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MGT613 Final Term Notes

INTRODUCTION TO PRODUCTION AND OPERATIONS MANAGEMENT

Lecture No.23

Quality

- The ability of a product or service to consistently meet or exceed customers' requirements.

Solved Anil

Quality Evolution

- Fredrick Winslow Taylor introduced the concept of "inspection".
- According to him, manager should inspect the product before giving it to end customer, that it is able to identify and meet its primary objectives.
- Redford introduced the concept of "quality in the design phase".
- In 1924, Walter Shewhart from Bell Technologies introduced the "statistical process control chart".
- In 1930, Dodge and Romich presented "acceptance sampling tables".
- In 1950, concept of "Total Quality Control" (TQC) was introduced which brought another concept called "Quality Assurance".
- In 1950, Deming, Juran and Feigenbaum converted the quality movement into a separate engineering field.
- In 1960, Phillip Crosby known as "quality guru" worked on the concept of zero defect.
- In 1970s, society started focusing more on services rather than manufacturing.
- In late 70s, David Given presented a theory.
- According to him, 'If you prevent mistake before occurring, you will be converting the concept of "quality assurance" into strategic quality approach'.



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Main Contributors towards Quality Management

- Kaoru Ishikawa presented the “fish bone diagram” or “cause effect diagram”.
- Taguchi presented “robust design”.
- Demings presented 14 points for quality management which focused primarily on common cause of variation.
- According to Juran, “Quality is the fitness for use”.
- Feigenbaum said, “Quality is a total field or total function”.
- According to Crosby, “Quality is free”.
- Ishikawa gave the idea of “Quality Circles”.
- Taguchi’s contribution was, “Taguchi loss function”.

Dimensions of Quality

Solved By Aneel

- **Performance**
 - Main characteristics of the product.
- **Esthetics**
 - Appearance of the product.
- **Special Features**
- **Conformance**
 - How well the product or service conforms to the customer’s expectations.
- **Reliability**
 - Consistency of performance.
- **Durability**
 - Useful life of product or service.
 - It is also called resilience or wear & tear.
- **Perceived Quality**
 - Indirect evaluation of quality.
- **Service Ability**
 - After sales service.

Service Quality Factors

- Identification of tangibles and intangibles
- Convenience
- Reliability
- Responsiveness
- Timeliness
- Assurance

Lecture No.24



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Moments of Truth

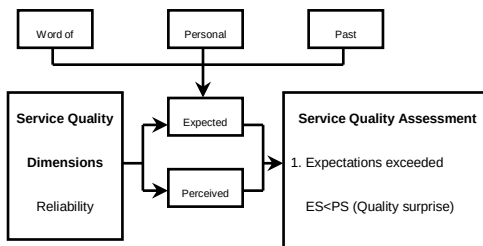
Solved B@!g

- Each customer contact is called a moment of truth.
- Your organization has the ability to either satisfy or dissatisfy them when you contact them.
- A service recovery is satisfying a previously dissatisfied customer and making them a loyal customer.

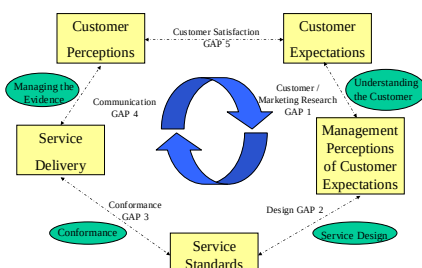
Dimensions of Service Quality

- Reliability: Perform promised service dependably and accurately. Responsiveness: Willingness to help customers promptly.
- Assurance: Ability to convey trust and confidence.
- Empathy: Ability to be approachable.
- Tangibles: Physical facilities and facilitating goods.

Perceived Service Quality



Service Quality Gap Model



Service Gap Analysis



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- Expected level of service vs. Actual level of service provided
- SERVQUAL (**Stands for SERVICEQUALITY**)
 - 5 gaps
 - 5 dimensions

SERVQUAL Model Gaps

Solved Haseeb Baig

- Gap 1
 - The difference between actual customer expectations and management's idea or perception of customer expectations
- Gap 2
 - Mismatch between manager's expectations of service quality and service quality specifications
- Gap 3
 - Poor delivery of service quality
- Gap 4
 - Differences between service delivery and external communication with customer
- Gap 5
 - Differences between Expected and Perceived Quality

Quality Service by Design

- Quality in the Service Package
- Taguchi Methods (Robustness)
- Poka-yoke
- Quality Function Deployment

Classification of Service Failures with Poka-Yoke Opportunities

<u>Server Errors</u>	<u>Customer Errors</u>
Task: Doing work incorrectly Treatment: Failure to listen to customer Tangible:	Preparation: Failure to bring necessary materials Encounter: Failure to follow system flow Resolution:

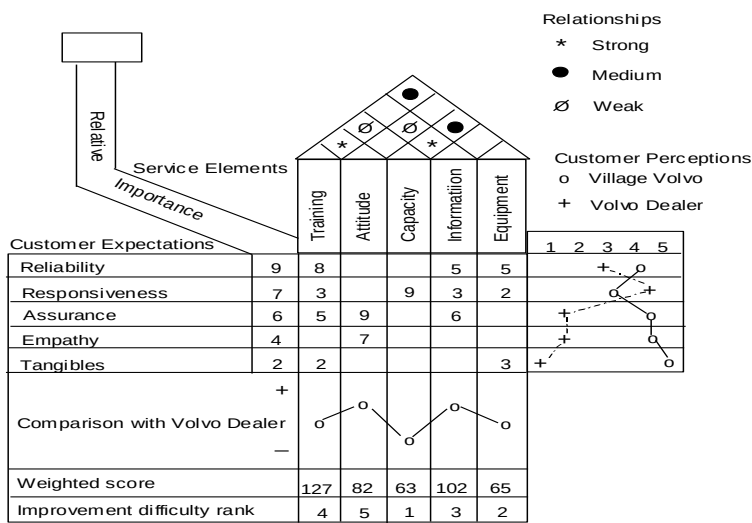


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Failure to wear clean uniform

Failure to signal service failure

House of Quality



Achieving Service Quality

- Cost of Quality
- Service Process Control
- Statistical Process Control
- Unconditional Service Guarantee

Costs of Service Quality (Bank Example)

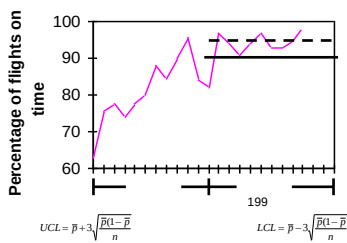
Failure costs	Detection costs	Prevention costs
External failure:		
Loss of future business	Process control	Quality planning
Negative word-of-mouth	Peer review	Training program



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Liability insurance	Supervision	Quality audits
Legal judgments	Customer comment card	Data acquisition and analysis
Interest penalties	Inspection	Recruitment and selection
		Supplier evaluation
Internal failure:		
Scrapped forms		
Rework		
Recovery:		
Expedite disruption		
Labor and materials		

Control Chart of Departure Delays



Lecture No. 25

Total Quality Management



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A philosophy that involves everyone in an organization in a continual effort to improve quality and achieve customer satisfaction.

The TQM Approach

1. Find out what the customer wants (**Marketing**)
2. Design a product or service that meets or exceeds customer wants (Design Dept)
3. Design processes that facilitates doing the job right the first time (Operations Dept)
4. Keep track of results (Sr/GM Managers)
5. Extend these concepts to suppliers (SCM / Logistics/Warehouse /Materials)

Elements of TQM

- Continual improvement
- Competitive benchmarking
- Employee empowerment
- Team approach
- Decisions based on facts
- Knowledge of tools
- Supplier quality
- Champion
- Quality at the source
- Suppliers

Continuous Improvement

- Philosophy that seeks to make never-ending improvements to the process of converting inputs into outputs.
- Kaizen: Japanese word for continuous improvement.

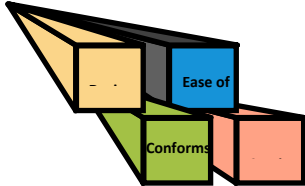
Quality at the Source

The philosophy of making each worker responsible for the quality of his or her work.

The philosophy of making each worker responsible for the quality of his or her work.



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Determinants of Quality (cont'd)

- Quality of design
 - Intension of designers to include or exclude features in a product or service
- Quality of conformance
 - The degree to which goods or services conform to the intent of the designers
- Quality of Ease of Use
 - Ease of use and instructions to use increase the chances but do not guarantee that a product will be used for intended purpose and function properly and safely.
- Quality of Service after Delivery
 - The degree to which goods or services can be recalled and repaired, adjustment, replacement or buyback or reevaluation of service all come under this category.

The Consequences of Poor Quality

- Loss of business
- Liability
- Productivity
- Costs

Responsibility for Quality

- Top management
- Design Department
- Procurement Department
- Production/operations Department
- Quality assurance Department
- Packaging and shipping Department
- Marketing and sales Department
- Customer service Department

Costs of Total Quality Management

- Failure Costs - costs incurred by defective parts/products or faulty services.
- Internal Failure Costs



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- Costs incurred to fix problems that are detected before the product/service is delivered to the customer.
- External Failure Costs
 - All costs incurred to fix problems that are detected after the product/service is delivered to the customer.
- Appraisal Costs
 - Costs of activities designed to ensure quality or uncover defects
- Prevention Costs
 - All TQ training, TQ planning, customer assessment, process control, and quality improvement costs to prevent defects from occurring

Quality and Ethics

Lecture No. 26

Quality Certification

- ISO 14000
 - A set of international standards for assessing a company's environmental performance.
- ISO 9000
 - Set of international standards on quality management and quality assurance, critical to international business.

Six Sigma

- Statistically
 - Having no more than 3 or 4 defects per million.
- Conceptually
 - Program designed to reduce defects.
 - Requires the use of certain tools and techniques.

Six Sigma Programs

1. Improve quality
 2. Cut costs
 3. Save time
- Employed in:
 1. Design
 2. Production
 3. Service
 4. Operation management
 5. Inventory management



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6. Delivery

Six Sigma Management characteristics include:

1. Providing strong leadership.
2. Defining performance merits.
3. Selecting projects likely to succeed.
4. Selecting and training appropriate people.

Six Sigma Technical

1. Improving process performance
2. Reducing variation
3. Utilizing statistical models
4. Designing a structured improvement strategy

Six Sigma Team

1. Top management
2. Program champions
3. Master “black belts”
4. “Black belts”
5. “Green belts”

Six Sigma Process

1. Define
2. Measure
3. Analyze
4. Improve
5. Control

Obstacles to Implementing TQM

- Lack of:
 1. Company-wide definition of quality.
 2. Strategic plan for change.
 3. Customer focus.
 4. Real employee empowerment.
 5. Strong motivation.
 6. Time to devote to quality initiatives.
 7. Leadership.
- Poor inter-organizational communication.
- View of quality as a “quick fix”.



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- Emphasis on short-term financial results.
- Internal political and “turf” wars.

Criticisms of TQM

1. Blind pursuit of TQM programs.
2. Programs may not be linked to strategies.
3. Quality-related decisions may not be tied to market performance.
4. Failure to carefully plan a program.

Basic Steps in Problem Solving

1. Define the problem and establish an improvement goal.
2. Collect data
3. Analyze the problem
4. Generate potential solutions
5. Choose a solution
6. Implement the solution
7. Monitor the solution to see if it accomplishes the goal.

Process Improvement

- A systematic approach to improving a process.
 1. Process mapping
 2. Analyze the process
 3. Redesign the process
- Process Improvement: A systematic approach to improving a process.
- Process mapping **consists mainly of collecting information about the process, identifying the process for each step and determining the inputs and outputs.**
- Analyze the process: **Ask questions about the process including process flow being logical, any activities or steps being missing or identification of duplication activities.**
- **Questions about each step which includes is a particular step necessary, does the step adds value, does it generates waste, could the time to perform the step be reduced, could two or more steps be combined.**
- Redesign the process

The PDSA Cycle (SHEWHART CYCLE/DEMING WHEEL)

1. PLAN
 - Study & Document the existing process.
 - Collect data to identify problems.
 - Survey data and develop a plan for improvement.
 - Specify measures for evaluating the plan.



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2. DO

- Implement the plan on a small scale.
- Document any changes made during this phase.
- Collect data systematically for evaluation.

3. STUDY

- Evaluate the data collection during this phase.
- Check how closely the results match the original goals of the plan phase.

ACT

1. If the results are successful, standardize the new method and communicate the new method to all people associate with the process.
2. Implement training for the new method.
3. If results are unsuccessful, revise the plan and repeat the process or cease this project.

