaluation Formulae According to Performance Analysis and Control (PAC)

The TPM Approach

Measures for Reducing the Six Big Losses

1. Breakdown losses
2. Setup and adjustment losses
3. Idling and minor stoppage losses
4. Speed losses
5. Defect and rework losses
6. Startup losses

→ Countermeasure Procedure

Step 1 : Implement the 5Ss
Step 2 : Apply breakdown-prevention measures
Step 3 : Apply defect-prevention measures
Step 4 : Establish daily countermeasures
Step 5 : Take measures to improve equipment reliability

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Develop equipment that does not break down and does not produce defects