Seven Basic Tools

1. Control Check Sheet
2. Flow Chart
3. Histogram
4. Pareto Chart
5. Scatter Diagram
6. Cause & Effect Diagram
7. Statistical Process

Quality Circles

- Team approach
 1. List reduction
 2. Balance sheet
 3. Paired comparisons

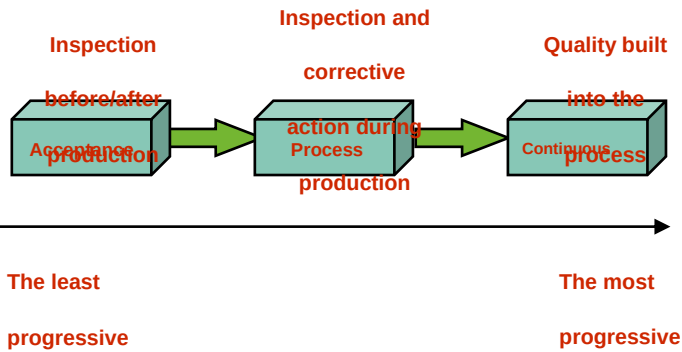
Benchmarking Process

1. Identify a critical process that needs improving.
2. Identify an organization that excels in this process.
3. Contact that organization.
4. Analyze the data.
5. Improve the critical process.

Phases of Quality Assurance

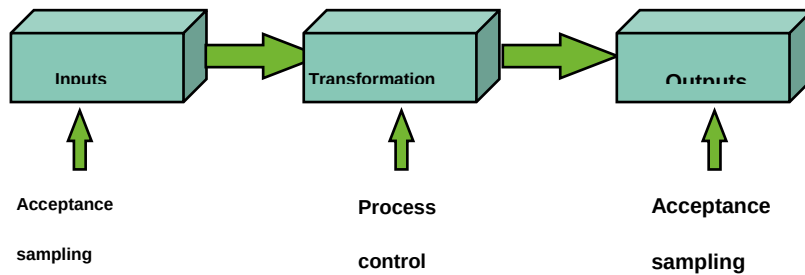


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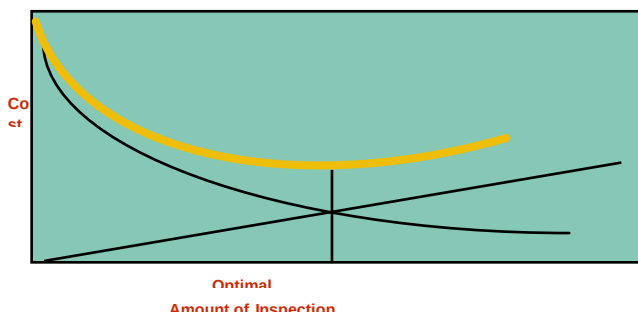


Inspection

- How Much/How Often
- Where/When
- Centralized vs. On-site



Inspection Costs for How Much/How Often



- With increase in Inspection activities the cost of undetected defectives decrease.

Where to Inspect in the Process



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1. Raw materials and purchased parts (DO not purchase poor quality products).
2. Finished products (Poor products returned by customers can also lead to additional shipping costs).
3. Before a costly operation (Do not waste Resources of Man, Material and Machine).
4. Before an irreversible process (Pottery, Ceramics, Tiles, PC chips, glass filaments).
5. Before a covering process (Before painting, plating and assembly).

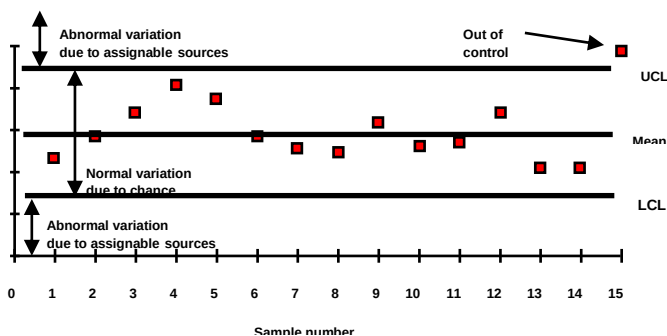
Centralized vs Onsite Inspection

- Inspection of Ships, Nuclear Plants, Petroleum Refinery, Chemical Plant equipments for cracks, brittle fracture etc both external and internal inspection.
- Lab tests include blood tests, material testing
- 1. Statistical Process Control:
Statistical evaluation of the output of a process during production.
- 2. Quality of Conformance:
A product or service conforms to specifications.
- Which Characteristics can be controlled: Only those characteristics which can be counted or measured .
- Main Task of QC: is to distinguish random from non random variability.

Control Chart

- Purpose: to monitor process output to see if it is random.
- A time ordered plot, representative of sample statistics obtained from an on going process.
- Upper and lower control limits define the range of acceptable variation.

Control Chart



Statistical Process Control

- The Control Process
 1. Define
 2. Measure
 3. Compare
 4. Evaluate



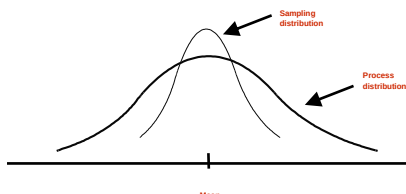
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5. Correct
 6. Monitor results
- Variations and Control
 1. Random variation: Natural variations in the output of a process, created by countless minor factors
Also called COMMON/ CHANCE. INHERENT and part of the process.
 2. Assignable variation: A variation whose source can be identified.
 - The variability of a sample statistic can be described by its SAMPLING DISTRIBUTION.
 - The goal of sampling is to determine whether non random /assignable/ correctable sources of variation are present in the output of the process.

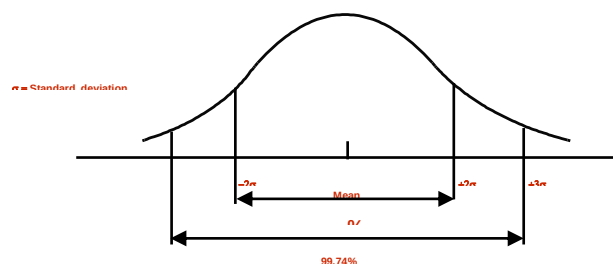
Control Charts

- A control chart is a time ordered plot of sample statistics.
- It is used to distinguish between random variability and non random variability.
- Theoretically any value is possible as the distribution extends to infinity.
- 99.7% of all values will be within ± 3 standard deviations.
- The basis of control chart is sample distribution which essentially describes random variability.
- A sample statistic that falls between UCL and LCL suggests (does not prove) randomness and a value outside suggests (does not prove) non randomness.

Sampling Distribution



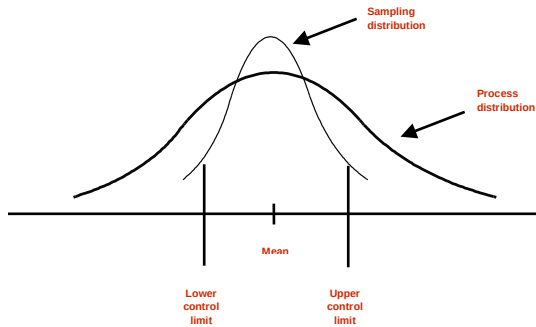
Normal Distribution



Control Limits



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Lecture No. 28

SPC Errors

- Type I error
 - Concluding a process is not in control when it actually is or concluding that nonrandomness is present when it is only randomness that is present.
- Type II error
 - Concluding a process is in control when it is not that nonrandomness is not present when it is present.

Control Chart for Attributes

- p-Chart - Control chart used to monitor the proportion of defectives in a process.
- c-Chart - Control chart used to monitor the number of defects per unit.

Use of p-Charts

- When the data consists of multiple samples of several observations each

Use of c-Charts

- Use only when the number of occurrences per unit of measure can be counted; non-occurrences cannot be counted.

Use of Control Charts

- What size samples to take.
- At what point in the process to use control charts.
- What type of control chart to use:
 - Variables
 - Attributes



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Run Tests

- Run test – a test for randomness.
- Any sort of pattern in the data would suggest a non-random process.
- All points are within the control limits - the process may not be random.

Nonrandom Patterns in Control charts

- Trend
- Cycles
- Bias
- Mean shift
- Too much dispersion

Process Capability

- Process variability relative to the specifications.
- Tolerances or specifications
 - Range of acceptable values established by engineering, design or customer requirements.
- Process variability
 - Natural variability in a process.
- Process capability
 - Process variability relative to specification.

Process Capability

- Case C, A manager in case C can take the following steps:
 - Redesign the process to obtain the desired output.
 - Use an alternative process to obtain the desired output.
 - Retain the current process but attempt to eliminate output using 100 percent inspection.
 - Examine the specifications to see if they are necessary or can be relaxed.
- Process Variability is the key factor in Process Capability.
- It is measured in terms of process standard deviation.
- Process capability is considered to be ± 3 Standard Deviations from the process mean.
- An insurance company provides a service of registering a new membership (filling of form) in 10 mins, acceptable range of variation around the time is ± 1 minute, the process has a standard deviation of 0.5min.It would not be capable because ± 3 SDs would be ± 1.5 Mins, exceeding the specification of ± 1 minute.

Process Capability Ratio



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Process capability ratio, $C_p = \frac{\text{specification width}}{\text{process spread}}$

$C_p = \frac{\text{Upper specification} - \text{lower specification}}{\text{process spread}}$

Improving Process Capability

1. Simplify
2. Standardize
3. Mistake-proof (Poka Yoke)
4. Upgrade equipment
5. Automate

Limitations of Capability Indexes

1. Process may not be stable
2. Process output may not be normally distributed
3. Process not centered but C_p is used

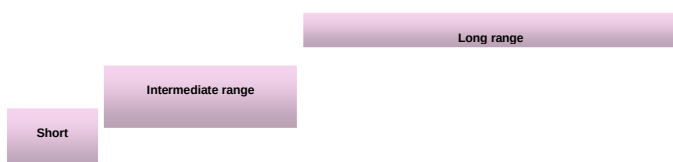
Operations Strategy WRT Q/C

1. Neither necessary nor desirable to use Control charts for every production process.
2. Some processes are highly stable and do not require Control Charts.
3. Use control Charts for new processes till they obtain stable results.
4. Managers should use Control Charts on processes that go out of control.
5. Judicious use of SPC will ensure detection of departures from randomness in a process.

Lecture No.29

Aggregate Planning

Planning Horizon



Aggregate planning: Intermediate-range capacity planning, usually covering 2 to

Overview of Planning Levels



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- Short-range plans
 - Job assignments
 - Machine loading
- Intermediate plans
 - Employment
 - Finished Good inventories
 - Subcontracting, Backorders
 - Output
- Long-range plans
 - Location / layout
 - Long term capacity

Aggregate Planning Inputs

- Resources
- Demand forecast
- Policies
- Costs

Aggregate Planning Inputs

○ Resources ○ Workforce ○ Machines ○ Facilities ○ Demand forecast ○ Policies ○ Subcontracting ○ Overtime ○ Inventory levels ○ Back orders	○ Costs ○ Inventory carrying ○ Back orders ○ Hiring/firing ○ Overtime ○ Inventory changes ○ subcontracting
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Aggregate Planning Outputs

- Total cost of a plan
- Projected levels of inventory
 - Inventory
 - Output
 - Employment
 - Subcontracting



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- Backordering

Aggregate Planning Strategies

- Proactive
 - Alter demand to match capacity.
- Reactive
 - Alter capacity to match demand.
- Mixed
 - Combination of both.

Demand Options

- Pricing
- Promotion
- Back orders
- New demand

Capacity Options

- Hire and layoff workers
- Overtime/slack time
- Part-time workers
- Inventories
- Subcontracting

Aggregate Planning Strategies

1. Maintain a level workforce.
2. Maintain a steady output rate.
3. Match demand period by period.
4. Use a combination of decision variables.

Which Strategy to Use

As a rule of thumb, aggregate planners seek to match supply and demand within in constraints by policies and minimum costs.

Lecture No. 30

BASIC STRATEGIES

- **LEVEL CAPACITY STRATEGY:**



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- ◆ MAINTAINING A STEADY RATE OF REGULAR-TIME OUTPUT WHILE MEETING VARIATIONS IN DEMAND BY A COMBINATION OF OPTIONS.

○ **CHASE DEMAND STRATEGY:**

- ◆ MATCHING CAPACITY TO DEMAND; THE PLANNED OUTPUT FOR A PERIOD IS SET AT THE EXPECTED DEMAND FOR THAT PERIOD.

CHASE APPROACH

◆ ADVANTAGES

- ◆ LABOR UTILIZATION IS HIGH.
- ◆ INVESTMENT IN INVENTORY IS LOW.

◆ DISADVANTAGES

- ◆ THE COST OF ADJUSTING OUTPUT RATES AND/OR WORKFORCE LEVELS.

LEVEL APPROACH

◆ ADVANTAGES

- ◆ STABLE OUTPUT RATES AND WORKFORCE.

◆ DISADVANTAGES

- ◆ GREATER INVENTORY COSTS.
- ◆ INCREASED OVERTIME AND IDLE TIME.
- ◆ RESOURCE UTILIZATIONS VARY OVER TIME.

TECHNIQUES FOR AGGREGATE PLANNING

- DETERMINE DEMAND FOR EACH PERIOD.
- DETERMINE CAPACITIES FOR EACH PERIOD.
- IDENTIFY POLICIES THAT ARE PERTINENT.
- DETERMINE UNIT COSTS.
- DEVELOP ALTERNATIVE PLANS AND COSTS.
- SELECT THE BEST PLAN THAT SATISFIES OBJECTIVES.

ASSUMPTIONS FOR AGGREGATE PLANNING

- THE REGULAR OUTPUT CAPACITY IS THE SAME FOR ALL PERIODS.
- COST (BACK ORDER, INVENTORY, SUBCONTRACTING ETC) IS A LINEAR FUNCTION COMPOSED OF UNIT COST AND NUMBER OF UNITS.
- PLANS ARE FEASIBLE (THERE IS SUFFICIENT INVENTORY EXISTS TO ACCOMMODATE A PLAN, SUBCONTRACTORS WOULD PROVIDE QUALITY PRODUCTS AND OUTSOURCERS WOULD BE SECURE).
- ALL COSTS ASSOCIATED WITH A DECISION OPTION CAN BE REPRESENTED BY A LUMP SUM OR BY UNIT COSTS THAT ARE INDEPENDENT OF THE QUANTITY INVOLVED.
- COST FIGURES CAN BE REASONABLY ESTIMATED AND ARE CONSTANT OVER THE PLANNING HORIZON.
- INVENTORIES ARE BUILT UP AND DRAWN DOWN AT A UNIFORM RATE.



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- OUTPUT OCCURS AT A UNIFORM RATE THROUGHOUT EACH PERIOD.
- BACKLOGS ARE TREATED AS IF THEY EXIST FOR THE ENTIRE PERIOD, EVEN THOUGH IN REALITY THEY TEND TO BUILD UP TOWARDS THE END OF THE PERIOD

AGGREGATE PLANNING RELATIONSHIPS

- NUMBER OF WORKERS IN A PERIOD EQUALS NUMBER OF WORKERS AT THE END OF THE PREVIOUS PERIOD PLUS NUMBER OF NEW WORKERS AT THE START OF THE CURRENT PERIOD - NUMBER OF LAID OFF WORKERS AT THE START OF THE CURRENT PERIOD.
- INVENTORY AT THE END OF A (CURRENT) PERIOD EQUALS INVENTORY AT THE END OF THE PREVIOUS PERIOD PLUS PRODUCTION IN THE CURRENT PERIOD – AMOUNT USED TO SATISFY THE DEMAND IN THE CURRENT PERIOD.

AVERAGE INVENTORY

AGGREGATE PLANNING RELATIONSHIPS

- COST FOR A (CURRENT) PERIOD EQUALS OUTPUT COST (REGULAR +OT+ SUBCONTRACT) + HIRE/LAYOFF COST+ INVENTORY COST + BACKORDER COST

REGULAR WORKFORCE

MATHEMATICAL TECHNIQUES

LINEAR PROGRAMMING: METHODS FOR OBTAINING OPTIMAL SOLUTIONS TO PROBLEMS INVOLVING ALLOCATION OF SCARCE RESOURCES IN TERMS OF COST MINIMIZATION.

LINEAR DECISION RULE: OPTIMIZING TECHNIQUE THAT SEEKS TO MINIMIZE COMBINED COSTS, USING A SET OF COST-APPROXIMATING FUNCTIONS TO OBTAIN A SINGLE QUADRATIC EQUATION.

SUMMARY OF PLANNING TECHNIQUES

AGGREGATE PLANNING IN SERVICES

- SERVICES OCCUR WHEN THEY ARE RENDERED.
- DEMAND FOR SERVICE CAN BE DIFFICULT TO PREDICT.
- CAPACITY AVAILABILITY CAN BE DIFFICULT TO PREDICT.
- DEMAND FOR SERVICE CAN BE DIFFICULT TO PREDICT.
- LABOR FLEXIBILITY CAN BE ADVANTAGE IN SERVICES.

AGGREGATE PLAN TO MASTER SCHEDULE

DISAGGREGATING THE AGGREGATE PLAN



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- ◆ **MASTER SCHEDULE:** THE RESULT OF DISAGGREGATING AN AGGREGATE PLAN; SHOWS QUANTITY AND TIMING OF SPECIFIC END ITEMS FOR A SCHEDULED HORIZON.
- ◆ **ROUGH-CUT CAPACITY PLANNING:** APPROXIMATE BALANCING OF CAPACITY AND DEMAND TO TEST THE FEASIBILITY OF A MASTER SCHEDULE.

MASTER SCHEDULING

- ◆ **MASTER SCHEDULE**
 - ◆ DETERMINES QUANTITIES NEEDED TO MEET DEMAND
 - ◆ INTERFACES WITH
 - ◆ MARKETING
 - ◆ CAPACITY PLANNING
 - ◆ PRODUCTION PLANNING
 - ◆ DISTRIBUTION PLANNING

PROJECTED ON-HAND INVENTORY

CHAPTER NO = 31

TYPES OF INVENTORIES

- RAW MATERIALS & PURCHASED PARTS.
- PARTIALLY COMPLETED GOODS CALLED WORK IN PROGRESS.
- FINISHED-GOODS INVENTORIES:
 - (MANUFACTURING FIRMS) OR MERCHANDISE, (RETAIL STORES)
- ◆ GOODS-IN-TRANSIT TO WAREHOUSES OR CUSTOMERS.
- ◆ REPLACEMENT PARTS, TOOLS, & SUPPLIES.

OBJECTIVE OF INVENTORY CONTROL

- ◆ TO ACHIEVE SATISFACTORY LEVELS OF CUSTOMER SERVICE WHILE KEEPING INVENTORY COSTS WITHIN REASONABLE BOUNDS.
 - ◆ LEVEL OF CUSTOMER SERVICE.
 - ◆ COSTS OF ORDERING AND CARRYING INVENTORY.

FUNCTIONS OF INVENTORY

1. TO MEET ANTICIPATED DEMAND.
2. TO SMOOTH PRODUCTION REQUIREMENTS.
3. TO DECOUPLE OPERATIONS.
4. TO PROTECT AGAINST STOCK-OUTS.
5. TO TAKE ADVANTAGE OF QUANTITY DISCOUNTS.
6. TO PERMIT OPERATIONS.
7. TO HELP HEDGE AGAINST PRICE INCREASES.
8. TO TAKE ADVANTAGE OF ORDER CYCLES.



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REQUIREMENTS OF EFFECTIVE INVENTORY CONTROL

1. MANAGEMENT HAS TWO BASIC FUNCTIONS CONCERNING INVENTORY.
2. TO MAKE DECISIONS ABOUT HOW MUCH AND WHEN TO ORDER.
3. TO ESTABLISH A SYSTEM OF KEEPING TRACK OF ITEMS IN AN INVENTORY.

EFFECTIVE INVENTORY MANAGEMENT

1. A SYSTEM TO KEEP TRACK OF INVENTORY.
2. A RELIABLE FORECAST OF DEMAND.
3. KNOWLEDGE OF LEAD TIMES.
4. REASONABLE ESTIMATES OF:
 - HOLDING COSTS
 - ORDERING COSTS
 - SHORTAGE COSTS
5. A CLASSIFICATION SYSTEM.

INVENTORY COUNTING SYSTEMS

1. PERIODIC SYSTEM
2. PERPETUAL INVENTORY SYSTEM(CONTINUAL)

INVENTORY COUNTING SYSTEMS

1. PERIODIC SYSTEM

PHYSICAL COUNT OF ITEMS MADE AT PERIODIC INTERVALS.

2. PERPETUAL INVENTORY SYSTEM(CONTINUAL)

SYSTEM THAT KEEPS TRACK OF REMOVALS FROM INVENTORY CONTINUOUSLY, THUS MONITORING CURRENT LEVELS OF EACH ITEM.

- ◆ TWO-BIN SYSTEM - TWO CONTAINERS OF INVENTORY; REORDER WHEN THE FIRST IS EMPTY.
- ◆ UNIVERSAL BAR CODE - BAR CODE PRINTED ON A LABEL THAT HAS INFORMATION ABOUT THE ITEM TO WHICH IT IS ATTACHED.

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KEY INVENTORY TERMS

3. LEAD TIME:
4. HOLDING (CARRYING) COSTS:
5. ORDERING COSTS:



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6. SHORTAGE COSTS
7. LEAD TIME: TIME INTERVAL BETWEEN ORDERING AND RECEIVING THE ORDER.
8. HOLDING (CARRYING) COSTS: COST TO CARRY AN ITEM IN INVENTORY FOR A LENGTH OF TIME, USUALLY A YEAR.
9. COSTS INCLUDE INTEREST, INSURANCE, TAXES, DEPRECIATION, OBSOLESCENCE, DETERIORATION, PILFERAGES, BREAKAGE, WAREHOUSING COSTS AND OPPORTUNITY COSTS .
10. HOLDING (CARRYING) COSTS: HOLDING COSTS ARE STATED IN TWO WAYS
 - ◆ PERCENTAGE OF UNIT PRICE OR
 - ◆ RUPEE
11. ORDERING COSTS: COSTS OF ORDERING AND RECEIVING INVENTORY. THESE ARE THE ACTUAL COSTS THAT VARY WITH THE ACTUAL PLACEMENT OF THE ORDER.
12. SHORTAGE COSTS: COSTS WHEN DEMAND EXCEEDS SUPPLY.

ABC CLASSIFICATION SYSTEM

AN IMPORTANT ASPECT OF INVENTORY MANAGEMENT IS THAT ITEMS HELD IN INVENTORY ARE NOT OF EQUAL IMPORTANCE IN TERMS OF RUPEES INVESTED, PROFIT POTENTIAL, SALES OR USAGE VOLUME.

CLASSIFY INVENTORY ACCORDING TO ABC CLASSIFICATION SYSTEM, RUPEE VALUE UP TO 50K AND 500K REPRESENT C AND B RESPECTIVELY.

CYCLE COUNTING

- ◆ A PHYSICAL COUNT OF ITEMS IN INVENTORY.
- ◆ CYCLE COUNTING MANAGEMENT:
 - ◆ HOW MUCH ACCURACY IS NEEDED?
 - ◆ WHEN SHOULD CYCLE COUNTING BE PERFORMED?
 - ◆ WHO SHOULD DO IT?

ECONOMIC ORDER QUANTITY MODELS

1. ECONOMIC ORDER QUANTITY MODEL
2. ECONOMIC PRODUCTION MODEL
3. QUANTITY DISCOUNT MODEL

ASSUMPTIONS OF EOQ MODEL

1. ONLY ONE PRODUCT IS INVOLVED.
2. ANNUAL DEMAND REQUIREMENTS KNOWN.
3. DEMAND IS EVEN THROUGHOUT THE YEAR.
4. LEAD TIME DOES NOT VARY.
5. EACH ORDER IS RECEIVED IN A SINGLE DELIVERY.
6. THERE ARE NO QUANTITY DISCOUNTS.



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THE INVENTORY CYCLE

TOTAL COST

COST MINIMIZATION GOAL

DERIVING THE EOQ

USING CALCULUS, WE TAKE THE DERIVATIVE OF THE TOTAL COST FUNCTION AND SET THE DERIVATIVE (SLOPE) EQUAL TO ZERO AND SOLVE FOR Q.

MINIMUM TOTAL COST

THE TOTAL COST CURVE REACHES ITS MINIMUM WHERE THE CARRYING AND ORDERING COSTS ARE EQUAL.

EXAMPLE 2

- A LOCAL DISTRIBUTOR FOR AN INTERNATIONAL AEROBIC EXERCISE MACHINE MANUFACTURER EXPECTS TO SELL APPROXIMATE 10,000 MACHINES. ANNUAL CARRYING COST IS RS. 2500 PER MACHINE AND ORDER COST IS RS. 10,000. THE DISTRIBUTOR OPERATES 300 DAYS A YEAR.
- FIND EOQ?
- THE NUMBER OF TIMES THE STORE WILL REORDER?
- LENGTH OF AN ORDER CYCLE?
- TOTAL ANNUAL COST IF EOQ IS ORDERED?

GIVEN DATA

- D=10,000 MACHINES.
- H= ANNUAL CARRYING COST IS RS. 2500 PER MACHINE.
- S=ORDER COST IS RS. 10,000.
- NO OF THE DISTRIBUTOR OPERATES 300 DAYS A YEAR.

EXAMPLE 2

- CALCULATION OF EOQ

$Q_0 = \text{SQ ROOT OF } (2 DS)/H =$

$\text{SQ ROOT } (2 \times 10,000 \times 10,000)/2500$

$= \text{SQ ROOT } (80,000)$

$= 283 \text{ MACHINES PER YEAR}$



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- THE NUMBER OF TIMES THE STORE WILL REORDER?

$$D/Q_0 = 10,000/283 = 35.34$$

= 35 TIMES

- THE LENGTH OF AN ORDER CYCLE?

$$Q_0/D = 283/10,000 = 0.0283 \text{ OF A YEAR} =$$

- $0.0283 \times 300 = 8.49 \text{ DAYS}$

- THE TOTAL ANNUAL COST, IF EOQ IS ORDERED

- $TC = \text{CARRYING COST} + \text{ORDERING COST}$

$$= Q_0/2 (H) + D/Q_0 (S)$$

$$= 283/2 (2500) + 10,000/283 (10,000)$$

$$= 353,750 + 353,353$$

$$= \text{RS. } 707,107$$

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EXAMPLE (IN TERMS OF PERCENTAGE)

- CNG-LPG COMPANY IN KARACHI, PURCHASES 5000 COMPRESSORS A YEAR AT RS.8,000 EACH. ORDERING COSTS ARE RS. 500 AND ANNUAL CARRYING COSTS ARE 20 % OF THE PURCHASE PRICE. COMPUTE THE OPTIMAL PRICE AND THE TOTAL ANNUAL COST OF ORDERING AND CARRYING THE INVENTORY.

EXAMPLE (IN TERMS OF PERCENTAGE)

- **DATA**

$$\blacklozenge D = \text{DEMAND} = 5,000$$

$$\blacklozenge S = \text{ORDERING} = \text{RS. } 500$$

$$\blacklozenge H = \text{HOLDING/CARRYING COST} = 0.2 \times 8,000 = \text{RS. } 1600$$

EXAMPLE 3 (IN TERMS OF PERCENTAGE)

- $Q_0 = \text{SQ ROOT OF } (2(5,000)(500)/(1600))$

- $= 55.9 = 56 \text{ COMPRESSORS}$

- $TC = \text{CARRYING COSTS} + \text{ORDERING COSTS}$

$$= Q_0/2 (H) + D/Q_0 (S)$$

$$= 56/2 (1600) + 5000/56 (500)$$

$$= 28 (1600) + 44,643$$



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=44,800+44,643=RS. 89,443

ECONOMIC PRODUCTION QUANTITY (EPQ)

- PRODUCTION DONE IN BATCHES OR LOTS
- CAPACITY TO PRODUCE A PART EXCEEDS THE PART'S USAGE OR DEMAND RATE.
- ASSUMPTIONS OF EPQ ARE SIMILAR TO EOQ EXCEPT ORDERS ARE RECEIVED INCREMENTALLY DURING PRODUCTION.

ECONOMIC PRODUCTION QUANTITY

ECONOMIC PRODUCTION QUANTITY ASSUMPTIONS

1. ONLY ONE ITEM IS INVOLVED
2. ANNUAL DEMAND IS KNOWN
3. USAGE RATE IS CONSTANT
4. USAGE OCCURS CONTINUOUSLY
5. PRODUCTION RATE IS CONSTANT
6. LEAD TIME DOES NOT VARY
7. NO QUANTITY DISCOUNTS
8. THE BASIC EOQ MODEL ASSUMES THAT EACH ORDER IS DELIVERED AT A SINGLE POINT IN TIME.
9. IF THE FIRM IS THE PRODUCER AND USER, PRACTICAL EXAMPLES INDICATE THAT INVENTORIES ARE REPLENISHED OVER TIME AND NOT INSTANTANEOUSLY.
10. IF USAGE AND PRODUCTION (DELIVERY) RATES ARE EQUAL, THEN THERE IS NO BUILDUP OF INVENTORY.
11. SET UP COSTS IN A WAY OUR SIMILAR TO ORDERING COSTS BECAUSE THEY ARE INDEPENDENT OF LOT SIZE.
12. THE LARGER THE RUN SIZE, THE FEWER THE NUMBER OF RUNS NEEDED AND HENCE LOWER THE ANNUAL SETUP.
13. THE NUMBER OF RUNS IS D/Q AND THE ANNUAL SETUP COST IS EQUAL TO THE NUMBER OF RUNS PER YEAR TIMES THE COST PER RUN (D/Q)S.
14. TOTAL COST IS
15. $TC_{MIN} = \text{CARRYING COST} + \text{SETUP COST}$
16. $= (I_{MAX}/2)H + (D/Q_0)S$ WHERE I_{MAX} = MAXIMUM INVENTORY

ECONOMIC RUN SIZE

ECONOMIC PRODUCTION QUANTITY ASSUMPTIONS

- WHERE P = PRODUCTION RATE
- U = USAGE RATE
- THE RUN TIME (THE PRODUCTION PHASE OF THE CYCLE) IS A FUNCTION OF THE RUN SIZE AND PRODUCTION RATE



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RUN TIME = Q_0/P

THE MAXIMUM AND AVERAGE INVENTORY LEVELS ARE

$I_{MAX} = Q_0/P (P-U)$

$I_{AVERAGE} = I_{MAX}/2$

EXAMPLE (ECONOMIC RUN SIZE)

QUANTITY DISCOUNT

- PRICE REDUCTIONS FOR LARGE ORDERS ARE CALLED QUANTITY DISCOUNTS.

TOTAL COSTS WITH PURCHASING COST

TOTAL COSTS WITH PD

EXAMPLE

- THE MAINTENANCE DEPARTMENT OF A LARGE CARDIOLOGY HOSPITAL IN ISLAMABAD USES ABOUT 1200 CASES OF CORROSION REMOVAL LIQUID, USED FOR MAINTENANCE OF HOSPITAL. ORDERING COSTS ARE RS 100, CARRYING COST ARE RS 20 PER CASE, AND THE NEW PRICE SCHEDULE INDICATES THAT

EXAMPLE

ORDERS OF LESS THAN 50 CASES WILL COST RS 1250 PER CASE, 50 TO 79 CASES WILL COST RS 1150 PER CASE , 80 TO 99 CASES WILL COST RS 1050 PER CASE AND LARGER COSTS WILL BE RS 1000 PER CASE.

- DETERMINE THE OPTIMAL ORDER QUANTITY AND THE TOTAL COST.

- $D=1200$ CASE.
- $S= RS. 100$ PER CASE
- $H=RS.20$ PER CASE

RANGE	PRICE
◆ 1 TO 49	RS 1250
◆ 50 TO 79	RS 1150
◆ 80 TO 99	RS 1050
◆ 100 OR MORE	RS 1000

EXAMPLE

- COMPUTE THE COMMON EOQ= $SQ \text{ ROOT } (2DS/H)$

= $SQ \text{ ROOT } (2 \times 100 \times 1200/20)$

= $SQ \text{ ROOT } (12000)$



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=109.5=110 CASES WHICH WOULD BE BROUGHT AT 1000 PER ORDER
THE TOTAL COST TO PURCHASE 1200 CASES PER YEAR WOULD BE

TC= CARRYING COST+ ORDER COST+ PURCHASE COST

$= (Q/2)H + (D/Q_0)S + PD$

$= (110/2)20 + (1200/110)100 + 1200 \times 1000$

$= 1100 + 1091 + 12000,000$

=RS. 1,202,191

WHEN TO REORDER WITH EOQ ORDERING

REORDER POINT - WHEN THE QUANTITY ON HAND OF AN ITEM DROPS TO THIS AMOUNT, THE ITEM IS REORDERED.

SAFETY STOCK - STOCK THAT IS HELD IN EXCESS OF EXPECTED DEMAND DUE TO VARIABLE DEMAND RATE AND/OR LEAD TIME.

SERVICE LEVEL - PROBABILITY THAT DEMAND WILL NOT EXCEED SUPPLY DURING LEAD TIME.

EXAMPLE

1. AN APARTMENT COMPLEX IN QUETTA REQUIRES WATER FOR ITS HOME USE.
2. USAGE= 2 BARRELS A DAY
3. LEAD TIME= 5 DAYS
4. ROP= USAGE X LEAD TIME
5. = 2 BARRELS A DAY X 7 = 14 BARRELS

DETERMINANTS OF THE REORDER POINT

1. THE RATE OF DEMAND
2. THE LEAD TIME
3. STOCK OUT RISK (SAFETY STOCK)
4. DEMAND AND/OR LEAD TIME VARIABILITY

EXAMPLE

- AN OWNER OF A MONTESSORI EQUIPMENT FIRM IN KARACHI, DETERMINED FROM HISTORICAL RECORDS THAT DEMAND FOR WOOD REQUIRED FOR MONTESSORI EQUIPMENT AVERAGES 25 TONES PER ANUM. HIS OPERATIONS MANAGEMENT EXPERTISE ALLOWED HIM TO DETERMINE THE DEMAND DURING LEAD THAT COULD



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BE DESCRIBED BY A NORMAL DISTRIBUTION THAT HAS A MEAN OF 25 TONS AND A STANDARD DEVIATION OF 2.5 TONS.

FIXED-ORDER-INTERVAL MODEL

- ORDERS ARE PLACED AT FIXED TIME INTERVALS.
- ORDER QUANTITY FOR NEXT INTERVAL?
- SUPPLIERS MIGHT ENCOURAGE FIXED INTERVALS.
- MAY REQUIRE ONLY PERIODIC CHECKS OF INVENTORY LEVELS.
- RISK OF STOCK OUT.

CHAPTER NO = 34

MRP

- MATERIAL REQUIREMENTS PLANNING (MRP): COMPUTER-BASED INFORMATION SYSTEM THAT TRANSLATES MASTER SCHEDULE REQUIREMENTS FOR END ITEMS INTO TIME-PHASED REQUIREMENTS FOR SUBASSEMBLIES, COMPONENTS, AND RAW MATERIALS.

MRP PROCESS

- THREE INPUTS
 - MASTER SCHEDULE PLAN
 - BILL OF MATERIALS
 - INVENTOR RECORDS

CUMULATIVE LEAD TIME

- CUMULATIVE LEAD TIME: THE SUM OF THE LEAD TIMES THAT SEQUENTIAL PHASES OF A PROCESS REQUIRE, FROM ORDERING OF PARTS OR RAW MATERIALS TO COMPLETION OF FINAL ASSEMBLY.

PRODUCT STRUCTURE TREE

MRP PROCESSING

- GROSS REQUIREMENTS
- SCHEDULE RECEIPTS
- PROJECTED ON HAND
- NET REQUIREMENTS
- PLANNED-ORDER RECEIPTS
- PLANNED-ORDER RELEASES

OTHER CONSIDERATIONS

- **SAFETY STOCK**
 - INVENTORY SYSTEMS WITH INDEPENDENT DEMAND SHOULD NOT REQUIRE SAFETY STOCK BELOW THE END ITEM LEVEL.



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OTHER CONSIDERATIONS

- LOT SIZING IS THE CHOOSING OF A LOT SIZE FOR ORDERING OR PRODUCTION.
- FOR DEPENDANT DEMAND, MANAGERS HAVE VARIETY OF METHODS AVAILABLE AS THERE IS NO CLEAR CUT ADVANTAGE ASSOCIATED WITH ANYONE PARTICULAR METHOD. THEY CAN USE
 - LOT FOR LOT ORDERING.
 - ECONOMIC ORDER QUANTITY MODEL
 - FIXED PERIOD ORDERING
 - PART PERIOD MODEL.
- **LOT-FOR-LOT ORDERING**
 - SIMPLEST METHOD
 - THE ORDER OR RUN SIZE FOR EACH PERIOD IS SET EQUAL TO DEMAND FOR THAT PERIOD.
 - ELIMINATES HOLDING COSTS FOR PARTS CARRIED OVER TO OTHER PERIODS.
 - MINIMIZES INVESTMENT IN INVENTORY.
 - IT INVOLVES DIFFERENT ORDER SIZES (CAN NOT MAKE USE OF FIXED ORDER SIZE , STANDARD CONTAINERS AND STANDARDIZED PROCEDURES) AND REQUIRES A NEW SETUP FOR EACH RUN.
 - IF SET UP COSTS CAN BE REDUCED THIS WOULD BE IDEAL TO APPROXIMATE THE MINIMUM COST LOT SIZE.
- ◆ ECONOMIC ORDER QUANTITY MODELS TENDS TO BE LESS IDEAL.
- ◆ FIXED PERIOD ORDERING PROVIDES COVERAGE FOR SOME PREDETERMINED NUMBER OF PERIODS.
- RULE OF THUMB BEING TO ORDER TO COVER A TWO PERIOD INTERVAL.
 - PART-PERIOD MODEL REPRESENTS AN ATTEMPT TO BALANCE SET UP AND HOLDING COSTS.
 - THE PART PERIOD TERM REFERS TO HOLDING PART OR PARTS OVER A NUMBER OF PERIODS, E.G IF A BUSINESS HOLDS 20 PARTS FOR 3 PERIODS THIS WOULD BE A $20 \times 3 = 60$ PARTS PERIOD.
 - ECONOMIC PART PERIOD (EPP) IS THE RATIO OF SETUP COSTS TO THE COST OF HOLD A UNIT FOR ONE PERIOD.
 - PART-PERIOD MODEL
 - VARIOUS ORDER SIZES ARE EXAMINED FOR PLANNING HORIZON AND EACH ONE'S NUMBER OF PART PERIOD IS DETERMINED.
 - THE ONE THAT IS CLOSET TO THE EPP IS SELECTED AS THE BEST LOT SIZE.
- EXAMPLE
- USE PART-PERIOD METHOD TO DETERMINE ORDER SIZES FOR THE DEMAND SCHEDULE OF A MONTESSORI EQUIPMENT MANUFACTURER IN KARACHI. THE SETUP COST IS RS. 8000 PER RUN FOR THIS ITEM AND UNIT HOLDING COST IS RS. 100 PER PERIOD.
- EXAMPLE
- STEP I : FIRST COMPUTE EPP WHICH IS $8000/100=80$



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CHAPTER NO = 35

MRP

- ◆ **MATERIAL REQUIREMENTS PLANNING (MRP)** IS A SOFTWARE BASED PRODUCTION PLANNING AND INVENTORY CONTROL SYSTEM USED TO MANAGE MANUFACTURING PROCESSES.
- ◆ AN MRP SYSTEM IS INTENDED TO SIMULTANEOUSLY MEET THREE OBJECTIVES:
 - ◆ ENSURE MATERIALS AND PRODUCTS ARE AVAILABLE FOR PRODUCTION AND DELIVERY TO CUSTOMERS.
 - ◆ MAINTAIN THE LOWEST POSSIBLE LEVEL OF INVENTORY.
 - ◆ PLAN MANUFACTURING ACTIVITIES, DELIVERY SCHEDULES AND PURCHASING ACTIVITIES.

MPR PROCESSING

GROSS REQUIREMENTS

- ◆ TOTAL EXPECTED DEMAND.

SCHEDULED RECEIPTS

- ◆ OPEN ORDERS SCHEDULED TO ARRIVE.

PLANNED ON HAND

- ◆ EXPECTED INVENTORY ON HAND AT THE BEGINNING OF EACH TIME PERIOD.

MPR PROCESSING

NET REQUIREMENTS

- ◆ ACTUAL AMOUNT NEEDED IN EACH TIME PERIOD.

PLANNED-ORDER RECEIPTS

- ◆ QUANTITY EXPECTED TO BE RECEIVED AT THE BEGINNING OF THE PERIOD.
- ◆ OFFSET BY LEAD TIME.

PLANNED-ORDER RELEASES

- ◆ PLANNED AMOUNT TO ORDER IN EACH TIME PERIOD.

UPDATING THE SYSTEM

REGENERATIVE SYSTEM

- ◆ UPDATES MRP RECORDS PERIODICALLY.



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NET-CHANGE SYSTEM

- ◆ UPDATES MPR RECORDS CONTINUOUSLY.

MRP OUTPUTS

1. PLANNED ORDERS - SCHEDULE INDICATING THE AMOUNT AND TIMING OF FUTURE ORDERS.
2. ORDER RELEASES - AUTHORIZATION FOR THE EXECUTION OF PLANNED ORDERS.
3. CHANGES - REVISIONS OF DUE DATES OR ORDER QUANTITIES, OR CANCELLATIONS OF ORDERS.

MRP SECONDARY REPORTS

1. PERFORMANCE-CONTROL REPORTS
2. PLANNING REPORTS
3. EXCEPTION REPORTS

REQUIREMENTS OF MRP

COMPUTER AND NECESSARY SOFTWARE

ACCURATE AND UP-TO-DATE

- MASTER SCHEDULES
- BILLS OF MATERIALS
- INVENTORY RECORDS

INTEGRITY OF DATA

BILL OF MATERIALS

A LISTING OF ALL RAW MATERIALS, PARTS, SUBASSEMBLIES, AND ASSEMBLIES NEEDED TO PRODUCE ONE UNIT

PRODUCT STRUCTURE TREE FOR AN ITEM X

CAPACITY PLANNING

CAPACITY REQUIREMENTS PLANNING: THE PROCESS OF DETERMINING SHORT-RANGE CAPACITY. REQUIREMENTS.

THE NECESSARY INPUTS ARE:

- ◆ PLANNED ORDER RELEASES FOR MRP
- ◆ THE CURRENT SHOP LOAD
- ◆ ROUTING INFORMATION
- ◆ JOB TIMES



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OUTPUTS INCLUDE LOAD REPORTS FOR EACH WORK CENTER.

CAPACITY PLANNING

LOAD REPORTS: DEPARTMENT OR WORK CENTER REPORTS THAT COMPARE KNOWN AND EXPECTED FUTURE CAPACITY REQUIREMENTS WITH PROJECTED CAPACITY AVAILABILITY.

AN ORGANIZATION GENERATES A MASTER SCHEDULE IN TERMS OF WHAT IS NEEDED AND NOT IN TERMS OF WHAT IS POSSIBLE OR AVAILABLE.

CAPACITY PLANNING

THE INITIAL SCHEDULE MAY OR MAY NOT BE FEASIBLE GIVEN THE LIMITS OF PRODUCTION OR AVAILABILITY OF MATERIALS.

TIME FENCES: SERIES OF TIME INTERVALS DURING WHICH ORDER CHANGES ARE ALLOWED OR RESTRICTED.

- AN OVER VIEW OF THE CAPACITY PLANNING PROCESS.
- THE MASTER SCHEDULE IS FIRST TESTED FOR FEASIBILITY AND POSSIBLY ADJUSTED BEFORE IT BECOMES PERMANENT.
- THE PROPOSED SCHEDULE IS PROCESSED USING MRP TO ASCERTAIN THE MATERIALS REQUIREMENTS THE SCHEDULE WOULD GENERATE.
- THESE ARE THEN TRANSLATED INTO CAPACITY REQUIREMENTS IN THE FORM OF LOAD REPORTS FOR EACH DEPARTMENTS OR WORK CENTERS.

MRP II

1. **MANUFACTURING RESOURCE PLANNING (MRP II)** IS DEFINED AND ACCEPTED BY PROFESSIONALS AS A METHOD FOR THE EFFECTIVE PLANNING OF ALL RESOURCES OF A MANUFACTURING COMPANY.
2. IDEALLY, IT SHOULD ANSWER OPERATIONAL PLANNING IN UNITS, FINANCIAL PLANNING IN RUPEES, AND HAS A SIMULATION CAPABILITY TO ANSWER "WHAT-IF" QUESTIONS. AND EXTENSION OF CLOSED-LOOP [MRP](#).
3. THIS IS NOT EXCLUSIVELY A SOFTWARE FUNCTION, BUT A MERGER OF PEOPLE SKILLS, DEDICATION TO DATA BASE ACCURACY, AND COMPUTER RESOURCES. IT IS A TOTAL COMPANY MANAGEMENT CONCEPT FOR USING HUMAN RESOURCES MORE PRODUCTIVELY.
4. [ACCOUNTING](#) AND [FINANCE](#) DEPARTMENTS GET ACCURATE [COSTS](#), AND PREDICT [CASH FLOW](#). [ENGINEERING](#) DEPT MUST AUDIT AND FEED IN ACCURATE DATA ON PRODUCTION METHODS IN DETAIL, SUCH AS:
 - ◆ [BILL OF MATERIAL](#)
 - ◆ [QUALITY CONTROL](#)



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ERP

◆ ENTERPRISE RESOURCE PLANNING (ERP):

- ◆ INTEGRATION OF FINANCIAL, MANUFACTURING, AND HUMAN RESOURCES ON A SINGLE COMPUTER SYSTEM.

ERP STRATEGY CONSIDERATIONS

1. HIGH INITIAL COST
2. TRAINING
3. HIGH COST TO MAINTAIN
4. FUTURE UPGRADES

CHAPTER NO = 36

JIT/LEAN PRODUCTION

LEAN MANUFACTURING: IS A MANAGEMENT PHILOSOPHY FOCUSING ON REDUCTION OF THE SEVEN WASTES.

- OVER-PRODUCTION (CAPACITY EXCEEDING DEMAND)
- WAITING TIME
- TRANSPORTATION
- PROCESSING
- COSTS
- INVENTORY
- MOTION (LACK OF COORDINATION OF BODY MOVEMENTS)

JIT/LEAN PRODUCTION FEATURES

1. BY ELIMINATING WASTE (MUDA), QUALITY IS IMPROVED, PRODUCTION TIME IS REDUCED AND COST IS REDUCED.
2. "PULL" PRODUCTION (BY MEANS OF KANBAN).

JIT/LEAN PRODUCTION

1. WHILE SOME BELIEVE THAT LEAN MANUFACTURING IS A SET OF PROBLEM SOLVING TOOLS.
2. IN ADDITION, EXPERTS IN THIS FIELD BELIEVE THAT PHILOSOPHY-BASED LEAN MANUFACTURING STRATEGY IS THE MOST EFFECTIVE WAY TO LAUNCH AND SUSTAIN LEAN ACTIVITIES.

KEY LEAN MANUFACTURING PRINCIPLES INCLUDE:

- PERFECT FIRST-TIME QUALITY - QUEST FOR ZERO DEFECTS
- WASTE MINIMIZATION



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- **CONTINUOUS IMPROVEMENT**

- **PULL PROCESSING:** PRODUCTS ARE PULLED FROM THE CONSUMER END, NOT PUSHED FROM THE PRODUCTION END.
- **FLEXIBILITY**
- **BUILDING AND MAINTAINING A LONG TERM RELATIONSHIP WITH SUPPLIERS THROUGH COLLABORATIVE RISK SHARING, COST SHARING AND INFORMATION SHARING ARRANGEMENTS.**

APPLICATIONS OF LEAN MANUFACTURING

- **LEAN HEALTHCARE SYSTEMS**
- **LEAN SOFTWARE MANUFACTURING**
- **SYSTEMS ENGINEERING**
- **LEAN SYSTEMS IN DEFENSE INDUSTRY**

GENERIC STRATEGY FOR IMPLEMENTATION OF A LEAN PROGRAM

- **SENIOR MANAGEMENT** TO AGREE AND DISCUSS THEIR LEAN VISION.
- **MANAGEMENT BRAINSTORM** TO IDENTIFY PROJECT LEADER AND SET OBJECTIVES.
- **COMMUNICATE PLAN AND VISION** TO THE WORKFORCE.
- **ASK FOR VOLUNTEERS** TO FORM THE LEAN IMPLEMENTATION TEAM.
- **APPOINT MEMBERS** OF THE LEAN MANUFACTURING IMPLEMENTATION TEAM.
- **TRAIN THE IMPLEMENTATION TEAM** IN THE VARIOUS LEAN TOOLS.

CHAPTER NO = 37

CHARACTERISTICS OF LEAN SYSTEMS: JUST-IN-TIME

CONTINUOUS

IMPROVEMENT

WITH LEAN SYSTEMS

LEAN SYSTEMS IN SERVICES

OPERATIONAL BENEFITS

IMPLEMENTATION ISSUES

1. **ORGANIZATIONAL CONSIDERATIONS**
 - **HUMAN COST OF JIT SYSTEMS**
 - **COOPERATION AND TRUST**
 - **REWARD SYSTEMS AND LABOR CLASSIFICATIONS**
2. **PROCESS CONSIDERATIONS**
3. **INVENTORY AND SCHEDULING**
 - **MPS STABILITY**
 - **SETUPS**
 - **PURCHASING AND LOGISTICS**



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KANBAN PRODUCTION CONTROL SYSTEM

- ◆ **KANBAN**: CARD OR OTHER DEVICE THAT COMMUNICATES DEMAND FOR WORK OR MATERIALS FROM THE PRECEDING STATION.
- ◆ KANBAN IS THE JAPANESE WORD MEANING “SIGNAL” OR “VISIBLE RECORD”.
- ◆ PAPERLESS PRODUCTION CONTROL SYSTEM.
- ◆ AUTHORITY TO PULL, OR PRODUCE COMES. FROM A DOWNSTREAM PROCESS.

KANBAN FORMULA

KANBANS

- ◆ PARTS' MOVEMENT AUTHORIZATION

N= # CARDS

D= USAGE

T = WAIT + PROCESS TIME

X = EFFICIENCY RATING

C = BIN CAPACITY

EXAMPLE

A COMPANY IN GUJRANWALA IS MAKING RUBBER TYRES AND TUBES. THE OPERATIONS MANAGER HAS JUST COMPLETED HIS MBA FROM VU AND HAS OBSERVED THAT THE FACTORY HAS AN INEFFICIENT MACHINE GROUP. HE RECORDS THAT THE DAILY DEMAND FOR 21" TUBE IS 1000 UNITS. THE AVERAGE WAITING TIME FOR A CONTAINER OF THE SAME PART IS 0.5 DAY. THE PROCESSING TIME FOR THE TYRE TUBE CONTAINER IS 0.25 DAY. A CONTAINER CAN HOLD 500 UNITS, CURRENTLY THERE ARE 20 CONTAINERS FOR THIS ITEM.

CALCULATE

1. WHAT IS THE VALUE OF POLICY VARIABLE ALPHA?
2. WHAT IS THE TOTAL PLANNED INVENTORY (WORK IN PROCESS AND FINISHED GOODS) FOR THE TYRE TUBE?
3. SUPPOSE THAT THE POLICY VARIABLE ALPHA IS 0, HOW MANY CONTAINERS WOULD BE NEEDED? WHAT IS THE EFFECT OF POLICY VARIABLE IN THIS PROBLEM?

SOLUTION

- WE USE THE EQUATION AND SUBSTITUTE VALUES
- WE USE THE EQUATION AND SUBSTITUTE VALUES



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- THEN WITH 20 CONTAINERS IN THE SYSTEM AND SINCE EACH CONTAINER CAN HOLD 500 UNITS, THE TOTAL PLANNED INVENTORY IS $20 (500) = 10,000$ UNITS
- IF ALPHA IS 0 THEN ON SUBSTITUTING VALUES WE HAVE

SINGLE-CARD KANBAN SYSTEM

CHAPTER NO = 38

JUST-IN-TIME (JIT) DEFINED

- JIT CAN BE DEFINED AS AN INTEGRATED SET OF ACTIVITIES DESIGNED TO ACHIEVE HIGH-VOLUME PRODUCTION USING MINIMAL INVENTORIES (RAW MATERIALS, WORK IN PROCESS, AND FINISHED GOODS).
- JIT ALSO INVOLVES THE ELIMINATION OF WASTE IN PRODUCTION EFFORT.
- JIT ALSO INVOLVES THE TIMING OF PRODUCTION RESOURCES (I.E., PARTS ARRIVE AT THE NEXT WORKSTATION “JUST IN TIME”).

JIT/LEAN PRODUCTION

1. JUST-IN-TIME (JIT): A HIGHLY COORDINATED PROCESSING SYSTEM IN WHICH GOODS MOVE THROUGH THE SYSTEM, AND SERVICES ARE PERFORMED, JUST AS THEY ARE NEEDED.
2. JIT $\leftrightarrow$ LEAN PRODUCTION
3. JIT $\rightarrow$ PULL (DEMAND) SYSTEM
4. JIT OPERATES WITH VERY LITTLE “FAT”

GOAL OF JIT

THE ULTIMATE GOAL OF JIT IS A BALANCED SYSTEM.

ACHIEVES A SMOOTH, RAPID FLOW OF MATERIALS THROUGH THE SYSTEM.

SUMMARY JIT GOALS AND BUILDING BLOCKS

SECONDARY GOALS

- ELIMINATE DISRUPTIONS
- MAKE SYSTEM FLEXIBLE
- ELIMINATE WASTE, ESPECIALLY EXCESS INVENTORY

BIG VS. LITTLE JIT

- BIG JIT – BROAD FOCUS (INCLUDES INTERNAL AS WELL AS EXTERNAL)
 1. VENDOR RELATIONS
 2. HUMAN RELATIONS
 3. TECHNOLOGY MANAGEMENT
 4. MATERIALS AND INVENTORY MANAGEMENT
- LITTLE JIT – NARROW FOCUS INTERNAL TO ORGANIZATION



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1. SCHEDULING MATERIALS
2. SCHEDULING SERVICES OF PRODUCTION

JIT BUILDING BLOCKS

1. PRODUCT DESIGN
2. PROCESS DESIGN
3. PERSONNEL/ORGANIZATIONAL ELEMENTS
4. MANUFACTURING PLANNING AND CONTROL

THE LEAN PRODUCTION SYSTEM

BASED ON TWO PHILOSOPHIES:

1. ELIMINATION OF WASTE
2. RESPECT FOR PEOPLE

TRANSITIONING TO A JIT SYSTEM

1. GET TOP MANAGEMENT COMMITMENT
2. DECIDE WHICH PARTS NEED MOST EFFORT
3. OBTAIN SUPPORT OF WORKERS
4. TRY TO REDUCE SCRAP MATERIAL
5. START BY TRYING TO REDUCE SETUP TIMES
6. INCORPORATE QUALITY
7. GRADUALLY CONVERT OPERATIONS
8. CONVERT SUPPLIERS TO JIT
9. PREPARE FOR OBSTACLES

OBSTACLES TO CONVERSION

1. MANAGEMENT MAY NOT BE COMMITTED
2. WORKERS/MANAGEMENT MAY NOT BE COOPERATIVE
3. SUPPLIERS RESIST

MAY

JIT IN SERVICES

1. ELIMINATE DISRUPTIONS
2. MAKE SYSTEM FLEXIBLE
3. REDUCE SETUP AND LEAD TIMES
4. ELIMINATE WASTE
5. SIMPLIFY THE PROCESS



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- ◆ THE BASIC GOAL OF THE DEMAND FLOW TECHNOLOGY IN THE SERVICE ORGANIZATION IS TO PROVIDE OPTIMUM RESPONSE TO THE CUSTOMER WITH THE HIGHEST QUALITY SERVICE AND LOWEST POSSIBLE COST.

JIT IN SERVICES (EXAMPLES)

1. UPGRADE QUALITY
2. CLARIFY PROCESS FLOWS
3. DEVELOP SUPPLIER NETWORKS
4. INTRODUCE DEMAND-PULL SCHEDULING
5. REORGANIZE PHYSICAL CONFIGURATION
6. ELIMINATE UNNECESSARY ACTIVITIES
7. LEVEL THE FACILITY LOAD

JIT II

JIT II: A SUPPLIER REPRESENTATIVE WORKS RIGHT IN THE COMPANY'S PLANT, MAKING SURE THERE IS AN APPROPRIATE SUPPLY ON HAND.

BENEFITS OF JIT SYSTEMS

- REDUCED INVENTORY LEVELS
- HIGH QUALITY
- FLEXIBILITY
- REDUCED LEAD TIMES
- INCREASED PRODUCTIVITY

CHAPTER NO = 39

SUPPLY CHAIN MANAGEMENT

SUPPLY CHAIN: THE SEQUENCE OF ORGANIZATION'S FACILITIES, FUNCTIONS, AND ACTIVITIES THAT ARE INVOLVED IN PRODUCING AND DELIVERING A PRODUCT OR SERVICE.

NEED FOR SUPPLY CHAIN MANAGEMENT

1. IMPROVE OPERATIONS
2. INCREASING LEVELS OF OUTSOURCING
3. INCREASING TRANSPORTATION COSTS
4. COMPETITIVE PRESSURES
5. INCREASING GLOBALIZATION
6. INCREASING IMPORTANCE OF E-COMMERCE
7. COMPLEXITY OF SUPPLY CHAINS
8. MANAGE INVENTORIES



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BENEFITS OF SUPPLY CHAIN MANAGEMENT

1. LOWER INVENTORIES
2. HIGHER PRODUCTIVITY
3. GREATER AGILITY
4. SHORTER LEAD TIMES
5. HIGHER PROFITS
6. GREATER CUSTOMER LOYALTY

ELEMENTS OF SUPPLY CHAIN MANAGEMENT

LOGISTICS

1. THE GOAL OF LOGISTIC WORK IS TO MANAGE THE COMPLETION OF [PROJECT LIFE CYCLES](#), [SUPPLY CHAINS](#) AND RESULTANT EFFICIENCIES.
2. LOGISTICS IS THE ART AND SCIENCE OF MANAGING AND CONTROLLING THE FLOW OF GOODS, ENERGY, INFORMATION AND OTHER RESOURCES LIKE [PRODUCTS](#), [SERVICES](#), AND PEOPLE, FROM THE SOURCE OF PRODUCTION TO THE MARKETPLACE.
3. REFERS TO THE MOVEMENT OF MATERIALS AND INFORMATION WITHIN A FACILITY AND TO INCOMING AND OUTGOING SHIPMENTS OF GOODS AND MATERIALS IN A SUPPLY CHAIN.
4. LOGISTICS IS THE TIME RELATED POSITIONING OF RESOURCES."
5. AS SUCH, LOGISTICS IS COMMONLY SEEN AS A BRANCH OF [ENGINEERING](#) WHICH CREATES "PEOPLE SYSTEMS" RATHER THAN "MACHINE SYSTEMS"
6. IT INVOLVES THE INTEGRATION OF INFORMATION, [TRANSPORTATION](#), [INVENTORY](#), [WAREHOUSING](#), MATERIAL HANDLING, AND [PACKAGING](#).

LOGISTICS: EVALUATING SHIPPING ALTERNATIVES

LOGISTICS EXAMPLE

DISTRIBUTION REQUIREMENTS PLANNING

1. [DISTRIBUTION REQUIREMENTS PLANNING](#) (DRP) IS A SYSTEM FOR INVENTORY MANAGEMENT AND DISTRIBUTION PLANNING.
2. EXTENDS THE CONCEPTS OF MRPII.

USES OF DRP

MANAGEMENT USES DRP TO PLAN AND COORDINATE:

1. TRANSPORTATION
2. WAREHOUSING
3. WORKERS
4. EQUIPMENT
5. FINANCIAL FLOWS



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ELECTRONIC DATA INTERCHANGE

EDI – THE DIRECT TRANSMISSION OF INTER-ORGANIZATIONAL TRANSACTIONS, COMPUTER-TO-COMPUTER, INCLUDING PURCHASE ORDERS, SHIPPING NOTICES, AND DEBIT OR CREDIT MEMOS.

ELECTRONIC DATA INTERCHANGE

1. INCREASED PRODUCTIVITY
2. REDUCTION OF PAPERWORK
3. LEAD TIME AND INVENTORY REDUCTION
4. FACILITATION OF JUST-IN-TIME SYSTEMS
5. ELECTRONIC TRANSFER OF FUNDS
6. IMPROVED CONTROL OF OPERATIONS
7. REDUCTION IN CLERICAL LABOR
8. INCREASED ACCURACY

EFFICIENT CONSUMER RESPONSE

EFFICIENT CONSUMER RESPONSE (ECR) IS A SUPPLY CHAIN MANAGEMENT INITIATIVE SPECIFIC TO THE FOOD INDUSTRY.

- ◆ REFLECTS COMPANIES' EFFORTS TO ACHIEVE QUICK RESPONSE USING EDI AND BAR CODES.

E-COMMERCE

THE USE OF ELECTRONIC TECHNOLOGY TO FACILITATE BUSINESS TRANSACTIONS.

SUCCESSFUL SUPPLY CHAIN

1. TRUST AMONG TRADING PARTNERS
2. EFFECTIVE COMMUNICATIONS
3. SUPPLY CHAIN VISIBILITY
4. EVENT-MANAGEMENT CAPABILITY
 - ◆ THE ABILITY TO DETECT AND RESPOND TO UNPLANNED EVENTS
5. PERFORMANCE METRICS

CHAPTER NO = 40

SUPPLY CHAIN OPERATIONAL REFERENCE (SCOR) METRICS

CPFR

COLLABORATIVE PLANNING, FORECASTING AND REPLENISHMENT.



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1. FOCUSES ON INFORMATION SHARING AMONG TRADING PARTNERS.
2. FORECASTS CAN BE FROZEN AND THEN CONVERTED INTO A SHIPPING PLAN.
3. ELIMINATES TYPICAL ORDER PROCESSING.

CPFR PROCESS

STEP 1 – FRONT-END AGREEMENT

STEP 2 – JOINT BUSINESS PLAN

STEPS 3-5 – SALES FORECAST

STEPS 6-8 – ORDER FORECAST

COLLABORATION

STEP 9 – ORDER GENERATION/DELIVERY EXECUTION

CREATING AN EFFECTIVE SUPPLY CHAIN

1. DEVELOP STRATEGIC OBJECTIVES AND TACTICS.
2. INTEGRATE AND COORDINATE ACTIVITIES IN THE INTERNAL SUPPLY CHAIN.
3. COORDINATE ACTIVITIES WITH SUPPLIERS WITH CUSTOMERS.
4. COORDINATE PLANNING AND EXECUTION ACROSS THE SUPPLY CHAIN.
5. FORM STRATEGIC PARTNERSHIPS.

SUPPLY CHAIN PERFORMANCE DRIVERS

1. QUALITY
2. COST
3. FLEXIBILITY
4. VELOCITY
5. CUSTOMER SERVICE

VELOCITY

INVENTORY VELOCITY

- ◆ THE RATE AT WHICH INVENTORY(MATERIAL) GOES THROUGH THE SUPPLY CHAIN.

INFORMATION VELOCITY

- ◆ THE RATE AT WHICH INFORMATION IS COMMUNICATED IN A SUPPLY CHAIN.

CHALLENGES

1. BARRIERS TO INTEGRATION OF ORGANIZATIONS
2. GETTING TOP MANAGEMENT ON BOARD
3. DEALING WITH TRADE-OFFS
4. SMALL BUSINESSES
5. VARIABILITY AND UNCERTAINTY



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6. LONG LEAD TIMES

TRADE-OFFS

- COST-CUSTOMER SERVICE

DISINTERMEDIATION

- LOT-SIZE-INVENTORY

BULLWHIP EFFECT

- INVENTORY-TRANSPORTATION COSTS

CROSS-DOCKING

- LEAD TIME-TRANSPORTATION COSTS
- PRODUCT VARIETY-INVENTORY

DELAYED DIFFERENTIATION

BULLWHIP EFFECT

- ◆ INVENTORIES ARE PROGRESSIVELY LARGER MOVING BACKWARD THROUGH THE SUPPLY CHAIN.

CROSS-DOCKING

- ◆ GOODS ARRIVING AT A WAREHOUSE FROM A SUPPLIER ARE UNLOADED FROM THE SUPPLIER'S TRUCK AND LOADED ONTO OUTBOUND TRUCKS.
- ◆ AVOIDS WAREHOUSE STORAGE.

DELAYED DIFFERENTIATION

- ◆ PRODUCTION OF STANDARD COMPONENTS AND SUBASSEMBLIES, WHICH ARE HELD UNTIL LATE IN THE PROCESS TO ADD DIFFERENTIATING FEATURES.

DISINTERMEDIATION

- ◆ REDUCING ONE OR MORE STEPS IN A SUPPLY CHAIN BY CUTTING OUT ONE OR MORE INTERMEDIARIES.

SUPPLY CHAIN ISSUES

SUPPLY CHAIN BENEFITS AND DRAWBACKS

SUPPLIER PARTNERSHIPS

- IDEAS FROM SUPPLIERS COULD LEAD TO IMPROVED COMPETITIVENESS
 - REDUCE COST OF MAKING THE PURCHASE



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- INCREASE REVENUES
- ENHANCE PERFORMANCE

CRITICAL ISSUES

- TECHNOLOGY MANAGEMENT
- 1. BENEFITS
- 2. RISKS
- 3. STRATEGIC IMPORTANCE
- 4. QUALITY
- 5. COST
- 6. AGILITY
- 7. CUSTOMER SERVICE
- 8. COMPETITIVE ADVANTAGE

OPERATIONS STRATEGY

- SCM CREATES VALUE THROUGH CHANGES IN TIME, LOCATION AND QUANTITY.
- SCM CREATES COMPETITIVE ADVANTAGE BY INTEGRATING AND STREAMLINING THE DIVERSE RANGE OF ACTIVITIES THAT INVOLVE PURCHASING, INTERNAL INVENTORY, TRANSFERS AND PHYSICAL DISTRIBUTION.

CHAPTER NO = 41

SCHEDULING

1. **SCHEDULING** IS AN IMPORTANT TOOL FOR MANUFACTURING AND SERVICE INDUSTRIES, WHERE IT CAN HAVE A MAJOR IMPACT ON THE PRODUCTIVITY OF A PROCESS.
2. IN MANUFACTURING, THE PURPOSE OF SCHEDULING IS TO MINIMIZE THE PRODUCTION TIME AND COSTS, BY TELLING A PRODUCTION FACILITY WHAT TO MAKE, WHEN, WITH WHICH STAFF, AND ON WHICH EQUIPMENT.
3. SCHEDULING IN SERVICE INDUSTRIES, SUCH AS AIRLINES AND PUBLIC TRANSPORT, AIM TO MAXIMIZE THE EFFICIENCY OF THE OPERATION AND REDUCE COSTS.

SCHEDULING

1. BACKWARD SCHEDULING IS PLANNING THE TASKS FROM THE DUE DATE TO DETERMINE THE START DATE AND/OR ANY CHANGES IN CAPACITY REQUIRED.
2. FORWARD SCHEDULING IS PLANNING THE TASKS FROM THE START DATE TO DETERMINE THE SHIPPING DATE OR THE DUE DATE.

THE BENEFITS OF PRODUCTION SCHEDULING INCLUDE:

1. PROCESS CHANGE-OVER REDUCTION
2. INVENTORY REDUCTION, LEVELING
3. REDUCED SCHEDULING EFFORT



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4. INCREASED PRODUCTION EFFICIENCY
5. LABOR LOAD LEVELING
6. ACCURATE DELIVERY DATE QUOTES
7. REAL TIME INFORMATION
- SCHEDULING: ESTABLISHING THE TIMING OF THE USE OF EQUIPMENT, FACILITIES AND HUMAN ACTIVITIES IN AN ORGANIZATION.
- EFFECTIVE SCHEDULING CAN YIELD:
 - COST SAVINGS
 - INCREASE IN PRODUCTIVITY

HIGH-VOLUME SYSTEMS

FLOW SYSTEM: HIGH-VOLUME SYSTEM WITH STANDARDIZED EQUIPMENT AND ACTIVITIES.

FLOW-SHOP SCHEDULING: SCHEDULING FOR HIGH-VOLUME FLOW SYSTEM.

HIGH-VOLUME SUCCESS FACTORS

1. PROCESS AND PRODUCT DESIGN
2. PREVENTIVE MAINTENANCE
3. RAPID REPAIR WHEN BREAKDOWN OCCURS
4. OPTIMAL PRODUCT MIXES
5. MINIMIZATION OF QUALITY PROBLEMS
6. RELIABILITY AND TIMING OF SUPPLIES

INTERMEDIATE-VOLUME SYSTEMS

1. OUTPUTS ARE BETWEEN STANDARDIZED HIGH-VOLUME SYSTEMS AND MADE-TO-ORDER JOB SHOPS
2. RUN SIZE, TIMING, AND SEQUENCE OF JOBS
3. ECONOMIC RUN SIZE:

SCHEDULING LOW-VOLUME SYSTEMS

- ◆ **LOADING** - ASSIGNMENT OF JOBS TO PROCESS CENTERS.
- ◆ **SEQUENCING** - DETERMINING THE ORDER IN WHICH JOBS WILL BE PROCESSED.
 1. JOB-SHOP SCHEDULING
 2. SCHEDULING FOR LOW-VOLUME SYSTEMS WITH MANY VARIATIONS IN REQUIREMENTS.

GANTT LOAD CHART

- USED AS A VISUAL AID FOR LOADING AND SCHEDULING.

LOAD CHART



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– A TYPE OF GANTT CHART THAT SHOWS THE LOADING AND IDLE TIMES FOR A GROUP OF MACHINES OR LIST OF DEPARTMENTS.

SCHEDULE CHART – A TYPE OF GANTT CHART THAT SHOWS THE ORDERS OR JOBS IN PROGRESS AND WHETHER THEY ARE ON SCHEDULE OR NOT.

INPUT/OUTPUT CONTROL CHART – A TYPE OF CONTROL CHART THAT SHOWS MANAGEMENT OF WORK FLOW AND QUEUES AT THE WORK CENTERS.

LOADING

1. INFINITE LOADING
2. FINITE LOADING
3. VERTICAL LOADING
4. HORIZONTAL LOADING
5. FORWARD SCHEDULING
6. BACKWARD SCHEDULING
7. SCHEDULE CHART
8. INFINITE LOADING: JOBS ARE ASSIGNED TO WORK CENTERS WITHOUT REGARD TO THE CAPACITY OF THE WORK CENTER.
9. FINITE LOADING: JOBS ARE ASSIGNED TO WORK CENTERS WITH REGARD TO THE CAPACITY OF THE WORK CENTER AND JOB PROCESSING TIMES.
10. VERTICAL LOADING: LOADING JOBS AT A WORK CENTER, JOB BY JOB, USUALLY ACCORDING TO SOME PRIORITY CRITERION, USING INFINITE LOADING I.E. JOBS ARE ASSIGNED TO WORK CENTERS WITHOUT REGARD TO THE CAPACITY OF THE WORK CENTER.
11. HORIZONTAL LOADING: LOADING EACH JOB ON ALL WORK CENTERS IT WILL REQUIRE, THEN THE NEXT JOB ON ALL WORK CENTERS, ACCORDING TO SOME PRIORITY, USING FINITE LOADING I.E. JOBS ARE ASSIGNED TO WORK CENTERS WITH REGARD TO THE CAPACITY OF THE WORK CENTER AND JOB PROCESSING TIMES.
12. FORWARD SCHEDULING: SCHEDULING AHEAD, FROM SOME POINT IN TIME.
13. BACKWARD SCHEDULING: SCHEDULING BY WORKING BACKWARDS FROM THE DUE DATE.
14. SCHEDULE CHART: A GANTT CHART THAT SHOWS THE ORDERS OR JOBS IN PROGRESS AND WHETHER THEY ARE ON SCHEDULE OR NOT.

ASSIGNMENT METHOD OF LINEAR PROGRAMMING

1. ASSIGNMENT MODEL IS A TYPE OF LINEAR PROGRAMMING MODEL FOR OPTIMAL ASSIGNMENT OF TASKS AND RESOURCES.
2. HUNGARIAN METHOD IS THE METHOD OF ASSIGNING JOBS BY A ONE FOR ONE MATCHING TO IDENTIFY THE LOWEST COST SOLUTION.

HUNGARIAN METHOD



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1. FIRST OF ALL, ACQUIRE THE RELEVANT COST INFORMATION AND ARRANGE IT IN TABULAR FORM.
2. SECOND, OBTAIN THE ROW REDUCTION, THIS IS OBTAINED BY SUBTRACTING THE SMALLEST NUMBER IN EACH ROW FROM EVERY NUMBER IN THE ROW. ENTER THE RESULTS IN A NEW TABLE.
3. THIRD, OBTAIN THE COLUMN REDUCTION BY SUBTRACTING THE SMALLEST NUMBER IN EACH COLUMN OF THE NEW TABLE FROM EVERY NUMBER IN THE COLUMN.
4. FOURTH, TEST WHETHER AN OPTIMUM ASSIGNMENT CAN BE MADE. YOU DO THIS BY DETERMINING THE MINIMUM NUMBER OF LINES NEEDED TO COVER CROSS OUT ALL ZEROS. IF THE NUMBER OF LINES EQUAL THE NUMBERS OF ROW, AN OPTIMUM ASSIGNMENT IS POSSIBLE. IN THAT CASE MOVE TO FINAL STEP.
5. **FIFTH**, IF THE NUMBERS OF LINES IS LESS THAN THE NUMBER OF ROWS, MODIFY THE TABLE IN THE FOLLOWING MANNER:
 - I. SUBTRACT THE SMALLEST UNCOVERED NUMBER FROM EVERY UNCOVERED NUMBER IN THE TABLE.
 - II. ADD THE SMALLEST UNCOVERED NUMBER TO THE NUMBERS AT THE INTERSECTIONS OF COVERING LINES.
 - III. NUMBERS CROSSED OUT BUT NOT AT INTERSECTIONS OF CROSS OUT LINES CARRY OVER UNCHANGED TO THE NEXT TABLE.
6. **SIXTH**, REPEAT STEPS FOURTH AND FIFTH UNLESS AN OPTIMAL TABLE IS OBTAINED.
7. **SEVENTH**, MAKE THE ASSIGNMENTS. BEGIN WITH ROWS OR COLUMNS WITH ONLY ONE ZERO. MATCH ITEMS THAT HAVE ZEROS, USING ONLY ONE MATCH FOR EACH ROW AND EACH COLUMN. CROSS OUT BOTH THE ROW AND COLUMN FOR EACH ROW.

HUNGARIAN METHOD EXAMPLE

SEQUENCING

DETERMINE THE ORDER IN WHICH JOBS AT A WORK CENTER WILL BE PROCESSED.

WORKSTATION:

AN AREA WHERE ONE PERSON WORKS, USUALLY WITH SPECIAL EQUIPMENT, ON A SPECIALIZED JOB.

SEQUENCING

JOB TIME: TIME NEEDED FOR SETUP AND PROCESSING OF A JOB.

PRIORITY RULES: SIMPLE HEURISTICS (COMMONSENSE RULES) USED TO SELECT THE ORDER IN **WHICH JOBS WILL BE PROCESSED**.

- I. LOCAL RULES (PERTAINING TO SINGLE WORKSTATION).
- II. GLOBAL RULES(PERTAINING TO MULTIPLE WORKSTATION).



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III. JOB PROCESSING TIMES AND DUE DATES ARE IMPORTANT PIECES OF INFORMATION.

IV. JOB TIME CONSISTS OF PROCESSING TIME AND SETUP TIMES.

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SEQUENCING

PRIORITY RULES

1. **FCFS - FIRST COME, FIRST SERVED**

- JOBS ARE PROCESSED IN THE ORDER IN WHICH THEY ARRIVE AT A MACHINE OR WORK CENTER.

2. **SPT - SHORTEST PROCESSING TIME**

- JOBS ARE PROCESSED ACCORDING TO PROCESSING TIME AT A MACHINE OR WORK CENTER, SHORTEST JOB FIRST.

3. **DD - DUE DATE**

- JOBS ARE PROCESSED ACCORDING TO DUE DATE, EARLIEST DUE DATE FIRST.

4. **CR - CRITICAL RATIO**

- JOBS ARE PROCESSED ACCORDING TO SMALLEST RATIO OF TIME REMAINING UNTIL DUE DATE TO PROCESSING TIME REMAINING.

5. **S/O - SLACK PER OPERATION**

- JOBS ARE PROCESSED ACCORDING TO AVERAGE SLACK TIME (TIME UNTIL DUE DATE MINUS REMAINING TIME TO PROCESS). COMPUTE BY DIVIDING SLACK TIME BY DIVIDING SLAC TIME BY NUMBER OF REMAINING OPERATIONS INCLUDING THE CURRENT ONE.

6. **RUSH – EMERGENCY**

- EMERGENCY OR PREFERRED CUSTOMERS FIRST.

ASSUMPTIONS TO PRIORITY RULES

1. SETUP TIME IS DETERMINISTIC.
2. THE SET OF JOBS IS KNOWN, NO NEW JOBS ARRIVE AFTER PROCESSING BEGINS AND NO JOBS ARE CANCELED.
3. PROCESSING TIMES ARE DETERMINISTIC RATHER THAN VARIABLES.
4. THERE WILL BE NO INTERRUPTIONS IN PROCESSING SUCH AS MACHINE BREAKDOWNS , ACCIDENTS OR WORKER ILLNESSES.

DEFINITIONS



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JOB FLOW TIME

THE LENGTH OF TIME A JOB IS IN THE SHOP AT A PARTICULAR WORKSTATION OR WORK CENTER.

JOB LATENESS

THIS IS THE LENGTH OF TIME THE JOB COMPLETION DATE IS EXPECTED TO EXCEED THE DATE THE JOB WAS DUE OR PROMISED TO A CUSTOMER.

MAKESPAN

THIS IS THE TOTAL TIME NEEDED TO COMPLETE A GROUP OF JOBS. IT IS THE LENGTH OF TIME BETWEEN THE START OF THE FIRST JOB IN THE GROUP AND THE COMPLETION OF THE LAST JOB IN THE GROUP.

AVERAGE NUMBER OF JOBS

JOBS THAT ARE CONSIDERED IN A SHOP ARE CONSIDERED TO BE WORK IN PROCESS INVENTORY. **MATHEMATICALLY**

$\text{AVERAGE NUMBER OF JOBS} = \text{TOTAL FLOW TIME} / \text{MAKESPAN}$

EXAMPLE

DETERMINE THE SEQUENCE OF JOBS, AVERAGE TIME FLOW, AVERAGE DAYS LATE AND AVERAGE NUMBER OF JOBS AT THE WORK CENTER, FOR EACH OF THESE RULES:

1. FCFS
2. SPT
3. DD
4. CR

EXAMPLE DATA

FCFS

- I. ASSUME JOBS ARRIVED IN THE FOLLOWING ORDER: A-B-C-D-E-F
- II. AVERAGE FLOW TIME= TOTAL FLOW TIME/NUMBER OF JOBS=120/6=20 DAYS
- III. AVERAGE TARDINESS=54/6=9
- IV. THE MAKESPAN =41 DAYS
- V. AVERAGE NUMBER OF JOBS AT WORKSTATION=



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VI. $120/41=2.93$ JOBS PER WORKSTATION

SPT RULE: THE SEQUENCE IS A-C-E-B-D-F

SPT RULE

- I. AVERAGE NUMBER OF JOBS AT WORKSTATION=
- II. $108/41=2.63$ JOBS PER WORKSTATION
- III. THE MAKESPAN =41 DAYS
- IV. AVERAGE TARDINESS= $40/6=6.67$ DAYS
- V. AVERAGE FLOW TIME= TOTAL FLOW TIME/NUMBER OF JOBS= $108/6=18$ DAYS

SUMMARY PART A,B,C AND D

TWO WORK CENTER SEQUENCING

JOHNSON'S RULE: TECHNIQUE FOR MINIMIZING COMPLETION TIME FOR A GROUP OF JOBS TO BE PROCESSED ON TWO MACHINES OR AT TWO WORK CENTERS.

MINIMIZES TOTAL IDLE TIME

SEVERAL CONDITIONS MUST BE SATISFIED

JOHNSON'S RULE CONDITIONS

1. JOB TIME MUST BE KNOWN AND CONSTANT.
2. JOB TIMES MUST BE INDEPENDENT OF SEQUENCE.
3. JOBS MUST FOLLOW SAME TWO-STEP SEQUENCE.
4. JOB PRIORITIES CANNOT BE USED.
5. ALL UNITS MUST BE COMPLETED AT THE FIRST WORK CENTER BEFORE MOVING TO SECOND.

CHAPTER NO = 43

PROJECT MANAGEMENT

PROJECT MANAGEMENT IS THE DISCIPLINE OF ORGANIZING AND MANAGING RESOURCES IN SUCH A WAY THAT THESE RESOURCES DELIVER ALL THE WORK REQUIRED TO COMPLETE A PROJECT WITHIN DEFINED SCOPE, TIME, AND COST CONSTRAINTS.

A PROJECT IS A TEMPORARY AND ONE-TIME ENDEAVOR UNDERTAKEN TO CREATE A UNIQUE PRODUCT OR SERVICE.

PROJECT MANAGEMENT

WHAT ARE THE TOOLS?



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1. GANTT CHARTS
2. PERT OR CPM TECHNIQUE
3. WORK BREAKDOWN STRUCTURE

PERT AND CPM

PERT: PROGRAM EVALUATION AND REVIEW TECHNIQUE

CPM: CRITICAL PATH METHOD

THE NETWORK DIAGRAM

8. ACTIVITIES
9. EVENTS
10. NETWORK (PRECEDENCE) DIAGRAM
11. ACTIVITY-ON-ARROW (AOA)
12. ACTIVITY-ON-NODE (AON)

PATH

SEQUENCE OF ACTIVITIES THAT LEADS FROM THE STARTING NODE TO THE FINISHING NODE.

CRITICAL PATH

THE LONGEST PATH; DETERMINES EXPECTED PROJECT DURATION.

CRITICAL ACTIVITIES

ACTIVITIES ON THE CRITICAL PATH.

SLACK

ALLOWABLE SLIPPAGE FOR PATH; THE DIFFERENCE THE LENGTH OF PATH AND THE LENGTH OF CRITICAL PATH.

PROJECT MANAGEMENT

WHAT ARE THE KEY METRICS

1. TIME
2. COST
3. PERFORMANCE OBJECTIVES



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PROJECT MANAGER

RESPONSIBLE FOR:

TECHNICAL AND FINANCIAL ANALYSIS

1. PMP CERTIFICATION
2. CFM, CFA AND CFP CERTIFICATION
3. FINANCIAL EVALUATION AND INVESTMENT ANALYSIS
4. COST BENEFIT ANALYSIS

CHAPTER NO = 44

PROJECT NETWORK – ACTIVITY ON ARROW

PROJECT NETWORK – ACTIVITY ON NODE

NETWORK CONVENTIONS

TIME ESTIMATES

DETERMINISTIC

TIME ESTIMATES THAT ARE FAIRLY CERTAIN.

PROBABILISTIC

ESTIMATES OF TIMES THAT ALLOW FOR VARIATION.

PROBABILISTIC TIME ESTIMATES

OPTIMISTIC TIME

TIME REQUIRED UNDER OPTIMAL CONDITIONS.

PESSIMISTIC TIME

TIME REQUIRED UNDER WORST CONDITIONS.

MOST LIKELY TIME

MOST PROBABLE LENGTH OF TIME THAT WILL BE REQUIRED.



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PROBABILISTIC ESTIMATES COMPUTING ALGORITHM

NETWORK ACTIVITIES

1. ES: EARLY START
2. EF: EARLY FINISH
3. LS: LATE START
4. LF: LATE FINISH

USED TO DETERMINE

1. CRITICAL PATH
2. SLACK TIME
3. EXPECTED PROJECT DURATION

EXPECTED TIME

VARIANCE

PATH PROBABILITIES

TIME-COST TRADE-OFFS: CRASHING

CRASH – SHORTENING ACTIVITY DURATION.

PROCEDURE FOR CRASHING

1. CRASH THE PROJECT ONE PERIOD AT A TIME.
2. ONLY AN ACTIVITY ON THE CRITICAL PATH.
3. CRASH THE LEAST EXPENSIVE ACTIVITY.
4. MULTIPLE CRITICAL PATHS: FIND THE SUM OF CRASHING THE LEAST EXPENSIVE ACTIVITY ON EACH CRITICAL PATH.

TIME-COST TRADE-OFFS: CRASHING

RISK MANAGEMENT

1. IDENTIFY POTENTIAL RISKS
2. ANALYZE AND ASSESS RISKS
3. WORK TO MINIMIZE OCCURRENCE OF RISK
4. ESTABLISH CONTINGENCY PLANS

CHAPTER NO = 45

WAITING LINES

WAITING LINES ARE NON-VALUE ADDED OCCURRENCES.



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QUEUING THEORY: MATHEMATICAL APPROACH TO THE ANALYSIS OF WAITING LINES.

GOAL OF QUEUING ANALYSIS IS TO MINIMIZE THE SUM OF TWO COSTS:

- CUSTOMER WAITING COSTS
- SERVICE CAPACITY COSTS

QUEUING ANALYSIS

QUEUING SYSTEMS

POISSON DISTRIBUTION

WAITING LINE MODELS

- BALKING

UPON ARRIVING, DECIDE THE LINE IS TOO LONG AND DECIDE NOT TO ENTER THE LINE.

- JOCKEYING

CUSTOMERS MAY SWITCH TO ANOTHER LINE.

- RENEGING

WAITING CUSTOMERS GROW IMPATIENT AND LEAVE THE LINE.

- PATIENT

CUSTOMERS ENTER THE WAITING LINE AND REMAIN UNTIL SERVED.

SYSTEM PERFORMANCE

1. AVERAGE NUMBER OF CUSTOMERS WAITING
2. AVERAGE TIME CUSTOMERS WAIT
3. SYSTEM UTILIZATION
4. IMPLIED COST
5. PROBABILITY THAT AN ARRIVAL WILL HAVE TO WAIT

QUEUING MODELS: INFINITE-SOURCE

1. SINGLE CHANNEL, EXPONENTIAL SERVICE TIME
2. SINGLE CHANNEL, CONSTANT SERVICE TIME
3. MULTIPLE CHANNEL, EXPONENTIAL SERVICE TIME
4. MULTIPLE PRIORITY SERVICE, EXPONENTIAL SERVICE TIME

FINITE-SOURCE FORMULAS



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OTHER APPROACHES

- **REDUCE PERCEIVED WAITING TIME**
 1. MAGAZINES IN WAITING ROOMS
 2. RADIO/TELEVISION
 3. IN-FLIGHT MOVIES
 4. FILLING OUT FORMS
- **DERIVE BENEFITS FROM WAITING**
 1. PLACE IMPULSE ITEMS NEAR CHECKOUT
 2. ADVERTISE OTHER GOODS/SERVICES

POMA BEYOND THE FINAL EXAM

1. IN THE LONG RUN (WHEN FACTORS OF PRODUCTION CHANGE, LABOR, LAND, TECHNOLOGY), PRODUCTIVITY GROWTH IS ALMOST EVERYTHING IF NOT EVERYTHING.
2. DO NOT CREATE ARTIFICIAL NON OPERATIONAL MANAGEMENT STRATEGIES TO BALANCE CAPACITY WITH DEMAND.
3. HOW MUCH DOES IT REALLY COST TO MANUFACTURE A PRODUCT OR DEVELOP A SERVICE.
4. COMPETITIVE ADVANTAGE IN OPERATIONAL AND ORGANIZATION STRATEGY CREATES A WIN WIN SITUATION FOR THE ORGANIZATION.
5. OPERATIONS MANAGER SHOULD LEARN TO THINK AT THE MARGIN.
6. HOW WE AS OPERATIONS MANAGER CAN PLAY A PART IN MINIMIZATION OF COSTS OF MOST IMPORTANT OF SERVICES.
7. HOW AND WHY PROJECT MANAGEMENT CONCEPTS ARE EQUALLY IMPORTANT TO PRODUCTION OPERATIONS MANAGEMENT AND VICE VERCA.
8. THE IMPORTANCE OF COORDINATING, PLANNING AND CONTROLLING AND BUDGETING OPERATIONS AND PROJECT ACTIVITIES IN ACHIEVING OUR FIRMS SHORT AND LONG TERM OBJECTIVES.
9. THE CONCEPTS OF STRATEGY, COMPETITIVENESS AND PRODUCTIVITY, DESIGN OF PRODUCT AND SERVICES, DESIGN OF WORK SYSTEMS AND FACILITIES, CONCEPT OF QUALITY AND SYSTEM IMPROVEMENT AS APPLICABLE IN ORGANIZATIONS BE APPLIED TO PAKISTAN.
10. HOW AS OPERATIONS MANAGER WE CAN COMMUNICATE TO MASSES THE IMPORTANCE OF PAKISTANI DOMESTIC MARKETS AND HOW THEY HELP IN CAPITAL FORMATION.



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Always Remember Our Group in Your Prayers:

(Naveed, Farhana Burhan, Humera Fazal, Ayesha Masood, Shaista, Zulfiqar Gill)